IN-DEPTH SURVEY REPORT: EVALUATION OF THE VENTILATION AND FILTRATION SYSTEM AND BIOHAZARD DETECTION SYSTEM FOR THE AUTOMATED FACER CANCELLER SYSTEM

At

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

REPORT WRITTEN BY
Jennifer L. Topmiller
Bryan Beamer
Keith G. Crouch

REPORT DATE
October 2003

REPORT NO
EPHB 279-16a

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, Dulles, Virginia
SIC CODE	
SURVEY DATES	October 7-8, 2002 December 12-13, 2002 January 27-28, 2003
SURVEYS CONDUCTED BY	Bryan Beamer, NIOSH Keith Crouch, NIOSH Jenny Topmiller, NIOSH
EMPLOYER REPRESENTATIVES CONTACTED	Leon Shiu 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 processing equipment - the Automated Facer Canceller System (AFCS) 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 The ventilation system for the AFCS was designed to be used with a Biohazard Detection System (BDS) that samples and analyzes air from the AFCS to determine if a biohazard is present This effort is in response to terrorist attacks in the fall of 2001 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 experiments, air velocity measurements, and smoke release observations The experiments showed that generally there is good capture by the VFS Without the BDS installed, the measured VFS capture efficiencies exceeded 98% except in two positions Lower efficiency was measured under the flats extractor, but following a modification by the vendor, the efficiency in this area was also greater than 98% Another position that had lower capture efficiency was above the first pinch point in the singulator This is the area in which the BDS would be installed, so it was not a concern Testing conducted with the BDS installed showed good capture efficiencies under most conditions When tracer gas was released around the BDS and under the BDS hood, capture efficiencies exceeded 98% for most positions and exceeded 90% for all positions Smoke release experiments and velocity measurements were consistent with the results of tracer gas testing

Based on the results in this report, the following recommendations are made to further improve the control of potential contaminants by the AFCS ventilation and filtration system

- All gaps between the BDS and the AFCS should be sealed to maximize the capture efficiency in this area

- Capture efficiency of the VFS alone in the area where the BDS is installed does not meet capture criteria As the VFS was designed to work with the BDS in place, this is not a concern However, should the BDS be removed for any reason, it should be noted that capture is not complete in the area of the singulator

- The temporary modification made to the VFS near the Flats Extractor should be made permanent

- By placing the exhaust duct in the center of the BDS hood or adding a tapered manifold to the hood, the capture efficiency of the BDS could be made more consistent along the length of the singulator

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 the performance of 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 control the release of contaminants into the work area of postal employees This report describes the evaluation of the capture efficiencies of the Ventilation/Filtration System (VFS) and the Biohazard Detection System (BDS) for the Advanced Facer Canceller System (AFCS)

BACKGROUND

Researchers from NIOSH were requested to assist the USPS in the evaluation of particulate 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 during normal mail processing This effort is driven by the terrorist attacks in the fall of 2001 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 controls evaluated in this report are the VFS and BDS for the Advanced Facer Canceller System The controls were designed and installed by USPS contractors to significantly reduce the potential for operator exposure to bacterial contaminants that could be contained in mail processed by this equipment This system was evaluated at the Dulles, Virginia Processing and

Distribution Center (P&DC) during three field surveys that took place October 7-8, 2002, December 12, 2002, and January 27-28, 2003

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[I] 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[II] 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 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 Mail is delivered to the AFCS from the 010 loose mail distribution system The AFCS culls the mail to remove flats and overthick (greater than 0 25 in) mail pieces The mail is then properly oriented so it may be cancelled Optical character recognition technology is used to read the addresses on the mail piece which is then sorted and distributed to numbered bins for further automated processing An overview of the AFCS is shown in Figure 1

The VFS for the AFCS consisted of an air handling/filtration unit that provided exhaust for locations of possible contaminant release The air handling unit was fitted with three stages of filtration composed of a pre-filter, a Minimum Efficiency Reporting Value (MERV) 14 filter, and a High Efficiency Particulate Air (HEPA) filter The effectiveness of the VFS was enhanced by enclosures put in place on the AFCS 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

The biohazard detection system was designed to draw air from an area of the AFCS that would most likely contain a contaminant emitted from an envelope due to agitation or compression – the singulator area of the AFCS The hood of the BDS is shaped like a tunnel and fits over the singulator area In this area, the mailpieces are tightly compressed and abruptly accelerated in a process that caused them to move as individual pieces The hood is approximately 4 inches wide by 5 5 inches high by 32 inches long Air is drawn from the hood through a flexible duct into the detector which then analyzes the air for potential biological agents If a hazard is detected, an alarm sounds and appropriate steps may be taken

Figures 2 and 3 show the shingler and singulator of the AFCS As mailpieces move through the shingler, they are forced into an overlapping position, similar to roof shingles on a house The mailstream continues to move toward the singulator In this assembly, the mailstream is separated into individual pieces with a constant gap between the pieces

METHODS

TRACER GAS

Apparatus

To quantitatively evaluate the capture efficiency of the ventilation system, a tracer gas method was used When the VFS alone was tested, the following conditions applied The gas, chemically pure sulfur hexafluoride (SF_6), was released at a constant rate at various points to determine the capture efficiency of the VFS and BDS 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 for particulates 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) at approximately 30 lpm, and using Tygon® tubing throughout the sampling system After exiting the pump, the sampled air was released into the workroom The analog 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

To test the BDS, some changes were made to the test setup due to the smaller size of the BDS The tracer gas used was 1% SF_6 The area sampled included points in and around the BDS hood Since the BDS exhausts close to the floor, this exhaust was directed to a fan to limit re-entrainment of the TG in the experiment

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 Tracer gas measurements were made with the ventilation system blower both on and off Some measurements were made while the AFCS processed mail

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 pinch points along the mail path of the AFCS and around the area of the singulator both with and without the BDS in place

CAPTURE VELOCITY

Apparatus

An anemometer was used to measure air speeds at exhaust openings on the AFCS and BDS (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 air flow direction at those points Velocity measurement points included typical worker positions during mail processing and points in the system where a contaminant could escape into the workroom

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 captured The relative concentration in the exhaust as a result of tracer dosing at any point along the VFS is then calculated from the measured concentrations The relative concentration is equivalent to the capture efficiency of the exhaust system at that particular point The efficiencies are shown for each case from the three surveys These results are found in Tables 1-4

AFCS without BDS

Survey 1

When the BDS was not installed, the tracer results showed lower levels of capture efficiency at the singulator (the position where the BDS would be installed) Results of tracer gas measurements also showed reduced capture efficiency below the Flats Extractor The hood added to the Cull Drum area did not seem to impact the capture efficiencies of the system Some of the capture efficiencies were higher than 100% This is likely due to drift of baseline during the relatively short measurement periods and represents complete capture of the tracer gas In the tables, all capture efficiencies higher than 98% are shown as >98% The tracer results for this condition are presented in Table 1

AFCS with BDS

Survey 1

During this survey, with the BDS installed, measurements were taken under two conditions 1) BDS exhausted into ambient air and 2) BDS exhausted into the VFS exhaust The purpose of this comparison was to evaluate how much tracer gas was captured by the BDS and how much was captured by the VFS

The capture efficiencies measured for all experiments with the BDS installed were approximately 100% when tracer gas was released at the BDS hood faces The proportion of tracer gas captured by the BDS was about 70% as measured at the upstream side of the BDS hood with the mail running Similarly, the BDS hood captured about 60% of the total as measured at the first pick off point of the singulator inside the BDS At the downstream side of the BDS, capture percentage by the BDS was approximately 88% to 93% of the total with the AFCS on and no mail running The results of the tracer testing with the BDS installed are shown in Table 2

Survey 2

During this survey, measurements were taken with the BDS and VFS running simultaneously When the BDS and VFS were both operating, tracer gas capture efficiency of the combined system was approximately 95% to >98% Measurements were also taken with only the BDS running These results showed capture efficiencies inside the BDS hood of >98% The capture efficiency of the BDS alone was also measured with the VFS on Table 3 presents these results

Survey 3

When the BDS and VFS were operating together, tracer gas capture of the BDS was measured to be 82% to >98% Under the BDS hood, average capture efficiency was measured to be 95% The BDS showed adequate capture of tracer gas when it was operating alone, without the VFS When both the BDS and VFS were working together, the total combined capture efficiency ranged from 91% to 99% These results are presented in Table 4

Smoke

Smoke release experiments were conducted to visually determine how effective the exhaust ventilation control is at various points around the AFCS Smoke was well controlled in most areas

Survey 1

Without the BDS installed, smoke was released in the area of the hopper, waterfall and transport upstream of the flats extractor Smoke was well contained during the clearance tests and results indicate that an operator would be at little risk of exposure to a recently released contaminant if it was necessary to open covers to clear a jam

Smoke generated inside the BDS hood was well captured by the BDS exhaust with mail running and the VFS off Smoke release near the hood faces was also well controlled under these conditions When smoke was released one to two inches from the faces of the BDS hood, not all smoke was controlled by the total system More than two inches away from the BDS hood face, the VFS exhaust controlled the released smoke

Survey 2

When the BDS was on and the VFS was off, smoke capture was generally good although some smoke escaped from gaps between the BDS and the VFS Following this discovery, the vendor sealed these gaps In subsequent trials, smoke generated under the BDS hood did not escape the BDS hood or was immediately entrained by the system When the BDS and VFS were both operating, all smoke generated at the hood faces or within the BDS was captured by one or both of the systems Smoke released at the first and second pinch points downstream of the BDS hood was not definitively captured when both systems were running

Survey 3

Smoke tests conducted during this survey showed that the smoke released at the AFCS operator position was well controlled Without the BDS present, the smoke was marginally controlled in this area However, the VFS was designed to work with the BDS in this area

Velocity

Air velocity measurements were taken in areas that require operator access during mail sorting

Survey 1

Air velocities were taken around the AFCS without the BDS installed The measured velocities indicate adequate control around the VFS As shown in Table 5, the area where the BDS was to be installed had generally low velocities However, the BDS was designed to not interfere with the VFS, so this is not a concern Other areas that had low velocities pose a minimal potential for contaminant release because they are well enclosed

Air velocities collected when the BDS was installed are shown in Table 6 These results are consistent with other findings in this survey Although the velocities are rather low, the BDS was designed not to interfere with the VFS

Survey 2

Table 7 shows air velocity measurements taken around the BDS during the second survey The low measured velocities do not contradict other results from this survey

Survey 3

There were no significant velocity measurements taken during this survey

DISCUSSION

Three surveys were conducted to evaluate the ventilation and filtration system for the AFCS in conjunction with the biohazard detection system The VFS was designed to work with the BDS which is a hood placed over a portion of the AFCS transport channel Overall, the VFS/BDS combination provided good control as shown by the experiments carried out in these three surveys

First, results of the tracer gas testing showed that when the BDS was not installed, the capture efficiencies were lower in the area that the BDS would be placed This was not surprising as the systems were designed to work together Without the BDS, smoke was released around the hopper, waterfall, and transport upstream of the flats extractor Smoke was well contained indicating little risk to the operator of being exposed to potential contaminants Air velocity measurements taken around the VFS without the BDS installed showed adequate capture velocities (greater than 100 fpm) in critical areas The velocities measured around the area where the BDS would be installed showed rather low velocities, but this was expected due to the design of the VFS

Later, the BDS was installed for further testing Some tracer tests were carried out to determine about how much of the tracer gas was captured by the BDS, and how much was captured by the VFS when tracer was released in the area of the BDS It was determined that approximately 60-70% of the total tracer gas captured was captured by the BDS [The total capture efficiency was generally >98%] Testing generally showed adequate capture efficiencies when the BDS was installed

Smoke release tests were also conducted when the BDS was installed These tests showed adequate control of smoke released around and under the BDS hood Velocity measurements taken in this area were consistent with these results

All of the tests indicated that contaminant control was marginal in the area of the BDS when the BDS was not installed Therefore, it is important to account for this should the BDS be removed from the AFCS

RECOMMENDATIONS

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

- Ensure that all gaps between the BDS and AFCS/VFS are sealed to assure optimum system performance
- Since the VFS was designed to be used with the BDS installed, the system should not be operated without the BDS
- In the event that the BDS hood is removed, it should be kept in mind that the area around the BDS does not experience complete capture efficiency This is particularly important if it is decided to sample for biocontamination from the VFS duct and not use the BDS
- Although the combined capture efficiency of the BDS/VFS is near 100%, there are several gaps between the BDS hood and the AFCS that should be sealed to maintain optimum capture efficiency
- A simple redesign of the BDS hood, placing the exhaust duct at the center of the hood or installing a tapered manifold, could increase the uniformity of capture across the singulator area

Table 1 Tracer Gas Capture Efficiencies for the AFCS without the BDS installed (Survey 1)

Position of Tracer Release	Contaminant Capture Efficiency
Center of hopper about 8" from bottom	>98%
Center of cull drum #1 before installation of larger hood	>98%
Cull drum #1 after installation of larger hood	>98%
Underneath flats extractor 2"above conveyor before vendor modification	92%, 92%
Underneath flats extractor 2" above conveyor after vendor modification	>98%
Above pinch point upstream of shingulator (6" upstream of flap)	>98%
Above first pinch point in singulator (BDS not installed)	81%
Above last pinch point in singulator (BDS not installed)	98%
Above last pinch point in transport before feeder	>98%
Left feeder - top inner envelope corner	>98%
Left feeder - top outer envelope corner	>98%
Left feeder - bottom outer envelope corner	>98%
Middle feeder - top inner envelope corner	>98%
Middle feeder - top outer envelope corner	>98%
Middle feeder - bottom outer envelope corner	>98%
Right feeder - top inner envelope corner	>98%
Right feeder - top outer envelope corner	>98%

Right feeder - bottom outer envelope corner	>98%
Stacker 1 (to left of paddle)	>98%
Stacker 2 (to left of paddle)	>98%
Stacker 3 (to left of paddle)	>98%
Stacker 4 (to left of paddle)	>98%
Stacker 5 (to left of paddle)	>98%
Stacker 6 (to left of paddle)	>98%
Stacker 7 (to left of paddle)	>98%
Center of opening for ejector between stackers and sensor mod	>98%

Table 2 Tracer Gas Capture Efficiencies for the AFCS with the BDS installed (Survey 1)

Position of Tracer Release	**Total Contaminant Capture Efficiency Measured at VFS Exhaust**
BDS Exhaust out to Ambient Air	
Upstream of singulator in center of BDS hood face (AFCS off)	61%
First pickoff point of singulator inside hood (AFCS off)	89%
Downstream of singulator in center of BDS hood face (AFCS off)	34%
At exhaust of BDS (AFCS off)	39%
Upstream of singulator in center of BDS hood face (AFCS on/no mail)	48%,37%
First pickoff point of singulator inside hood (AFCS on/no mail)	62%
Downstream of singulator in center of BDS hood face (AFCS on/no mail)	11%, 7%
First pickoff point of singulator inside of hood (AFCS on/mail running)	40%
Upstream of singulator in center of BDS hood face (AFCS on/mail running)	30%
BDS Exhaust out to VFS	
Upstream of singulator in center of BDS hood face (VFS off)	>98%
First pickoff point of singulator inside hood (VFS off)	>98%
Downstream of singulator in center of BDS hood face (VFS off)	>98%

Table 3 Tracer Gas Capture Efficiencies for AFCS with BDS Installed to determine percentage captured by BDS (Survey 2)

Release Position	Capture of BDS alone, measured at BDS with VFS off	Capture of BDS alone, measured at BDS with VFS on	Capture of BDS alone, measured at VFS with VFS on	Total combined capture
Upstream BDS face	>98%	71%	64%	>98%
Inlet 1	>98%	80%	87%	>98%
Inlet 2	>98%	85%	85%	>98%
Inlet 3	>98%	96%	92%	>98%
Inlet 4	>98%	91%	94%	>98%
Downstream BDS face	>98%	61%	88%	>98%
Downstream pinch point 1	1%	0%	-1%	97%
Downstream pinch point 2	0%	0%	-2%	95%

Table 4 Tracer Gas Capture Efficiency for BDS Installed (Survey 3)

Release Position	**Capture of BDS alone, measured at BDS with VFS off**	**Capture of BDS alone, measured at BDS with VFS on**	**Capture of BDS alone, measured at VFS with VFS on**	**Total combined capture**
Upstream pinch point	34%	10%	31%	92%
Upstream BDS face	>98%	93%	77%	91%
Inlet 1	96%	92%	82%	97%
Inlet 2	>98%	>98%	85%	94%
Inlet 3	96%	>98%	96%	>98%
Inlet 4	>98%	>98%	98%	97%
Downstream BDS face	96%	83%	>98%	98%
Downstream pinch point	2%	-4%	22%	96%

Table 5 AFCS Air Velocity Data (Survey 1)

Area of Measurement	Average Contaminant Capture Velocity (FPM)
Center of vertical opening between 010 system and hopper	45
Center of hopper	43
Center of opening between hopper and incline	106
Inside center of cull drum 1	26
Inside center of cull drum 2	9,8
Directly above waterfall	176
Above singulator upstream of first pinch point	20
Above singulator at first pinch point	4
Above singulator downstream of first pinch point	36
Pinch point at pre-feeder transport	245
Left feeder - top inner corner	114, 110, 102
Left feeder - top outer corner	139, 137, 138
Left feeder - bottom outer corner	164, 160, 165
Middle feeder - top inner corner	247, 251, 245
Middle feeder - top outer corner	125, 118, 108
Middle feeder - bottom outer corner	189, 187, 186
Right feeder - top inner corner	304, 323, 318

Right feeder - top outer corner	120, 119, 107
Right feeder - bottom outer corner	230, 218, 217
Feeder pickup point	162, 164, 158
Stacker 1 (to left of paddle)	124
Stacker 2 (to left of paddle)	101
Stacker 3 (to left of paddle)	109
Stacker 4 (to left of paddle)	115
Stacker 5 (to left of paddle)	126
Stacker 6 (to left of paddle)	121
Stacker 7 (to left of paddle)	140
Inside AFCS between stackers and scanner modules	115
At opening in ejector between stacker mods and scanner mod	201, 202, 146

Table 6 Air Velocity Measurements with BDS Installed (Survey 1)

Area of Measurement	Average Contaminant Capture Velocity (FPM)
Upstream of singulator in top-center of BDS hood face (AFCS off)	23
Upstream of singulator in center of BDS hood face (AFCS off)	39
Upstream of singulator in bottom-center of BDS hood face (AFCS off)	45
Downstream of singulator in top-center of BDS hood face (AFCS off)	71
Downstream of singulator in center of BDS hood face (AFCS off)	65
Downstream of singulator in bottom-center of BDS hood face (AFCS off)	46
Upstream of singulator in top-center of BDS hood face (AFCS on/mail on)	37
Upstream of singulator in center of BDS hood face (AFCS on/mail on)	42
Upstream of singulator in bottom-center of BDS hood face (AFCS on/mail on)	27
Downstream of singulator in top-center of BDS hood face (AFCS on/mail on)	61
Downstream of singulator in center of BDS hood face (AFCS on/mail on)	34
Downstream of singulator in bottom-center of BDS hood face (AFCS on/mail on)	49

Table 7 Air Velocity Measurement with BDS Installed (Survey 2)

Measurement Position	Upper Face (FPM)	Lower Face (FPM)
Upstream BDS hood face (VFS on)	23	39
Downstream BDS hood face (VFS on)	52	80
Upstream BDS hood face (VFS off)	4	1
Downstream BDS hood face (VFS off)	82	57

Figure 1   Overview of Automated Facer Canceller System

Figure 1 1
AFCS/ISS Major Units

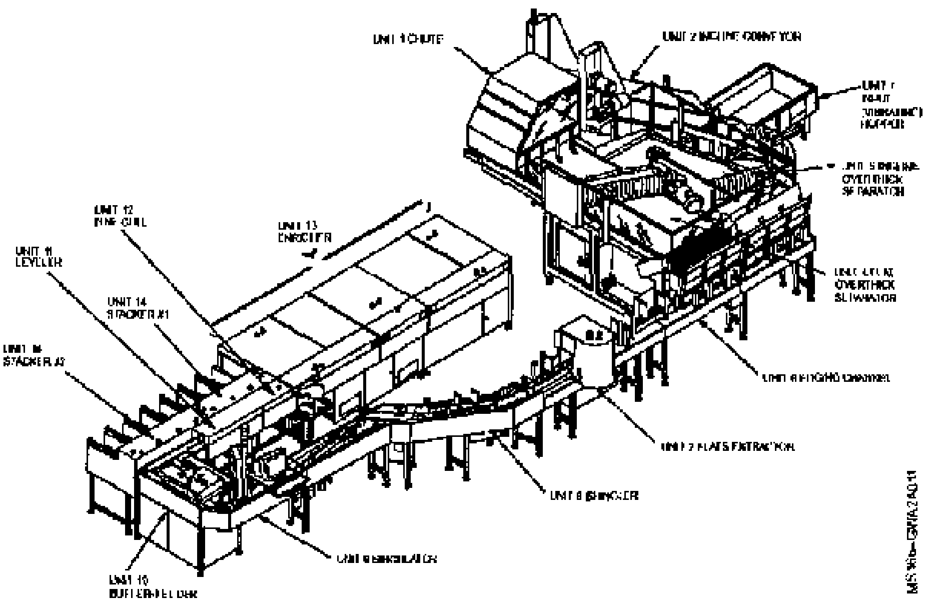


Figure 2 Shingler Area of the AFCS

Figure 2 1 8
Shingler Assembly

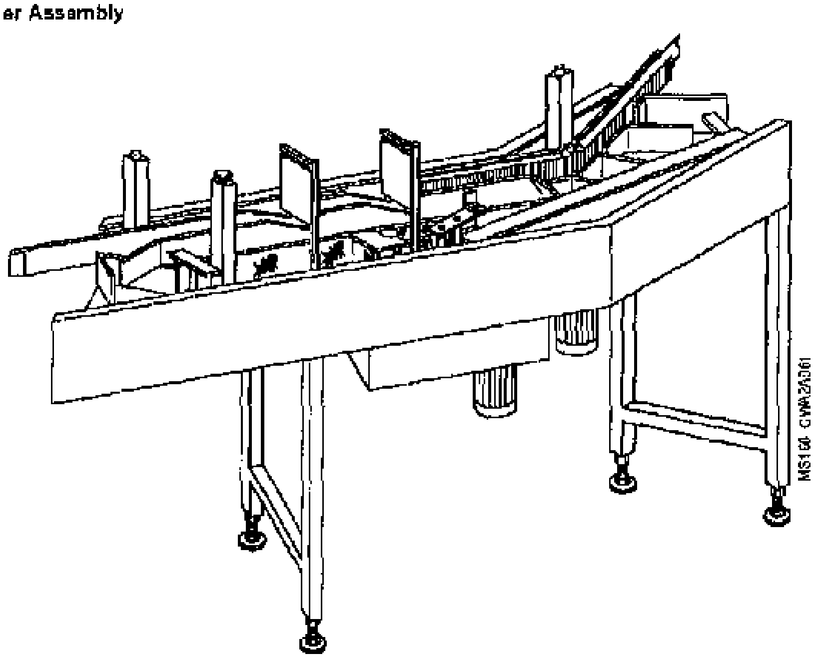
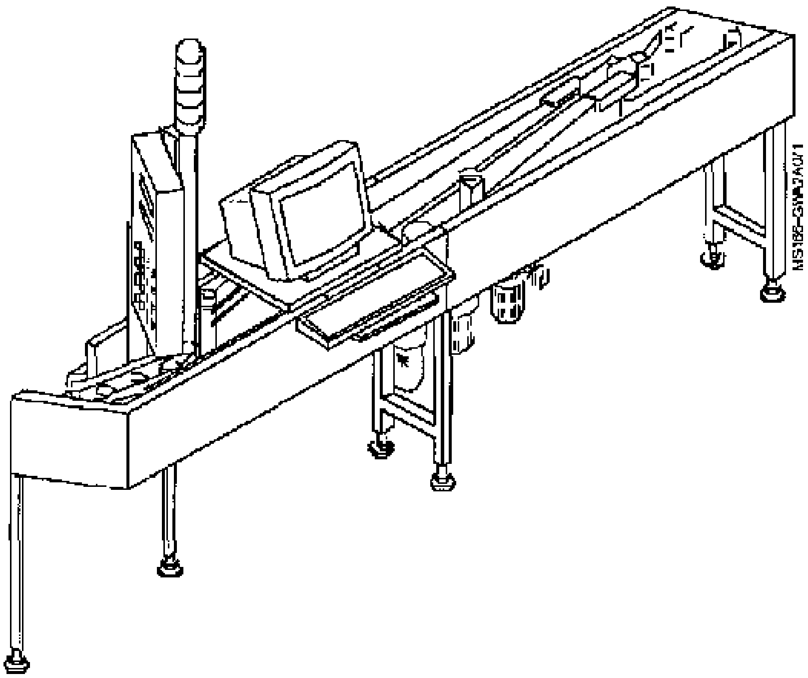


Figure 3 Singulator Area of the AFCS

Figure 2-1 9
Singulator Assembly



REFERENCES

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

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