IN-DEPTH SURVEY REPORT: EVALUATION OF VENTILATION/FILTRATION SYSTEM FOR ADVANCED FLAT SORTER MACHINE 100

at

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

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DISCLAIMER

ABSTRACT

Researchers from the National Institute for Occupational Safety and Health (NIOSH) conducted evaluations of a ventilation and filtration system (VFS) 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 of the contaminant capture capabilities of the system were based on a variety of tests including tracer gas experiments, air velocity measurements and smoke release observations and smoke clearance observations under hoods. The experiments showed that, overall, there is good capture by the ventilation system. Tracer gas tests indicated that the capture was essentially 100% between the Feeder Module and the bucket injection point underneath the Interface 950 module for Feed Stations 1, 2 and 3. The ventilation system also exhibited good capture characteristics based on smoke release experiments and smoke clearance tests under hoods. Furthermore, air velocity measurements support these findings based on NIOSH criteria.

It is, however, recommended that the USPS vent the VFS exhaust to the ambient air, outside of the plant, if at all possible. Furthermore, the filtration component of the system should be evaluated to determine filtration efficiency of the system. Also, NIOSH recommends that a plan of routine preventative maintenance be implemented to ensure proper function of the contaminant capture and filtration capabilities of the VFS.

BACKGROUND

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 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

Researchers from EPHB were requested to assist the United States Postal Service (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 automatically sorted 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 This is one of several reports in a project to evaluate controls that are put in place by the 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 for the Automated Flat Sorting Machine (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 that could be contained in mailpieces processed by the AFSM 100 Please note that the control at the time of evaluation was a prototype that continues to change Consequently, any comments made are only applicable to the evaluation conducted by NIOSH on June 4, 2002 Furthermore, during the June 4, 2002 evaluation, the system's filtration capabilities were not evaluated

HAZARD 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 and impacted in a number of places that could cause the release of substances from the mail

DESCRIPTION OF MAIL PROCESSING EQUIPMENT

The ventilation/filtration system evaluated at the Baltimore Processing and Distribution Center on June 4, 2002 was installed onto the AFSM 100 The AFSM 100 is an automated flat sorting machine Mail is fed into the machine through three Feed Stations (These Feed Stations will henceforth be referred to as Feed Stations 1, 2 and 3, Feed Station 1 being furthest away from the 120 sort bins at the end of the processing equipment) Once in the transport system of any of the three Feed Stations, the image of each individual piece is captured An optical character reader (OCR) reads any barcodes and the content of the address The mailpieces are then injected into one of 759 pockets that circulate around the AFSM 100 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 [3]

Each of the three Feed Stations that supply mail to 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, Destacker 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 Moreover, 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 any of the three Feed Stations, mailpieces are treated in the following manner

1 At the Feeder Module, the mail is manually loaded onto the feeder belt
2 The conveyor on the feeder belt advances the mail to the Destacker Module where the individual pieces of mail are separated
3 The mailpieces are then tilted in preparation for entering the OCR Module
4 In the OCR Module, the mailpieces are passed over a scanner to obtain an image
5 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 (termed a ventilation/filtration system, or VFS, by the USPS) has been retrofitted for the AFSM 100 by the manufacturer and consists of contaminant capture capabilities at each of the three Feed Stations By taking advantage of the enclosed OCR and Interface 950 Modules at each of the Feed Stations, the interior of the machine was ventilated by adding exhausts to the machine cabinets Inside the cabinets, exhaust slots were placed along the path taken by the mailpieces to collect any contaminant potentially in the mail These exhaust slots focused on the areas around pinch points as these have the highest potential for releasing a substance At the time of the June survey, the three Feeder Modules of the AFSM 100 were also controlled by exhaust slots located perpendicular to the Feeder Module belts and above the mailpieces For each of the three Feed Stations, exhaust ductwork was located over the middle of the OCR cabinet However, additional exhaust ductwork was located over the Feeder Module of Feed Station 1

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 Filtration for the ventilation system consisted of a three stage filtration system intended to meet USPS standards The first stage is a perforated plate pre-filter intended to provide 25-30% capture efficiency and the second stage is intended to provide 90-95% capture efficiency These first 2 stages are intended to meet USPS requirements and ANSI/ASRAE 52 1 testing standards The third filter in the filtration system is a High Efficiency Particle Air filter designed to capture at least 99 97% of particulate 0 3 microns in diameter After filtration, the air was released back into the workroom environment The filtration system was not evaluated as a part of this survey as its evaluation falls under USPS statements of work

METHODS

TRACER GAS

Apparatus

To quantitatively evaluate the capture efficiency of the VFS, a tracer gas method was used The gas, CP sulfur hexafluoride (SF_6), was released at a constant rate at points in and near Feed Stations 1, 2 and 3 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, Six Shattuck Road, Andover, Massachusetts, 01810) set to produce about 4 ppm in the exhaust outlet of the VFS The exhaust from the VFS 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 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 simply 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

Procedures

The Miran® data was recorded at one second intervals For each experiment, measurements were recorded for 2 to 5 minutes, depending on the time required to achieve equilibrium, as indicated in a real-time display of concentration vs time 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 belt 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 VFS 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 in the "Location" column Three locations near the Feeder Module were sampled, referenced to the largest piece of mail that could be handled by the AFSM 100 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 Module The "right" position was closest to the Destacker Module 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 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 exhaust inlet, the VFS design was considered marginal at that point Smoke release observations were made at each Feed Station's Feeder Module, pinch point area at front of destacker module, and underneath 950 Modules where mail drops into bins (under Injector/Accelerator cover)

In addition, areas underneath access covers were filled with smoke and then opened while the degree of containment of the smoke was observed These smoke clearance tests were done in order to characterize the potential hazard of anthrax exposure to workers who need to open access covers in order to clear jams These observations were made both with no mail in place and with the sorter in operation using test mail

CAPTURE VELOCITY

Apparatus

A hot-wire 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 exhaust slot, the anemometer was held where the outer corner of the largest piece of mail accepted by the machine would be

RESULTS

Tracer Gas

The concentration at each of the tracer gas dosing points relative to the concentration where 100% of the tracer gas was being captured, 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 1 It is clear that all of the tested points have a measured capture efficiency of 1 00 +/- 0 04, which is the estimated range of accuracy of the measurements Note that analysis of TG data does not indicate a significant difference in observations between different feeders or with mail on vs mail off

Smoke

Smoke release experiments were conducted to visually determine how effective the control is at various locations around the machine At Feed Stations 1, 2 and 3, the smoke was effectively captured by the control at 1) the Feeder Module, 2) pinch point area at the front of the destacker module and 3) underneath the 950 Module where mail drops into bins (under Injector/Accelerator cover) Furthermore, smoke clearance tests showed no locations that exhibited an undue delay in clearance of smoke

Air 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 At the edge of the various Feeder Modules, air velocities ranged from approximately 67 to 119 fpm

DISCUSSION

Overall, TG capture efficiency of the VFS was good at all locations tested, achieving nominally 100% capture under the conditions of the test Smoke release observations reinforced results from the tracer gas tests In addition, smoke clearance test 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

NIOSH defined performance criteria regarding appropriate capture velocities are based on values recommended by the American Conference of Governmental Industrial Hygienists' Industrial Ventilation Manual Accordingly, where potential contaminant is released with practically no velocity into quiet air, the recommended capture velocity is 100 fpm However, where a potential contaminant is released at low velocity into moderately still air, the recommended capture velocity is 200 fpm [5]

It should be noted that the above guidelines set forth in the Industrial Ventilation Manual are qualified by the statement that

> Exceptionally high air flow hoods may require less air flow than would be indicated by the capture velocity values recommended for small hoods This phenomenon may be ascribed to
>
> - The presence of a large air mass moving into the hood
> - The fact that the contaminant is under the influence of the hood for a much longer time than is the case with small hoods
> - The fact that the large air flow rate affords considerable dilution as described above [6]

Based on these considerations, the NIOSH position is that air velocity measurements do not contradict findings that contaminant capture is effective for the AFSM 100 evaluated on June 4, 2002 Furthermore, although contaminant capture velocities less than 100 fpm were recorded, investigators have found that TG measurements and smoke release observations tend to be a more reliable indicator of effectiveness of VFS developed for the USPS

It should, however, be noted that the USPS performance criteria for contaminant capture velocity have been set at a minimum of 100 feet per minute at all critical locations regardless of any other considerations

The system, as observed on June 4, 2002, seems to be operating as intended Analysis of data done so far does not indicate any areas of poor or marginal performance in terms of contaminant capture efficiency It is, however, recommended that the USPS vent VFS exhaust to the ambient air, outside of the plant, if at all possible Furthermore, the filtration component of the system should be evaluated to determine filtration efficiency of the system Also, NIOSH recommends that a plan of routine preventative maintenance be implemented to ensure proper function of the contaminant capture and filtration capabilities of the VFS

Table 1 TG capture Efficiencies at Evaluated Locations

Experiment Number	Location (Initial Number Indicates Feed Station Number	Mail On? (Y/N)	% Capture Effectiveness	Dummy Mail in Place on Feeder
TG1	3-feeder table-left	N	99 69	Y
TG2	3-feeder table-middle	N	100 18	Y
TG3	3-feeder table-right	N	99 79	Y
TG4	3-destacker pinch area	N	99 51	N
TG5	N/A	N/A	N/A	N
TG6	3-inside front filter cover	N	100 60	N
TG7	3-inside front OCR cover	N	99 99	N
TG8	3-inside front buffer cover	N	99 81	N
TG9	3-inside front injector/accelerator cover	N	98 87	N
TG10	3-underneath MC-near inj /acc cover	N	97 93	N
TG11	3-feeder table-left	N	99 90	Y
TG12	3-feeder table-middle	N	99 55	Y
TG13	3-feeder table-right	N	98 89	Y
TG14	3-destacker pinch area	N	99 40	N
TG15	1-feeder table-left	N	99 46	Y
TG16	1-feeder table-middle	N	99 28	Y
TG17	1-feeder table-right	N	99 53	Y
TG18	1-destacker pinch area	N	99 54	N
TG19	1-inside front filter cover-vent fans not on	N	99 36	N
TG20	1-inside front OCR cover-vent fans not on	N	99 39	N
TG21	1-inside front filter cover	N	99 37	N
TG22	1-inside front OCR cover	N	99 65	N
TG23	1-inside front buffer cover	N	99 41	N
TG24	1-inside front injector/accelerator cover	N	99 55	N
TG25	1-underneath MC-near inj /acc cover	N	99 32	N
TG26	2-inside front filter cover/top	Y	99 29	N
TG27	2-feeder table-left	N	99 22	Y
TG28	2-feeder table-middle	N	99 45	Y
TG29	2-feeder table-right	N	99 50	Y
TG30	2-underneath MC-near inj /acc cover	N	99 94	N
TG31	3-inside front filter cover/top	Y	99 29	N
TG32	3-inside front buffer cover	Y	99 45	N
TG33	3-underneath MC-near inj /acc cover	Y	99 82	N
TG34	3-feeder table-left	N	97 03	Y
TG35	3-feeder table-middle	N	96 80	Y
TG36	3-feeder table-right	N	97 11	Y
TG37	1-feeder table-left	N	103 70	Y
TG38	1-feeder table-middle	N	100 00	Y
TG39	1-feeder table-right	N	99 34	Y
TG40	1-underneath MC-near inj /acc cover	Y	100 74	N
TG41	1-inside front injector/accelerator cover	Y	99 34	N
TG42	1-inside front buffer cover	Y	103 60	N
TG43	1-inside front OCR cover	Y	103 61	N

Table 2. Air Velocity Measurements at Evaluated Locations (Initial Number Indicated Feed Station Number)

Location	Air Velocity (feet per minute)
1-feeder table-left	106
1-feeder table-middle	108
1-feeder table-right	119
2-feeder table-left	86
2-feeder table-middle	67
2-feeder table-right	88
3-feeder table-left	85
3-feeder table-middle	104
3-feeder table-right	103

Figure 1 Tracer Gas Levels Over Entire Period of Experimentation

Drastic drops in TG levels are due to periods where the control was not being evaluated or the TG monitor was being zeroed. Large instantaneous variations represent periods when the TG source was being moved; such values were not used for capture efficiency calculations.

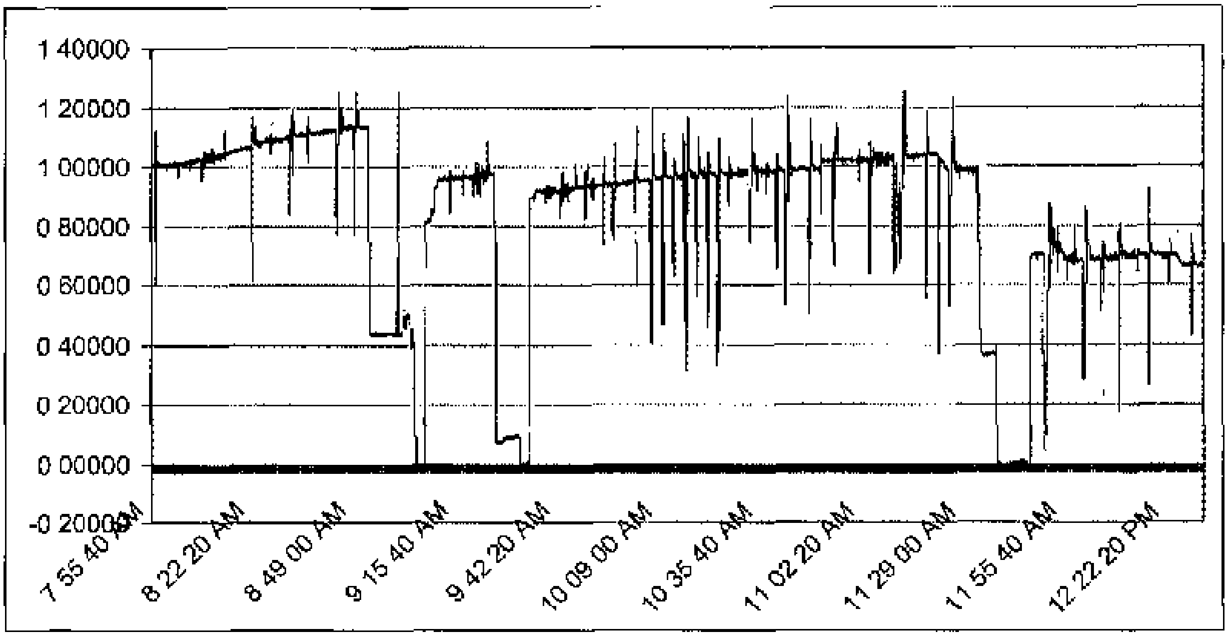
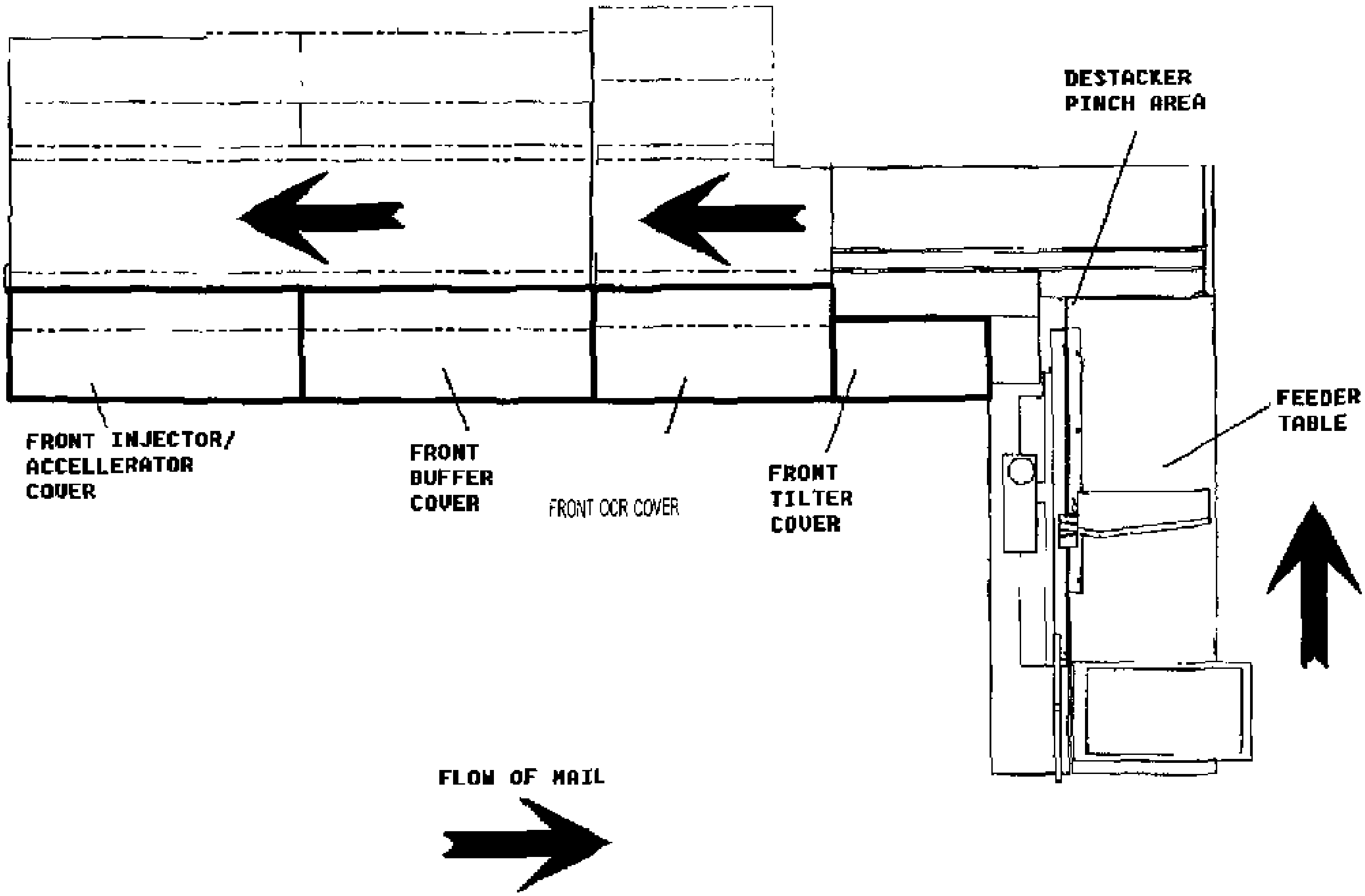


Figure 2. Schematic of Typical Feed Station for AFSM 100



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4 Preliminary Testing Procedure for the Evaluation of Local Exhaust Ventilation for the United States Postal Service National Institute for Occupational Safety and Health Report No EPHB 279-13a

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