IN-DEPTH SURVEY REPORT:

EVALUATION OF VENTILATION AND FILTRATION SYSTEM FOR DELIVERY BAR CODE SORTER

at

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

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

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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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

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SURVEYS CONDUCTED BY	Bryan Beamer Keith Crouch
EMPLOYER REPRESENTATIVES CONTACTED	Tom Potter Senior Mechanical Engineer Leon Shiu Senior Mechanical Engineer
EMPLOYEE REPRESENTATIVE CONTACTED	W. Corey Thompson Safety and Health Specialist American Postal Workers Union AFL-CIO

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ABSTRACT

Researchers from the National Institute for Occupational Safety and Health (NIOSH) conducted evaluations of a Ventilation and Filtration System (VFS) for the United States Postal Service's Delivery Bar Code Sorter (DBCS) The VFS was designed by the manufacturer of the DBCS to reduce operator exposure to any potentially hazardous contaminants emitted from letter mail during normal mail processing Evaluations were conducted at the Dulles, Virginia Processing and Distribution Center (P&DC) on December 13, 2002

Evaluations were based on a variety of tests including air velocity measurements, smoke release observations and tracer gas experiments Testing indicated the following regarding DBCS locations targeted by the VFS

- Smoke observations indicate that the VFS is highly effective at capturing potential contaminants at all Stacker Modules except at the far-right end
- Some smoke escapes at the far-right side of the Stacker Modules when large amounts of smoke are introduced This situation could be easily improved by attaching a panel to the right hand side of the Stacker Modules
- The capture of the VFS at the Feeder Table and Jogger Module is good along the intake slot
- Smoke generated at about 11 inches away from the slots (location of envelope corner) takes much longer to become entrained into the VFS
- The VFS was effective at capturing smoke at exposed locations of the Feeder Module
- At the Jogger Module and Feeder Table, TG capture efficiencies as low as 77% were recorded at locations representing envelope corners away from the intake slot
- At the Jogger Module and Feeder Table, TG capture was highly variable, ranging from about 40% to 100% capture efficiency
- At the Jogger Module and Feeder Table, air velocities were consistently low at locations away from the intake slot These measurements reinforce results from TG experimentation and smoke release observations

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

- It is recommended that a panel be attached to the right hand side of the Stacker Modules
- It is also recommended that the VFS be modified so that there is higher contaminant capture capability at points corresponding to the corners of letters that are not adjacent to the VFS intake slots at the Feeder Table and Jogger Module

INTRODUCTION

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

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

This report is one of a series describing evaluation of controls that are being developed by the United States Postal Service (USPS) to prevent the release of contaminants into the work area of postal employees A number of mail processing machines are being considered for ventilation controls EPHB researchers were requested by the USPS to evaluate the performance of the Ventilation and Filtration System (VFS) on the Delivery Bar Code Sorter (DBCS)

BACKGROUND

Researchers from NIOSH were requested to assist the USPS in the evaluation of particulate controls for various pieces of mail-processing equipment as a part of the USPS Emergency Preparedness Plan (EPP)[1] The EPP was implemented to prevent future biological attacks and stem their possible effects Measures planned focus on a variety of issues including deployment of vacuum/filtration technology on automated sorting equipment This new technology is being installed to reduce operator exposure to any potentially hazardous contaminants emitted from letter mail during normal mail processing NIOSH researchers have subsequently made several trips to Washington, DC area postal facilities to observe mail-processing machinery in operation and to study the effectiveness of the newly designed controls

The particular control evaluated in this report is a VFS, designed and installed by the DBCS manufacturer to reduce operator exposure to potential biological or chemical contaminants contained in the mail The VFS was evaluated at the Dulles, Virginia Processing and Distribution Center (P&DC) on December 13, 2002

HAZARDS TO POSTAL EMPLOYEES

The bacterium bacillus anthracis is a spore-forming bacterium, with spores typically in the size range 1-5 µm Disease caused by anthrax manifests in one of three ways inhalational, cutaneous, and gastrointestinal" 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"' One potential area of exposure is the automated mail processing equipment used to sort incoming mail As the mail passes through the equipment, it is compressed and impacted in a number of places that could cause the release of substances from the mail

DESCRIPTION OF EQUIPMENT

The DBCS is a multilevel, high speed bar code sorter capable of processing bar coded mailpieces at an average rate of 35,000 mailpieces per hour This equipment can process mail between the dimensions of 3 5 inches by 5 inches and 6 125 inches by 11 5 inches" The DBCS unit that was retrofitted with a VFS consisted of a Jogger Module, Feeder Table, Computer System, Feeder Module, Transport Module, Reader Module and multiple Stacker Modules Observed treatment of the mail through the system is described below A schematic of the DBCS is shown in Figure 1

- Containers full of mail are taken from a large material handling cart behind the operator and placed or dumped onto either the Jogger Module or the Feeder Table The purpose of the Jogger Module is to settle the mail into the best position for acceptance by the Feeder Module An on-off switch, controlled by the worker, operates the Jogger Module The Jogger Module is sometimes bypassed when the mail is already well oriented for intake into the Feeder Module

- Following the Jogger Module is a Feeder Table, which serves as a buffer for mail moving into the Feeder Module

- The Feeder Module is the first place at which mailpieces are conveyed through pinch rollers It is here that the greatest potential exists for discharge of dust into the ambient air, as mechanical forces of the pinch rollers can be as much as 22 pounds

- From here mail is automatically conveyed to the Reader Module by means of the Transfer Module The Reader Module collects address data for routing of mail to the Stacker Modules Both of these modules incorporate moving belts, rollers and route-switching gates to control mail movement

- Once mail has been conveyed to the Stacker Modules, it is fed into individual bins The mail piece experiences high deceleration as it is stopped in the bin An auger provides a constant, low mechanical force to the last letter delivered to the bin

- Another worker is responsible for manually moving sorted mail from the Stacker Module bins into appropriate containers for further processing

DESCRIPTION OF CONTROL

The VFS has been designed and installed for the DBCS by the Siemens AG The VFS was designed to reduce the potential for emission of biological contaminants such as spores of B anthracis into the ambient atmosphere through use of local exhaust ventilation (LEV) and air filtration units Additionally, the VFS was designed to reduce machine down time and maintenance caused by paper dust accumulation

Filtration System

The VFS manufacturer claims that the filtration system of the VFS will remove particles as small as 0 5 micron with an efficiency of 99 999% and particles as small as 0 3 microns with an efficiency of 99 97% with a combination of standard filtration and high-efficiency particulate air (HEPA) filters According to the manufacturer, the primary filter cleans itself automatically and needs to be changed every 1 to 1 5 years, while the HEPA (secondary) filters must be changed about every 3 to 4 5 years

Contaminant Collection Unit

The manufacturer's strategy for contaminant collection was, in part, to modify access covers of the machines to totally or partially enclose the source of contaminant and control the direction of airflow into the machine Areas that were targeted for contaminant collection were the Stacker Module, Transport Module, Reader Module, Jogger Module, Feeder Table and Feeder Module

Letter transport locations such as the Transport Module and Feeder Module were fitted with vented covers, where needed, to surround dust-emitting areas In applicable Transport Module locations, turbulent induction methods were used to prevent dust particles from settling

In the Stacker Modules, clear, polyvinyl slitted curtains were installed to reduce airflow area and increase capture velocities, as well as to reduce sound emissions, while still permitting worker access to remove mail The rear doors of the Stacker Modules, not accessed during normal operation, were fitted with slotted plenum structures to more evenly distribute the flow of air at the front, working side of the module

METHODS

AIR VELOCITY MEASUREMENTS

Velocity measurements were taken using a Velocicalc Air Velocity Meter (TSI, Incorporated, Shoreview, MN) Measurements were taken at exhaust inlets to the DBCS, including at the Feeder Module and Stacker Modules Each value reported represents an average of 3 measurements taken at approximately 2 second intervals

SMOKE RELEASE OBSERVATIONS

Smoke was released at all gaps in the machine chassis, where internally released aerosol might escape into the workroom environment Qualitative observations centered on determination of how quickly and effectively the control captured smoke generated For example, if the smoke was captured quickly and directly by the exhaust system, it was a good indication of acceptable control design and performance However, if the smoke was slow to be captured when released at a certain point, or took a circuitous route to the exhaust inlet, the ventilation system design was considered marginal at that location These observations were aided by the use of a focused, high-intensity light source

Smoke was generated where mechanical forces from the machine are greatest and where potential contaminant release is furthest away from the control's exhaust, these locations have the greatest potential for release of contaminant into the workroom environment At the Jogger Module and Feeder Table, the smoke was introduced at a point where contaminant would be released from the corner of a business envelope furthest away from the control, 5 in out from the slot and 3 5 in above the top of the module surface At the Feeder Module, the smoke was released at several pinch points where mechanical forces are the greatest, including the set of pinch rollers closest to the face of the control's exhaust At the Stacker Modules, each row was tested (rows 1-4) at right, left and center Stacker Modules (Modules 1,6,12) for a total of 12 recorded observations Smoke for each one of these observations was directed at the area between the tail end of the mail piece and the deceleration pad at the adjacent stacker bin (see figure 2)

TRACER GAS EVALUATIONS

By releasing a tracer gas (TG) at a constant rate where contaminant control is desired, and by measuring the corresponding TG concentration downstream inside the exhaust duct, a quantitative measure of control efficiency can be made The first step was to release the TG inside the duct to find the concentration C100 corresponding to 100% capture, this was done before and after other TG experiments were made Then, when the TG was released at a point near the Feeder Module, for example, resulting in a concentration C in the duct, the capture efficiency at the feeder point was calculated as C/C100 While the exhaust air carrying the TG should ideally be released outside to eliminate an increase of the background level of TG, experimentation in a large room such as the one containing the DBCS should not significantly increase the background concentration during testing For these experiments, 100% sulfur hexafluoride was used as the tracer The instrument used to detect the sulfur hexafluoride was a Miran 203 Specific Vapor Analyzer (The Foxboro Company, Foxboro, MA)

In each TG trial, approximately one minute was allowed for the concentration to equilibrate before average concentrations were determined The numerator of the efficiency determinations was the mean of the trial concentration values C In addition, a measure of variability was computed for each trial – the interquartile range, the difference between the 75th and 25th percentiles

At the center, right-hand side and left-hand side of the Jogger Module, TG was released at points corresponding to the top-outer corner, top-inner corner (along the VFS intake slot) and bottom-outer corner of a standard business envelope At the right-hand side and center of the Feeder Table, TG was released at points corresponding to the top-outer corner, top-inner corner (along the VFS intake slot) and bottom-outer corner of a standard business envelope Here, the Feeder Table was loaded with test mail to more accurately simulate working conditions At the Feeder Module, TG was released at the first pinch rollers (location "C"), and at points corresponding to the top-inner corner (location "B") and top-outer corner (Location "A") of a standard business envelope (see figure 3) For Feeder Module experiments, test mail was on the adjacent Feeder Table to simulate regular working conditions At all Stacker Module locations, the TG was released at a point halfway between the top and bottom corners of a standard business envelope on the left side (see figure 2) Moreover, one envelope was placed in each Stacker Module bin to simulate standard working conditions Stacker Module locations tested were at bins 1-3, 7 (Stacker 1) bins 80-83 (Stacker 6) and bins 187-190 (Stacker 12) These stacker locations represented all four rows of bins at the far left, center and far right of the bank of Stacker Modules

RESULTS

AIR VELOCITY MEASUREMENTS

Air velocity measurements were made at the entrance to the Jogger Module, Feeder Table, Feeder Module and at various locations of the Stacker Module Most significantly, at the Jogger Module and Feeder Table, air velocities were consistently low at locations away from the intake slot These measurements reinforce results from TG experimentation and smoke release observations Results are given in Table 1 below

Table 1 Air Velocity Measurements Highlighted values are less than 100 feet per minute

AREA	CONTAMINANT CAPTURE VELOCITY (VALUES OF TRIALS IN FEET PER MINUTE)
JOGGER- BACK RIGHT	84
JOGGER- FRONT RIGHT	22
JOGGER- BOTTOM RIGHT	44
JOGGER- BACK MIDDLE	149
JOGGER- FRONT MIDDLE	21
JOGGER- BOTTOM MIDDLE	34
JOGGER- BACK LEFT	125
JOGGER FRONT LEFT	10
JOGGER- BOTTOM LEFT	44
FEEDER TABLE- BACK RIGHT	98
FEEDER TABLE- FRONT RIGHT	40
FEEDER TABLE- BOTTOM RIGHT	33
FEEDER TABLE- BACK MIDDLE	57
FEEDER TABLE- FRONT MIDDLE	48
FEEDER TABLE- BOTTOM MIDDLE	29
BIN 1	105
BIN 2	115
BIN 3	101
BIN 7	101
BIN 80	115
BIN 81	107
BIN 82	105
BIN 83	129
BIN 187	109
BIN 188	124
BIN 189	112
BIN 190	118
FEEDER MODULE PINCH POINT A	121
FEEDER MODULE PINCH POINT B	96
FEEDER MODULE PINCH POINT C	110

SMOKE RELEASE EXPERIMENTS

Smoke Release experiments showed the following results regarding the capture efficiency of the VFS

- Smoke observations indicate that the VFS is highly effective at capturing potential contaminants at all Stacker Modules except at the far-right end
- The possibility exists for some smoke to escape to the far-right side of the Stacker Modules when large amounts of smoke are introduced This situation could be easily improved by attaching a panel to the right hand side of the Stacker Modules
- The capture of the VFS at the Feeder Table and Jogger Module is good along the intake slot
- Smoke generated at about 11 inches away from the slots (location of envelope corner) takes much longer to become entrained into the VFS
- The VFS was effective at capturing smoke at exposed locations of the Feeder Module

Table 2 Smoke Release Observations Slow capture areas are shaded

AREA	COMMENTS
JOGGER- BACK RIGHT	GOOD SMOKE CAPTURE
JOGGER- FRONT RIGHT	SMOKE IS SLOW TO BE CAPTURED
JOGGER- BOTTOM RIGHT	SMOKE IS SLOW TO BE CAPTURED
JOGGER- BACK MIDDLE	GOOD SMOKE CAPTURE
JOGGER- FRONT MIDDLE	SMOKE IS SLOW TO BE CAPTURED
JOGGER- BOTTOM MIDDLE	SMOKE IS SLOW TO BE CAPTURED
JOGGER- BACK LEFT	GOOD SMOKE CAPTURE
JOGGER- FRONT LEFT	SMOKE IS SLOW TO BE CAPTURED
JOGGER- BOTTOM LEFT	SMOKE IS SLOW TO BE CAPTURED
FEEDER TABLE- BACK RIGHT	GOOD SMOKE CAPTURE
FEEDER TABLE- FRONT RIGHT	SMOKE IS SLOW TO BE CAPTURED
FEEDER TABLE- BOTTOM RIGHT	SMOKE IS SLOW TO BE CAPTURED
FEEDER TABLE- BACK MIDDLE	GOOD SMOKE CAPTURE
FEEDER TABLE- FRONT MIDDLE	SMOKE IS SLOW TO BE CAPTURED
FEEDER TABLE- BOTTOM MIDDLE	SMOKE IS SLOW TO BE CAPTURED
BIN 1	GOOD SMOKE CAPTURE
BIN 2	GOOD SMOKE CAPTURE
BIN 3	GOOD SMOKE CAPTURE
BIN 7	GOOD SMOKE CAPTURE
BIN 80	GOOD SMOKE CAPTURE
BIN 81	GOOD SMOKE CAPTURE
BIN 82	GOOD SMOKE CAPTURE
BIN 83	GOOD SMOKE CAPTURE
BIN 187	GOOD SMOKE CAPTURE-SOME SMOKE ESCAPES WITH LARGE VOLUME OF SMOKE
BIN 188	GOOD SMOKE CAPTURE-SOME SMOKE ESCAPES WITH LARGE VOLUME OF SMOKE
BIN 189	GOOD SMOKE CAPTURE-SOME SMOKE ESCAPES WITH LARGE VOLUME OF SMOKE
BIN 190	GOOD SMOKE CAPTURE-SOME SMOKE ESCAPES WITH LARGE VOLUME OF SMOKE
FEEDER MODULE PINCH POINT A	GOOD SMOKE CAPTURE
FEEDER MODULE PINCH POINT B	GOOD SMOKE CAPTURE
FEEDER MODULE PINCH POINT C	GOOD SMOKE CAPTURE

TRACER GAS EXPERIMENTS

Tracer gas experiments showed the following results regarding the capture efficiency of the VFS

- At the Jogger Module and Feeder Table, TG capture efficiencies as low as 77% were recorded at locations representing envelope corners away from the intake slot
- Moreover, at these locations, TG capture was highly variable, ranging from about 40% to 100% capture efficiency

Table 3. Tracer Gas Experiments Highlighted areas do not meet USPS requirements

AREA	CONTAMINANT CAPTURE EFFICIENCY	INTERQUARTILE RANGE
STACKER BIN 1	> 98%	04
STACKER BIN 2	> 98%	06
STACKER BIN 3	> 98%	07
STACKER BIN 7	> 98%	07
STACKER BIN 80	> 98%	05
STACKER BIN 81	> 98%	05
STACKER BIN 82	> 98%	05
STACKER BIN 187	> 98%	03
STACKER BIN 188	> 98%	02
STACKER BIN 189	> 98%	03
STACKER BIN 190	> 98%	03
JOGGER- BACK RIGHT	> 98%	05
JOGGER- FRONT RIGHT	96%	05
JOGGER- BOTTOM RIGHT	98%	04
JOGGER- BACK MIDDLE	97%	01
JOGGER- FRONT MIDDLE	90%	10
JOGGER- BOTTOM MIDDLE	80%	12
JOGGER- BACK LEFT	93%	13
JOGGER- FRONT LEFT	82%	08
JOGGER- BOTTOM LEFT	95%	12
FEEDER TABLE- BACK RIGHT	98%	04
FEEDER TABLE- FRONT RIGHT	92%	16
FEEDER TABLE- BOTTOM RIGHT	77%	25
FEEDER TABLE- BACK MIDDLE	> 98%	18
FEEDER TABLE- FRONT MIDDLE	86%	27
FEEDER TABLE- BOTTOM MIDDLE	94%	10
FEEDER MODULE PINCH POINT A	99%	02
FEEDER MODULE PINCH POINT B	99%	03
FEEDER MODULE PINCH POINT C	100%	03

DISCUSSION AND RECOMMENDATIONS

STACKER MODULES

All Stacker Modules performed adequately in TG experimentation and air velocity measurements (see Tables 1 and 3) Furthermore, smoke release observations show that the capture capability of the VFS at the Stacker Modules is good, overall However, when large amounts of smoke are introduced into the control of the VFS at Stacker 12 at the right-hand side of the Stacker Bank, some smoke did escape (see Table 2)

On one hand, an actual condition in which a large amount of contaminant is generated, equivalent to the amount of smoke produced in experimentation, is not likely On the other hand, it is hard to determine exactly what amounts of contaminant might be produced in an anthrax attack Furthermore, the recommended remedy, a panel attached to the right side of the Stacker Modules, should be very inexpensive and easy to implement

JOGGER MODULE AND FEEDER TABLE

At the Jogger Module and Feeder Table, it was clearly shown that the performance of the VFS at locations of potential contaminant release that were not immediately adjacent to the intake slot was marginal It is therefore recommended that the VFS be modified so that there is higher contaminant capture capability at points corresponding to envelope corners that are not adjacent to the VFS intake slots

APPLICABILITY TO OTHER EQUIPMENT

Lastly, it must be reinforced that the methodology presented in this report is appropriate for a wide variety of other applications For instance, government agencies like the Internal Revenue Service, Department of State, and U S Congress, as well as private companies like United Parcel Service or Federal Express, could benefit from using these procedures to evaluate LEV for mail and/or package processing machinery

Figure 1 Delivery Bar Code Sorter Overview and Location of Proposed Guard

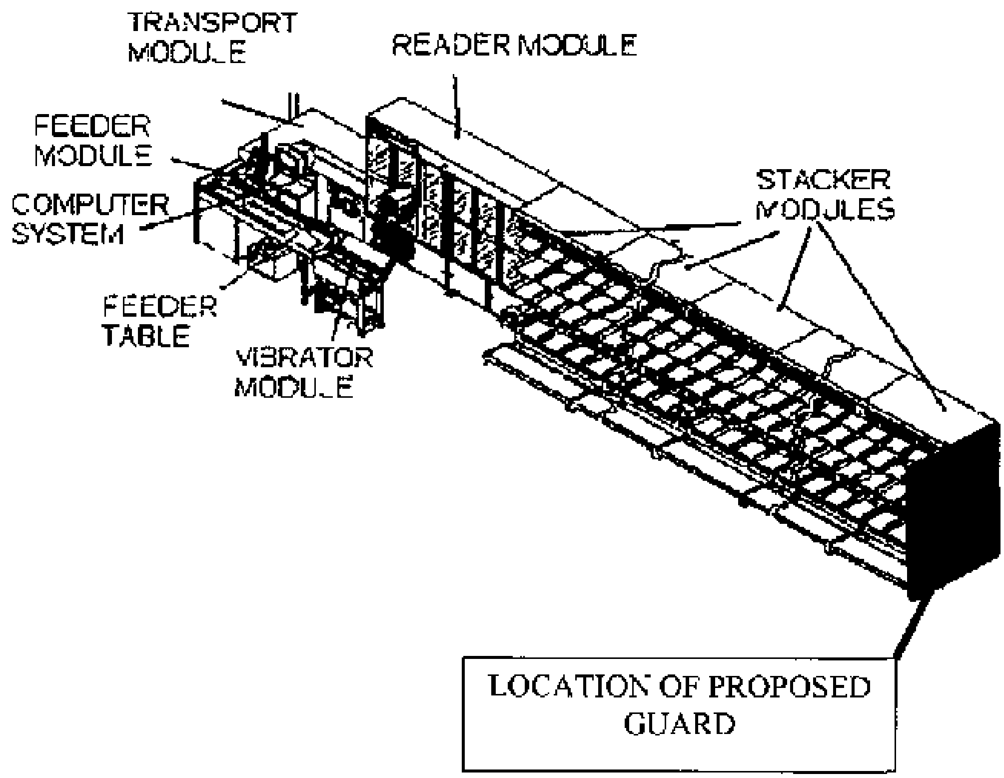


Figure 2. Point Representing Potential Contaminant Release Points. This location was used as the focus of TG experimentation and smoke release observations at the Stacker Modules

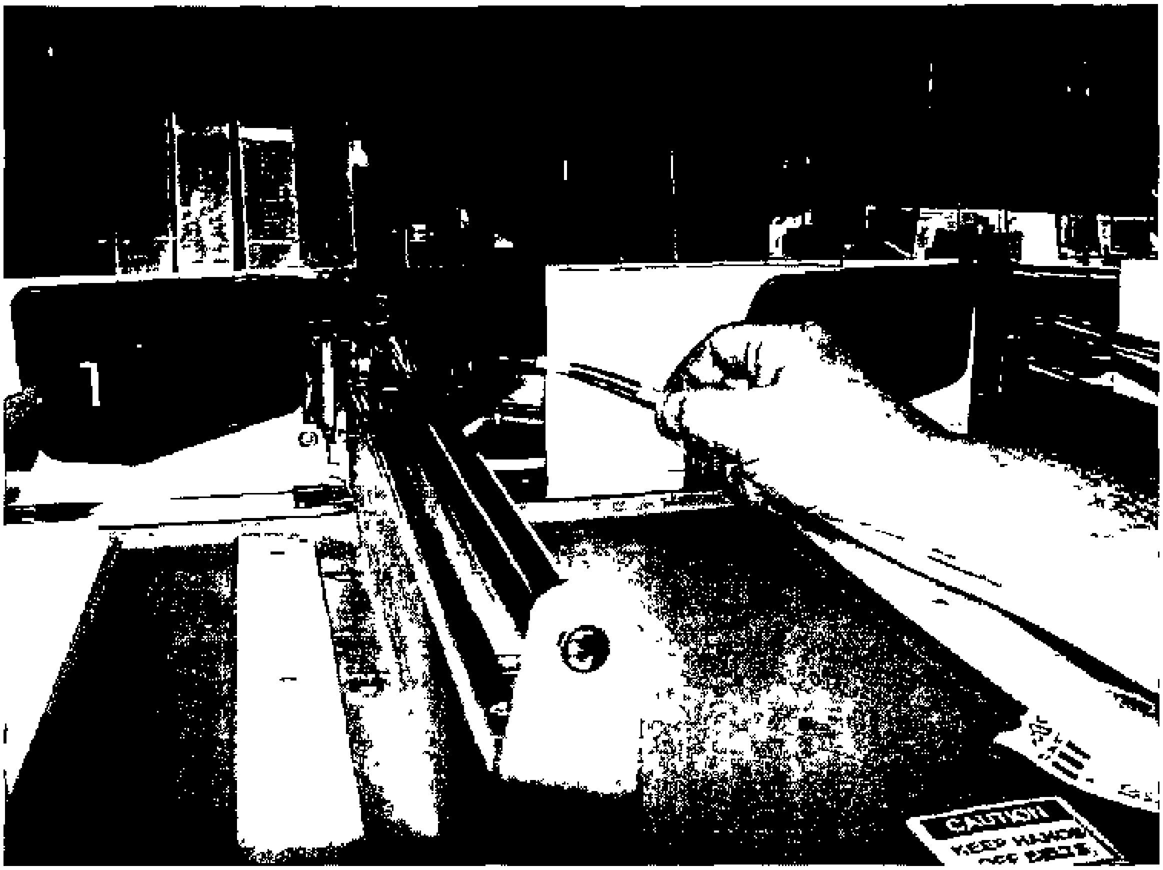
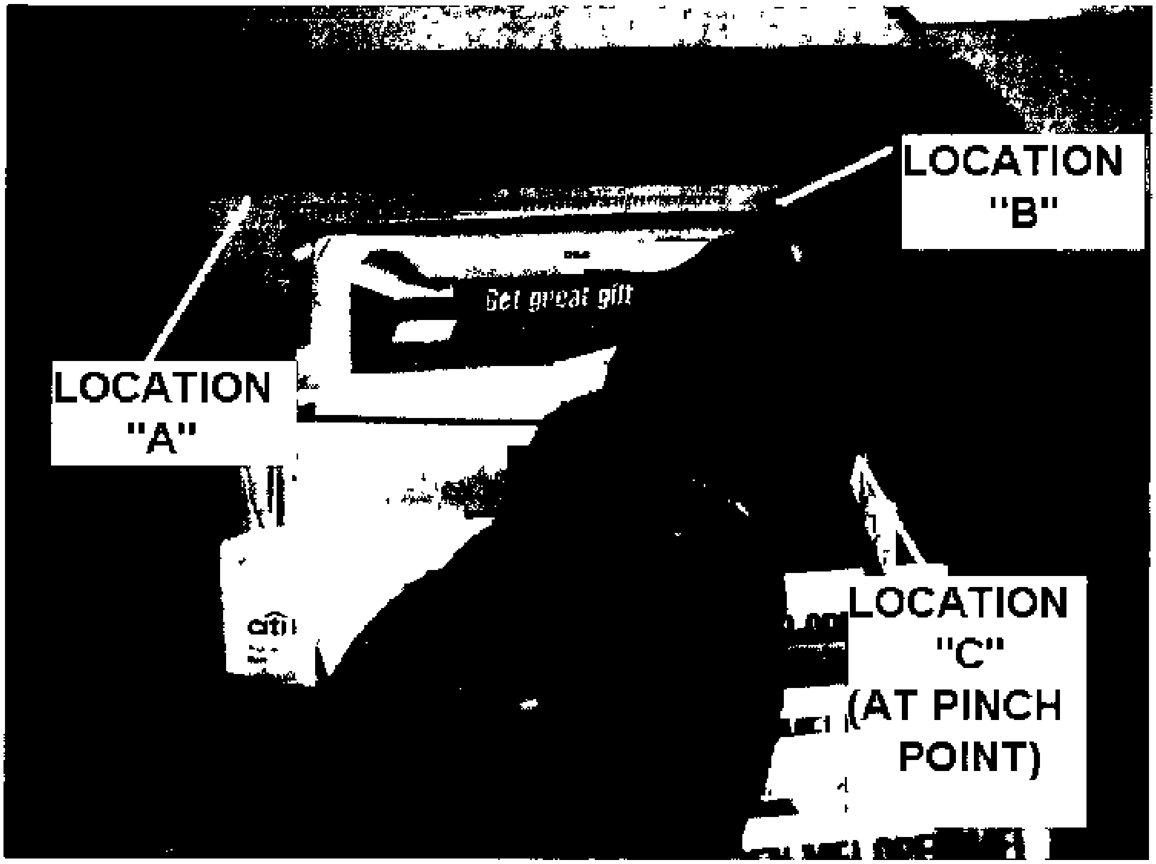


Figure 3. Locations of TG release at the Feeder Module.



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