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November 1989

An Investigation Conducted by:
Engineering Management Concepts
Camarillo, CA 93010

TEST AND EVALUATION OF PLASTIC MEDIA RECYCLING FLOORING - FINAL REPORT

ABSTRACT The performance of existing plastic media blasting (PMB) recovery floors and recycling equipment was evaluated to determine operational efficiencies. Emphasis was placed on the reliability, maintainability, operating costs, and the separation efficiency of the PMB equipment. Although dependent on site specific information, economic analyses appeared to favor partial recovery floor system using a pneumatic undergrate and transport system. Samples of usable media reclaimed by the recycling system and unusable media rejected as waste were classified by size and analyzed for contaminants to evaluate recycling system efficiency.

NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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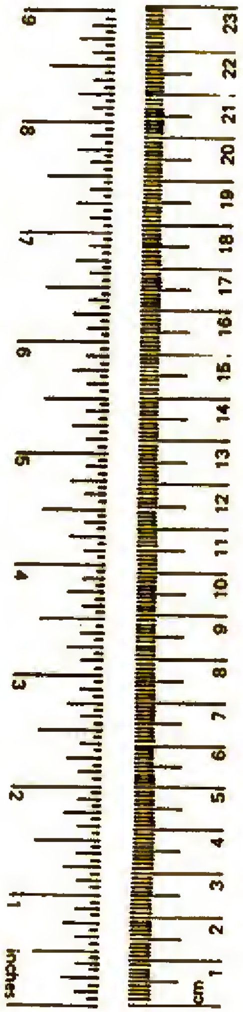
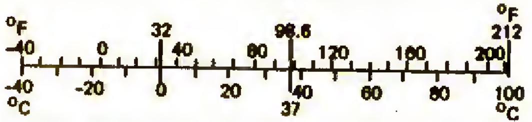
*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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The performance of existing plastic media blasting (PMB) recovery floors and recycling equipment was evaluated to determine operational efficiencies. Emphasis was placed on the reliability, maintainability, operating costs, and the separation efficiency of the PMB equipment. Although dependent on site specific information, economic analyses appeared to favor partial recovery floor system using a pneumatic undergrate and transport system. Samples of usable media reclaimed by the recycling system and unusable media rejected as waste were classified by size and analyzed for contaminants to evaluate recycling system efficiency.

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EXECUTIVE SUMMARY

The performance of plastic media blasting (PMB) recovery floors and recycling equipment was evaluated. Three existing PMB booth installations were analyzed to determine their relative operational efficiencies. The installations were located at Naval Weapons Station, Seal Beach, CA; Naval Undersea Weapons Engineering Station, Keyport, WA; and Naval Air Station (NAS), Barbers Point, HI. Emphasis was placed on the reliability, maintainability, operating costs and separation efficiency of the PMB equipment.

Design theory and options for floor recovery systems were reviewed. Potential floor recovery system designs for a larger enclosure such as a hangar installation were also presented. Design information acquired from observing the three PMB installations was used to evaluate the design options. Although dependent on site specific information, economic analyses appeared to favor a partial recovery floor system using a pneumatic undergrate and transport system.

Samples of usable media reclaimed by the recycling system and unusable media rejected as waste were classified by size and analyzed for contaminants. Size classification tests showed significant concentrations of reusable media (20 to 60 mesh) in the rejected material indicating recycling system efficiency could be improved. Most of this reusable media could be recovered by slowly adding the rejected material into the floor recovery system and allowing it to pass through the recycling system. The highest metal contents were found in the undersize (<60 mesh) reject material and in the dust removed from the ventilation system. Concentrations of chromium, lead, and other toxic metals were high enough to classify the rejected material as hazardous waste. Freon float tests showed concentrations of hard particle contaminants averaging about 0.4 percent on a weight basis. However, significant hard particle contamination of virgin media samples was also observed.

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INTRODUCTION

The Naval Civil Engineering Laboratory (NCEL) has been tasked to review the operations of three naval plastic media blasting (PMB) installations. Engineering Management Concepts (EMC) of Camarillo, CA has been contracted to perform this work. The installations were located at Naval Weapons Station (NWS), Seal Beach, CA; Naval Undersea Weapons Engineering Station (NUWES), Keyport, WA; and Naval Air Station (NAS), Barbers Point, HI.

1.1 Background

PMB is a new technology currently being implemented as a replacement for wet chemical stripping of painted surfaces. The process utilizes small plastic beads composed of granular amino thermoset or unsaturated polyester resins, that are dispersed at high velocity through a nozzle towards the surface to be blasted. The rough edges of the plastic media act as an abrasive to shatter and dislodge surface coatings. The PMB process is similar to conventional abrasive grit blasting, but is much less aggressive to the substrate.

The use of plastic media for removing coatings from aircraft and aircraft components is increasing at Department of Defense activities. PMB is able to remove coatings faster and more economically than current chemical stripping methods. PMB also reduces labor requirements and the costs and volume of hazardous wastes that need to be disposed.

Labor and media replacement are the two major operating costs of a PMB installation, so improving the effectiveness of the floor recovery and media recycling systems is one of the best ways to increase the cost savings associated with using PMB. During PMB operations, used media will pile up on any level surface in the blasting booth, requiring extensive effort to move the media into the recovery system. Labor costs devoted to recovering usable media are minimized by having a functional, automatic recovery floor. During regular use, the plastic media slowly degrades to dust and must be replaced. An efficient media recycling system minimizes the cost of replacement media by continuously reusing the media until it is no longer large enough to be effective.

The three naval installations evaluated have successfully reduced the operating costs of their paint stripping activity by implementing PMB at their installations. Each site uses a different floor recovery and media recycling system.

1.2 Objectives

The objectives of this task were to:

- Test and evaluate the performance of recycling equipment and floors in PMB installations currently used by the Navy. This included:
    - Process Efficiency
    - Costs
    - Reliability and Maintainability
- Analyze samples of recycled and rejected media for:
    - Percentage of usable media in the reject dust
    - Percentage of dust in the recycled media
    - Percentage of metal, sand, and other hard particle contamination in the media and dust

1.3 Scope

Each of the three PMB facilities were visited to evaluate their operation and maintenance history. Operational tests were conducted to determine floor capacity and design bottlenecks. Floor recovery and recycling equipment was inspected for wear and samples were taken at each site for chemical and physical analysis.

2.0 RECOVERY FLOOR OPERATING THEORY AND DESIGN

The purpose of the recovery floor is to collect and transfer material from the floor to the media recycling equipment. The used media falls or is swept through the floor grating where undergrate equipment conveys the media to the edge of the floor. Transfer equipment is then used to convey material from the floor edge to the media recycling equipment.

Floor systems can either remove material from the entire floor (full floor recovery) or from selected areas of the working floor (partial floor recovery). Full floor recovery systems require larger initial capital investment, but necessitate less manual clean-up than partial floor recovery systems. Partial floor recovery systems may be more economic, however, for larger blasting enclosures such as aircraft hangars. These systems lessen the initial capital cost of the floor recovery equipment, but require more manual clean-up than full floor recovery systems. Strategic positioning of partial recovery floor sections can minimize this labor requirement.

Typical floor arrangements use parallel, equally spaced strips of floor recovery equipment running in one direction in the blasting room. A good arrangement for a 45 foot wide booth would use five 3 foot wide recovery strips separated by four 6 foot wide solid strips. Two other solid 3 foot wide strips are placed along the edge as shown in Figure 1. This arrangement allows the bulk of blasting debris to fall within 3 feet of a floor recovery grating and minimizes sweeping labor. Floor recovery strips are not located at the wall edges of the floor because the blasting debris cannot be pushed into the strip from both sides. Concrete floors adjacent to floor recovery equipment strips should be sealed with a heavy coat of epoxy or covered with solid rubber sheeting to prevent contamination of the media with concrete particles.

Commercially available, partial and full floor recovery equipment is designed to operate between floor support beams and underneath floor grating laid across the beams. The floor must structurally support personnel and the equipment being blasted. The system should not damage media while conveying it to the recycling equipment. Pneumatic or mechanical conveying systems can be used as undergrate collection and transport equipment. The following paragraphs discuss various system designs of commercially available conveying equipment.

2.1 Pneumatic Undergrate Floor Recovery Systems

Pneumatic systems use induced draft fans to vacuum material from the undergrate area beneath the worksite and convey it to the media recycling equipment. Conveying ducts are sized to give air flow rates between 25 and 75 feet per second (fps). Velocities greater than 75 fps will tend to cause unacceptably high erosion rates in the ductwork and media degradation. Velocities less than 25 fps may cause media plugs in the ductwork. The two principal designs for a pneumatic floor are a trough or funnel system (see Figure 2) and a moving vacuum head system (see Figure 3). These systems are discussed in the following sections.

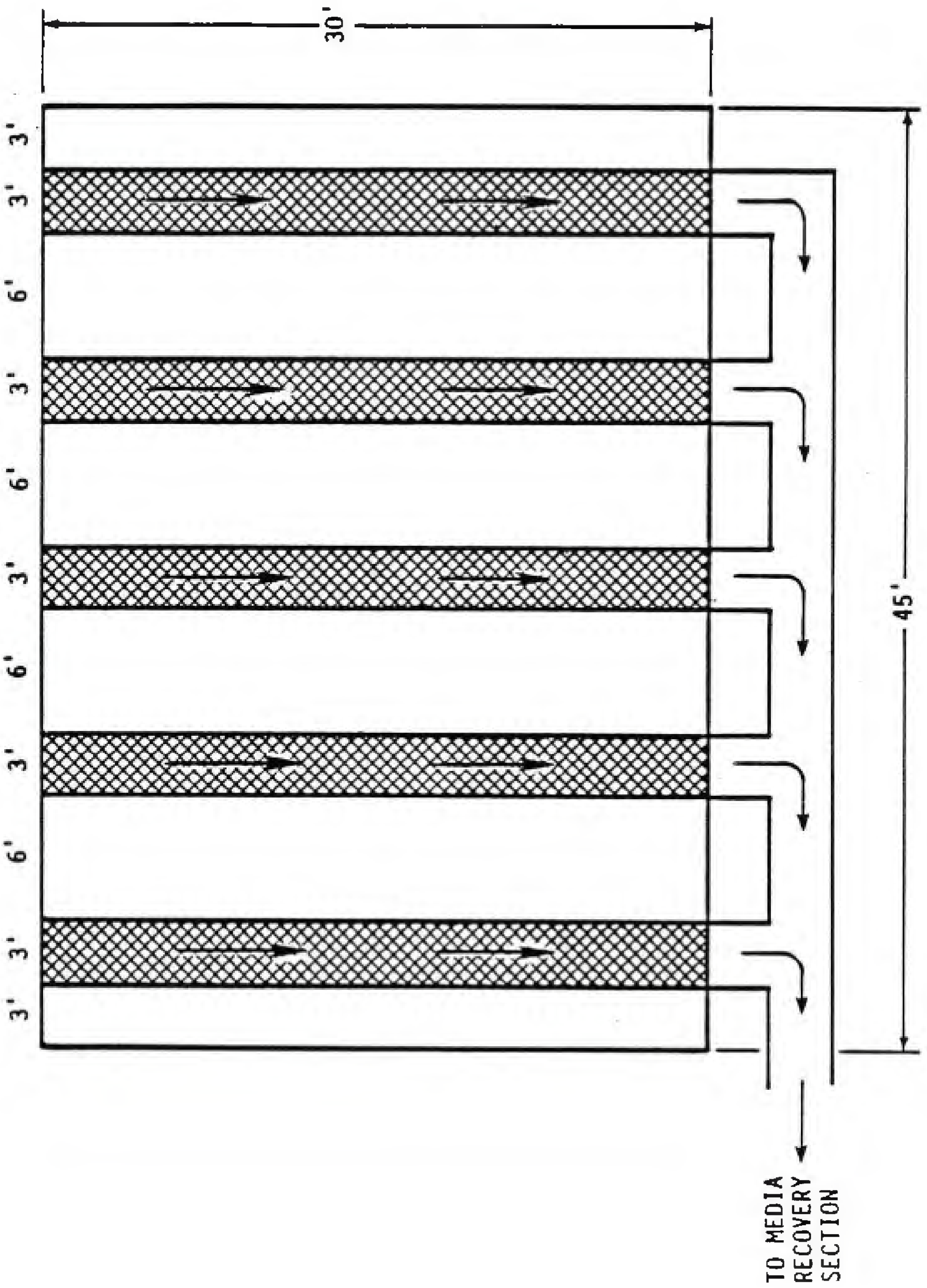


FIGURE 1. TYPICAL PARTIAL FLOOR RECOVERY LAYOUT.

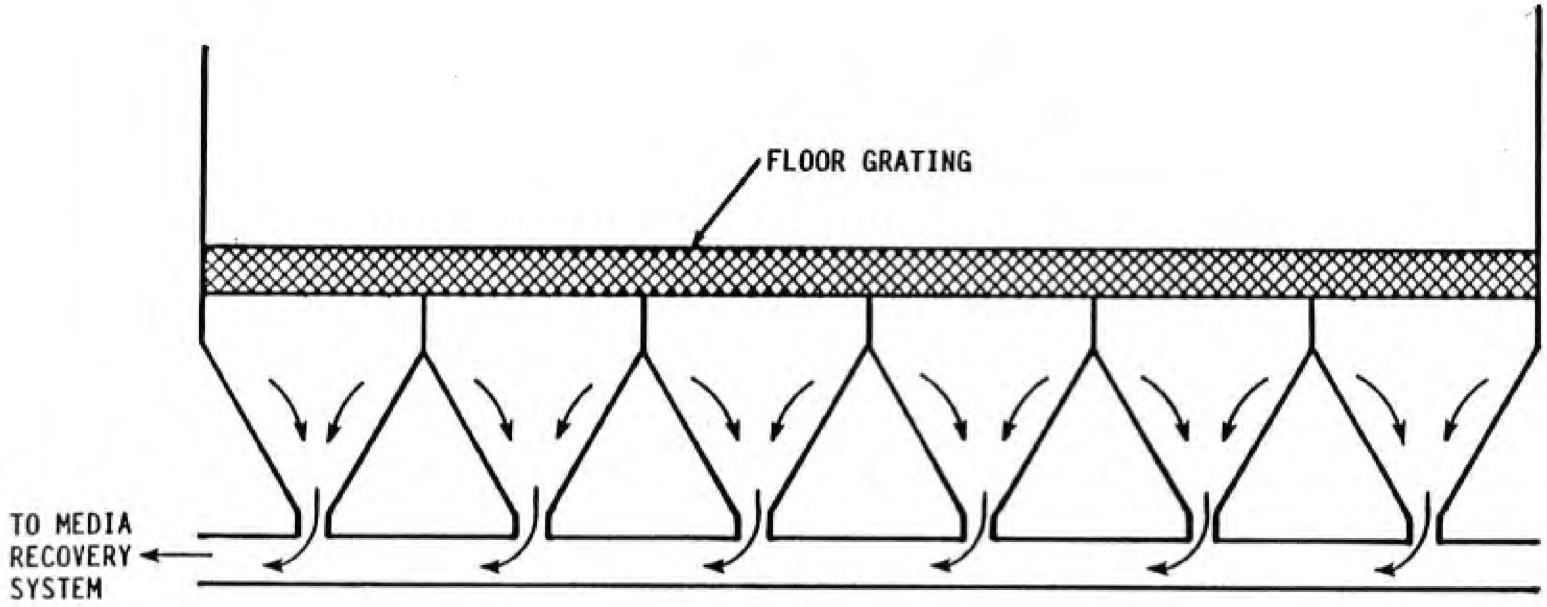


FIGURE 2. TROUGH OR FUNNEL PNEUMATIC FLOOR RECOVERY SYSTEM.

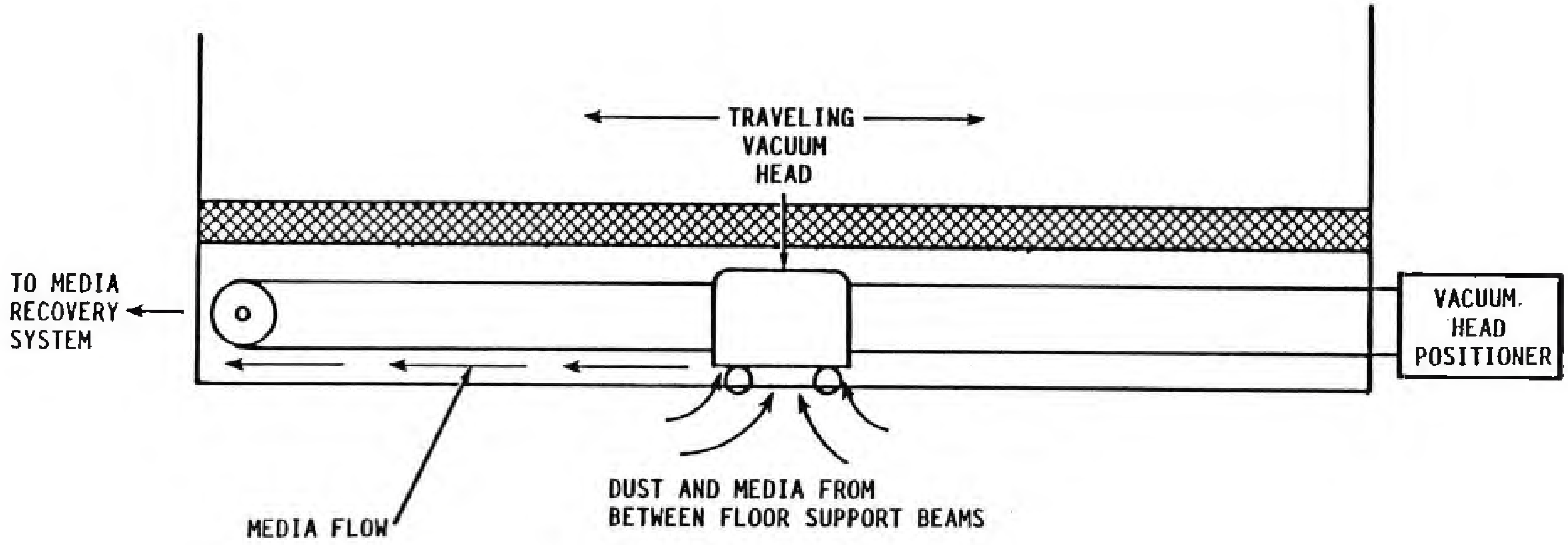


FIGURE 3. TRAVELING VACUUM HEAD FLOOR RECOVERY SYSTEM.

2.1.1 Pneumatic Funnel System

One common pneumatic system uses a series of 60 degree angle, undergrate funnels to collect the material and gravity feed it to a conveying pipe system. The funnels and conveying pipes run lengthwise in rows between floor support beams (See Figure 2). In lieu of funnels, a single trough can be used to run lengthwise in the floor recovery system. Material falling into the collection pipe is transported pneumatically to the recycling equipment. The bottom outlet hole of the collection funnels should be large enough to prevent the material from bridging, but not large enough to overload the material transport system at the end of the collection pipe. When the funnel outlets are too large, excess air volume enters at the beginning of the collection pipe (closest to the vacuum pump) causing inadequate air flow at the end of the pipe. Insufficient air flow at the end of the row will not move media into the recycling system.

Sequencing the operation of parallel sections of the conveying pipes can reduce energy usage and the size of the media recycling equipment required, especially for full-floor recovery systems. The sequencing system operates a fraction of the rows (usually 20-30 percent of the total number of rows) at one time, alternating between the rows to clean the entire floor. The sequencing is performed by a series of solenoid-operated valves placed between the collection header and the individual lines. When the valve is open, the induced draft fan vacuums air and used material from that line alone. The media recycling system may thus be designed for only a fraction of the air flow that would be needed if all the lines were continuously operated.

2.1.2 Traveling Vacuum Head System

A system based on a mechanically operated vacuum head is now available to remove material from the flat surface between the floor support beams. This system (See Figure 3) requires less clearance underneath the floor grating than funnel systems. The vacuum head is moved steadily back and forth at a constant speed with a cable drive system that is usually not sensitive to blasting dust and used media. Media vacuumed into the system is transported to the recycling system in a duct along one side of the vacuum head equipment. The constant speed of the drive system helps to meter the amount of media flowing into the pneumatic duct work and media recycling equipment and helps to eliminate plugging elsewhere in the system.

2.2 Mechanical Undergrate Floor Recovery Systems

In addition to pneumatic systems just discussed, several undergrate floor recovery systems are commercially available that gather material mechanically from beneath the floor grating and convey it to the edge of the blasting floor. These systems use less energy to operate than pneumatic systems since they only convey the material and not large quantities of air. The four types of systems discussed below involve the use of the screw conveyer, the reciprocating pan, the flat conveyer belt, and traveling sweeper arms.

2.2.1 Screw Conveyer System

In a screw conveyer system, material falls through the floor grating into a conveyer trough equipped with a rotating screw that propels material to the end of the floor (see Figure 4). A screw conveyer can easily propel large amounts of used media with minimal energy usage since the system does not lift the media. (Additional equipment is required if material must be lifted to the first stage of the recycling system.) Clearances in the screw trough must be adequate to allow the screw to rotate without grinding and so that reusable media is not destroyed against the internal surface of the trough. A significant amount of media is retained in the screw conveyer trough due to this clearance. This media accumulation in the screw conveyer trough can usually be removed using an external source of compressed air.

2.2.2 Reciprocating Pan System

A reciprocating pan system uses inertial force to propel material along a shaking pan to the edge of the floor. Large flat pans are suspended directly below the floor grating. The pans are slowly driven upward and slightly off center by a mechanical drive system consisting of an eccentric cam and follower connected to the reciprocating pan system (see Figure 5). The pans are released at the maximum distance of travel, then swung forward and down until they are abruptly stopped by a bumper. Jarring caused by the sudden stop moves the material on the pan forward toward a collection trough. Total deflection of the pan from rest position is usually less than one inch and completes about one cycle per second. The floor recovery system tends to be noisy due to the impacts of the reciprocating pans. A more detailed description of this type of system is given in Section 3.1.

2.2.3 Flat Conveyer Belt System

A conveyer belt system has been used to continuously remove material from beneath the floor. A wide rubber or plastic belt loop travels continuously beneath the grating to convey material to the edge of the floor (see Figure 6). The belt drive is attached to one of the support pulleys. The conveyer system can quickly remove large volumes of material without affecting the belt speed. Methods are needed to prevent media from falling off the sides of the belts, and the belts should be self aligning to minimize maintenance.

2.2.4 Traveling Sweeper Arms System

This system uses a belt driven collection of brushes (sweeper arms) to push media from under the floor grating toward the edge of the floor (see Figure 7). The brushes are attached to a circular belt or cable loop and are subject to same type of functional problems as a conveyer belt. Proper tension on the belt or cable loops is important to maintain the correct arm position. Sweeper arms that are too loose will not provide stiff resistance to the media accumulations on the floor and will tend to ride over the media without moving it.

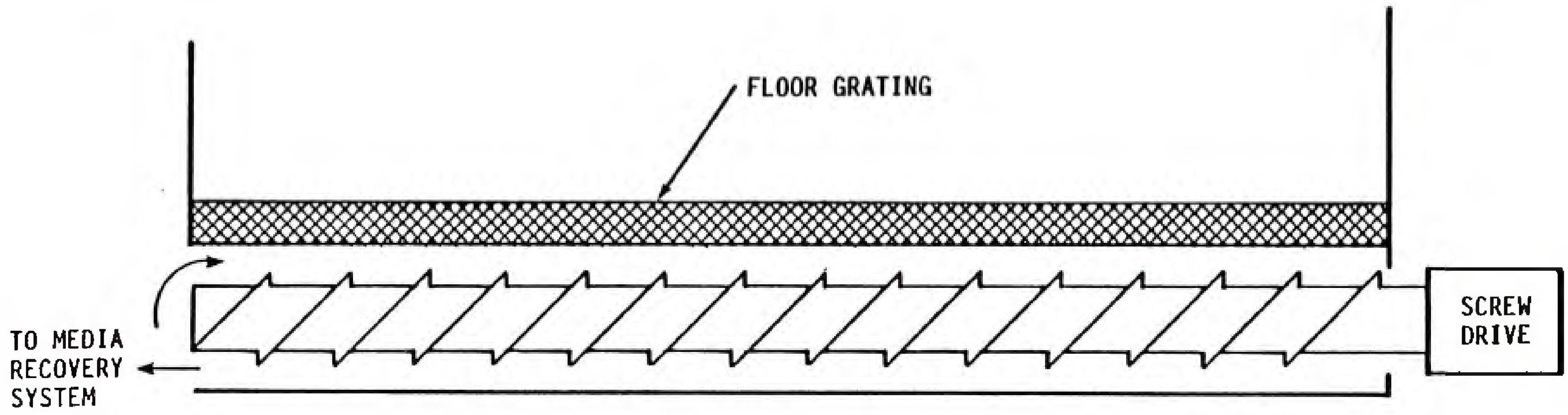


FIGURE 4. SCREW CONVEYOR FLOOR RECOVERY SYSTEM.

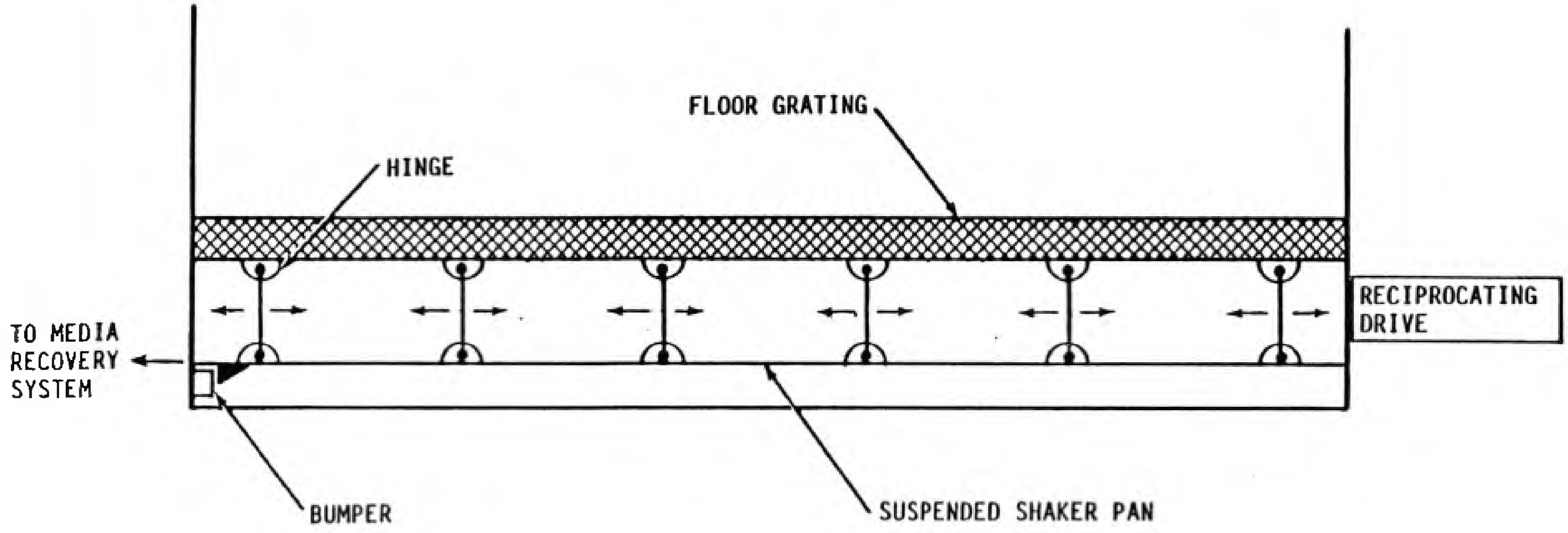


FIGURE 5. RECIPROCATING SHAKER PAN FLOOR RECOVERY SYSTEM.

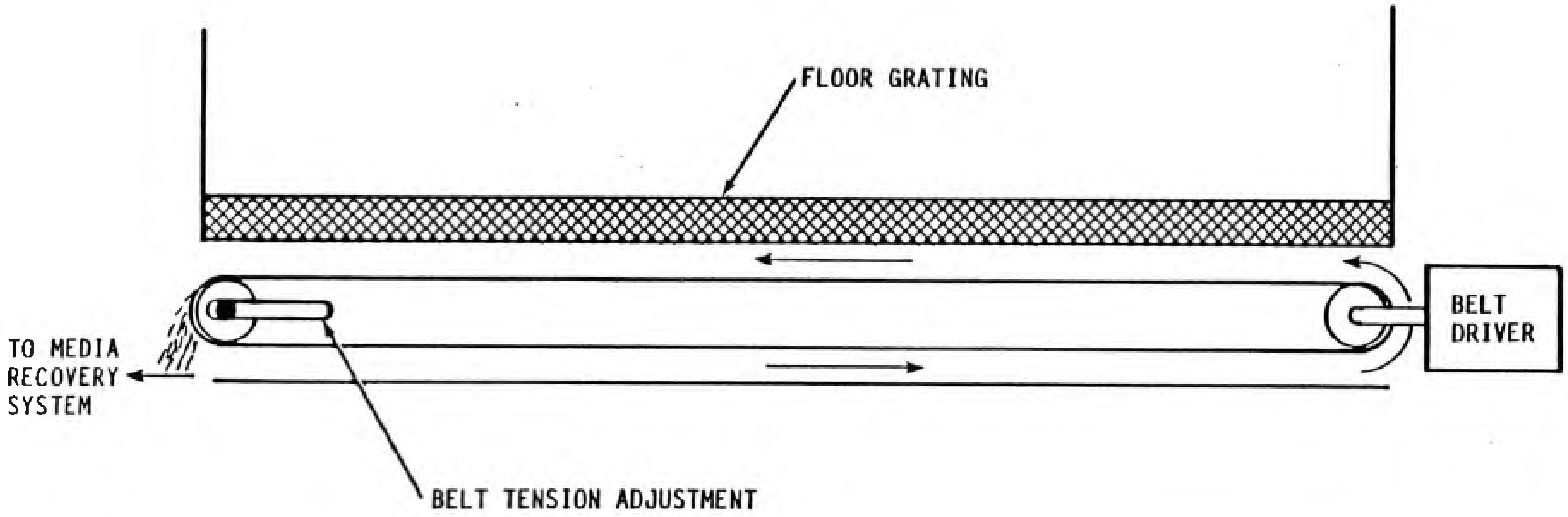


FIGURE 6. CONVEYOR BELT FLOOR RECOVERY SYSTEM.

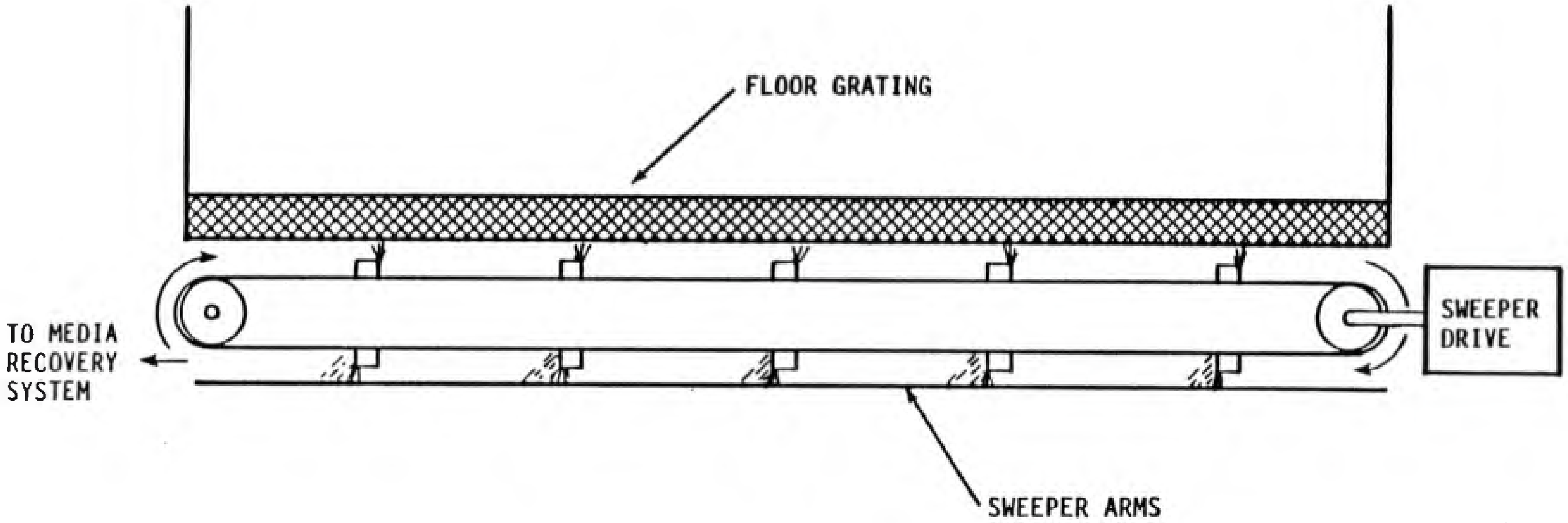


FIGURE 7. TRAVELING SWEEPER ARMS FLOOR RECOVERY SYSTEM.

2.3 Transfer Systems

PMB installations commonly use pneumatic or mechanical systems to convey the used media from the collection device to the recycling system.

2.3.1 Pneumatic Transfer Systems

Pneumatic transfer systems use air flow to carry the collected material to the recycling equipment. The first piece of equipment in the recycling system is usually a cyclone separator. Therefore, the pneumatic method of transfer is predominantly used in commercial applications because the transfer air flow automatically becomes the cleaning force in the cyclone, transporting fines and dust through the cyclone to the dust collector (air cleaner). The simplicity and cost effectiveness of this arrangement accounts for its widespread use.

As with the pneumatic undergrate recovery systems, transfer velocities in the ducts should be maintained between 25 and 75 fps. The draft for the air flow is usually created by the induced draft fan at the exhaust of the dust collector.

2.3.2 Mechanical Transfer Systems

Mechanical transfer systems may be needed if there is a large distance between the PMB booth and the recycling equipment. The draft provided by the induced draft fan may not be sufficient to transport material across the distance pneumatically, so a portion of the distance may have to be traversed mechanically. If the recycling system does not have a cyclone as the first separation step, then pneumatic air flow is unnecessary.

If a mechanical transfer system must lift material vertically to the recycling equipment or between recycling stages, then vertical bucket elevators are typically employed.

The vertical bucket elevator is a simple system used frequently in many industrial applications. A series of identical buckets are evenly spaced on a traveling conveyer belt or wheel. The buckets are inverted as they travel down. The buckets are moved through the media at the bottom of their travel and start to hold material as they revolve to travel upward. Material is then carried up along the belt until the top is reached. The buckets empty into the recycling equipment and then slowly invert again to travel down. The bucket elevator belt tension must be set correctly to ensure good operation. The application of this system is limited to situations requiring a vertical, or near vertical, lift effect.

3.0 NAVAL WEAPONS STATION, SEAL BEACH

3.1 Description of Equipment

The PMB booth at NWS Seal Beach is used for stripping coatings from radar equipment and support stands. The booth was manufactured by Aerolyte and utilizes a reciprocating shaker pan floor recovery system.

The booth is 10 feet wide, 20 feet long, and 10 feet high. Parts to be stripped are moved into the booth through rear doors that open to provide a 10 foot wide entrance. Ventilation air enters at baffles located in the rear doors and travels lengthwise to the ventilation system intake on the front wall (see Figure 8).

The elevated floor houses the floor recovery equipment beneath it. Two reciprocating pans, about 3.5 feet wide and 20 feet long, operate along the outside edges of the booth. The strip of floor in the center of the booth is used for a rail mounted workpiece table. The floor is made of steel grating to provide structural support while allowing blasting debris and reusable media to fall into the pans (see Figure 9).

The reciprocating pan surface is located about 6 inches below the grating. Rubber strips are used as sloped sides of the shaker pan to prevent media from falling off the sides of the pan. The slight vacuum in the booth causes air to flow between the bottom edge of the rubber strips and the pan surface and blow media away from the pan edges.

The reciprocating motion of the pans is provided by a stepped cam and bumper. The pan is suspended and free to move slightly lengthwise like a pendulum. The pan rests against a rotating eccentric cam with a 0.5 inch step at the point of highest eccentricity. When the cam is rotated, the pan is slowly pushed away from the cam shaft until it reaches the cam step and suddenly falls 0.5 inch back toward the cam shaft causing the media to move forward. A bumper is positioned to take the impact of the swinging pan.

Material moves along the pans until it passes through the holes in a scalping screen and falls off the front edge of the pan. The scalping screen, fabricated of perforated metal, is placed at an angle of about ten degrees to the pan surface along the front edge to keep large objects from damaging the screw conveyer. Material then falls into a rotary screw trough located along the entire front wall of the booth. The screw propels the collected material to a pneumatic suction hose that conveys it to the first cyclone in the media recycling system.

The cyclone separates the material by size. Fines and dust carried by the air stream through the first cyclone enters a second cyclone. The fines and dust carried through the second cyclone then travel to the dust collector. Material recovered in the first cyclone falls into the reusable media hopper. Material recovered by the second cyclone is stored in a barrel for disposal. The air flow through the system is provided by an eductor using compressed air.

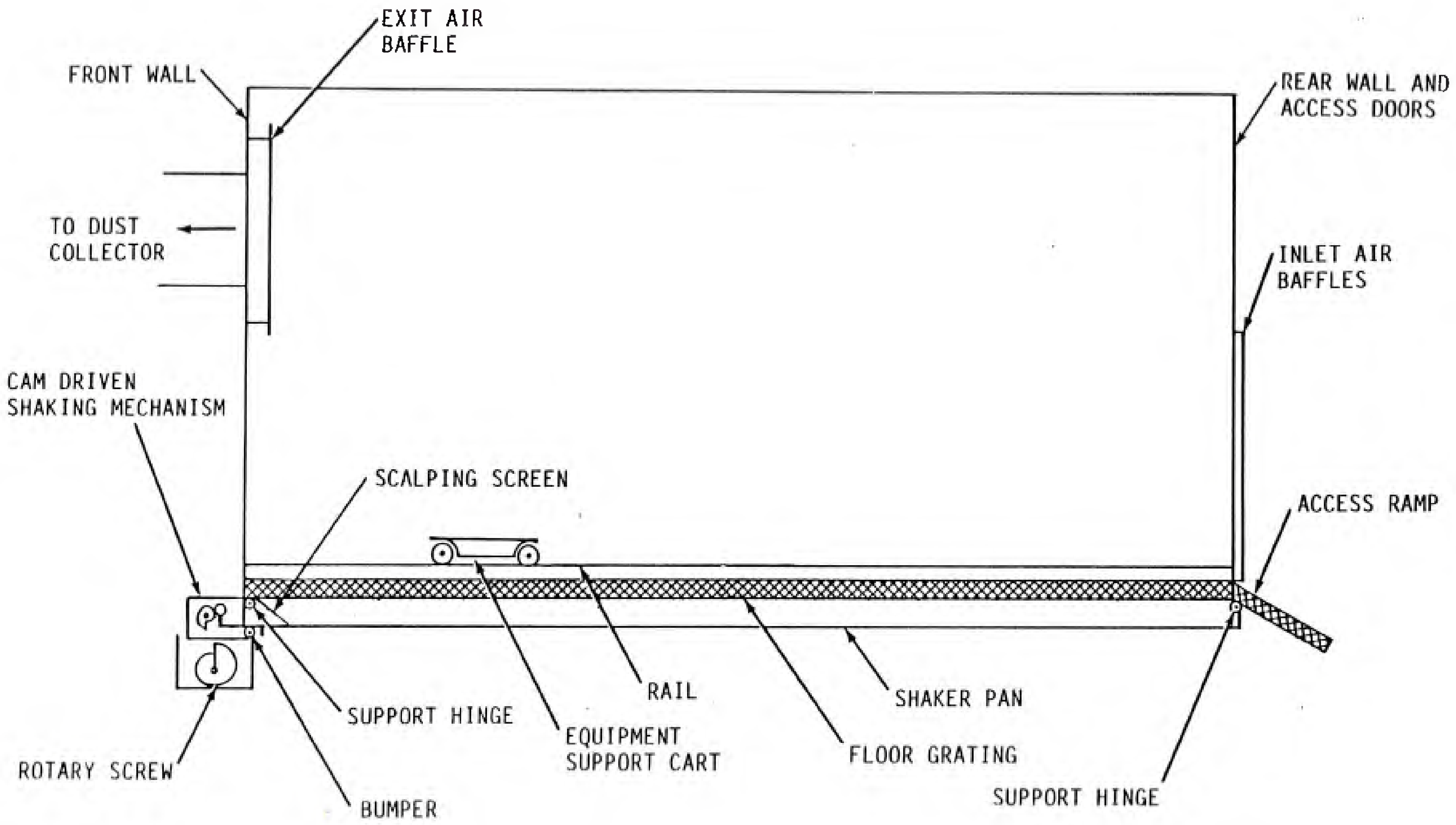


FIGURE 8. NAVAL WEAPONS STATION SEAL BEACH PMB BOOTH.

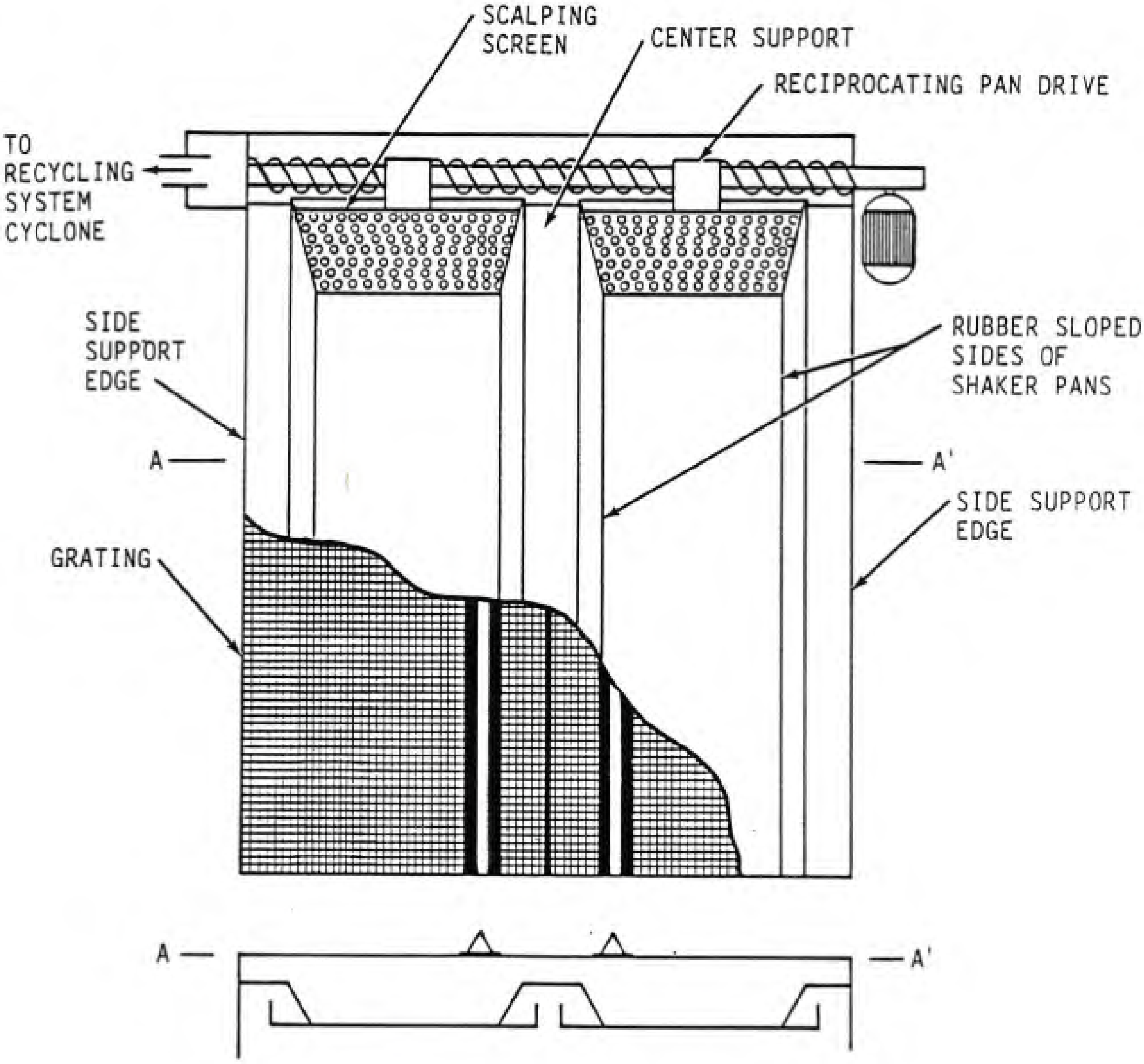


FIGURE 9. NAVAL WEAPONS STATION SEAL BEACH FLOOR RECOVERY SYSTEM.

3.2 Operating and Maintenance History

Compared with paint stripping operations using chemical solvents, operation of the PMB booth at NWS Seal Beach has been shown to reduce labor hours and hazardous waste disposal costs. The exact cost savings have not been determined because the booth was only in operation for about two months before it was shut down due to a temporary lack of paint stripping work.

Inspection of the blasting booth showed it to be in new condition. Weatherproofing problems and corrosion were not evident since the booth was located completely within a larger weatherproof building. The cam driven reciprocating drive mechanism showed only minor discoloration along wear surfaces.

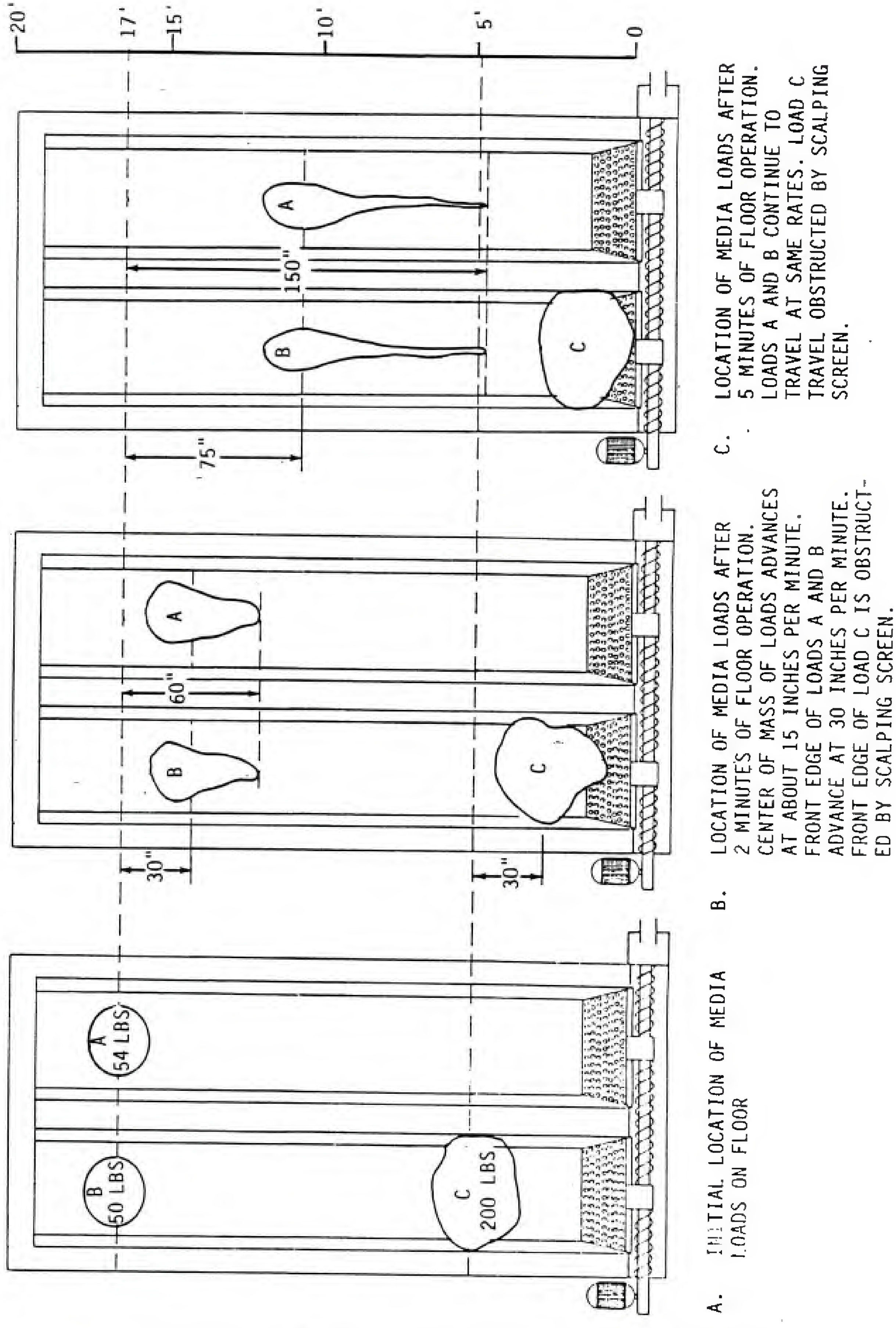
Approximately 250 pounds of media are normally retained in the system along the inside edges and center of the booth where it could not fall directly onto the shaker pan and in the clearance areas of the rotary screw trough. Removal of this excess material, by blowing it out of the edges and onto the reciprocating floor, tended to quickly overload the pneumatic suction hose. The excess material would then ride over the screw trough and spill onto the floor outside of the booth. In addition, the first cyclone would be overloaded with the sudden increase in material flow. The media storage hopper at the base of the first stage cyclone tended to overfill, block the cyclone exit, and caused all material entering the cyclone to be carried to the second cyclone. The manufacturer installed a warning light to indicate when the storage hopper is full, but there is no automatic system shutdown to prevent media from going to the second cyclone.

3.3 Equipment Performance Tests

The reciprocating pan floor recovery system was tested to determine its media handling capacity. The test objectives were to estimate the maximum flow of media that could be handled by this type of floor system and identify the design limitations of the system.

Three piles of media were placed on the reciprocating pan floor. The first load (A) of 54 pounds of virgin (new) media was placed on the left pan about 3 feet from the rear of the booth. The second load (B) of 50 pounds of new media was placed on the right pan about 3 feet from the rear of the booth. The third load (C) of 200 pounds of new media was placed 5 feet from the front of the booth on the right side. The booth floor recovery system was then activated and observed (See Figure 10).

The load at (A) progressed slowly towards the front of the booth and tended to stay together as a pile. The speed of travel tended to match the pattern and speed of the driving cam. The 0.5 inch step in the cam caused a 0.5 inch movement in the reciprocating pan. The speed of the cam was sixty revolutions per minute. The theoretical velocity of the media expected from the product of 60 strokes per minute times 0.5 inch per stroke was 30 inches per minute. This was the speed observed for a small portion of the load along the front edge of the pile. This portion of the load was only about 0.25 inch thick and 2 to 6 inches wide. The bulk of the load tended to travel at about half this rate or about 15 inches per minute. The lower speed could be attributed to the inefficiencies of translating motion from the pan to the thicker pile of media.



A. INITIAL LOCATION OF MEDIA LOADS ON FLOOR

B. LOCATION OF MEDIA LOADS AFTER 2 MINUTES OF FLOOR OPERATION. CENTER OF MASS OF LOADS ADVANCES AT ABOUT 15 INCHES PER MINUTE. FRONT EDGE OF LOADS A AND B ADVANCE AT 30 INCHES PER MINUTE. FRONT EDGE OF LOAD C IS OBSTRUCTED BY SCALPING SCREEN.

C. LOCATION OF MEDIA LOADS AFTER 5 MINUTES OF FLOOR OPERATION. LOADS A AND B CONTINUE TO TRAVEL AT SAME RATES. LOAD C TRAVEL OBSTRUCTED BY SCALPING SCREEN.

FIGURE 10. NWS SEAL BEACH EQUIPMENT CAPACITY TEST DETAILS.

The load at (B) progressed in a similar manner as the load at (A) until its motion was affected by the load at (C). The media load at (C) moved in a manner similar to loads (A) and (B), although its bulk was about four times greater than those at (A) and (B). The estimated rate of travel for (C) was also about 15 inches per minute. A bottleneck was noted to occur at the scalping screen. A large amount of media accumulated on the screen and did not pass easily through it. The scalping screen was necessary since a large mesh screen was not present elsewhere in the recycling system to collect oversized material.

The similarity in travel rate lengthwise along the pan between the test loads at (B) and (C) indicated the amount of loading was not a significant factor. A completely full pan would also move media along at about 15 inches per minute. The bottleneck observed at the scalping screen could be eliminated with an improved design. The screen could be moved from the front edge of the pan to cover the top of the rotary screw trough, thereby exposing more screen area to the media falling off the pan.

The cross-sectional area of each pan is 1.3 square feet. At a speed of 15 inches per minute, therefore, a full pan (assuming a level pile) would be able to move about 1.6 cubic feet per minute. This rate should be doubled for this booth since it had two operating pans. Plastic media has bulk density of about 60 pounds per cubic foot, therefore, the overall transport rate for this booth was the product of two pans times 1.6 cubic feet per minute per pan times 60 pounds per cubic foot or 190 pounds per minute. The floor area of the booth is 200 square feet. The overall media recovery rate for the booth is, therefore, 0.9 pounds per square foot of floor area per minute.

4.0 NAVAL UNDERSEA WEAPONS ENGINEERING STATION, KEYPORT

4.1 Description of Equipment

The PMB booth at NUWES Keyport, Washington is used for stripping coatings from torpedoes and their components. The booth was manufactured by Pauli and Griffin. Due to space limitations, the 10 foot wide by 13 foot long booth was set into an alcove in the chemical stripping area. Components are moved into the booth through the rear doors. An external ramp provides a smooth access from the shop floor to the elevated booth floor for moving equipment in and out of the booth. Ventilation air enters at baffles in the rear doors and travels lengthwise to the ventilation system intake to the dust collector on the front wall (see Figure 11).

The booth originally used a conveyer belt floor recovery system. Failure of the belt system caused personnel at Keyport to retrofit the booth with a pneumatic floor system of their own design. The replacement pneumatic floor, designed by Jim Adams (Code 26323) of NUWES Keyport, has successfully resolved the problems of the belt floor. The new floor far outperforms the conveyer belt system. Mr. Adams used a sequenced pneumatic system that would also maintain adequate air velocities in the cyclone for good media classification. The air velocity within each four inch pipe segment was slightly over 100 fps. No plugging problems with the pneumatic system have been reported. The air velocities may be high enough over time to cause abrasive wear of the collection pipes and header and degradation of the media. The booth tended to accumulate some minimum amount of media on the slopes of the collection troughs, however, it was easily blown down into the system when necessary.

Inspection of the system showed the equipment to be operating with minimal wear. Routine maintenance primarily consists of cleaning the oversize screen and magnetic separator. The floor screens covering the inlet to the collection pipes also have to be occasionally cleaned.

The modified floor recovery system is housed under the elevated floor. Three identical trough sections funnel material falling through the floor grating into longitudinally centered, four inch pipes (See Section A-A of Figure 12). Each section is about 40 inches wide and runs the length of the booth. The sides of each trough are smooth sheet metal sloped at about 25 degrees. The slope is limited due to the lack of adequate clearance underneath the floor. Pneumatic vibrators are attached to the walls of the trough to keep material from accumulating (see Figure 12).

The bottom of each of the three troughs has a narrow slit about 0.5 inch wide which leads to a four inch media suction pipe. The slit is covered with a metal screen to prevent oversize material from entering. Air flow in each pipe is cycled on and off with solenoid operated valves. The duty cycle period for each of the three pipes is about 20 seconds per minute. The three collection pipes connect to a common header terminating at the outlet of the solenoid-operated valve manifold. The draft for the air flow is provided by the induced draft fan which is located on the exhaust side of the dust collector.

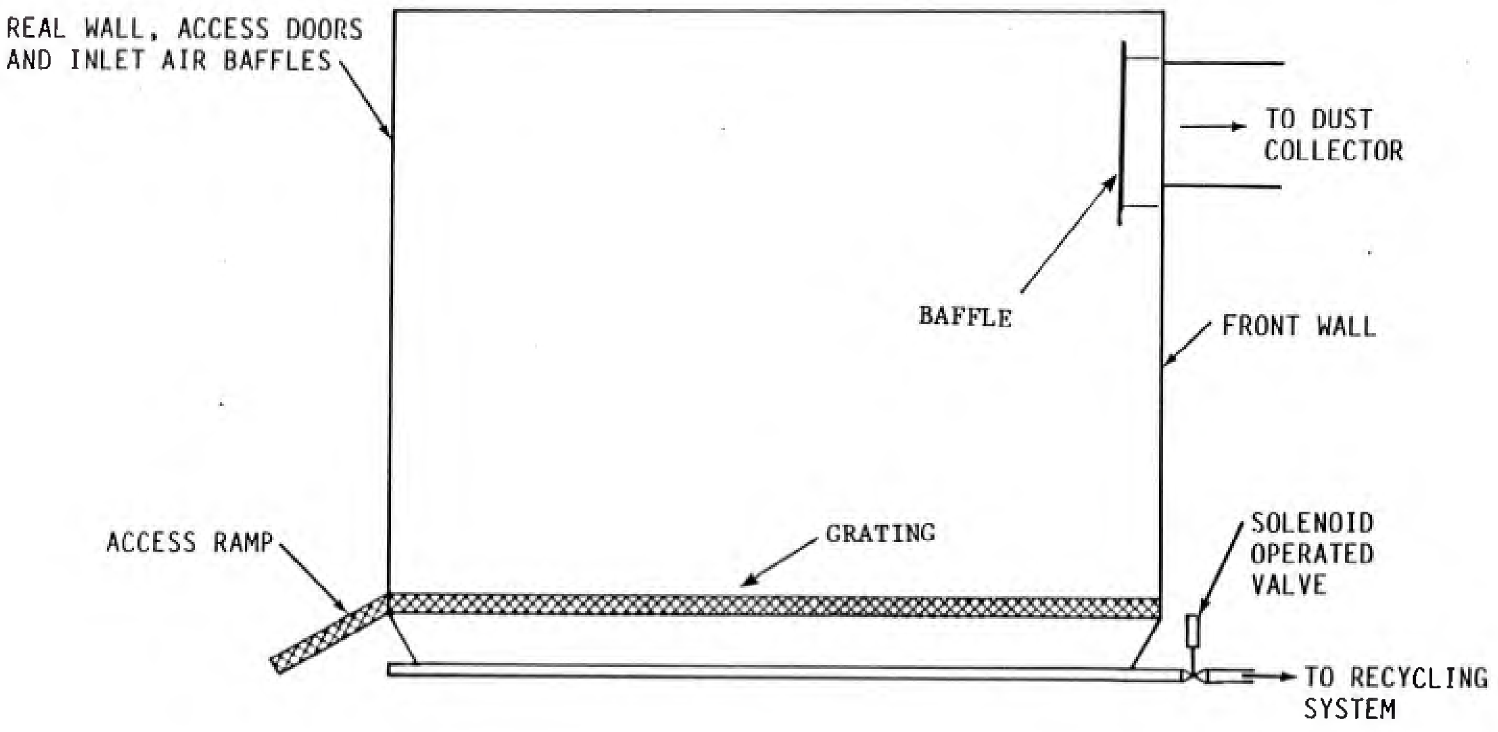


FIGURE 11. NUWES KEYPORT PMB BOOTH.

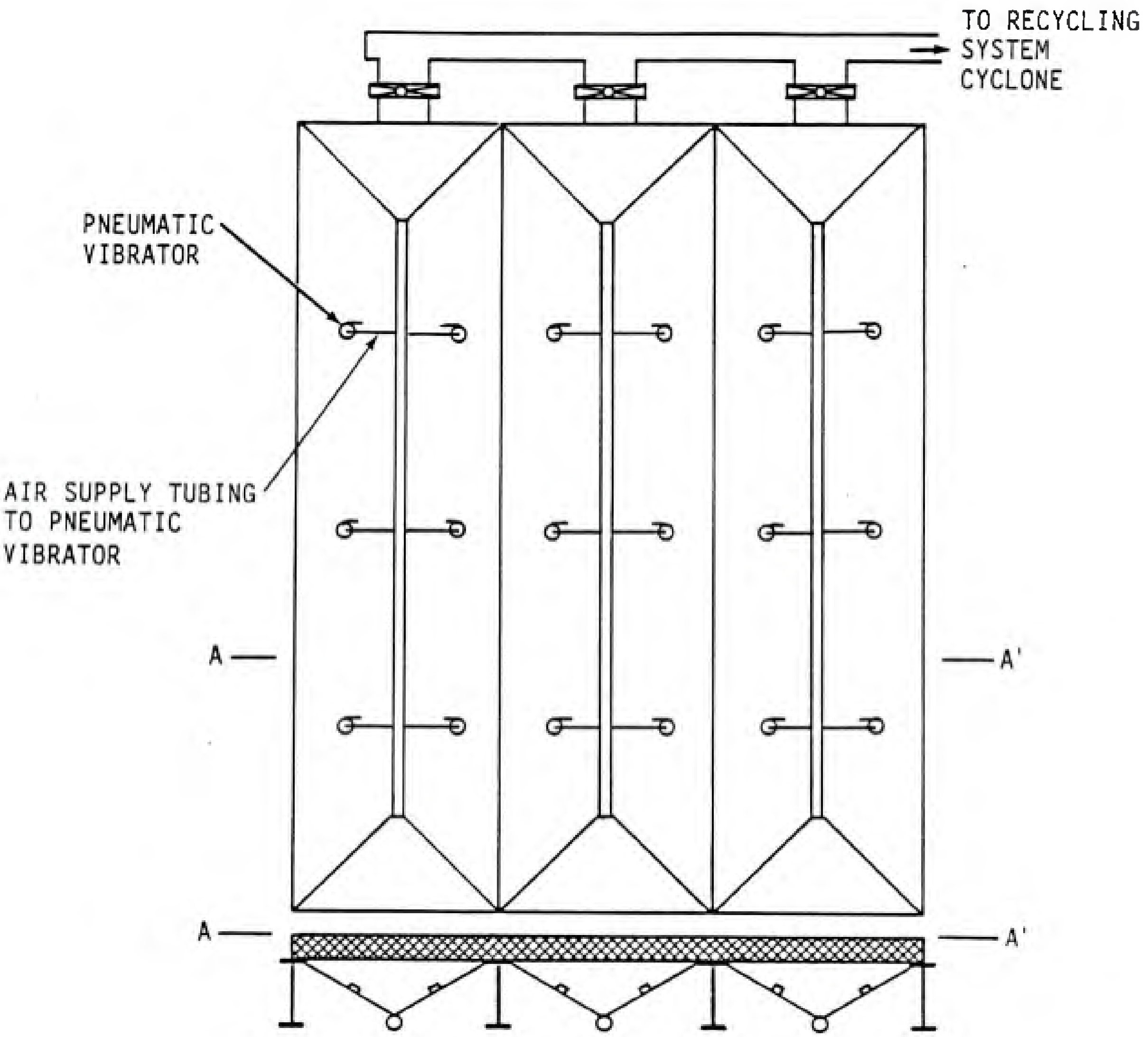


FIGURE 12. NUWES KEYPORT FLOOR RECOVERY SYSTEM.

Blasting debris, containing reusable media, is conveyed pneumatically from the collection header to a cyclone. Fines and dust separated in the single stage cyclone continue toward the dust collector. Material recovered in the cyclone falls perpendicularly across an airstream as it travels down to the reusable media storage hopper. The velocity of the air stream is set to remove plastic media under the size of about 80 mesh and carry it to the dust collector. The recycling system did not include an undersize (<80 mesh) vibrating screen to remove fines because of the efficiency of the air wash system. A second, manually cleaned, perforated metal screen is installed below the cyclone to remove any oversize material. A small pneumatic vibrator is attached to the latter screen to help move material through it and into the reusable-media storage hopper. The storage hopper feeds the blasting pot automatically when the pot is depressurized. A small, manually cleaned magnet is placed in the cleaned media stream below the exit from the blasting pot to remove magnetic contaminants.

4.2 Operating and Maintenance History

The PMB booth has been effective in reducing the costs of paint stripping operations at NUWES Keyport. Full cost reduction benefits were realized after the floor recovery system was modified from a conveyer belt system to a pneumatic system.

The original floor recovery system shown in Figure 13 consisted of three flat, reinforced polyvinyl chloride (PVC), 36-inch wide conveyer belts. The design rate of the floor for media reclamation was 6,400 pounds per hour. The conveyer belts traveled under the floor grating at a speed of 36 feet per minute. The material was conveyed by the belt to a trough on the front edge of the booth where the material was then pneumatically carried to the media recycling cyclone. Material falling onto the belt was deflected away from the belt edges by angled media diverter shields. Belt tension was adjusted using a take-up threaded rod and nut assembly.

The primary maintenance concern with the conveyer belt system was the constant belt alignment problems. The pulleys were not sloped to help maintain the correct belt position. The belts tended to slowly travel to one side of the pulley. If not immediately corrected, the belt would start to shred and cause the pulley axle to shear. The downtime caused by the frequent repairs of the system was excessive. The belt travel problem occurred despite frequent adjustments to the positioning rod and nut assembly. The belt system did not keep media from falling off the edges of the belt. Accumulations of blasting debris would periodically have to be removed from the floor underneath the booth.

4.3 Equipment Performance Tests

The pneumatic floor recovery system was tested to determine its media handling capacity. The test objectives were to estimate the maximum flow of media that can be handled by this type of floor system and to identify the functional limitations of the system.

The first test evaluated the media removal capability as a function of the position of the media in the booth. Three 60 pound loads of media were placed on the floor. The first load (A) was placed in the left trough about three feet from the front of the booth. The second load (B) was placed in the center trough about seven feet from the front of the booth. The third load (C) was placed in the right trough about eleven feet from the front of the booth. The floor was then activated and observed (See Figure 14).

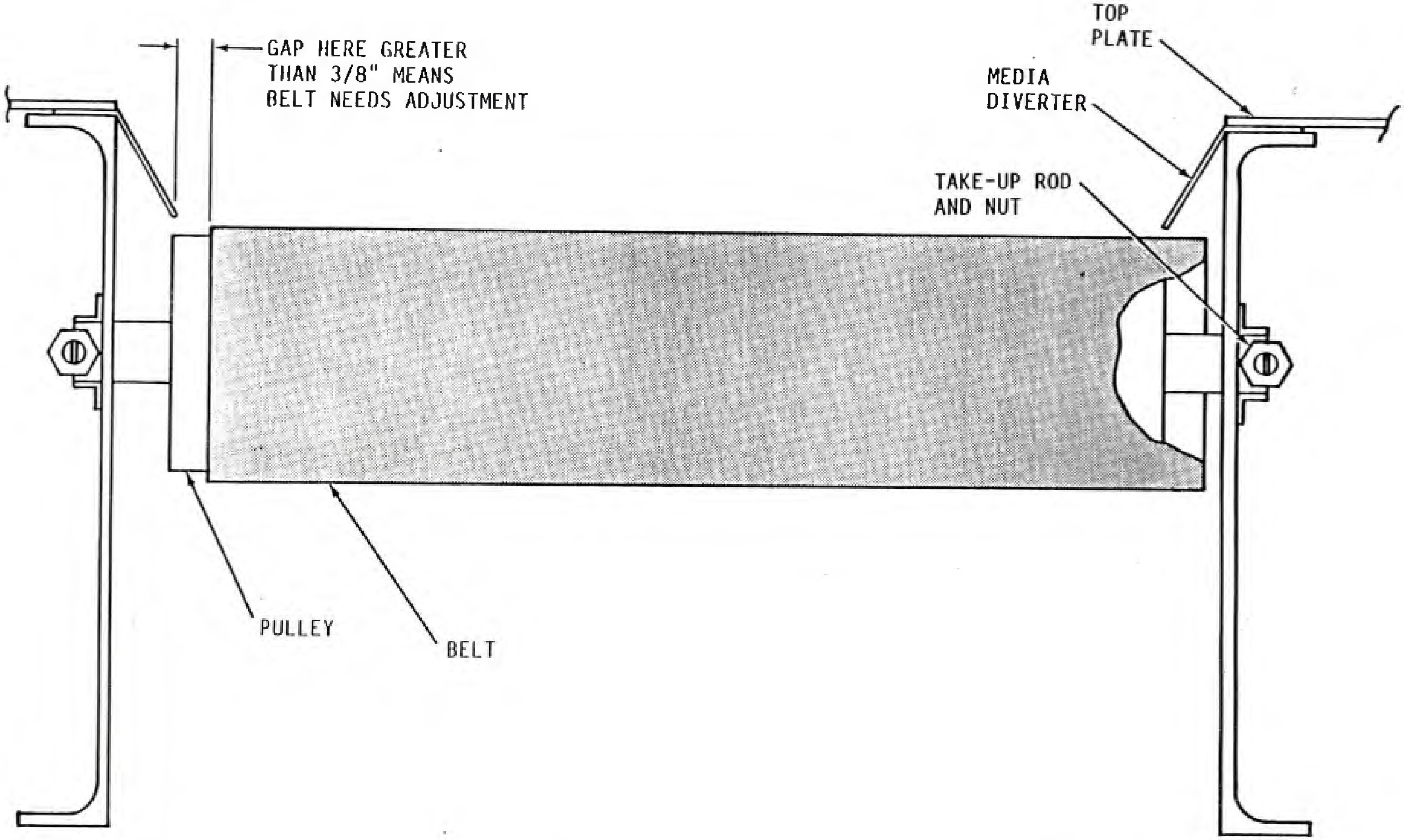


FIGURE 13. END VIEW OF BELT USED IN ORIGINAL FLOOR RECOVERY SYSTEM AT NUWES, KEYPORT.

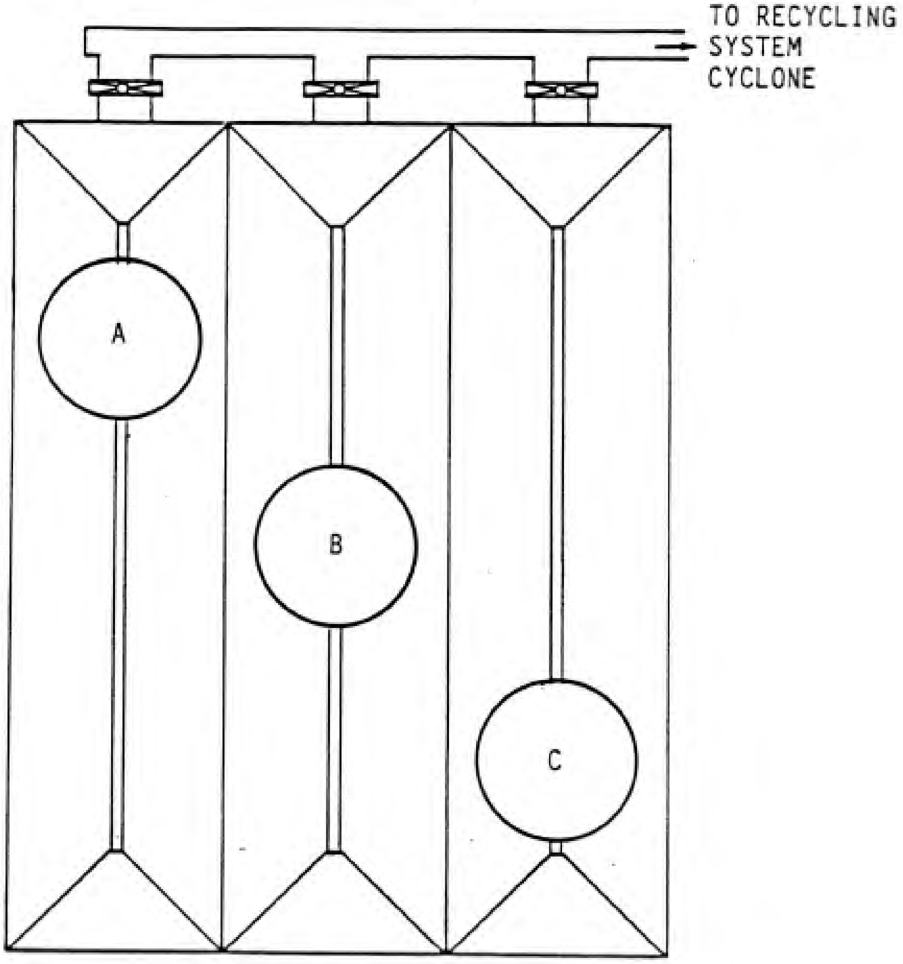


FIGURE 14. LOCATION OF TEST LOADS AT NUWES KEYPORT FLOOR RECOVERY SYSTEM.

The media removal rate was about the same for loads (A) and (B). In each of these piles, almost half of the media was removed during the first 20 second duty cycle. The screen at the bottom of the trough became visible after the second cycle. The removal rate was slower for load (C), probably due to the length of the slotted pipe in front of the load that was drawing air. It took three complete 20 second cycles to expose the screen at (C).

The second test evaluated the effect of overloading the floor recovery system to determine the maximum removal rate. Three hundred pounds of media were placed in a pile about seven feet long, loading the system with about 40 pounds of media per foot. Observations for this test are given in Table 1.

The system did not plug with this exceptionally high load. Normal operation using one or two nozzles, which adds 40 pounds of material per minute distributed over three troughs, should not overload the system.

The media removal rate during duty cycles was consistently measured at about six inches of pipe at the front of the pile cleared per cycle. At forty pounds per foot about 20 pounds of media will be removed per cycle. As only one trough is in operation at any given time, the media removal rate for the booth was about 60 pounds per minute. The total floor area was 130 square feet. The overall media recovery rate for the booth was, therefore, 0.46 pounds per square foot of floor area per minute.

TABLE 1. CAPACITY LOAD TEST OBSERVATIONS, NUWES KEYPORT

DUTY CYCLE*	OBSERVATION
0.	Initial load of 300 pounds media placed along front seven feet of trough. Six inches of pipe visible between front of trough and beginning of media pile. Trough loaded about half full.
1.	System did not plug. Media removal could be observed in front twelve inches of pile as it slowly decreased in size.
2.	Eighteen inches of pipe visible. Media removal continued to be evident only at front of the pile.
3.	Twenty-four inches of pipe visible. Media removal continued to be evident only at front of the pile. Elevation of pile elsewhere, including back end, remained unchanged.
4.	Thirty inches of pipe visible.
5.	Thirty-six inches of pipe visible. Some media adhering to trough sides in front of the pile fell into pipe.
6.	Forty-three inches of pipe visible. Remaining pile remained constant in size except for front section.
7.	Fifty inches of pipe visible. Media fell slowly into open screen from the accumulations remaining on the sides of the trough.
8.	Fifty-six inches of pipe visible.
9.	Sixty inches of pipe visible (remaining length of pipe - twenty-two inches). Media removal evident along entire pile but still primarily at the front of the pile.
10.	Media removal occurred along entire remaining section. Remaining covered area nine inches long after cycle completed.
11.	Pipe is entirely visible. Media still fell slowly into pipe along sides of trough.

*NOTE: Cycle was one 20 second period of floor operation every minute.

5.0 NAVAL AIR STATION, BARBERS POINT

5.1 Description of Equipment

The PMB booth at NAS Barbers Point, Hawaii, is used to remove coatings from ground support equipment (GSE) used at the base. The booth was manufactured by ZERO and features a completely pneumatic floor recovery system. The booth is 10 feet wide by 20 feet long, and is similar in construction to the PMB booth at NWS, Seal Beach. The back wall fully opens to provide a 10-foot wide access. An external ramp is used to move equipment in and out of the booth (See Figure 15).

The recovery system consists of 10 adjacent rows of 20 square funnels each as shown in Figure 16. Each funnel has a 12 inch by 12 inch square top tapering along four sides at 60 degrees to a 0.75 inch x 0.63 inch bottom exit hole. The exit holes of each row of funnels direct media to a common pneumatic collection duct. The ten parallel collection ducts route the media to a common collection header for pneumatic transport to the media recycling system. The 200 funnels are covered by grating to provide floor support.

The pneumatic collection ducts are operated in sequence with solenoid-operated gate valves. Five pairs of collection ducts are sequentially opened to the induced draft of the ventilation fan for 15 seconds during each 75 second cycle. This sequential design allows the media recycling system to be downsized versus a full recovery floor because only 20 percent of the total possible volume of air and media are flowing at any one time.

Flow from the collection header is directed to a cyclone. The dust and fines not removed in the cyclone continue to the ventilation system cartridge-style dust collector. The solids recovered in the cyclone are further classified by a vibrating screen with a 12 mesh screen above a 60 mesh screen stacked in the vibrating assembly. Oversize material retained on the 12 mesh screen is directed to a 55 gallon storage drum for disposal. Undersized material passing through the 60 mesh screen is directed to another drum for disposal. Reusable media retained on the 60 mesh screen falls into a media storage hopper above the blasting pot.

The ventilation system moves air through the length of the booth. Outside air enters through baffles located on the rear access doors and traverses to the intake baffle at the front wall. Ventilation draft is provided by an induced draft fan that moves the air through a cartridge style dust collector for cleaning.

5.2 Operating and Maintenance History

Operation of the PMB booth has successfully reduced the operating costs of depainting the GSE at NAS Barbers Point. The amount of hazardous waste generated at the facility has also been significantly reduced. The installation of the booth was not completely finished by the original installing contractor, and additional assistance by ZERO was required to make the booth operational. The recycling system is still missing a large magnetic separator which will be installed in the near future. Magnetic separation is very important in PMB operations because most of the GSE equipment is constructed of steel. Abraded steel particles must be removed from the recycled media to prevent blasting damage by hard particle contamination.

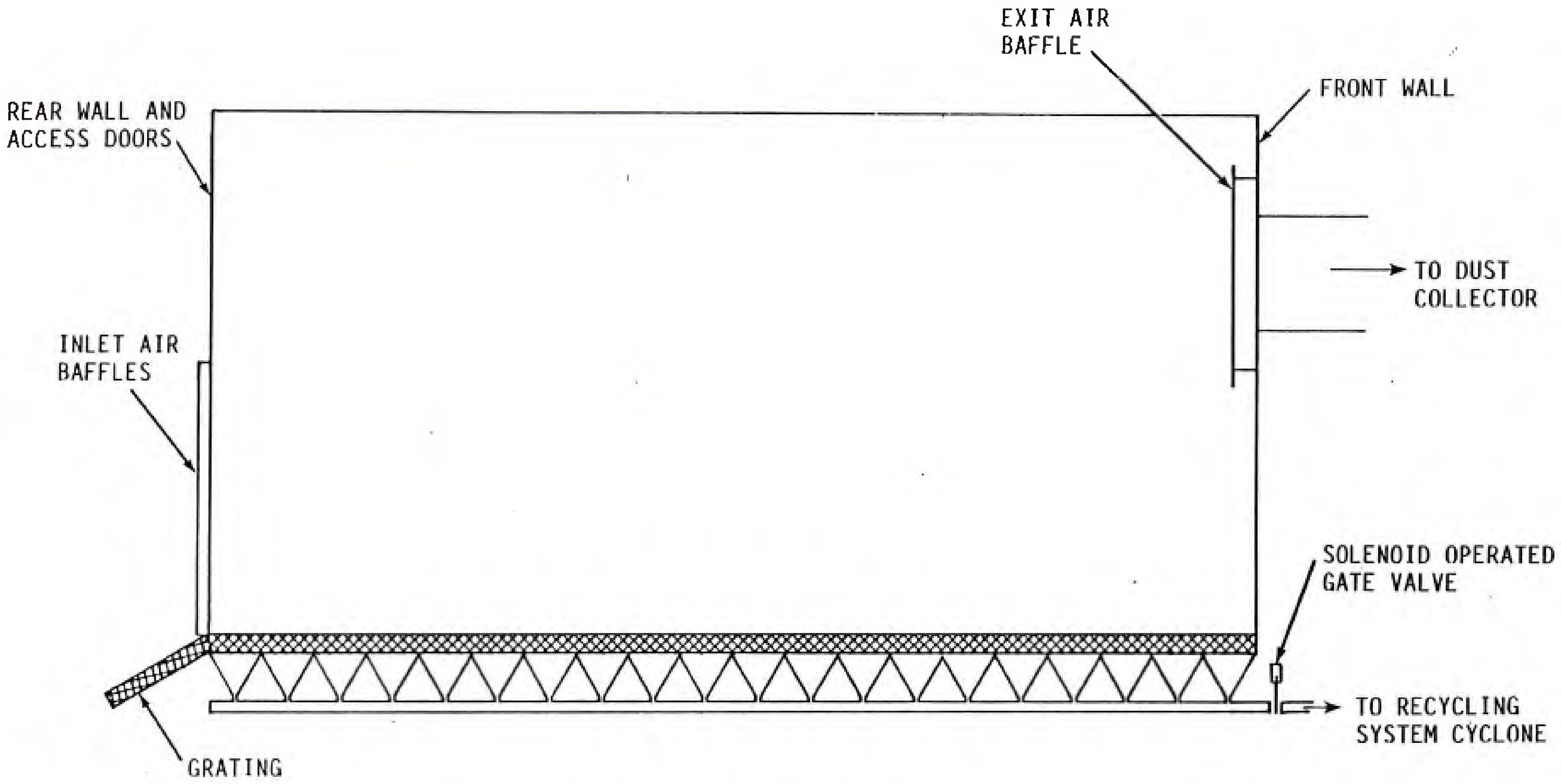


FIGURE 15. NAVAL AIR STATION BARBERS POINT PMB BOOTH.

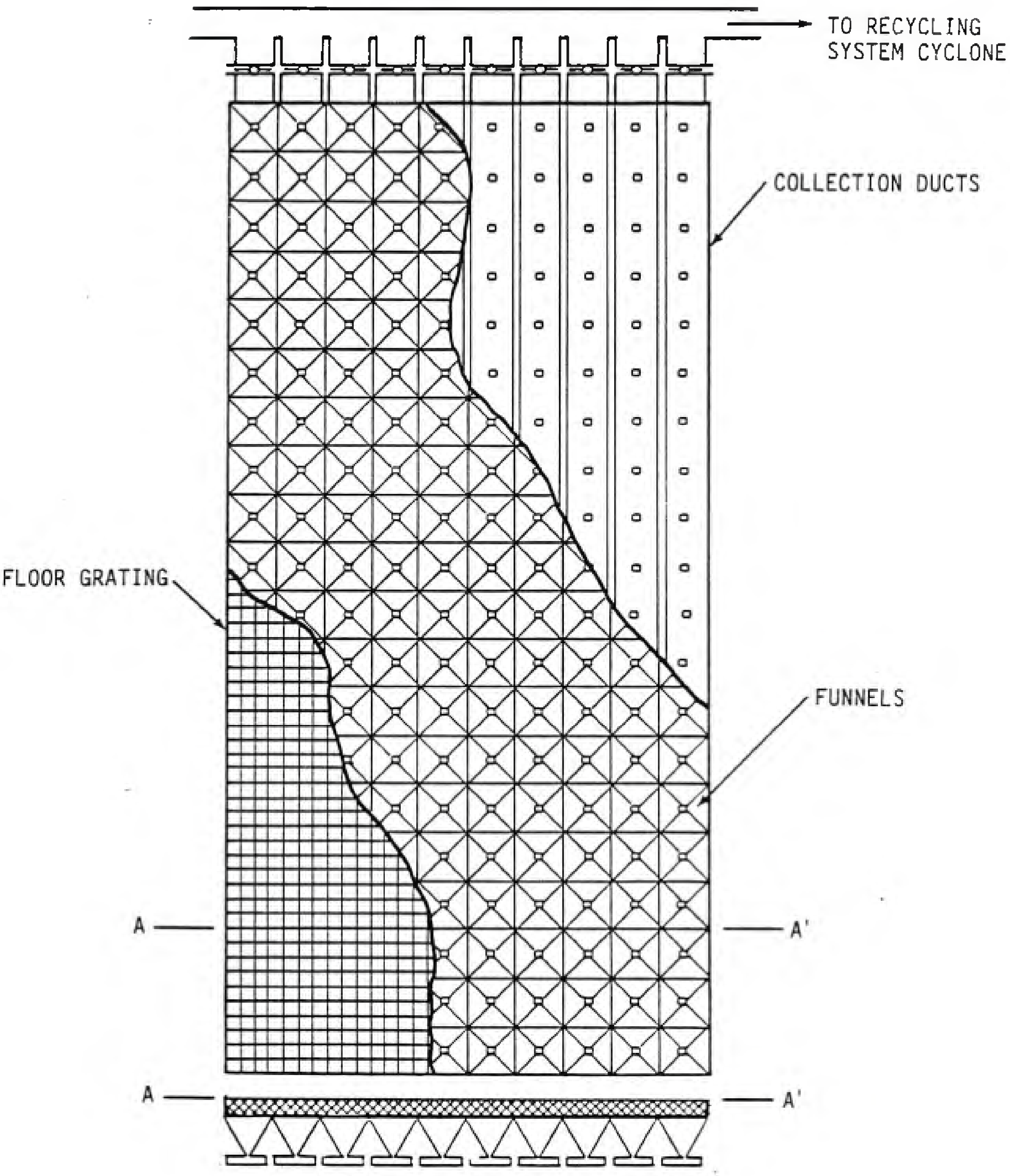


FIGURE 16. NAVAL AIR STATION BARBERS POINT FLOOR RECOVERY SYSTEM.

Inspection of the blasting booth showed it to be in good operating condition. The floor showed no significant erosion damage. Caulking had been applied to seal the four corner seams of each funnel. This caulking was showing significant wear. The solenoid gate valve system was in good working order with no reported maintenance problems.

The overall condition of the recycling and ventilation systems was good. The high humidity of the area did not seem to have affected the equipment except for the normal corrosion typical for the area, noted within the blasting booth itself. No plugging problems were reported with the floor recovery system. Media consumption rates ranged between 7 to 10 pounds per hour of operation.

5.3 Equipment Performance Tests

The pneumatic floor recovery system was tested to determine its media handling capacity. The test objectives were to estimate the maximum flow of media that could be handled by this type of floor system and identify the performance limitations of the system.

A single recovery funnel, located near the center of the floor, was filled with an estimated 0.27 cubic feet of media. The floor recovery system was then started. The funnel emptied after 28 cycles of 15 seconds or a total operating time of 7 minutes. The average flow rate of media from the single funnel was 67 cubic inches per minute or about one cubic inch per second of operating time. An entire row of funnels could not be filled and tested due to limited capacity in the reusable media storage hopper.

As expected, observations during the test indicated that the limiting flow factor was the size of the hole at the bottom of the funnel. The design intention for the pneumatic collection duct was to limit the amount of material flowing from the funnel so that blockages would not build-up in the air path. This design should allow each funnel in a completely filled row to empty at approximately the same rate regardless of funnel position in the row.

The total flow capacity of the floor is a function of the number of funnels active at one time. The continuous flow rate of media per row (assumes that all funnels empty at same rate) is the product of 20 funnels and the flow rate of 67 cubic inches per minute per funnel, or 0.76 cubic feet per minute. This corresponds to about 45 pounds of media per minute (bulk density of media of 60 pounds per cubic foot). The booth has a floor area of 200 square feet. The overall maximum media recovery rate for the booth with two rows operating at any given time is 0.45 pounds per square foot of floor area per minute.

6.0 SAMPLE ANALYSIS OF RECYCLED MEDIA AND REJECTED DUST

Samples of recycled and waste media were taken at each PMB installation to determine the effectiveness of the recycling equipment as measured by size distribution and hard particle analyses. Size distribution tests will demonstrate how effectively the recycling system removed oversize and dust contamination from the reusable media, and how much reusable media was lost to the waste fractions. Hard particle analyses will indicate how well the recycling system removes hard particles from the reusable media. Hard particles include metal, sand, or other foreign material in the media. Samples were taken of the:

- new media,
- recycled or reusable media,
- cyclone reject material,
- oversize and undersize reject material (if applicable), and
- ventilation dust.

6.1 Percentage of Usable Media in the Rejected Material

Particle size distributions were determined by sieving the samples into five different size ranges. A complete summary of the size distribution data from samples taken at the three sites is included in Table 2. Excerpts of this data are included in Tables 3 and 4. The percentage of reusable media shown in Table 3 was calculated by dividing the weight of the size fraction between 12 and 60 mesh by the total weight of the sample. The total weight percent dust shown in Table 4 was calculated by adding together the weight of all size fractions less than 60 mesh.

6.1.1 NWS, Seal Beach Rejected Media Analysis

The NWS, Seal Beach media recycling system consists of a pair of cyclones in series, followed by the dust collector for trapping the fines. A separate baghouse removed dust from the ventilation air.

There was an average of 90 percent reusable media in the material recovered in the second cyclone. This reusable media was carried into the second cyclone primarily because the media level in the storage hopper occasionally rose to where it interfered with the operation of the first cyclone. The secondary cyclone reject should be recycled through the recovery system to try and recover the reusable media.

A small amount of dust was collected in the media recycling system dust collector. The sample measured almost 14 percent reusable media with the balance less than 200 mesh. This cyclone reject should not be recycled because there is not enough recoverable media available.

The ventilation system had an average concentration of about 30 percent reusable media in the dust collector bin. This dust collection system was similar to the NAS, Barbers Point system that collected about 7.5 percent reusable media. The difference was caused by the different recovery floor arrangement at each location. The reciprocating pan system at Seal Beach has an opening to the rotary screw trough at the front wall directly below the ventilation system intake and baffle. Air flow into the negatively pressured booth at this point tended to lift media up underneath the baffle and into the ventilation system. This media could be deflected back into the booth and away from the ventilation system intake by installing a small horizontal plate extending about six inches from the front wall about three feet above the floor.

TABLE 2. SIEVE ANALYSIS OF COLLECTED SAMPLES

SAMPLE*	GRAMS OF SAMPLE	PERCENTAGE BY WEIGHT				
		>12	12-60	60-100	100-200	<200
NWS, SEAL BEACH						
New U.S. Tech Media, A	100	0	99.98	0.02	0	0
New U.S. Tech Media, B	100	0	99.48	0.26	0.18	0.08
Media Recycling Dust	12.37	0	13.99	0.65	0.32	85.04
Secondary Cyclone, A	100	0	90.74	7.18	1.47	0.61
Secondary Cyclone, B	100	0	94.18	4.80	0.72	0.30
Secondary Cyclone, C	100	0	86.25	11.40	2.16	0.55
Secondary Cyclone, D	100	0	91.03	6.81	1.54	0.62
Recycled Media, A	100	0	94.58	4.82	0.46	0.14
Recycled Media, B	100	0	91.95	7.16	0.70	0.19
Ventilation Dust, A	100	0	34.11	24.89	21.50	19.50
Ventilation Dust, B	100	0	25.14	29.47	24.20	21.19
Ventilation Dust, C	100	0	30.04	24.00	24.73	21.23
NUWES, KEYPORT						
New Comp Material Media,A	100	0	99.99	0.01	0	0
New Comp Material Media,B	100	0	100.00	0	0	0
New Comp Material Media,C	100	0	100	0	0	0
Ventilation Dust, A	100	0	72.13	16.89	7.09	3.89
Ventilation Dust, B	100	0	85.94	6.57	6.23	1.26
Recycled Media	100	0.02	95.95	3.10	0.85	0.08
NAS, BARBERS POINT						
New Aerolyte Media	100	0	99.00	1.00	0	0
New Comp Material Media	100	0	99.93	0.02	0.01	0
Ventilation Dust	50	0	7.8	17.04	17.38	57.78
Oversize Screen Reject	100	2.24	97.28	0.28	0.14	0.06
Undersize Screen Reject	100	0	0	23.93	69.60	6.47

* Letters in this column indicate sample number; i.e. "A" means first sample; "B" means second sample; and so on.

Table 3. Percentage of Reusable Media in Rejected Material

SAMPLE LOCATION	PERCENTAGE OF REUSABLE MEDIA BETWEEN 12 AND 60 MESH
NWS, SEAL BEACH	
Secondary Cyclone (Sample A)	90.74
Secondary Cyclone (Sample B)	94.18
Secondary Cyclone (Sample C)	86.25
Secondary Cyclone (Sample D)	91.03
Average	90.55
Recycled Media Dust Collector	13.99
Ventilation System Baghouse Fines (Sample A)	30.04
Ventilation System Baghouse Fines (Sample B)	34.11
Ventilation System Baghouse Fines (Sample C)	25.14
Average	29.76
NUWES, KEYPORT	
Dust Collector Fines (Sample A)	72.13
Dust Collector Fines (Sample B)	85.94
Average	79.04
NAS, BARBERS POINT	
Oversize Reject	97.28
Undersize Reject	0.00
Baghouse Fines	7.80

Table 4. Sieve Size Analysis of Media Samples

SAMPLE LOCATION	WEIGHT PERCENT BY MESH SIZE >12	12-60	60-100	100-200	<200	TOTAL WT % <
NWS, SEAL BEACH						
Recycled Media (A)	0.00	94.58	4.82	0.46	0.14	5.42
Recycled Media (B)	0.00	91.95	7.16	0.70	0.19	8.05
Average	0.00	93.27	5.99	0.58	0.17	6.73
NUWES, KEYPORT						
Recycled Media	0.02	95.95	3.10	0.85	0.08	4.03
NAS, BARBERS POINT	No recycled media sample was available.					

6.1.2 NUWES, Keyport Rejected Media Analysis

The NUWES, Keyport media recycling system used a cyclone and wind sifting system to clean the media of undersize material. The rejected undersize material from the recycling system is conveyed to the dust collector and is combined with the material recovered from the separate ventilation system. The dust collector fines average about 78 percent reusable media, primarily 60 mesh in size. The dust collector material could be recycled through the floor recovery system to recapture the rejected reusable media.

The amount of reusable media reaching the dust collector could be reduced with simple modifications to the existing recycling system and the ventilation system. First, the wind sifter cone at the bottom of the cyclone could be adjusted to decrease the air flow to the ventilation system. Lower air velocities might help minimize the amount of reusable media carry-over out of the recycling system to the ventilation system. Second, reusable media directly entering the ventilation system could be reduced by adding baffles to deflect media away from the ventilation ducts during blasting operations. The smaller size of this booth caused the workpieces to be closer than usual to the ventilation intake ducts increasing the possibility that usable media would be accidentally sucked into the ventilation system.

A pneumatically vibrated oversize screen underneath the cyclone is manually cleaned to remove oversize material. No sample was taken of material retained on the oversize screen. This screen was observed to be effective in retaining oversize paint flakes and other material.

6.1.3 NAS, Barbers Point Rejected Media Analysis

The NAS, Barbers Point media recycling system uses a two-tiered vibrating screen to remove oversize and undersize material from the media. Dust is collected from the ventilation system with a small reverse pulse style baghouse.

The oversize media screen also removes usable media. The oversize screen did not have enough surface area to handle the higher material flow rates, so over 97 percent of the oversize reject material was found to be usable media. The oversize reject material should be recycled into the system to recover the usable media. The undersize screen was more effective and did not pass material larger than its 60 mesh rating.

The material collected in the ventilation system baghouse had almost 8 percent reusable media. This occurred primarily because of the design of the ventilation system baffle. The baffle consists of a single solid plate positioned about 6 inches in front of the front wall and the duct entrance. During blasting operations, some reusable media passed behind the baffle and was pulled into the ventilation duct. A larger plate, slightly further from the wall could be used to reduce these losses.

6.2 Percentage of Dust in the Recycled Media

The effectiveness of the media recycling equipment in removing undersized material from the recycled media was determined by classifying the material into size ranges. Reusable media is found between 12 to 60 mesh. Undersize material or dust is defined in three categories; 60 to 100 mesh, 100 to 200 mesh, or less than 200 mesh. The data and the calculated percentage of dust in the recycled media and other samples are shown in Table 4.

The recycling system at Seal Beach uses only a single cyclone without an air wash or vibrating screen to remove additional fines. The average concentration of undersize material was 6.73 percent. Not surprisingly, this was higher than the averages for the other recycling systems using multiple cleaning devices. Typical guarantees on new PMB equipment specify no greater than 5 percent undersize material in the recycled media.

The Keyport cyclone is combined with a wind sifter to more effectively clean the media. The reusable media tested had only a 4.03 percent concentration of undersize material. The contamination with oversize material was negligible.

The Barbers Point site uses a cyclone combined with a two tier vibrating screen assembly. Used media was not available to obtain a sample of recycled media. Separation process theory, however, predicts that there should be some undersize material retained on the screen. This is demonstrated by the smooth distribution curve for the size fractions isolated by a classification device. The cutoff point of a classification device is the size of particle where half of the particles of that size are retained on the screen and half pass though the screen. There was no reusable media in the rejected material from the 60 mesh screen. This indicated that the particle size cutoff point is smaller than 60 mesh. Therefore the screen was retaining some undersize material, the amount of which could not be accurately estimated.

6.3 Hard Particle Contamination

Hard particles are defined as particles in the recycled media stream of greater density than the plastic media. These particles are typically sand, steel, iron oxide scale, or other higher density contaminants. These particles travel at the same velocity from the blasting nozzle, but have greater momentum than the plastic media particles due to their greater density. The result is that the hard particles often damage soft substrates such as aluminum, fiberglass, and other composite materials.

Hard particles can be isolated in media samples using a freon float test. The density of freon at room temperature is between the density of plastic media and hard particle contaminants. A sample of media placed in a freon bath will separate as the hard particles sink and the plastic media floats. The two fractions are then dried and weighed after separation occurs.

Table 5 shows the percentages of hard particle contamination in the various samples of media taken at the three PMB installations. The greatest concentrations of hard particles occurred in the accumulations of undersize or dust collector reject material. These accumulations ranged from 5,000 parts per million (ppm), or 0.5 percent, at Keyport, to over 60,000 ppm, or 6 percent, at Barbers Point.

A number of new media samples were tested for hard particle contamination during this study. The new media had been purchased for use at each of the respective PMB installations. Based on a limited number of samples, the measured concentration of hard particles in the various samples ranged from 30 ppm to 13,000 ppm. The average concentration was about 2,500 ppm. The one Aerolyte sample had a 13,000 ppm hard particle concentration. The two U.S. Technology samples averaged 2,030 ppm of hard particle contaminants. The four Composition Materials samples averaged only 83 ppm. The Air Force recommends that hard particle contamination not exceed 200 ppm. Based on these samples, only the new Composition Material media was able to satisfy this criteria.

The recycled media in these three booths did not meet the Air Force criteria. The average concentration of hard particle contaminants in the three recycled media samples was 3,800 ppm, well in excess of the 200 ppm limit. These media can, however, still be used to blast durable surfaces. Higher quality new media that meets the media specification and more efficient recycling equipment would improve the quality of the recycled media.

TABLE 5. CONCENTRATION OF HARD PARTICLE CONTAMINANTS

DESCRIPTION OF SAMPLE*	HEAVY CONTAMINANT CONCENTRATION (ppm)
NWS, SEAL BEACH	
New U.S. Technology Media, Type III (20-30 Mesh),A	1,210
New U.S. Technology Media Type III (20-30 Mesh),B	2,850
Media Recycling System Dust Fines	Insufficient Sample
Secondary Cyclone, A	6,660
Secondary Cyclone, B	3,250
Secondary Cyclone, C	4,530
Secondary Cyclone, D	2,930
Recycled media, A	5,320
Recycled media, B	3,740
Ventilation System Dust Fines, A	30,800
Ventilation System Dust Fines, B	24,600
Ventilation System Dust Fines, C	26,400
NWS, KEYPORT	
New Composition Material Media, A	160
New Composition Material Media, B	30
New Composition Material Media, C	40
Ventilation System Dust Fines, A	3,900
Ventilation System Dust Fines, B	5,130
Recycled Media	2,410
NAS, BARBERS POINT	
New Aerolyte Media 3.5 MOH (20-30 Mesh)	13,000
New Composition Materials Media, (20-30-Mesh)	100
Ventilation System Dust Fines	Insufficient Sample
Oversize Screen Reject	10,300
Undersize Screen Reject	61,800

* Letters in this column indicate sample number; i.e. "A" means first sample; "B" means second sample; and so on.

6.4 Total Metal Concentration Analyses

The total metal concentration was measured in eighteen of the samples covering all three sites. The testing procedure was in accordance with SW-846 of the Environmental Protection Agency (EPA) Test Methods for Evaluating Solid Waste Physical/Chemical Methods. The test results are summarized in Table 6. The limit of detection has been reached or exceeded when the data is preceded by the less than symbol (<).

These total metal results are not directly comparable to the results from the hard particle analyses. Metals in the hard particle analyses are typically chunks and slivers of metal. Metals measured in the total metal analyses would include all metals, no matter what the size.

6.4.1 Total Metal Concentration in New Media Samples

The total metal concentrations in the new media samples consistently showed high levels of zinc. Zinc concentrations among the six samples ranged from 687 to 5,566 ppm, averaging over 2,000 ppm. The zinc concentration was usually the highest metal contaminant of the nine metals tested. The other metal contaminants did not show an apparent pattern in these samples. All were below 50 ppm in nickel, chromium, and titanium. The Aerolyte new media sample had a high iron concentration of 3,579 ppm, which may indicate metal contamination. The U.S. Technology new media samples had noticeably higher concentrations of lead. The Composition Material new media samples did not indicate a consistent pattern of high metals concentrations except for zinc.

6.4.2 Total Metal Concentration in Used Media

Samples from rejected undersize material or dust collector fines usually had the highest concentrations of total metals. These high concentrations tended to follow the accumulations of paint dust. This pattern was most evident from the samples taken at NAS, Barbers Point. The ground support equipment blasted at this facility typically had steel substrates coated with a primer and paint system with high levels of zinc, lead, and chromium. The result was samples of rejected material from the undersize screen that had high levels of iron, zinc, lead, and chromium. The ventilation system dust had high levels of only the zinc, lead and chromium. The iron from the equipment tended to fall to the floor of the booth and be recovered with the media rather than be removed as dust by the ventilation system.

6.5 Leachable Metal Concentrations in Collected Samples

The collected samples were subjected to EP toxicity tests to determine leachable metal concentrations. Table 7 presents the leachable metal concentrations in units of milligrams per liter (mg/l) consistent with EP Toxicity protocol. Ventilation system dust samples typically exceeded the maximum allowable concentration (MAC) limits set for levels of chromium, cadmium, and lead. This confirmed that respiratory equipment is essential in protecting the health of personnel working in PMB facilities.

TABLE 6. TOTAL METAL CONCENTRATION IN COLLECTED SAMPLES

	TOTAL METAL CONCENTRATION (ppm)								
SAMPLE LOCATION*	Cd	Cr	Ni	Pb	Zn	Ba	Al	Fe	Ti
NWS, SEAL BEACH									
New U.S. Tech. Media, A	115.00	48.90	<0.20	220.00	5566.0	78.40	219.0	46.9	10.20
New U.S. Tech. Media, B	1.38	1.62	<0.20	20.60	687.0	308.00	326.0	119.0	22.30
Media Recycling Dust	113.00	66.20	47.30	197.00	2781.0	164.00	3728.0	4361.0	42.40
Secondary Cyclone	10.30	<0.20	<0.20	2.86	2754.0	87.90	305.0	878.0	23.20
Recycled Media	9.87	<0.20	<0.20	<0.20	2685.0	138.00	344.0	1078.0	29.00
Ventilation Dust, A	8.38	96.90	<0.20	311.00	1210.0	389.00	910.0	587.0	14.50
Ventilation Dust, B	55.80	<0.20	<0.20	61.30	2346.0	138.00	1855.0	1529.0	27.30
Ventilation Dust, C	43.50	16.90	<0.20	42.90	2604.0	136.00	1556.0	1255.0	21.20
NUWES, KEYPORT									
New Comp Material Media, A	17.40	<0.20	<0.20	12.70	1308.0	225.00	305.0	510.0	17.70
New Comp Material Media, B	35.80	<0.20	<0.20	5.93	2249.0	78.30	33.8	29.9	2.88
Ventilation Dust	0.32	<0.20	<0.20	<0.20	560.0	110.00	244.0	169.0	19.60
Magnetic Separator	288.00	3498.00	703.00	503.00	403.0	<0.20	1104.0	1188.0	438.00
Recycled Media	5.34	<0.20	<0.20	239.00	2917.0	1304.00	283.0	1198.0	8.41
NAS, BARBERS POINT									
New Aerolyte Media	<0.20	<0.20	<0.20	<0.20	730.0	529.00	366.0	3579.0	7.07
New Comp Material Media	<0.20	<0.20	<0.20	<0.20	1936.0	<0.20	178.0	89.8	21.40
Ventilation Dust	659.00	2316.00	<0.20	6314.00	2764.0	673.00	1413.0	10.6	131.00
Oversize Screen Reject	146.00	508.00	6.83	1494.00	1023.0	742.00	557.0	6000.0	25.20
Undersize Screen Reject	246.00	2149.00	<0.20	8456.00	1910.0	632.00	823.0	5976.0	140.00

* Letters in this column indicate sample number; i.e. "A" means first sample; "B" means second sample; and so on.

TABLE 7. LEACHABLE METAL CONCENTRATION IN COLLECTED SAMPLES

FACILITY AND SAMPLE LOCATION*	LEACHABLE METAL CONCENTRATION (mg/l)								
	Cd	Cr	Ni	Pb	Zn	Ba	Al	Fe	Ti
MAXIMUM ALLOWABLE CONCENTRATION (mg/l)	1.00	5.00	--	5.00	--	100.00	--	--	--
NWS, SEAL BEACH									
New U.S. Technology Media,A	0.23	<0.05	<0.05	5.48	7.64	3.70	<0.05	6.81	4.31
New U.S. Technology Media,B	39.70	<0.05	<0.05	0.13	312.00	15.70	0.90	5.08	7.82
Recycled Media	<0.05	1.41	<0.05	0.25	317.00	16.00	<0.05	3.80	4.25
Media Recycling Dust	<0.05	<0.05	<0.05	3.26	61.70	22.10	<0.05	0.95	<0.05
Secondary Cyclone	45.00	1.56	<0.05	5.51	467.00	21.10	0.48	6.97	6.09
Ventilation Dust, A	109.00	7.12	2.24	13.50	467.00	153.00	113.00	1.74	16.80
Ventilation Dust, B	1.77	0.87	<0.05	0.92	120.00	25.00	<0.05	2.69	4.22
Ventilation Dust, C	7.45	<0.05	<0.05	2.76	130.00	18.30	<0.05	1.58	1.69
NUWES, KEYPORT									
New Comp Material Media, A	0.39	0.06	<0.05	<0.05	37.30	3.02	<0.05	0.63	<0.05
New Comp Material Media, B	0.07	0.09	<0.05	<0.05	48.00	12.50	<0.05	7.29	<0.05
Ventilation Dust	<0.02	0.30	<0.05	0.06	48.00	0.26	<0.05	0.32	<0.05
Recycled Media	<0.02	<0.05	<0.05	6.27	73.10	9.66	<0.05	75.30	<0.05
NAS, BARBERS POINT									
New Aerolyte Media	<0.20	3.17	<0.05	0.19	4.67	8.36	<0.05	0.48	<0.05
New Comp Material Media	0.46	0.33	<0.05	1.24	49.30	0.23	<0.05	3.33	<0.05
Ventilation Dust	322.00	135.00	11.40	1.33	1420.00	15.00	<0.05	2.38	<0.05
Oversize Screen Reject	2.39	26.40	<0.05	0.10	52.30	6.91	1.86	0.63	<0.05
Undersize Screen Reject	9.16	270.00	<0.05	<0.05	643.00	5.32	<0.05	0.95	<0.05

* Letters in this column indicate sample number; i.e. "A" means first sample; "B" means second sample; and so on.

7.0 SELECTION OF A LARGE ENCLOSURE PMB FLOOR

The three PMB booth floor recovery systems reviewed in this report each functioned well enough to continuously remove media from the blasting area and transfer it to the media recycling equipment. The systems did not plug and reusable media was not damaged during transfer.

This section analyzes the available information for equipment selection and scale-up decisions for large blasting enclosures. The information presented can be used to compare equipment design options and select the most economic floor recovery system for a large blasting enclosure, such as an aircraft hangar. The enclosure size was assumed to be an area 50 feet wide by 100 feet long.

The main consideration in the selection of a large enclosure floor recovery system is whether a full or partial recovery floor system should be used. The design parameters of maximum material removal rate and maximum transfer rate are then calculated by scaling up the existing rates determined in the functioning smaller enclosures. These design parameters are applied to the available undergrate recovery systems and transfer system options. Finally, an economic analysis is used to compare the initial and operating costs of each option.

7.1 Full or Partial Floor Selection

The first selection factor is an economic analysis to compare the installation and operation costs of both a partial floor recovery system and a full recovery floor system.

A full recovery floor system would recover material from the entire 5,000 square foot area. A partial floor recovery system, however, costs less to install than a full floor since it covers a fraction of the total floor area. The cost per square foot to install a partial floor is further reduced if the system is constructed by trenching an existing concrete floor. In this case, concrete supports most of the total floor area, therefore, less structural steel in the floor supports would be required.

The additional capital cost to install a full floor can be estimated on a square foot basis. If it is assumed that a partial floor would cover 25 percent of the area (1,250 square feet), then the full floor would require an additional 3,750 square feet of recovery equipment. Based on estimated installation costs of approximately $40 per square foot, a full floor system would add an additional capital cost of $150,000 over a partial floor system.

The operating and maintenance (O&M) costs for a full recovery floor are approximately two to four times larger (on a size basis - See Section 7.1.1) than that of a partial recovery floor due to the increase in power requirements and maintenance for the larger floor. The lower multiple (2x) will apply for a sequenced pneumatic system. Based on costs calculated in Section 7.4, the O&M costs for a full recovery floor will range from $82,000/yr (four times $20,500/yr for a reciprocating pan floor) to $64,000/yr (twice the $32,000/yr for a pneumatic floor) for an average of approximately $75,000/yr. This is an increase of approximately $50,000/yr for O&M costs for a full floor over a partial floor.

The extra labor costs of the partial floor recovery system can be estimated by assuming that two hours of labor per shift has to be devoted to sweeping material into the partial recovery floor rather than productive blasting. Annual labor costs for sweeping would total $35,000 based on labor rates at $35 per hour, 2 shifts per day, 5 days per week, 50 weeks per year.

These labor costs are completely offset by the increased cost to operate a full recovery floor. The comparative savings resulting from the installation of the partial recovery floor amount to approximately $15,000 per year ($50,000 in increased operating costs - $35,000 in labor). These estimates indicate that a partial floor recovery system is the economical choice.

7.1.1 Partial Floor Layout For a Large Enclosure

The partial floor design should minimize cleaning labor costs while maximizing sweeping efficiency. Observations of partial floor systems indicate that about 25 percent of the floor area should be dedicated to recovery grates. The other 75 percent should be solid floor. A typical manual sweeping distance is about 3 feet per stroke. Using 3 feet as the design width multiple for the solid portion of the floor then sets the layout pattern for the recovery system. Three foot wide floor sections should be separated by one foot wide grating sections. Similarly, where six foot floor sections are needed, these should be separated by two foot wide grating sections to maintain this ratio. The six foot wide floor sections are easily cleaned by sweeping from the middle of the solid strip 3 feet in either direction.

The length of the grating floor sections should be minimized in order to minimize cost. Pneumatic recovery systems should have short runs so that the air flow is more evenly distributed along the length of the collection duct. Long collection ducts require more induced draft fan horsepower to provide adequate air flow at the far ends of the ducting. Mechanical recovery systems should also have short runs. The shorter sections require reduced structural support than extended sections and are less expensive to build and install.

The 50 foot width of the proposed PMB facility floor can have 25 foot long recovery strips by running a common transfer system lengthwise 100 feet down the middle of the floor (See Figure 17). One foot or two foot wide sections running perpendicular to the common transfer system on both sides would cover the entire area, yet only be 25 feet long. The transfer system can terminate at the media recycling system located outside of the blasting enclosure at one end of the floor.

7.1.2 Recovery Floor Maximum Material Removal Design Rate

The floor recovery system must have sufficient capacity so that the material flow in the PMB system is not restricted. Inadequate capacity will cause larger accumulations of media on the floor and require additional cleaning labor. Blasting work may also be impeded by large accumulations of media on the floor. The material recovery rate should be at least great enough to remove media from localized areas of concentrated blasting where media accumulations will be significantly higher than the floor average.

The three floor recovery systems analyzed maintained adequate media removal rates. Maximum removal rates were 0.9 pounds per square foot per minute (lbs/sf/min - square footage based on entire facility floor area) for the reciprocating pan system, 0.46 lbs/sf/min for the slotted pneumatic collection pipe system and 0.45 lbs/sf/min for the pneumatic funnel system. A maximum material removal rate of about 0.5 lbs/sf/min, should be adequate to avoid localized media accumulations for large enclosures. A higher maximum recovery rate is not necessary and would only increase costs. For example, with 5,000 square feet of total floor area, a maximum removal rate of 2,500 pounds per minute (lbs/min) should suffice.

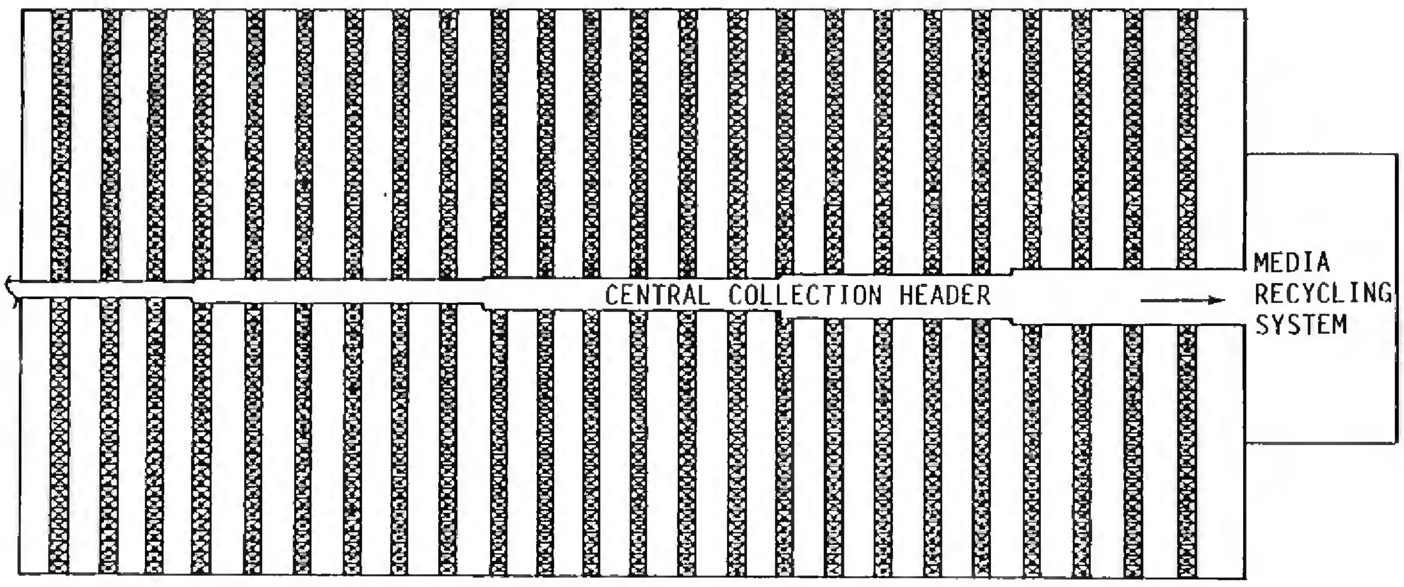


FIGURE 17. PNEUMATIC UNDERGRATE FLOOR RECOVERY SYSTEM.

7.1.3 Recovered Material Transfer to the Recycling System

The design rate for transferring the media from the recovery system to the recycling system is based on the actual rate at which media is added/blasted into the PMB facility and is therefore a function of the number of nozzles used and the rate of media discharge from the nozzles. The transfer rate should be large enough to avoid accumulating media within the transfer system. This transfer rate is not the same as the maximum media removal rate of 2500 lbs/min calculated in Section 7.1.2 because the removal rate is based on clearing localized build-ups of media not overall media transfer.

The maximum media flow rate for a typical nozzle used in PMB operations is estimated to be 20 lbs/min. The three systems reviewed in this report all had design capacity for using two nozzles at the same time, or 40 lbs/min. By calculating the ratio of the maximum media flow rate out of the nozzles (40 lbs/min) to the maximum media recovery rate, a percentage can be determined which represents the actual requirement for media transfer. This percentage was 22 percent for the reciprocating pan recovery system, 66 percent for the slotted collection pipe and 44 percent for the funnel system. The average ratio is thus 44 percent. Dividing the nozzle rate by the average ratio and doubling the result as a safety factor, a PMB facility of the same size as the booths studied would need a transfer rate of 180 lbs/min or 4.5 times the media flow rate.

As another example, a larger enclosure will have an assumed capacity of 5 nozzles that provide a maximum media flow rate of 100 lbs/min. In this case, the transfer is 4.5 times the value of 100 lbs/min or 450 lbs/min.

7.2 Undergrate Recovery System Options

The undergrate recovery system should accommodate the following operating conditions and constraints:

- The maximum overall media recovery rate should be about 0.5 lbs/sf/min per the analysis of paragraph 7.1.2, or 2500 lbs/min in a 5000 square foot enclosure,
- The recovery system should handle sudden large media loads caused during sweeping or new media loading operations,
- The recovery system should be capable of operating with long recovery section lengths, up to 25 feet,
- Recovery equipment such as mechanical drive systems or pneumatic solenoid valves should be placed below the floor level to reduce dust contamination on moving parts.

These criteria have been considered in the following evaluation of the floor recovery systems and their relative effectiveness for large enclosures. Performance data obtained from the inspections of the three existing PMB facilities and design information from paragraph 2.0 were used in the evaluation.

7.2.1 Pneumatic Undergrate Recovery System

A series of funnels over parallel pneumatic collection ducts appear to be the best design for a pneumatic system. The test data obtained at NUWES Keyport indicated that a single slotted collection duct in a trough was not as effective as the funnel system for long collection systems. The cross sectional area of the opening in a slotted collection duct allowed too much air flow at the beginning of the duct and caused insufficient air flow at the end of the collection duct. The lower air flow rates at the end of the duct did not remove media efficiently. A pneumatic floor, using rows of funnels similar to the floor at NAS Barbers Point could limit the air flow along a collection duct. The total cross sectional area of the outlet ports at the bottom of the funnels was much less than that in a slotted collection pipe, thus promoting more equal air distribution. As duct length increases, the cross sectional area of the collection duct and the volume of air flow in the duct must be increased.

The pneumatic funnel recovery system can handle large loads by virtue of the temporary storage capacity of each funnel. Media then meters into the recovery system through the funnel outlet ports. The floor at NAS Barbers Point had a media flow rate per funnel of about 67 cubic inches or 2.3 lbs/min. The floor must have about 1,100 similarly sized funnels in operation at any one time to achieve an overall floor recovery rate of 2,500 lbs/min.

For a large facility, a suggested array of 1 foot wide strips of recovery floor funnels, covering 25 percent of the total floor area, would contain about 1,200, one foot square funnels. This partial recovery system would meet the minimum media removal requirements and would not need a solenoid operated valve system to sequence the rows of funnels. Rather, all funnels would be continuously operated. Elimination of the solenoid valve operating system would increase the economic incentive for this type of partial recovery floor. Maintenance costs for the valve system would also be eliminated. Normally, a solenoid system is used to minimize the operational costs of a full floor media recovery system by decreasing air flow requirements. The capital cost of the ventilation sections of a media recovery system would also be reduced because the required throughput capacity would be reduced by 75 percent by going to a partial recovery floor.

The smaller booths used the vacuum available from the ventilation induced draft fan to provide adequate air flow in the media recovery system. A ventilation system in a large hanger would have an induced draft fan designed to have high air flow velocities with relatively low head losses. A separate draft fan for the floor recovery system would therefore be required because the recovery system needs a high draft fan to generate adequate air flow in the long collection ducts with relatively low air volume transported.

The operational costs of the pneumatic undergrate recovery system were calculated by determining the required air flow volume to reach air velocities between 25 fps and 75 fps in each recovery row, including an estimate of flow losses through the ducting. An average of 50 fps was assumed for this analysis. As described in paragraph 7.1.1, a main collection header running 100 feet down the center of the hangar floor with fifty 25 foot long perpendicular branches would minimize the total draft requirements (see Figure 17). Each branch would have a 10 inch by 4 inch collection duct with a cross sectional area of 0.28 square feet. The air flow required in one branch, to achieve a 50 fps velocity would be 50 fps x 60 sec/min x 0.28 sf or 840 cubic feet per minute (cfm). The total air flow requirement would be about 40,000 cfm for the fifty branches. The main collection header would gradually decrease in cross sectional area as it moved away from the media recycling system to maintain adequate air flow velocities. It would still need additional air flow, however, to prevent plugging. The additional air would be approximately 10,000 cfm pulled into the far end of the collection header by the vacuum created in the induced draft fan. Total air flow in the system should be about 50,000 cfm.

The required fan head to achieve this air flow rate was calculated by adding draft requirements from individual sections of the floor. These sections were the funnel row, the main header, and the cyclone. The draft measured at NAS, Barbers Point was observed to be about 5 inches of water just downstream of the cyclone. This was a good estimate of the draft conditions for air flow through the funnel row and the cyclone. The draft conditions for the main collection header could be estimated by taking the average air flow and cross section over its entire length. The air flow at the end of the header was 10,000 cfm, the air flow at the recycling equipment end was 50,000 cfm, and the average air flow was 30,000 cfm. The air velocity in the main header should be increased to 75 fps to help decrease the diameter and cost of the header. The cross sectional area necessary to sustain a 75 fps velocity in the main header was 6.7 square feet, or a three foot diameter circular duct. The estimated pressure drop for a 100 foot length of three foot diameter circular duct with 30,000 cfm flow was about 1 inch of water. Total pressure drop required was about 6 inches of water for the entire system.

The calculated fan horsepower for generating 50,000 cfm and 6 inches of draft was about 100 horsepower. The hourly operating cost for a motor this size, using an electricity cost of $0.07 per kilowatt hour, was about $5.60. This cost would be about the same if the draft was generated using the ventilation fans or a separately dedicated floor recovery fan.

7.2.2 Reciprocating Pan Undergrate Recovery System

If a reciprocating pan undergrate recovery system was used in the large enclosure, then the transport pans would be more economically installed by using 2 foot wide pans (instead of the 1 foot strips used in a pneumatic system) to reduce by half the number of pans required. The solid concrete strips between the pans would be 6 feet wide to maintain the 25 percent ratio of floor recovery sections to total floor area.

The arrangement of the reciprocating floor system is similar to the pneumatic system. The length of each pan should be minimized because the media moves slowly on a pan and there is a greater chance of a rapid media build-up during continuous operation compared to the other two systems. A series of twelve 25-foot long reciprocating pans arranged on each side of a central rotary screw conveyer running the entire 100 foot length of the enclosure is one floor recovery option (See Figure 18). Two rotary cam shafts along both sides of the enclosure could be used to operate all of the pans.

Each of the 24 pans would accommodate material from about 200 square feet of floor area or a maximum of about 100 pounds of media per minute per pan. Using the same 15 inches per minute media conveyance speed of NWS, Seal Beach equipment, the height of media in a 2 foot wide pan would be about 8 inches. This media height is within the capability of a reciprocating pan. The height could be decreased by increasing the amplitude of the reciprocating action.

The single screw conveying media down the center of the floor to the media recycling system would be sized to handle 2,500 pounds of media per minute. The motor size needed to turn the screw shaft would be about 30 horsepower to ensure adequate torque on start up with a fully loaded system, but actual power consumption would be 15 horsepower. The power requirements were conservatively estimated as twice the power necessary to lift 2,500 pounds of media per minute 100 feet up. This would allow adequate power for overcoming the frictional forces of the screw faces turning in the media.

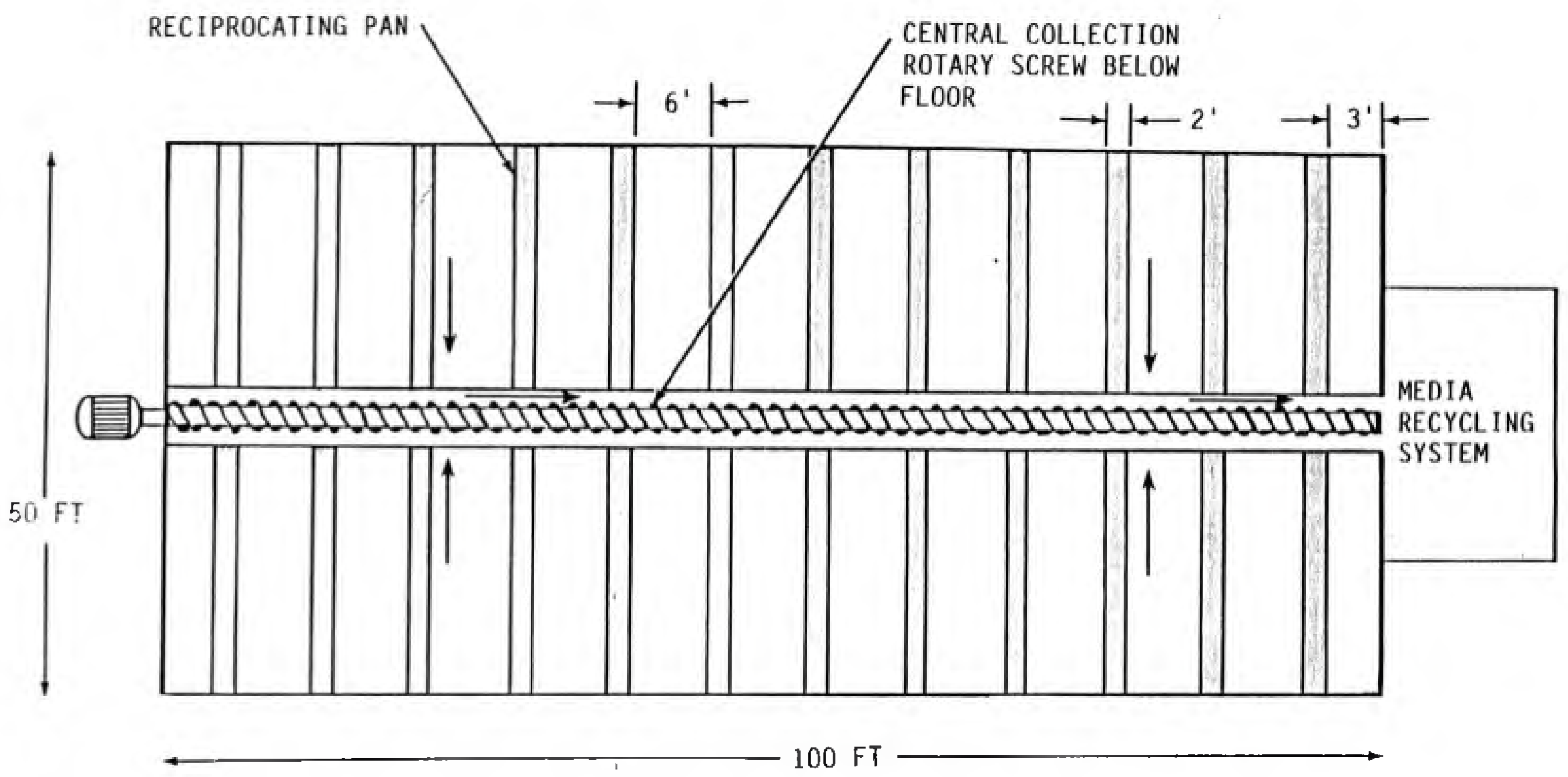


FIGURE 18. RECIPROCATING PAN FLOOR RECOVERY SYSTEM.

The power requirements for the reciprocating pans were similarly estimated. Twenty-four pans, each weighing 200 pounds and filled 8 inches high with media along each 25 foot length, would have a total weight of 54,000 pounds. This weight was lifted one inch per second. The total power required was 4,500 foot pounds per second or about 8 horsepower. The total operating horsepower required for this system was 23 horsepower. The hourly cost of operating these motors, with a $0.07 per kilowatt hour energy cost, was about $1.20 per hour.

7.2.3 Rotary Screw Undergrate Recovery System

A rotary screw undergrate recovery system would have similar features to those of the reciprocating pan floor. The center collection screw and the spacing of 2 foot wide sections with 6 foot strips of solid floor would be used. Many optional arrangements for the rotary screw were possible. The arrangement shown in Figure 19 was one option. The individual screw lengths would be only 25 feet long. Rotation of the screws could be performed either by one long power shaft and gearboxes or by an individual motor on each screw. The power shaft and gearboxes were chosen because they eliminated substantial electrical switchgear, conduit runs, and because they should be less expensive to install. A single motor would be used to drive a shaft connecting the twelve screws along one side of the booth. Gearboxes would be used to translate the power shaft rotation to each screw.

Each of the screws must handle a media flow rate of about 100 lbs/min. The power necessary to operate the screw could be conservatively estimated by calculating the power necessary to lift 100 pounds vertically 25 feet in one minute. The power required would be 42 foot pounds per second, or about one tenth of a horsepower. The total power required has been rounded to one half horsepower per rotary screw for a total of 12 horsepower. The drive motor should be about 25 horsepower to ensure that adequate starting torque power is available.

The power cost to run the rotary screw undergrate system was calculated using a cost of $0.07 per kilowatt hour. The operating cost for the total 27 horsepower was about $1.40 per hour.

7.3 Transfer System Options

The transfer system for a partial recovery floor must effectively transport gathered material to the media recycling system. The system design should consider the following operating conditions and constraints:

- The transfer system should carry material to the recycling system by a mechanism that interfaces with the first separation step,
- The material flow rates to the recycling system should be relatively unaffected by the uneven rate at which material is introduced into the system, and
- The rate of media flow from the transport system should be about 450 lbs/min.

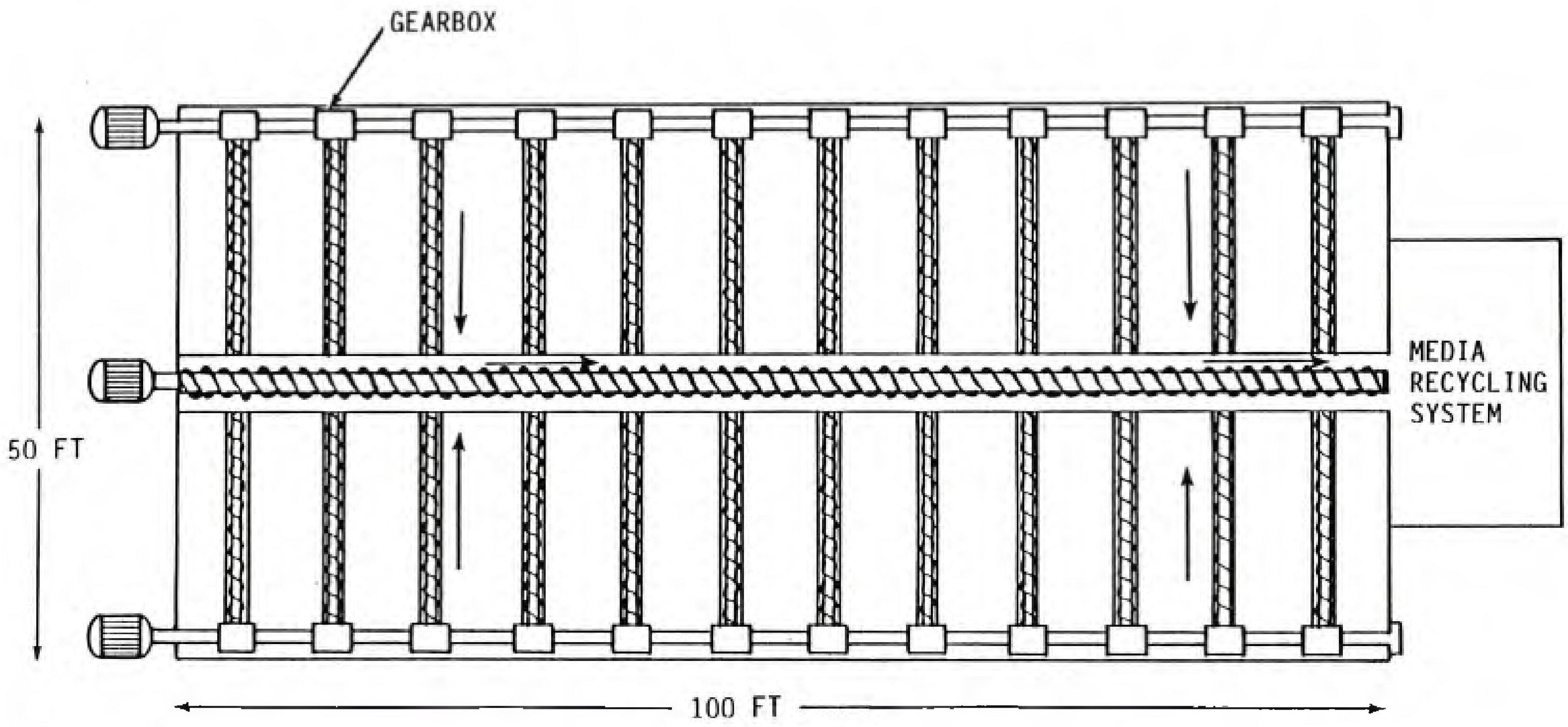


FIGURE 19. ROTARY SCREW FLOOR RECOVERY SYSTEM.

7.3.1 Pneumatic Transfer System

A pneumatic system can transfer material from the discharge point of either a central mechanical conveyer (usually a rotating screw) or a pneumatic undergrate system, to the first separation stage of the recycling system. Most media recycling systems use a cyclone separator, as the first separation step, to remove fines and dust from the reusable media. The transfer duct to the cyclone typically rises about 25 feet from the enclosure floor. The induced draft fan for the pneumatic system can either be placed downstream from the system baghouse or the ventilation system.

A completely pneumatic floor recovery and transfer system (based on funnel arrays) does not need surge capacity. The system is able to automatically manage sudden large media flow increases because the floor funnels limit the total flow to the recovery and transport system. Excess material is temporarily stored in the funnels or on the floor above the funnel.

A pneumatic transfer system that conveys material from a mechanical undergrate recovery system to the media separation equipment will require surge capacity. Large and sudden media flow increases into the recovery system will surge to and overload the inlet of the pneumatic transfer system. Surge capacity in the form of a pit or flared rotary screw trough is necessary to handle the variations in media flow rate. An example surge pit (3 feet deep, 6 feet long, and 2 feet wide) located at the end of the central rotary screw is capable of temporarily storing 2,000 pounds of media.

The required fan head and air volume for a completely pneumatic system was estimated in paragraph 7.2.1 as being 6 inches of water with a required air volume of 50,000 cfm. A pneumatic transfer system for a mechanical undergrate system requires less air volume. Assuming that an air volume equal to 200 times that of the material volume is required, the air flow should only be about 1500 cfm. A transfer velocity of about 75 fps should be used to help fluidize the media in the air stream as it is lifted vertically. The required 8 inch diameter duct will have a corresponding pressure drop of about 2 inches of water. A one horsepower motor is required to generate this air flow.

7.3.2 Mechanical Transfer System

A mechanical transfer system must lift material vertically about 25 feet to the entrance of the recycling system. The best method to accomplish this lift is with a device such as a bucket elevator like the one described in paragraph 2.4.1. The conveyer can steadily remove material from the discharge of the central rotary screw, lift it vertically, and deposit it into a conveying air stream when a cyclone separator is installed. A surge pit, similar in size to the one suggested for the pneumatic system, is required at the rotary screw discharge. The bucket elevator should lift a maximum of 450 pounds of material per minute. A one horsepower motor is required to rotate the elevator buckets, but a 2 horsepower motor should be used to provide sufficient starting torque.

7.4 Comparison of Floor Recovery System Design Options

This section discusses the requirements and equipment options for a PMB floor recovery system in a 50 foot wide by 100 foot long facility. A partial floor recovery system was determined to be more economical. Media flow requirements were determined by scaling up the performance data from the three PMB booths. The maximum floor undergrate recovery rate should be about 2500 lbs/min. The transfer and media recycling systems throughput capacity would be sized for a minimum of 450 lbs/min in a five nozzle facility. The system was assumed to operate for two shifts per day, five days per week, or a total of

5,000 hours per year.

Equipment options for the system have been reduced to three choices that are summarized and compared below:

- Pneumatic undergrate and pneumatic transfer,
- Reciprocating pan undergrate with a rotary screw central collector routing media to a pneumatic transfer, and
- Rotary screw undergrate with a rotary screw central collector routing media to a pneumatic transfer.

7.4.1 Pneumatic Undergrate and Pneumatic Transfer

The proposed pneumatic undergrate floor and transfer system was described in paragraphs 7.2.1 and 7.3.1. Air flow in the system was estimated to be about 50,000 cfm. The required horsepower of the induced draft fan was about 100 hp. Operating cost of the fan was $5.60 per hour or $28,000 per year.

The chief benefit of the system was the low amount of maintenance required. The only moving part in the system was the induced draft fan. Abrasive wear of the funnels or collection header duct work would require occasional replacement of the easily fabricated pieces. Estimated annual maintenance labor and material costs were about $4,000. Total operating and maintenance costs were estimated at $32,000 per year.

The disadvantage of this system was the cost of the larger cyclone separator that was required because of the high air flows in this combination pneumatic undergrate and transfer system. The other options have cyclone air flows that are about thirty times less costly.

7.4.2 Reciprocating Pan Undergrate and Pneumatic Transfer

The reciprocating pan undergrate system was described in paragraph 7.2.2. The pneumatic transfer system was described in paragraph 7.3.1. The installation costs for this type of system were greater than a totally pneumatic system due to the large amount of mechanical equipment.

The major benefit of the system was its low operating costs. The reciprocating pan driver was estimated to require about 8 hp to operate. The central rotary screw was estimated to require about 15 horsepower. The induced draft fan for the pneumatic transfer system with about 1500 cfm, would require a one horsepower motor. Operating costs for the 23 total horsepower was $1.20 per hour or $6,000 per year.

Maintenance costs, posing one disadvantage, were higher than those for a totally pneumatic system because of the reciprocating action of this design. Lubrication and alignment of the floor system would require an estimated six labor hours per week. The annual cost of this labor, at $35 per hour, was $10,500 per year. Replacement parts would be more expensive than those for the pneumatic system. Bearings and other mechanical parts would wear and need frequent replacement. Total estimated maintenance costs, including $4,000 per year replacement part costs, were $14,500 per year. Annual operating and maintenance costs were about $20,500.

Another disadvantage of this system was the noise generated by the pans. The constant banging of 24 individual reciprocating pans, at one second intervals, could be distracting to the operators.

7.4.3 Rotary Screw Undergrate and Pneumatic Transfer

The rotary screw undergrate system with pneumatic transfer was described in paragraphs 7.2.3 and 7.3.1. The installation costs for this type of system were greater than a completely pneumatic system due to the larger amount of machined equipment. The rotary screw system was also more expensive than the reciprocating pan system due to the greater complexity of the drive mechanism and higher mechanical costs.

The two side mounted motors to drive the screw were estimated to require about 12 horsepower each to operate. The central rotary screw was estimated to require about 15 horsepower. The induced draft fan for the pneumatic transfer system, with about 1,500 cfm, would require a one horsepower motor. Operating cost of the total 39 horsepower was $2.00 per hour, or $10,000 per year.

This system had lower operating costs than a pneumatic system and lower maintenance costs than a reciprocating pan system. The smoother mechanical action of the rotary screws should allow the system to operate with less adjustments and repairs than a reciprocating pan system. Estimated maintenance costs for weekly lubrication of the floor system and occasional bearing replacement would require an estimated four hours per week. The annual cost of this labor, at $35 per hour, was $7,000 per year. Replacement parts would be more expensive than for the pneumatic system, and were estimated at about $6,000 per year. Total operating and maintenance costs were estimated at about $23,000 per year.

The disadvantage of this system was its higher capital cost. Once installed, it should operate with only minor maintenance required.

7.4.4 Comparison of Systems

Table 8 is an economic comparison of the three recovery systems. The capital cost values represent a relative comparison of the costs for installing the same size and capacity system of each type. The actual installation costs and site specific information would be needed to complete a more accurate economic comparison between the three systems.

The pneumatic system has the economic and performance advantage over the other two systems or the no undergrate option because pneumatic systems are cheaper to install and simpler to operate, maintain, and install. Pneumatic systems do have higher O&M costs due to the energy cost of moving the air, but these costs minor compared to the installation savings and the operating efficiency. A reciprocating pan floor must have an installed cost less than $87,000 or 7.6 times the additional operating costs ($11,000) of a pneumatic system before the additional investment becomes economical.

Table 8: ECONOMIC COMPARISON OF THE RECOVERY SYSTEMS - HANGER SIZE FACILITY

UNDERGRATE SYSTEM	CAPITAL COSTS, $*	O&M COSTS, $
Pneumatic	120,000	32,000
Reciprocating Pan	170,000	20,500
Rotary Screw	200,000	23,000
No Undergrate	0	70,000[a]

* Capital Costs are site dependent. The values given represent a relative estimate for comparison purposes.

[a] Based on 1 person at $35/hr burdened rate, needed fulltime for sweeping

8.0 CONCLUSIONS

The performance of PMB recovery floors and recycling equipment was evaluated. Three existing PMB booth installations were analyzed to determine their relative operational efficiencies. The installations were located at Naval Weapons Station, Seal Beach, CA; Naval Undersea Weapons Engineering Station, Keyport, WA; and Naval Air Station (NAS) Barbers Point, HI.

The three sites were all found to have PMB booths in good working order. Personnel at the sites reported that PMB had increased the efficiency of their coating removal work and decreased the volume of hazardous waste generated at the site. Maintenance requirements were minimal, except that the original conveyer belt style floor recovery system at NUWES Keyport had been replaced with a retrofitted pneumatic floor.

Design information acquired from observing the three PMB installations was used to evaluate the design options. Although dependent on site specific information, economic analyses favored a partial recovery floor system covering 25% of the floor area and using a pneumatic undergrate and transfer system. The pneumatic recovery floors should be designed for removing 0.5 lbs/sf/min of media from the floor (based on total facility footage). Transfer and recycling systems should be designed to handle 4.5 times the maximum media blasting rate for the facility. The maximum blasting rate can be estimated at 20 lbs/min/nozzle. A 5 nozzle facility using 100 lbs/min of media would require a transfer rate of 450 lbs/min.

Size classifications of recycled and rejected media samples showed significant concentrations of reusable media in the rejected material. At a loss of over $2.00/lb for replacement media and waste disposal, it is beneficial to reduce these losses. In older facilities, most of the reusable media could be recovered by adding it slowly into the floor recovery system. New facilities should use properly sized recycling equipment to improve recovery of reusable media (more efficient cyclones, ventilation baffles, large over-size and undersize vibrating screens, and large magnetic separators).

Freon float tests were performed on the collected samples to determine the concentration of hard particle contaminants. The recycled media had concentrations averaging about 0.4 percent. Significant contamination of new media samples was also observed. These hard particle concentrations exceeded the Air Force standard of 0.02 percent. The media can still be used to strip paint from durable surfaces. Higher quality new media and better recycling equipment would improve these results.

Samples of recycled and rejected media were analyzed for total and leachable metals. The metal content of the samples tended to concentrate in the undersize reject material and the ventilation system dust collector. This was where the old coating materials blasted off the substrate would tend to accumulate. Concentrations of chromium, lead, and other toxic metals were high enough to further justify breathing air protection for operating personnel. The waste material from a PMB booth should continue to be considered as hazardous waste unless proven otherwise by the EP Toxicity test.

APPENDIX A

BTC ENVIRONMENTAL, INC.
LABORATORY REPORT

BTC ENVIRONMENTAL, INC.
2978 Seaborg Avenue
Ventura, CA 93003
(805) 644-1095

LABORATORY REPORT

Prepared for: **Engineering Management Concepts**
1305 Del Norte Road, Suite 220
Camarillo, CA 93003

Date: May 1, 1989

Laboratory Number: 890396
Date Recieved: March 9, 1989
Sample I.D: Plastic Media

Job Number: 89-1100
Sampled By: Client
Date Sampled: NA

RESULTS

Attn: Becky Radonvich

Dense Particle Concentration

Sample ID	Freon Extract (%)
A1	insufficient sample
A2	1.35
A3	6.18
A4	1.30
A5	0.010
B1	0.016
B2	0.003
B3	0.004
B4	0.390
B5	0.513
B7	0.241
C1	0.121
C2	insufficient sample
C3	2.64
C4	0.666
C5	0.325
C6	0.532
C7	0.374
C8	0.285
C9	3.08
C10	2.46
C11	0.453
C12	0.293

Analyst: AMC

Sieve Size Analysis

		% BY WEIGHT				
SAMPLE	Grams OF SAMPLE	≥12	12-60	60-100	100-200	≤200
A1	50	0	7.8	17.04	17.38	57.78
A2	100	2.24	97.28	0.28	0.14	0.06
A3	100	0	0	23.93	69.60	6.47
A4	100	0	99.00	1.00	0	0
A5	100	0	99.93	0.02	0.01	0
B1	100	0	99.99	0.01	0	0
B2	100	0	100.00	0	0	0
B3	100	0	100	0	0	0
B4	100	0	72.13	16.89	7.09	3.89
B5	100	0	85.94	6.57	6.23	1.26
B7	100	0.02	95.95	3.10	0.85	0.08
C1	100	0	99.98	0.02	0	0
C2	12.37	0	13.99	0.65	0.32	85.04
C3	100	0	30.04	24.00	24.73	21.23
C4	100	0	90.74	7.18	1.47	0.61
C5	100	0	94.18	4.80	0.72	0.30
C6	100	0	94.58	4.82	0.46	0.14
C7	100	0	91.95	7.16	0.70	0.19
C8	100	0	99.48	0.26	0.18	0.08
C9	100	0	34.11	24.89	21.50	19.50
C10	100	0	25.14	29.47	24.20	21.19
C11	100	0	86.25	11.04	2.16	0.55
C12	100	0	91.03	6.81	1.54	0.62

SAMPLE ID: A-1

RESULTS

	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	659	0.20	322	0.02
Chromium	2316	0.20	135	0.05
Nickel	BQL	0.20	11.4	0.05
Lead	6314	0.20	1.33	0.05
Zinc	2764	0.20	1420	0.05
Barium	673	0.20	15.0	0.05
Aluminum	1413	0.20	BQL	0.05
Iron	10.6	0.20	2.38	0.05
Titanium	131	0.50	BQL	0.05

SAMPLE ID: A-2

RESULTS

	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	146	0.20	2.39	0.02
Chromium	508	0.20	26.4	0.05
Nickel	6.83	0.20	BQL	0.05
Lead	1494	0.20	0.095	0.05
Zinc	1023	0.20	52.3	0.05
Barium	742	0.20	6.91	0.05
Aluminum	557	0.20	1.86	0.05
Iron	6000	0.20	0.63	0.05
Titanium	25.2	0.50	BQL	0.05

SAMPLE ID: A-3

RESULTS

METAL	(MG/KG) TOTAL	MQL	(MG/L) LEACHABLE	MQL
Cadmium	246	0.20	9.16	0.02
Chromium	2149	0.20	270	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	8456	0.20	BQL	0.05
Zinc	1910	0.20	643	0.05
Barium	632	0.20	5.32	0.05
Aluminum	823	0.20	BQL	0.05
Iron	5976	0.20	0.95	0.05
Titanium	140	0.50	BQL	0.05

SAMPLE ID: A-4

RESULTS

METAL	(MG/KG) TOTAL	MQL	(MG/L) LEACHABLE	MQL
Cadmium	BQL	0.20	BQL	0.02
Chromium	BQL	0.20	3.17	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	BQL	0.20	0.19	0.05
Zinc	730	0.20	4.67	0.05
Barium	529	0.20	8.36	0.05
Aluminum	366	0.20	BQL	0.05
Iron	3579	0.20	0.48	0.05
Titanium	7.07	0.50	BQL	0.05

SAMPLE: A-5

RESULTS

	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	BQL	0.20	0.459	0.02
Chromium	BQL	0.20	0.329	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	BQL	0.20	1.24	0.05
Zinc	1936	0.20	49.3	0.05
Barium	BQL	0.20	0.227	0.05
Aluminum	178	0.20	BQL	0.05
Iron	89.8	0.20	3.33	0.05
Titanium	21.4	0.50	BQL	0.05

SAMPLE ID: B-1

RESULTS

	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	17.4	0.20	0.394	0.02
Chromium	BQL	0.20	0.059	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	12.7	0.20	BQL	0.05
Zinc	1308	0.20	37.3	0.05
Barium	225	0.20	3.02	0.05
Aluminum	305	0.20	BQL	0.05
Iron	510	0.20	0.63	0.05
Titanium	17.7	0.50	BQL	0.05

SAMPLE ID: B-3

	RESULTS			
	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	35.8	0.20	0.066	0.02
Chromium	BQL	0.20	0.090	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	5.93	0.20	BQL	0.05
Zinc	2249	0.20	48.0	0.05
Barium	78.3	0.20	12.5	0.05
Aluminum	33.8	0.20	BQL	0.05
Iron	29.9	0.20	7.29	0.05
Titanium	2.88	0.50	BQL	0.05

SAMPLE ID: B-4

	RESULTS			
	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	0.320	0.20	BQL	0.02
Chromium	BQL	0.20	0.300	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	BQL	0.20	0.063	0.05
Zinc	560	0.20	48.0	0.05
Barium	110	0.20	0.259	0.05
Aluminum	244	0.20	BQL	0.05
Iron	169	0.20	0.32	0.05
Titanium	19.6	0.50	BQL	0.05

SAMPLE ID: B-6

	RESULTS (MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	288	0.20	*	0.02
Chromium	3498	0.20		0.05
Nickel	703	0.20		0.05
Lead	503	0.20		0.05
Zinc	403	0.20		0.05
Barium	BQL	0.20		0.05
Aluminum	1104	0.20		0.05
Iron	1188	0.20		0.05
Titanium	438	0.50		0.05

SAMPLE ID: B-7

	RESULTS (MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	5.34	0.20	BQL	0.02
Chromium	BQL	0.20	BQL	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	239	0.20	6.27	0.05
Zinc	2917	0.20	73.1	0.05
Barium	1304	0.20	9.66	0.05
Aluminum	283	0.20	BQL	0.05
Iron	1198	0.20	75.3	0.05
Titanium	8.41	0.50	BQL	0.05

* INSUFFICIENT SAMPLE

SAMPLE ID: C-1

	RESULTS (MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	115	0.20	0.230	0.02
Chromium	48.9	0.20	BQL	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	220	0.20	5.48	0.05
Zinc	5566	0.20	7.64	0.05
Barium	78.4	0.20	3.70	0.05
Aluminum	219	0.20	BQL	0.05
Iron	46.9	0.20	6.81	0.05
Titanium	10.2	0.50	4.31	0.05

SAMPLE ID: C-2

	RESULTS (MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	113	0.20	109	0.02
Chromium	66.2	0.20	7.12	0.05
Nickel	47.3	0.20	2.24	0.05
Lead	197	0.20	13.5	0.05
Zinc	2781	0.20	467	0.05
Barium	164	0.20	153	0.05
Aluminum	3728	0.20	113	0.05
Iron	4361	0.20	1.74	0.05
Titanium	42.4	0.50	16.8	0.05

SAMPLE ID: C-3

RESULTS

	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	43.5	0.20	45.0	0.02
Chromium	16.9	0.20	1.56	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	42.9	0.20	5.51	0.05
Zinc	2604	0.20	467	0.05
Barium	136	0.20	21.1	0.05
Aluminum	1556	0.20	0.48	0.05
Iron	1255	0.20	6.97	0.05
Titanium	21.2	0.50	6.09	0.05

SAMPLE ID: C-4

RESULTS

	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	10.3	0.20	1.77	0.02
Chromium	BQL	0.20	0.867	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	2.86	0.20	0.920	0.05
Zinc	2754	0.20	120	0.05
Barium	87.9	0.20	25.0	0.05
Aluminum	305	0.20	BQL	0.05
Iron	878	0.20	2.69	0.05
Titanium	23.2	0.50	4.22	0.05

SAMPLE ID: C-6

RESULTS

	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	9.87	0.20	7.45	0.02
Chromium	BQL	0.20	BQL	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	BQL	0.20	2.76	0.05
Zinc	2685	0.20	130	0.05
Barium	138	0.20	18.3	0.05
Aluminum	344	0.20	BQL	0.05
Iron	1078	0.20	1.58	0.05
Titanium	29.0	0.50	1.69	0.05

SAMPLE ID: C-8

RESULTS

	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	1.38	0.20	BQL	0.02
Chromium	1.62	0.20	BQL	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	20.6	0.20	3.26	0.05
Zinc	687	0.20	61.7	0.05
Barium	308	0.20	22.1	0.05
Aluminum	326	0.20	BQL	0.05
Iron	119	0.20	0.95	0.05
Titanium	22.3	0.50	BQL	0.05

SAMPLE ID: C-9

	RESULTS			
	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	8.38	0.20	BQL	0.02
Chromium	96.9	0.20	1.41	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	311	0.20	0.253	0.05
Zinc	1210	0.20	317	0.05
Barium	389	0.20	16.0	0.05
Aluminum	910	0.20	BQL	0.05
Iron	587	0.20	3.80	0.05
Titanium	14.5	0.50	4.25	0.05

SAMPLE ID: C-10

	RESULTS			
	(MG/KG)		(MG/L)	
METAL	TOTAL	MQL	LEACHABLE	MQL
Cadmium	55.8	0.20	39.7	0.02
Chromium	BQL	0.20	BQL	0.05
Nickel	BQL	0.20	BQL	0.05
Lead	61.3	0.20	0.127	0.05
Zinc	2346	0.20	312	0.05
Barium	138	0.20	15.7	0.05
Aluminum	1855	0.20	0.896	0.05
Iron	1529	0.20	5.08	0.05
Titanium	27.3	0.50	7.82	0.05

TOTAL METALS BY SW 846-6010
LEACHABLE METALS BY SW 846-6010 APPENDIX II EP TOXICITY TEST PROCEDURE (66702)