CR 87.006
December 1986

NCEL
Contract Report

An Investigation Conducted By Engineering Management Concepts

Sponsored By Naval Facilities Engineering Command

AD-A176 905

PLASTIC MEDIA BLASTING DATA GATHERING STUDY: FINAL REPORT

ABSTRACT Plastic Media Blasting (PMB) is proving to be a cost effective method of paint removal with many benefits. Economic savings may reach 50 percent of chemical stripping costs, while hazardous waste volumes can be reduced by up to 90 percent.

This task gathered data in five areas: chemical stripping, equipment and facilities, economics, safety and health, and surface effects. The Chemical Stripping section details cost breakdowns for chemical stripping. The Equipment and Facilities section describes existing facilities; needed blasting and media recovery equipment; different types of media; and media disposal. The Economics section gives two examples of economic analyses conducted for the blast booth at Hill Air Force Base. The Safety section discusses the safety and health risks associated with PMB such as explosion, dust irritation and toxicity, and identifies the appropriate OHSA and ANSI safety standards. The Surface Effects section identifies possible damage and crack closure effects, and also identifies materials that have been safely blasted.

NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043

Approved for public release; distribution is unlimited

METRIC CONVERSION FACTORS

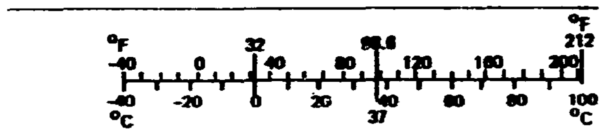
Approximate Conversions to Metric Measures

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

*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



REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CR 87.006	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Plastic Media Blasting Data Gathering Study: Final Report		5. TYPE OF REPORT & PERIOD COVERED Final Jul 1986 - Oct 1986
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s) N00123-85-D-0191
9. PERFORMING ORGANIZATION NAME AND ADDRESS Engineering Management Concepts 1305 DelNorte Rd, Ste 230 Camarillo, CA 93010		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 71-026
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Civil Engineering Laboratory Port Hueneme, CA 93043-5003		12. REPORT DATE December 1986
		13. NUMBER OF PAGES 76
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Facilities Engineering Command 200 Stovall Street Alexandria, VA 22332-2300		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

plastic media blasting, PMB, health, materials, safety, equipment, facilities, chemical stripping

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Plastic Media Blasting (PMB) is proving to be a cost effective method of paint removal with many benefits. Economic savings may reach 50 percent of chemical stripping costs, while hazardous waste volumes can be reduced by up to 90 percent.

This task gathered data in five areas: chemical stripping, equipment and facilities, economics, safety and health,

and surface effects. The Chemical Stripping section details cost breakdowns for chemical stripping. The Equipment and Facilities section describes existing facilities; needed blasting and media recovery equipment; different types of media; and media disposal. The Economics section gives two examples of economic analyses conducted for the blast booth at Hill Air Force Base. The Safety section discusses the safety and health risks associated with PMB such as explosion, dust irritation and toxicity, and identifies the appropriate OHSA and ANSI safety standards. The Surface Effects section identifies possible damage and crack closure effects, and also identifies materials that have been safely blasted.

TABLE OF CONTENTS

TABLE OF CONTENTS, CONTINUED

TABLE OF CONTENTS, CONTINUED

LIST OF FIGURES AND TABLES

LIST OF APPENDICES

ENCLOSURES

EXECUTIVE SUMMARY

Plastic Media Blasting (PMB) is proving to be a cost effective method of paint removal with many benefits. Economic savings may reach 50 percent of chemical stripping costs, while hazardous waste volumes can be reduced by up to 90 percent. A great deal of knowledge about PMB has been generated, but most of this information is in the private sector and considered to be proprietary. This task was organized to gather as much data as possible on PMB, so that Government research programs and operations can be organized more effectively.

This task gathered data in five areas: chemical stripping, equipment and facilities, economics, safety and health, and surface effects. The chemical stripping section details cost breakdowns for chemical stripping. The equipment and facilities section describes existing facilities; needed blasting and media recovery equipment; different types of media; and media disposal. The economics section gives two examples of economic analyses conducted for the blast booth at Hill Air Force Base. Savings ranged from $5 to $14 million/year. PMB is not as hazardous as chemical stripping, but does present some problems to personnel. The safety section discusses the safety and health risks associated with PMB such as explosion, dust irritation and toxicity, and identifies the appropriate OHSA and ANSI safety standards. PMB can be used on most metals, but few composites. The Surface Effects section identifies possible damage and crack closure effects, and also identifies materials that have been safely blasted.

Areas that need further research include new media effectiveness, safety and health protection, and long-term effects on surfaces. Also, media and equipment specifications still need to be prepared.

1.0 INTRODUCTION

The Naval Civil Engineering Laboratory (NCEL) has been tasked to provide an assessment of a new technology for paint removal from aircraft and other items with delicate substrates. This technology, called Plastic Media Blasting (PMB), is a candidate to replace wet chemical stripping of painted airframes and component parts throughout the Department of the Navy. A number of reports and studies have been completed on PMB, but the information is not widely available. To maintain a well-rounded knowledge of PMB technology, the NCEL tasked Engineering Management Concepts (EMC) under Contract N00123-85-D-0191, Delivery Order J3-22, to gather data on PMB.

1.1 Objective

The objective of this study is to research and assemble all available data pertaining to PMB, and to summarize the data in a single report. This report expands on the summary report completed by the Naval Air Rework Facility (NARF) Alameda which is included as Enclosure 1.

1.2 Background

Plastic media blasting is a paint removal technique in which small, granular amino thermoset or unsaturated polyester resins (plastic beads) are forced at high velocity through a nozzle at a painted surface. The plastic beads have rough edges which serve as an abrasive to shatter and dislodge surface coatings of paint and grit. This process is similar to conventional sandblasting. However, the plastic media is much less aggressive than sand and other abrasives and therefore will not damage delicate substrates.

Plastic as a media eliminates storage and handling perishablity problems that now are associated with organic abrasives such as rice hulls or walnut shells. Through careful control of the size of the beads and blasting parameters, the plastic media, unlike many of the more conventional abrasives, may be separated from the loosened paint particles and dust, and be recycled again and again. The generation of caustic solvents and paint sludge associated with chemical stripping is almost completely eliminated. In addition, the greater process control achieved in PMB as compared to chemical stripping results in reduced damage to underlying surfaces.

PMB enjoys limited use by the Navy, Army and Air Force, and is used by commercial air carriers such as United Airlines and Republic Airlines. Concerns remain regarding the long term effects of PMB on metallic and composite substrates, as well as safety and health-related issues.

2.0 TECHNICAL APPROACH

2.1 Data Search

An in-depth data search was initiated using contacts provided by the NCEL. This list of initial contacts is provided in Enclosure 2. The data search process used phone calls, letters, and site visits to gather information, and is documented by Appendix A. The search was expanded to include technical research firms such as the Department of Commerce National Technical Information Service (NTIS) and the North Carolina Science and Technical Center. An extensive computer data base search of over 630 data bases also was performed. However, the technical research firms and computer searches yielded little useful information, attesting to the newness of the PMB technology. However, through contacts in the Government and industry, 91 reports, brochures, catalogs, letters, and other pieces of data were collected. This data is identified in the bibliography, and copies of the documents identified are provided to the NCEL in a box file that accompanies this report. These documents were organized and the useful information abstracted for inclusion in this summary report.

2.2 Data Categories

Eleven broad information categories established by the NCEL were the focus of the data gathering efforts. Information collected in these eleven categories were then arranged into five groups according to a logical assessment of interrelated characteristics. The five groups are as follows:

- Chemical Stripping
- Facility and Equipment
- Economics
- Safety and Health
- Surface Effects

These groups have been expanded to include specific areas of interest to the NCEL. Information gathered has been organized, summarized and placed in the appropriate data grouping. Sections 3 through 7 of this report contain the actual technical summary of all information located through the data search process. Information has been abstracted from the various reports, logically grouped, and presented in a catalog-like format. Every attempt has been made to abstract precise information from the source documentation. However, analysis of this data for technical accuracy is beyond the scope of this report.

3.0 CHEMICAL STRIPPING

Approximately 10 documents present useful information regarding chemical stripping. The basic statistics on chemical paint stripping are provided in the following subcategories:

- Stripper Cost
- Manpower Used
- Disposal Cost
- Wastewater Generation and Treatment Costs

Statistics presented herein represent operations at Hill Air Force Base (AFB), where operations were specially designed to gather PMB data under controlled conditions. It is estimated that 205 aircraft per year are processed at this facility.

3.1 Stripper Cost

An average of 468 gallons of non-phenol paint stripper is used per F-4 aircraft at a cost of $11.40 per gallon[11]. There also are indirect costs related to chemical stripping. These are in electric power and heat/steam to maintain the temperatures required for effective stripping operations.

3.2 Manpower Used

Chemical paint stripping of an F-4 aircraft requires an average of 364 man-hours as compared to an average of 183 man-hours for plastic media blasting. Processing time is 5.4 flow days for chemical stripping, as compared to 3.2 flow days for PMB[38].

3.3 Disposal Costs

Chemically derived waste averages 105 tons per year, as compared to an average of 154 tons of dust and dry waste for PMB. Disposal at a waste dump is priced at the rate of $200 per ton for chemically derived wastes, as compared to $260 per ton for PMB derived waste[38]. The Safety Department at NARF Pensacola stated that dry waste disposal costs $0.35 per pound ($700 per ton).

3.4 Wastewater Generation/Treatment Costs

At least 20,000 to 30,000 gallons of rinse water are required to remove stripper and paint residue after each stripper application on an F-4 aircraft and major components[38]. Several stripper applications normally are required and generate an average total volume of 210,000 gallons of wastewater per day. Based on processing 205 F-4 aircraft per year, the total wastewater and treatment costs amount to $480,000 per year[38].

4.0 EQUIPMENT AND FACILITIES

Information pertaining to the actual PMB process, equipment and facilities constitute the bulk of the documents gathered in this study. Approximately 30 documents contain useful information. These documents are in the form of letters, technical reports and evaluations, and equipment manufacturer's literature.

The data was extracted, assembled, and organized into groupings. The data is presented here in the following major subcategories:

- Facilities and blast equipment
- Plastic media
- Media recycling

4.1 Facilities and Blast Equipment

Facilities for PMB are from designs derived from conventional abrasive blasting concepts. Two distinctly different types of facilities presently are in operation. These are as follows:

- Blast rooms and booths
- Blast cabinets

Blast rooms and booths typically are larger facilities designed to accommodate whole airframes or large component parts. They usually provide some type of media recovery system and a ventilation system designed to keep the air flowing in the room for dust removal.

The PMB operator performs blasting operations within the room. Operator safety equipment normally is used with a blast booth or room, and should consist of a Class A OSHA/NIOSH approved protective helmet with a wide span viewing lens, a helmet air filter, and a carbon monoxide monitor/alarm on the breathing air supply. A climate control tube allowing the operator the choice of air conditioned or heated air is highly recommended to reduce fatigue. A leather-faced, cotton-backed blast suit and leather gloves will complete the blast operator safety package. The blast room designed and built at Hill AFB by Royce Systems is shown in Figure 1. An example of a smaller blast booth manufactured by Zero Manufacturing Company is provided as Figure 2.

Blast cabinets are the smallest type of PMB facility and are used to remove paint from small parts and components. These cabinets, commonly referred to as "glove boxes", normally are of the pressure-blast type, and are ideal for surface preparation of aircraft sub-components. It is important to differentiate between suction blast designs and pressure blast cabinets. Suction blast equipment only achieves 20% of the cleaning rate of a pressure blast cabinet, and is less suitable for PMB applications[18]. The latter are high production units which incorporate a small blast machine outside of the glove box, and a completely enclosed blasting area.

All blasting is performed in the enclosed cabinet and there is no dust or media penetration outside the enclosure. The operator remains outside of the cabinet, and special operator safety equipment is not required. A blast cabinet provided by Aerolyte Systems is illustrated in Figure 3.

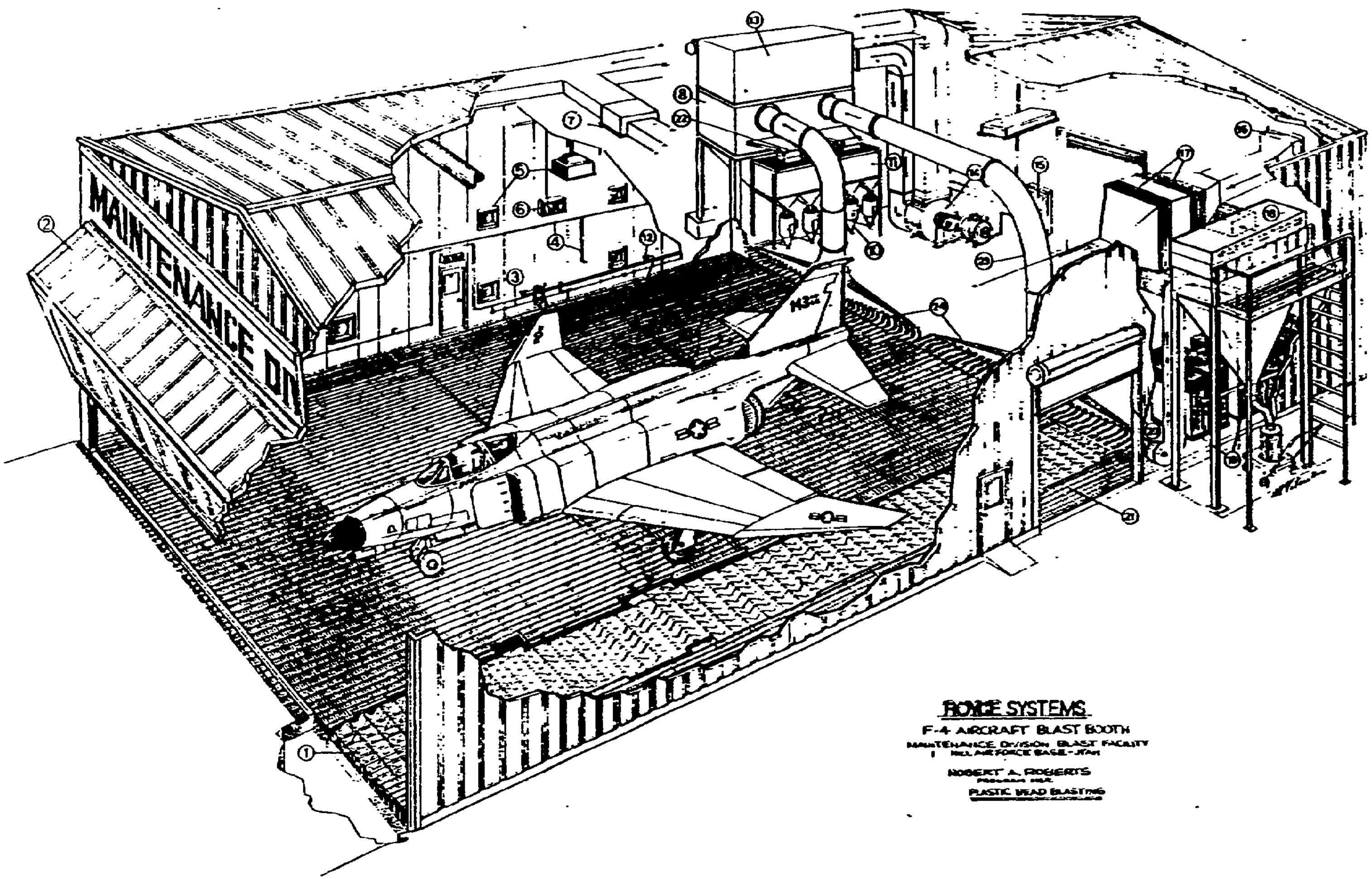
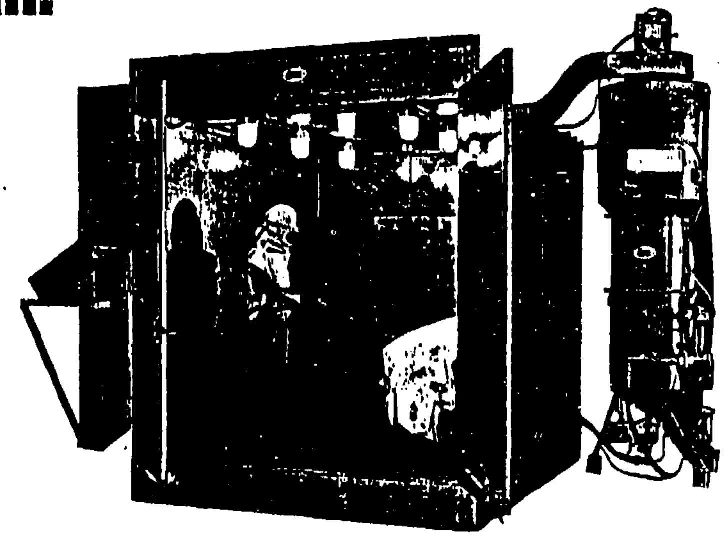


Figure 1. Building 223 at Hill AFB - Plastic Media Blasting Facility.

Zero has it all.



- Proven engineering.
- Modular design.
- "M" section floors.
- Dust-tight incandescent lighting.
- Fast, easy erection.
- Any size. No excavation.
- Efficient reclaim system.
- Economical operation.
- Downdraft or crossdraft air movement.
- Clean environment.
- Good visibility. Less fatigue.
- Reversed air flow bag cleaner.
- Personnel doors (when required).
- A.S.M.E. Code, 125 p.s.i. pressure generator.
- Work car with track (optional).
- Monorail with manual hoist (optional).
- All units can be designed to meet requirements of Occupational Health and Safety Act, state safety codes and special customer needs.
- For any abrasive: Glass beads, steel grit, steel shot, aluminum oxide, silicon carbide, garnet, emery.

Installations featured in this brochure.

1. General Electric Company
   3306 Main Avenue
   Erie, PA 16531
   12' X 14' X 10' Blast Room
   50' Downdraft
   8400 CFM reclaim
2. Mixing Equipment Company
   135 Mount Read Boulevard
   Rochester, NY 14611
   12' X 30' X 12' Blast Room
   50' Crossdraft
   7200 CFM dust collector
   2500 CFM reclaim
   Work car and track
3. Van Air Systems
   350 Mechanic Street
   Lake City, PA 16423
   16' X 20' X 20' Blast Room
   80' Crossdraft
   16,000 CFM dust collector
   3600 CFM reclaim
   6000 lb. monorail
4. General Electric Company
   Apparatus Service Division
   1040 E. Erie Avenue
   Philadelphia, PA 19124
   16' X 36' X 19' Blast Room
   50' Downdraft
   1200 CFM reclaim
   28,800 CFM dust collector
5. Raymond Corporation
   Greene, NY 13778
   12' X 24' X 12' Blast Room
   50' Crossdraft
   3600 CFM reclaim
   7200 CFM dust collector

Figure 2. Blast Booth Manufactured by Zero Mfg. Co.

AEROLYTE Systems

practical systems designed especially for paint stripping with plastic media

AEROLYTE Media
All cabinets are designed especially for use with reusable plastic media. Aerolyte Media is manufactured to the highest quality standards.

AEROLYTE Model PCN 4050 A
The largest of the Aerolyte Cabinets will easily handle components up to 48" long. Comes standard with a 900 CFM reclaimer

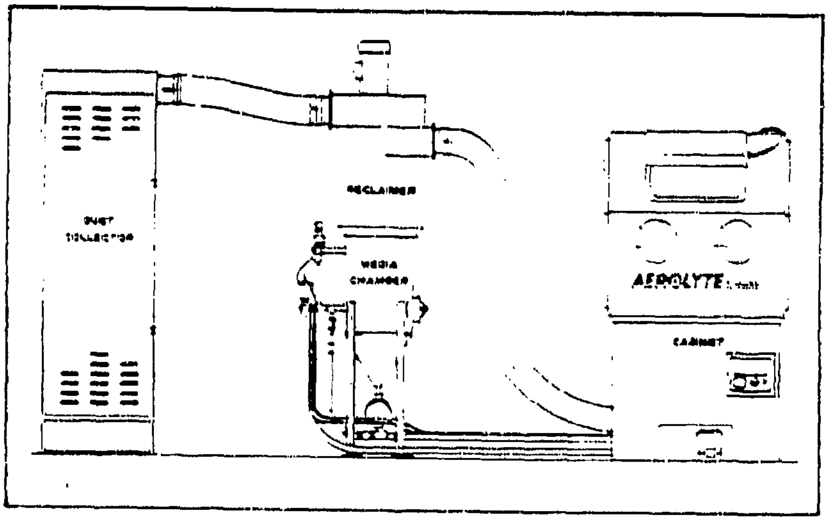
AEROLYTE CABINET SYSTEMS

Eliminate Chemical Stripping

Dry paint-stripping is a precisely controlled process for removing paint from delicate surfaces. With this system the need for laborious sanding operations or the use of chemicals is a thing of the past. The Aerolyte System of paint stripping uses metered propulsion of plastic particles which are directed at low pressures toward the painted substrate. The velocity and angular shape of the Aerolyte Plastic Media results in breakdown and removal of the paint to effect a cleaned surface. Because the process is operator controlled and sight-oriented, selective layer-by-layer paint removal is possible.

Aerolyte cabinet systems allow for complete surface preparation of subcomponent parts. Each cabinet system incorporates a complete paint-stripping mechanism as well as a media reclaim and dust-collection system designed specifically for use with plastic media. Aerolyte cabinets permit the same precise control over surface preparation activities that is the hallmark of Aerolyte's larger systems.

Many quality and high performance features are offered as standard items on the Aerolyte cabinets.



MEDIA CHAMBER
- Pinch valve media control
- 45° media flow
- Remote controls
- 60° conical bottom
- Pressure relief valve

CABINET
- High volume foot valve
- Large armholes
- Rubber curtains
- Moisture separator
- Pressure gauge
- Pressure regulator
- Doors on both sides

DUST COLLECTOR
- Tubular cloth filters
- Steel enclosure
- Dust drawer
- Air volume damper

MEDIA RECLAIMER
- Adjustable air inlet
- Debris screen
- Efficient dust separation

Figure 3. Blast Cabinet Manufactured by Aerolyte Systems.

Regardless of the size of the facility, a PMB operation must contain certain components in order to be functional. All facilities must have:

1) a source of dry, compressed air,
2) blast machines,
3) abrasive recovery systems and
4) dust handling equipment.

The following paragraphs address the compressed air and blast machine requirements in detail. Abrasive recovery systems, dust handling systems, and specific equipment data are detailed in Sections 4.3.1, 4.3.2 and 4.3.3.

4.1.1 Air Compressor. Clean, dry compressed air is essential for any stripping operation. Even in non-humid climates, the natural cooling of compressed air from the compressor will result in condensation in the system. If moisture adversely affects system performance by causing media agglomeration, it is recommended that an aftercooler be used in conjunction with coalescing filters. Under extreme conditions of heat, humidity and a poorly maintained compressor, the addition of an air dryer may be necessary.

4.1.2 Blast Machines. Blast machines are the key component in the PMB paint stripping process. There are two types of blast apparatus designs[91]:

1) Direct Pressure Design: The plastic media is stored in a specially designed pressure vessel (described in detail below) which is pressurized during the blasting cycle. The plastic media feeds into the blast hose where it is conveyed to the blast nozzle at a high velocity. This design provides the most powerful and elaborate system.

2) Venturi or Suction Design: This design employs a nozzle-orifice combination in which compressed air is allowed to expand through a nozzle creating a venturi effect inside the nozzle. The plastic media is pulled in front of the orifice, and then forced through the nozzle and against the work piece

A typical direct pressure apparatus consists of an American Society of Mechanical Engineers (ASME) coded pressure vessel available in a variety of sizes. The most common size is six cubic feet, and the bottom has a 60 degree conical shape. This configuration is critical to ensure the correct angle necessary for uninterrupted abrasive flow. A pressure regulator with gauge is required to allow the operator precise control over the blast pressure, which normally is maintained at approximately 40 pounds per square inch gauge (psig). Media is conveyed pneumatically from the pressure vessel through a hose to a nozzle, where it is ejected at high velocity toward the working surface.

Some desirable blast machine features include:

- Unrestricted formed piping to guarantee air flow without pressure loss caused by elbows and sharp bends.
- Self cleaning exhaust muffler to reduce bleed off noise to an acceptable level.
- Electrically operated remote controls incorporating an abrasive cutoff switch. This configuration provides the dead man on/off control required by the Occupational Safety and Health Administration (OSHA). It also allows the blast operator the option of turning off the abrasive supply while maintaining the compressed air supply for blow-down and cleanup purposes. Electrically operated controls save weight over pneumatically operated controls.
- Moisture separator to remove moisture condensation, due to the hydro-agglomerating nature of plastic abrasives.
- Lightweight flexible blast hose, nylon couplings and a urethane jacketed silicon carbide nozzle to allow for the required degree of operator precision and control.

4.1.3 Operation and Maintenance. In general, PMB requires a very short period of training for proficiency. The distance between the work piece and nozzle, and the blasting pressure can be varied to produce different removal rates. The distance from the nozzle to the blasted surface usually is maintained at 6 to 8 inches, and the nozzle pressure is usually between 30 and 40 psig[3].

Factors affecting blasting performance can be divided into two major categories: (a) those related to the work-piece, (b) those requiring control in the blasting process[18].

The major variables associated with the work-piece are:

- Material composition (including substrate and bonded surface characteristics)
- Material thickness
- Coatings to be removed (types, layers, age)
- Desired results (degree of stripping, stripping surface requirement, etc.)

The major variables in process control are:

- Air pressure
- Nozzle diameter
- Nozzle-to-workpiece distance and angle, and dwell time
- Metering of air and media
- Recovery system efficiency
- Equipment design safeguards
- Physical properties of the plastic media, including size, hardness, angularity, static conductivity
- Consistency of the plastic media, including composition, size, dust content

The ability to control the process variables in an optimal way is the key to successful PMB operation.

Modifying an existing facility is a cost-effective method of achieving a complete paint stripping operation[18]. The basic components are:

- An existing weatherproof hangar or similar enclosure which can be converted into a blast room by the addition of a dust-tight door, screened air inlets, an exhaust outlet, and dust-tight fluorescent light modules. These modifications allow for ventilation of the enclosure for blast control purposes. The enclosures should be sized to allow a minimum of 4 feet around the largest work-piece, but should not be significantly larger because enclosure size affects the dust collection (air flow) requirements.

- A complete abrasive blasting and recovery system. For recovery, the spent abrasive could be blown toward a recessed hopper via use of the abrasive cut-off switch at the blast nozzle. Plastic abrasives are moved quite readily over a concrete floor by compressed air, and the cleanup of even large areas is easily accomplished. Once in the hopper, the abrasive is processed through the recovery/reclaimer system and returned to the blast machine for reuse.

- Ventilation and dust collection system for operation visibility and containment of dust emissions. In most cases this will be an independent component and not tied to the recovery system.

Complete blast facilities are available incorporating all of the features noted.

4.2 Plastic Media

Another vital component of the PMB system is the media itself. The original media, called Polyextra, was developed by what is now U.S. Technology Corporation, and consists of an unsaturated polyester thermoset resin. U.S. Technology found the abrasive properties of this media to be less aggressive than necessary for some applications, and developed two harder medias, called Polyplus and Type III. Until recently, U.S. Technology plastic media were the only ones authorized for Government purchase by the General Services Administration. Recently Aerolyte Systems media was placed on the Qualified Products List (QPL) on some type of trial basis.

The following sub-paragraphs identify the physical properties of U.S. Technology plastic media, and the application of these media in various PMB operations.

4.2.1 Physical Data. Some physical properties of three standard types of media are shown in Table 1. Polyextra, Polyplus, and Type III are available in six size distributions (12-16, 16-20, 20-30, 30-40, 40-60, and 60-80 mesh) for use in a wide variety of stripping applications.

Table 1. Physical Properties of U.S. Technology Plastic Media[3,90].

	POLYEXTRA	POLYPLUS	TYPE III
Hardness (Moh scale)	3.0	3.5	4.0
Specific Gravity (gms/cc)	1.15	1.50	1.50
Bulk Density (lbs./cu. ft.)	45-48	58-60	58-60
Operational Temperature (deg. C)	0-250	0-300	0-350
Ignition Temp. (deg. C)	440	530	>530
Min. Explosive Conc.(oz./ft.3)	.045	.085	0.09
Chemical Nature	inert	inert	inert
Impact Strength (Scale 1 to 10)	4+	6	7+
Moisture Content	<0.1%	<0.1%	<0.1%
Water Absorption (24 hrs. at 25 deg. C)	0.13%	0.5%	0.25%
Explosive Index	5	0.2	>0.2

Several companies other than U.S. Technology now are producing plastic media, including Clemco Inc. (Aerolyte Systems) and Du Pont Chemical Corporation. They suggest that military specifications for plastic media should be written to reflect the desired performance of the media.

An effective specification might provide a specific gravity range of 1.0 to 2.0 for all types of media, and eliminate reference to Rockwell hardness (measured by indentation techniques), which has no relevance to the media surface qualities responsible for paint removal. Moh hardness (measured by surface abrasion techniques) and particle shape are the best predictors of paint removal performance that Du Pont has observed to date[57].

Other types of media are being developed, and their manufacturers insist these types have all of the necessary characteristics of the original media. Du Pont plans to market two thermosetting (4.0 Moh) materials and two thermoplastic (3.0 and 3.5 Moh) products[57]. The fact that the thermoplastics have flash ignition temperatures in the 390 degree to 400 degree Centigrade range may eliminate undue concern about surface residue due to the heat fusion. Du Pont is working with DoD to try and establish a test of thermoplastic resin viability for PMB operations.

Another product under development by Du Pont is a filled plastic abrasive. This product has been tested on a variety of substrates (including "Kevlar" parts) at the Coast Guard Facility (Elizabeth City) without producing substrate damage. It is also capable of removing top coats without lifting the primer when propelled at a 45 degree blast angle[57]. The product still needs to be carefully appraised.

4.2.2 Media Applications. Military applications of PMB are numerous, and extensions to nonmilitary applications appear to be beneficial. General cleaning, deflashing, deburring and surface preparation applications are listed in Table 2.

Table 2. Applications of Plastic Blast Media[50]

Cleaning	Deflashing	Deburring & Surface Preparation
mold cleaning	electronic components	aluminum housings core
boxes	lead frames	watch casings
paint removal	plastic moldings	zinc die castings
aircraft landing gear	alloy die castings	gear faces
pistons		plastic controls
propeller blades		alloy fuel tanks
aircraft fuselage		
truck wheels		
boat hulls		
boat bilges		
heat exchangers		
armature wires		
engine parts		
airline ovens		
composite surfaces		

Appendix B contains a list of additional general applications of plastic media, and includes recommended media types, and comments regarding blast parameters and blasting results.

PMB should not be used on the following materials or surfaces based on current data[23]:

- Hand laid-up fiberglass
- Glass or plastic plexiglass
- Honeycomb
- Soft fiberglass,
- Kevlar
- Dead soft aluminum
- Polyurethane boot of the S-3 aircraft nose radome
- Laminar X-500 carbon-filled polyurethane paint from E-2/C-2 aircraft propeller blade assembly

4.3 Media Recycling

The third component of a PMB operation is the media reclamation system. Estimates from various manufacturers and PMB facilities assert that 90 to 95 percent of the media may be reclaimed after each blast cycle[87]. One source claims that new media may be recycled between 10 and 20 times before complete breakdown is reached[91].

4.3.1 Media Recycling Systems. The media recycling process consists of recovering the spent media and blast products from the blast area; transporting it to media recycling equipment; extracting clean, usable media from the media, dust and paint mixture; and reinserting the clean, sized media in the blast cycle.

Recycling system types vary according to the size of the operation. Blast rooms and booths may be complete with pneumatic floor recovery systems which automatically convey spent media to the recycling equipment as shown in Figure 4. Less complex installations and blast cabinets use a manual system to convey the media to a central location where a vacuum then conveys the media to the recycling equipment. Booth or cabinet recycling systems are depicted in Figure 5.

A blast room is only as good as it's reclaim system.

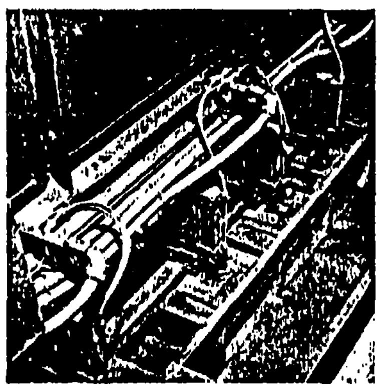
The unique Zero reclaim system strikes an optimum balance between the separation program dimensions and cubic feet per minute, delivering maximum efficiency and speed of operation with a minimum of media consumption. Reusable media is centrifugally separated from the air stream, air washed, and deposited in the storage hopper. Totally pneumatic. No mechanical conveyors! Minimum maintenance.

Zero Reclaim Systems are a minimum of 90% efficient. The efficiency of the reclaim can be increased or decreased by how closely the system is adjusted and monitored for the type of media being used.

Reclaim efficiency is determined by the amount of media of the original size remaining in the reclaim and the amount of original size media in the dust collection system . . . after a prolonged use. At any time during operation of a properly sized and adjusted reclaim, a minimum 90% of original sized media by weight must be in the reclaim. At the same time a maximum 5% of the original sized media by weight can be in the dust collection system.

Transition System. A specially designed transition connects directly to all floor channels. Waste, dust, and the reusable media is pneumatically conveyed from the "M" channels through the transition and then on to the reclaim system for separation.

Dry Exhaust Filter System. The Zero Unit is designed with a reversed air flow bag cleaning system which operates without shutting down the blasting operation. The filters are not harmed by continuous beating which occurs with most bag rapping mechanisms. System is controlled from main electrical panel.



Compare the Zero reclaim system with any other. You'll see why we say "Zero is Number One."

Figure 4. Automatic Floor Media Recovery System by Zero Mfg. Co.

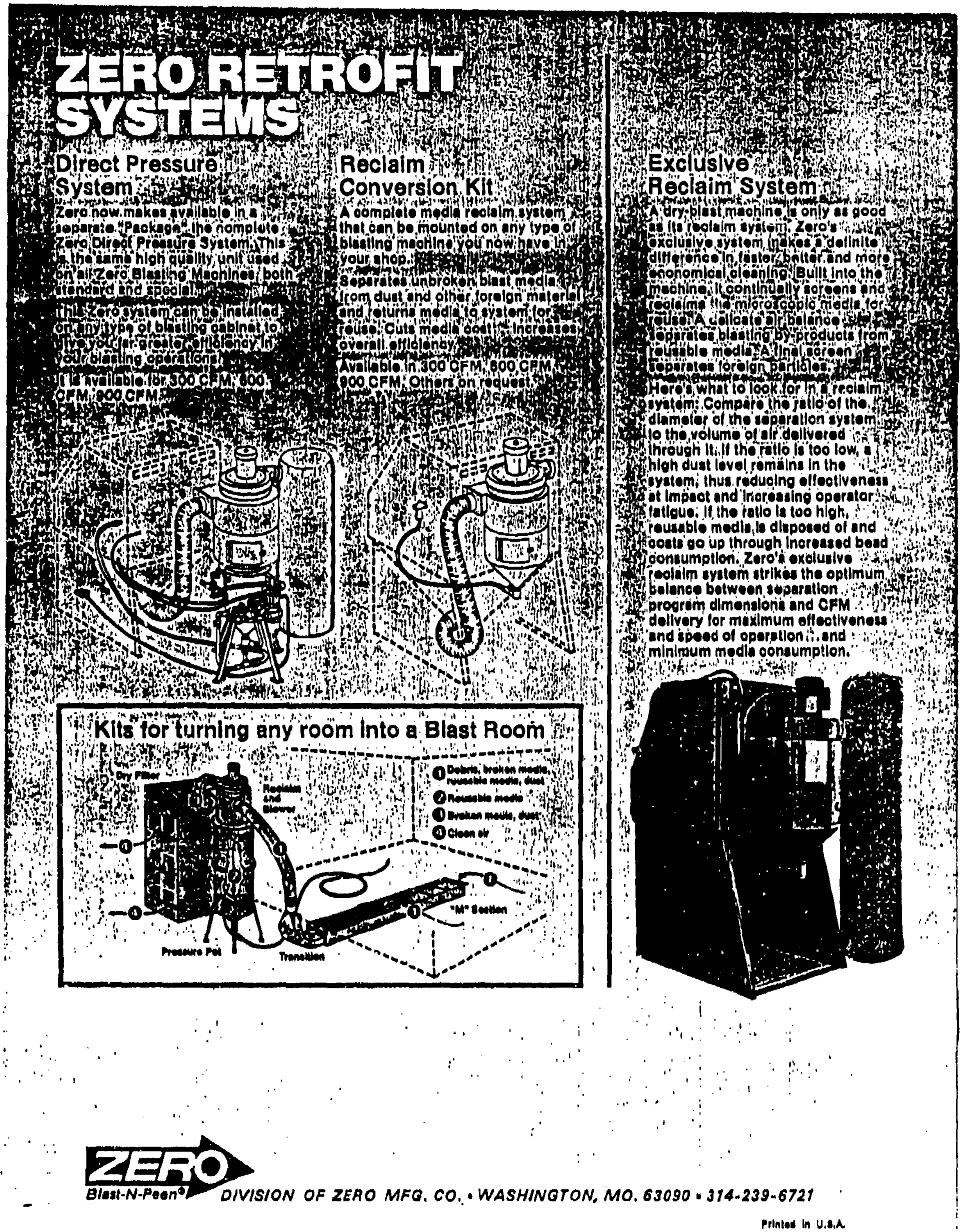


Figure 5. Booth or Cabinet Reclamation System by Zero Mfg. Co.

A typical skid mounted or yard towable blasting system would incorporate an abrasive recovery system design that allows for vacuum pick up of spent abrasives from the floor area via a choice of lightweight hand held pickup tools. A high pickup rate of up to seven tons per hour is highly recommended to minimize disruptions and blasting operation downtime.

Abrasive reclamation (media separation) systems are available either in pneumatically driven adjustable classifiers (cyclones), or in mechanical multi-deck vibratory screening systems. The pneumatically-driven adjustable classifier offers the tremendous advantage of speed in separating dust and fines from reusable abrasives. This system design should include a simple vibrating trash screen for removal of debris and large paint chips.

Multi-deck, mechanically driven, gyroscopic vibrating screen systems also are available as an alternative method for separation of debris and fines from reusable abrasive. However, these systems form a bottleneck to the entire process because of their slow screening rate.

The clean, recovered abrasive is returned to the blast machine either pneumatically or mechanically. The speed of abrasive transfer should be a primary consideration. An advantage of the pneumatic design is the ability to reload abrasive rapidly. A pneumatic system also allows for a quick return of screened and size-classified abrasives into their original containers at the end of blasting operations.

The recovery and reclamation system design is a critical factor with regards to media contamination. Plastic media has a low particle density weight (57 lbs./cubic ft.) and the aerodynamic qualities of plastic particles are similar to those of paint chips. The reclamation system design must be one engineered specifically for use with plastic media. Conventional cyclones typically do not provide acceptable cleaning of plastic media. Their use in PMB can result in reuse of media with a high content of dust, debris and paint chips. This could prove hazardous to thin-skinned aluminum or composite substrates.

4.3.2 Dust Collection Systems. A dust collection system is included in the recovery system for the containment of dust and fines separated from the spent abrasive. Dust collectors are available in a variety of designs ranging from simple, manually cleaned cloth filter systems to sophisticated, automatic systems. Five types of dust collection systems are described below[91].

1) Wet Collectors: Wet dust collectors clean the air by the combined action of centrifugal force and the intermixing of water with the dust laden air. Wet collectors are not as efficient in removing fine particles, and the sludge that is produced must be disposed of in an approved land fill. Wet collectors contribute to humid conditions which may be detrimental to media flow.

2) Envelope Collectors: Envelope style collectors consist of a series of fabric-type filters shaped like an envelope. These filters are placed side by side in a vertical position. This type of filter tends to matt, reducing the filtering surface.

3) Cartridge Collectors: Cartridge dust collectors consist of a number of nonwoven tubular filters placed vertically in the collector housing. The filters are similar in design to automotive air filters. Cartridge dust collectors can handle a maximum of one cubic feet per minute (CFM) of air for each square foot of filtering area. Cartridge dust collectors are more expensive than cloth filter (tubular bag) collectors.

4) Tubular Bag Collectors: This type of collector consists of a steel housing containing a number of cloth filter bags or tubes. These bags collect the dust on either the outside or the inside of the filter tubes, depending on the design. Various diameter filter tubes and types of filtering fabric are used depending on the manufacturer and the application. For cloth collectors, the maximum allowable air flow is 3-1/2 CFM for each square foot of filter cloth.

5) Reverse Pulse Jet Collectors: A reverse pulse jet collector is automatically self-cleaning, and provides for continuous operation without any disruption to the blasting operator for cleaning activities. This design allows dust particles to collect on the outside of tubular bag filters. Timed, reverse pulses of air dislodge the accumulated dust, and automatically keep the tubular bags clean and at peak efficiency.

The most common air filtering system in use is the "baghouse" tubular bag collector (Type 4 above) that collects dust on the interior surface of the cloth filters. Blasting systems that use this type of filter must shut down operations during the mechanical bag-cleaning cycle. These filter systems are classified as "intermittent dust collectors".

The second most common design in use is the reverse pulse jet dust collector. This type of collector is capable of continuous operation, has a higher air-to-cloth ratio, and is more compact than the tubular bag collector type.

In spite of disadvantages, the baghouse design should not be discounted. Although it is not state-of-the-art design, this type system has proven to be reliable, and is far less costly than reverse pulse jet dust collector types.

Dust collector sizing can be directly related to the interior dimensions of the blast enclosure. The minimum air flow in CFM should provide for at least one air change per minute. For example, in a large room with dimensions of 30 feet width x 20 feet height = 600 sq. ft. cross-section x 85 ft. length = 51,000 CFM[18].

For rooms under 50 feet in length, and for rough calculation purposes, the cross sectional area can be multiplied by a 50 feet per minute (FPM) air flow to arrive at the total air volume required. As an example, a 30 foot wide by 20 foot high enclosure 40 feet long would require 20 ft. x 30 ft.= 600 sq. ft. x 50 FPM = 30,000 CFM of ventilation[18].

4.3.3 Commercial Recovery Equipment. Standard recovery equipment is produced by several manufacturers, including Clemco Inc. (Aerolyte systems), Pauli & Griffin Inc., Caber Inc., Zero Manufacturing Inc., and the Schmidt Manufacturing Company. To provide an overview of typical commercial recovery equipment, the following paragraphs provide descriptions of systems manufactured by Pauli & Griffin, Incorporated, and Schmidt Manufacturing.

4.3.3.1 Pauli & Griffin System. Pauli & Griffin, Inc. manufactures Plastic Reclaimable Abrasive Machines (PRAM). The PRAM 21 Portable Cleaning and Reclaiming System is designed to allow continual reuse of the media, and consists of a PRAM 11 blast machine, a cyclone reclaimer, and a 495 CFM dust collector, all mounted on a wheeled frame for easy mobility at the job site[87].

The Pauli and Griffin System component description:

- PRAM 11 blasting machine, 6 cubic ft. pressure vessel with a 60 degree conical bottom, RC 150P remote control system, special metering valve and fluidizing section, moisture separator, pressure regulator and gauge at inlet.
- 495 CFM cyclone reclaimer with vibrating screen plus 4 air valves and internally adjustable cones, fine tunable two-stage air wash system.
- 495 CFM dust collector with a 7-1/2 Horsepower (HP) TEFC motor and high static pressure blower, side mounted hose storage rack.
- Removable loading hopper with 25 ft. of 4 in. inside diameter (I.D.) reinforced vacuum hose (up to 100 ft. of 4 in. I.D. hose may be used).
- Wheeled mounting frame of channel steel, 6 ft. x 7-1/2 ft., with four 16 in., 16 x 400 zero pressure tires at one end and two 8 in. swivel wheels with brakes and tow bar at other end.

The reclaimer principle of operation is straightforward. The reclaiming system, powered by the 7-1/2 HP motor with high static pressure blower, pneumatically conveys spent media to a cyclone separator designed specifically for the density of the plastic media being used.

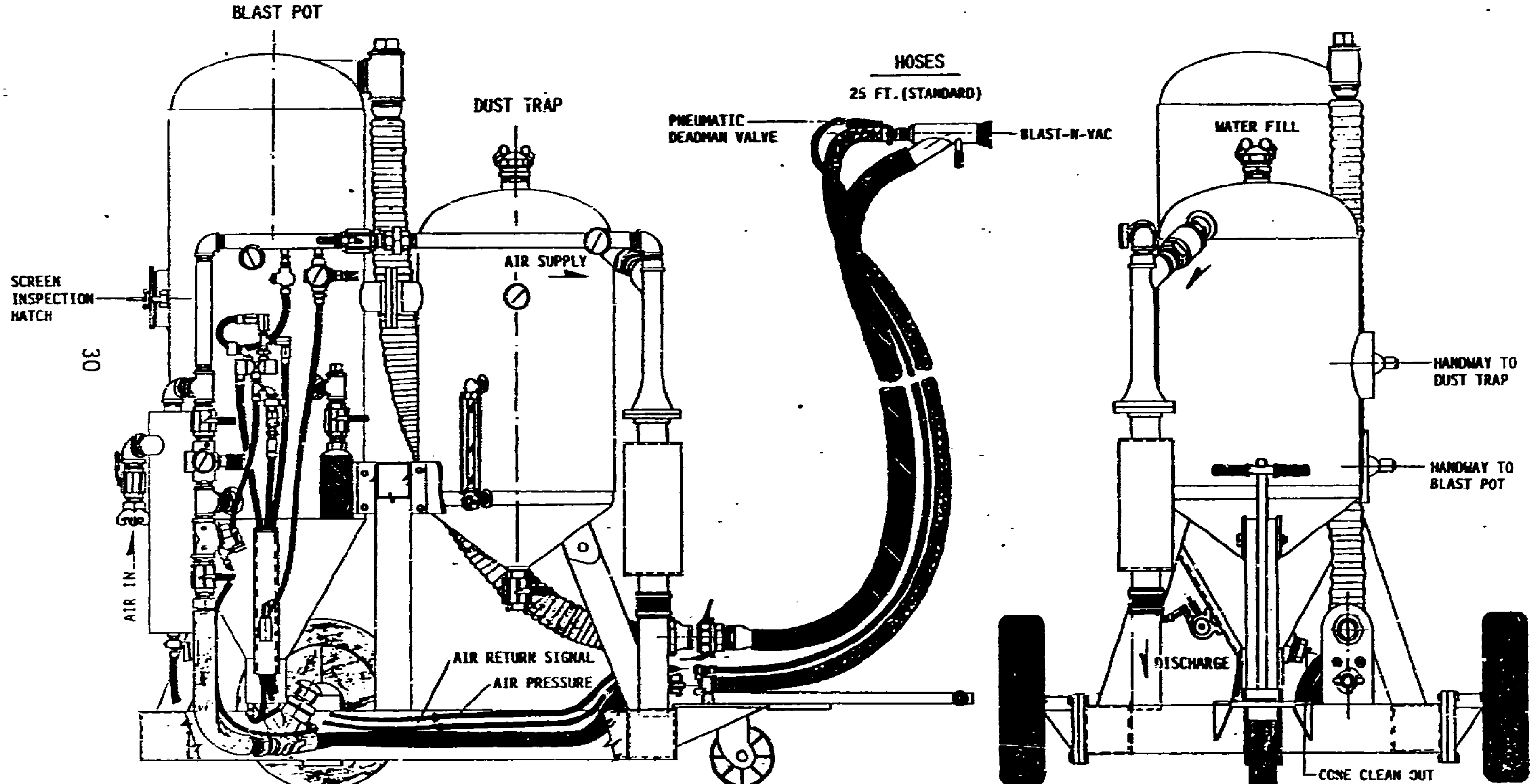
Media and heavy debris fall from the cyclone to a vibrating screen. This screen contains the debris, and allows reusable, correctly sized media to fall through to the storage hopper located over the PRAM machine. This 24 in. x 24 in. loading hopper can be located anywhere within 100 feet of the reclaimer inlet.

Each time the operator stops blasting, remote control valves automatically depressurize the machine, and the reclaimed media falls from the storage hopper to refill the PRAM Cleaning Machine.

The dust and fines are pulled from the center of the cyclone and pneumatically conveyed to a high efficiency dust collector with tubular dust bags. The bags filter all dust down to 1 micron, and exhaust cleaned air to the atmosphere.

4.3.3.2 Schmidt System. Schmidt Manufacturing has designed a system that may be used in a closed blasting and recovery cycle. A combination blasting and vacuum head is attached to the blast hose and vacuum return hose. During operation, the plastic media is blasted against the surface being stripped, and the vacuum picks up the spent media, dust, and debris, and pulls it through the reclamation and dust separation system. The Schmidt system also may be used in the conventional method, with spent media reclaimed from the floor. Figure 6 is a drawing of the Schmidt system.

DRY STRIPPING SYSTEMS



SCHMIDT MFG. INC.
P. O. Box 37, Fresno, Texas 77545
11927 So. Hwy. 6,
Fresno (Houston), Texas 77545
713/431/0581
800/231-2085

Pneumatic PMB-BV

Figure 6. Schmidt Blasting System.

4.3.4 Spent Media and Waste. Because of the concentration of metals in the dust and spent media, the waste must be considered hazardous material, and be disposed of in accordance with applicable regulations.

At the Hill Air Force Base (AFB) PMB facility, the stripping of each F-4 aircraft results in nearly 1,500 lbs. of dry paint chips and dry spent media. (PRAM Project 00-143, August, 1986) On an annual basis, based on the stripping of 205 aircraft at Hill AFB, the amount of media required and waste developed would be 307,500 pounds. This is approximately 154 tons of dry waste generated from PMB operations, as compared to an average of 105 tons of hazardous waste and sludge from chemical stripping[38].

It should be noted that the actual amount of media used is a function of efficiencies of the equipment (such as the media reclamation system), and the number of layers of paint on aircraft and component parts. Coatings on F-4 aircraft might include epoxies, polyurethanes, enamels, and lacquers, and therefore could require more or less than this estimated amount of media.

The disposal cost for plastic media derived dust and waste is $260 per ton. The cost of transporting hazardous sludge and waste derived from chemical stripping and disposing at a waste dump is nearly $200 per ton[38].

5.0 ECONOMICS

The Manpower Installations and Logistics Department of The Environmental Protection Agency (EPA) estimates that the potential savings in chemical pollution costs alone could exceed $100 million in the first year of PMB operation at DoD facilities (see data on page 38).

The economics of PMB can be assessed by projects implemented at Hill AFB. The examples shown below describe the important economic parameters, and provide a comparative analysis of potential savings of plastic media blasting over conventional solvent stripping methods.

5.1 Example I - Hill AFB, PRAM Project 00-143, August 1986[38].

All costs given are based on paint stripping of 205 F-4 aircraft during a working year comprised of 260 days.

Investment Cost:

The equipment consists of two blasting machines with special circulation systems, nozzles designed for use with plastic blasting media, and a recovery system in the floor to provide for reuse of the blasting media. The investment cost: $757,183.

Labor Savings:

Number of man-hours for chemical stripping	364		
Less number of man-hours for PMB	183		
Number of man-hours saved per aircraft	181		
Number of F-4 aircraft Fiscal Year (FY) 1986	x 205		
Total number of man-hours saved		37,105	
Cost per man-hour		x $16.76	
Total labor savings			$621,880

Flow Day Savings:

As determined using AFR 173-13 cost and planning factors:

- F-4 utilization rate is 0.68 hours per day
- F-4 life cycle cost is $3,086 per flying hour
- F-4 cost per flow day (0.68 x $3,086) is $2,098

Flow days per aircraft with chemical stripping	5.4	
Flow days per aircraft with bead blasting	3.2	
Number of flow days saved per aircraft	2.2	
Number of F-4 aircraft (FY 1986)	x 205	
Total number of flow days saved	451	
Cost per flow day	x $2,098	
Total flow day savings		$946,198

Hazardous Waste Removal Savings:

The chemical method of paint removal produces an average of 105 tons per year of hazardous sludge which must be transported to a waste disposal site at $200 per ton. PMB generates dust that is considered hazardous waste and must be disposed of at a cost of $260 per ton. Nearly 1,500 pounds of dust per aircraft are generated.

Cost per year with PMB (1,500 lbs. per aircraft x 205 aircraft divided by 2,000 lbs. per ton x $260 per ton)	$39,975
Less cost per year with chemical stripping ($200 per ton x 105 tons)	21,000
Total hazardous waste removal cost increase	$18,975

Water and Water Treatment Savings:

In addition to the cost of water used, the spent water must be treated in the industrial waste treatment plant before it is disposed of in the county sewer system.

Cost of water used with chemical stripping (210,000 gallons per day x $0.43 per 1,000 gallons x 22 work days per month x 12 months per year)	$23,839	
Cost of treating water (210,000 gallons per day x $8.24 per 1000 gallons x 22 work days per month x 12 months per year	456,826 480,665	
Less cost of water used for PMB		0
Total water and water treatment savings		$480,665

Electric Power Savings:

The use of chemical strippers requires continuous ventilation of the area. The ventilation system includes eight 25 HP supply fans and sixteen 7-1/2 HP exhaust fans for a total capacity of 320 HP. The PMB method requires a 150 HP fan for primary air, a 25 HP fan for secondary air, a 150 HP air compressor, and a 15 HP refrigerated dryer for a total requirement of 340 HP. This equipment is used only during the actual blasting of the aircraft (10 hours).

Cost of electric power used during chemical stripping (.7457 KW per HP x 320 HP x 16 hours per day x 260 days per year x $0.05 per KWH)	$49,634
Less cost of electric power used during PMB (.7457 KW per HP x 340 HP x 10 hours per aircraft x 205 aircraft x $0.05/KWH)	25,988
Total electric power savings	$23,646

Heat and Steam Savings:

The chemical stripping area of Building 220 must be heated to 70 degrees Fahrenheit for 2 shifts per day. The average year-round air temperature at Ogden Air Logistics Center (ALC) is about 51 degrees Fahrenheit. The makeup air provided to Building 220 is 507,000 CFM. The cost of heating can be computed by using the basic air conditioning formula, sensible load (BTU/hour) or Q is equal to air volume (CFM) times 1.08 times the difference between the entering and leaving dry bulb temperature of the air. The 1.08 has been adjusted to 0.9 in the calculations to compensate for the altitude at Ogden ALC.

Fresh air requirement	507,000	
	x 0.9	
	456,300	
Difference between entering (70 deg. F) and leaving (51 deg. F) temperatures	x 19	
BTUs per hour	8,669,700	
Hours per day (2 shifts at 8 hours each)	x 16	
Total BTUs per day	138,715,200	
Days per year	260	
Total BTUs per year	36,065,952,000	
MBTUs (million BTUs) per year	36,066	
Cost per MBTU	$ 5.59	
Total heating costs		$201,609
Fresh air requirement	36,800	
	x 0.9	
	33,120	
Difference between entering (60 deg. F) and leaving (51 deg. F) temperatures	x 9	
BTUs per hour	298,080	
Hours per day (2 shifts at 8 hours each)	x 16	
Total BTUs per year	4,769,280	
Days per year	260	
Total BTUs per year	1,240,012,800	
MBTUs per year	1,240	
Cost per MBTU	$ 5.59	
Total heating costs	$ 6,932	
Total heat/steam savings		$194,677

Material Savings:

Chemical paint stripper is used at a rate of 468 gallons per aircraft and costs $11.40 per gallon. PMB requires the use of a plastic material which costs $1.76 per pound. The plastic media is cleaned and recirculated for reuse. An estimated 1,500 pounds of media is lost per aircraft during the paint stripping operation.

Number of gallons of chemical stripper required per aircraft	468
Number of aircraft per year	205
Total number of gallons	95,940
Cost per gallon	$11.40
Cost of material for chemical stripping	$1,093,716
Number of pounds of plastic media	1,500
Number of aircraft per year	205
Total number of pounds	307,500
Cost per pound	$1.76
Cost of plastic media	$541,200
Total material savings	$552,516

Summary of Savings:

Total labor savings	$621,880
Total flow day savings	946,198
Total hazardous waste removal savings	(18,975)
Total water and water treatment savings	480,665
Total electric power savings	23,646
Total heat/steam savings	194,677
Total material savings	552,516
Total gross annual savings	$2,800,607
Total five-year gross savings	$14,003,035

Savings-to-Cost Ratio: ($14,003,035/$757,183)	18.5 to 1

5.2 Example II - CH_2M Hill Report[11]

Estimate of Savings Comparison Between Plastic Media and Solvent Paint Stripping

Item ($)	Savings	Annual Cost Savings
Hazardous Waste	Generates 1/100 the waste sludge which requires hazardous waste disposal	218,000*
Wastewater Pollution	Eliminates generation of 210,000 gallons per day of wastewater which must be treated in on-base waste treatment plant before discharge to the city municipal treatment plant	526,375
Materials	Eliminates the use of chemical solvents and requires minimal use of plastic media to makeup for worn out media	1,091,340
Labor	Requires 1/10 labor	2,179,060
Energy	Requires 1/10 energy	223,929
Flow Days	Provides increased flow day utilization of aircraft	1,353,210
Total Annual Savings for 215 F-4 aircraft		$5,591,914

* This figure is in conflict with that in Example I

Manpower - 39 Labor hours per aircraft; labor rate $33.65 per hour; cost per plane $1309; annual cost $281,400

Energy used - Energy required to operate equipment at Building 223, Hill AFB; 340 motor HP $8.25 hr./day at 260 days per year at .051 KWH energy cost has annual cost of $27,305.

Tests at Hill AFB with PMB on F-4 aircraft suggest labor and material savings of better than 10 to 1 over chemical stripping. In terms of cost, labor and material for chemical stripping is about $9.20 per square foot compared to $0.95 per square foot for PMB.

Operating costs at Hill AFB have resulted in 50% less energy use over solvent stripping in terms of heating, ventilation, and mechanical equipment. The media loss per aircraft is about $346.

Estimate of Annual Savings Comparison for all DoD Facilities

Item	Solvent/Chemical Stripping	Plastic Media Stripping
Labor and Material		
Manhours	3,360,000 hr.	1,426,000 hr.
Solvents/chemicals	7,000,000 gal	0
Wash water	100,000,000 gal	0
Wastes lbs.	107,000,000 gal	500,000
Operating Costs ($)		
Manhours	136,516,000	67,698,380
Material supplies	30,960,000	4,400,000
Waste treatment and disposal	8,000,000	1,500,000
Total Operating Costs	175,476,800	73,598,380
Cost Savings		$101,878,420

The cost savings in the previous two examples shown are different because of different operating assumptions, and different cost assumptions.

6.0 SAFETY AND HEALTH

Plastic media blasting, although considered less hazardous to personnel than chemical stripping, presents certain health and safety concerns. This section contains an overview of applicable worker safety standards, personnel health and safety, and air/dust handling equipment designed to minimize health and safety risks.

6.1 Safety

Worker safety is of primary concern in every industrial process. PMB, as is typical of any abrasive paint removal technique, generates quantities of media and paint dust that pose a threat to worker safety. Suspended dust particles in the blast area may seriously limit worker visibility, but probably do not pose an explosion hazard[80].

6.1.1 Explosivity and Fire. Whether or not the dust will ignite depends on particle size, dust concentration, impurities present (from blast surfaces), oxygen concentrations, and ignition source strength. Deposits of dust on beams, machinery, and other surfaces can cause flash fires. In the actual operating environment, NARF Alameda reports that little dust is removed by the horizontal ventilation and the greater portion of dust falls to the floor.

In some cases, media manufacturers may be underestimating the potential for explosions and fire during plastic media blasting. Data provided by most manufacturers are based on virgin media from the manufacturing process. The test procedures followed are those recommended either by the American Society for Testing and Materials (ASTM), or by the Underwriters Laboratories (UL). These tests primarily are designed for use during the production of plastic materials and have no bearing on the actual hazards of paint-contaminated dust generated during PMB operations. The U.S. Bureau of Mines recommended that large-scale explosivity testing be conducted on virgin plastic media, and on used plastic media and dust[80].

Theoretical calculations have shown that 2.85 timos more plastic than is delivered by a 1/2 inch nozzle at 45 psig would have to be 100% destroyed to reach 25% of the lower explosive limit (LEL)[61]. LEL is defined in this case as 150 grams per cubic meter of plastic with 360 air changes per hour.

Explosivity tests on new and used plastic media were conducted in a 20-L chamber designed at the U.S. Bureau of Mines. The dust was placed in the bottom of the chamber which was then partially evacuated. An air blast dispersed the dust and raised the pressure back to 1 atmosphere absolute.

Optical dust probes were used to measure the uniformity of the dispersion. Strong chemical ignitors at 2500 and 5000 Joules (J) calorimetric energy were used for the tests. The coarse, new media could not be ignited in the 20-L chamber. However, the fine material showed the same explosion potential as pulverized Pittsburgh seam coal. Pittsburgh seam coal has been a cause of numerous industrial explosions[54].

The presence of fines in the coarse material tends to increase the explosion hazard. This was determined by testing recycled material supplied by the Navy. As a result, it is recommended that any used material be sieved before recycling to remove fine particles that are less than 200 microns in size (70 mesh). Particles this size and smaller are the most hazardous[6]

As a result of the March 1985 U.S. Bureau of Mines study, the Air Force has recommended that a 64 mesh screen be used to remove the fines within the explosive index. Commercially, a safety factor may be obtained by using a 50 mesh screen for plastic media dust separation[37].

The latest Bureau of Mines letter states that fines (less than 80 mesh) were explosive, while the coarser material including recirculated blast media could not be made to explode or thermally ignite under normal test conditions[80].

6.1.2 Visibility. Low visibility in the blasting environment could pose a threat to worker safety. Even with good lighting in the area, the visibility may be less than four feet when three operators are blasting simultaneously (observed). Minimum visibility requirements are three feet[53].

6.1.3 Safety Standards. The only safety standards that exist which are applicable to PMB operations are OSHA Standard 29 CFR 1910.1000 and OSHA Standard 29 CFR 1910.94[33]. These address dust concentrations and explosiveness. ANSI Standard Z9.4-1985 requires that dust concentrations be kept below 25% of the LEL because of the potential explosiveness of the dust.

An alarm system had been recommended in the literature as a precautionary measure. This is no longer required by the Navy.

6.1.4 Safety Equipment. Operator safety equipment should be used in blast rooms and booths. The equipment should consist of a Class A OSHA/NIOSH approved protective helmet air filter, a carbon monoxide monitor/alarm on the breathing air supply (where applicable), a climate control tube allowing the operator choice of air conditioned or heated air is to reduce fatigue, hearing protection, a leather faced cotton backed blast suit, and leather gloves.

6.2 Health

Plastic media blasting presents long term health concerns related to worker exposure to high levels of dust contaminated by various metals. Also, personnel are exposed to consistently high levels of noise which may cause hearing problems.

6.2.1 Air Flow and Dust. The air flow rate in a blast facility is maintained at a minimum of 50 ft./min. This is necessary to avoid any possibility of reaching the air/contaminate mixture which would be explosive[18].

Dust collection systems also aid in keeping the dust concentration in the safe range. Most commercial suppliers of PMB equipment also provide dust collection systems. Zero's dust collection systems have been approved by the San Francisco Bay Area Air Pollution Control District. Such dust collection systems prevent operator discomfort, prevent environmentally unsatisfactory conditions, and eliminate dangerous or explosive hazards.

Dust still is a major problem. Concentrations as high as 31 milligrams (mg) per cubic meter have been measured. The maximum allowable level for "nuisance" particulates is 10 mg per cubic meter, or 5 mg per cubic meter if the particulate has an aerodynamic diameter of respirable size. Respirable samples taken during PMB operations usually exceed this concentration. In one instance, the measured average concentration was 13.8 mg per cubic meter for the 10 samples[34].

Airborne particulate concentrations vary widely throughout the system, both temporally and spatially, and depend on many parameters. Some of the factors affecting airborne particulate levels are:

1) Quality and type of media used
2) Blast velocity
3) Quality and conditions of paint removed
4) Media recycle system
5) Used media collection system
6) Ventilation and air flow

6.2.2 Toxicity. The amino thermoset resins (Polyplus and Type III) are basically the reaction products of organic compounds containing the amino group ($-NH_2$) and an aldehyde. The better known members of this group are urea formaldehyde (a suspected carcinogen) and melamine formaldehyde. The actual composition and toxicity of the dust from the various operations must be collected and laboratory evaluated for potential health hazards. Suitable ventilation must exist to maintain the concentration of respirable dust in the breathing zone of the abrasive-blasting operator and all other workers in the area below hazardous levels. In the event of fire, toxic gases including carbon monoxide, and carbon dioxide, and poisonous ammonia gas could be generated[33]

Observations show that toxic effects from PMB media are minimal. There is minimal risk to skin, little oral or eye irritation, and inhalation studies have shown no observed signs of toxicity. Some allergic reactions are possible. However, proper hygienic precautions would mitigate these effects. Toxicity studies reveal[79]:

- skin contact may sometimes result in slight toxic effects
- minor eye irritation from media powder
- very minor inhalation effects
- non-carcinogenic attributes
- low toxicity if ingested

However, the media and paint dust is laden with certain heavy metals due to the paint removal operation. The concentration of these metals should be monitored for compliance with the Threshold Limit Values (TLV) established by the American Conference of Governmental Industrial Hygienists.

6.2.3 Noise. Noise can be a serious health hazard[34]. Standard AFR 161-35 defines hazardous noise as levels greater than 84 decibels absolute (dBA).

At Hill AFB, sections of the building exceed 105 dBA, and dosimetry measurement of noise inside the Class A approved helmet was greater than 100 dBA. These measurements show that the facilities must be considered a noise hazard, and must be posted as such. Operators assigned in the blasting area must use hearing protection, and must be included in the Hearing Conservation Program as required by AFR 161-35.

6.2.4 Standards. Standards are being reviewed to determine applicability to PMB[33,55,56,68,70,71]. Present standards include:

- OSHA 29 CFR 1910.94
- ANSI Z9.4a 1981.
- ANSI Z9.4 1985.

The NARFs currently must comply with ANSI Z9.4 1985. The Navy believes that compliance with the ANSI Standard is sufficient, but is prepared to comply with either standard.

7.0 SURFACE EFFECTS

Any operation in which an abrasive is impacted onto a substrate produces some sort of effect on that substrate. Surface effects may be visible to the eye, or they may be determined only after microstructural examination of the substrate. Some detrimental surface effects may include stress corrosion cracking, and crack closure. However, some surface effects may actually improve the character of the substrate or leave a more desirable surface for painting. This section summarizes information on surface effects, including damage and crack closure. It also identifies various substrates that have been subjected to PMB.

7.1 Damage

When blasting with a 40 psig nozzle pressure, damage to the substrate was negligible in all cases. Even dead-soft aluminum showed little sign of damage when the blast nozzle was held the nominal 6 to 8 inches from the surface. Soft aluminum shows the effects of impact by the sharp edges of the plastic, but tests have proven that this provides a surface with a better "tooth" to paint. Furthermore, the finished product does not appear to be a blasted surface when visually inspected.

Tests conducted at Corpus Christi Army Depot showed that plastic media removed less clad from Al-clad than walnut shells. Walnut shells require 2 to 3 times higher blast pressure than PMB, which results in damage to some aircraft parts[49]. Tests conducted by NESO North Island Materials Engineering Lab concluded that Polyplus (20-30 mesh) blasting parameters could be exceeded without detrimental effects to low-alloy steels, corrosion resistant steels and titanium[29].

Recommendations on media selection and process control to avoid detrimental surface effects are as follows:

- Plastic media Polyextra or Polyplus, sieve size 30 to 40 or finer is recommended for the following metals: Low-alloy steel, corrosion resistant steel, titanium, and aluminum alloys.

- Composite laminates require Polyextra plastic media to minimize surface abrasion such as resin fragmentation, fiber exposure, and fiber fracture.

- Blast parameters are recommended as follows[27]:

  - Nozzle pressure of 45 psi +/- 5 psi (later sources cite 40 psi)
  - Stand off distance is the minimum distance necessary to remove paint.
  - Dwell time is minimum time to remove topcoat and primer.
  - Angle of blast direction is 45 degrees from perpendicular to surface.

7.2 Crack Closure

Observations made by Mr. R. A. Roberts of Hill AFB indicate that blasting helps to stress-relieve surfaces and does not heal cracks in aluminum. However, some crack closure has been noticed when blasting with Polyplus 12-16 at 60 psi. Tests conducted by the Materials Engineering Division at NARF Pensacola and NARF Jacksonville showed some crack closure on various aluminum alloys. Crack detection should be performed by ultrasonic testing[30,36,45].

7.3 Materials Blasted

The following substrates can be safely blasted with plastic media[23]:

- Low-alloy steels
- Corrosion resistant steels
- Titanium
- Al-clad aluminum alloy, use Polyextra (30-40) at 20 psi
- 7178-T6 Al-clad
- 2024-T4 aluminum alloy
- 7075-T6, 7075-T-73, 7075-T-76 aluminum alloys
- Epoxy cast fiberglass/laminate/composite
- Polyester fiberglass laminate
- Graphite epoxy
- Magnesium
- Anodized aluminum

The usual blast parameters for the substrates are as follows[23]:

- Nozzle pressure of 40 psig is recommended.
- Media type/grit size: Polyextra (30-40 size) for fiberglass;
  Polyplus/(30-40 size) for most substrates;
  Type III or Polyplus (11-16 size) for aggressive or glass-bead type of operation.
- Stand off distance is usually 6 to 8 inches, and up to 3 feet.
- Angle of substrate to nozzle is usually at a 45 degree angle.
- Nozzle size of 1/2 inch diameter is recommended, and no lining is necessary.

PMB has been performed on the following aircraft parts, components and substrates without damage[23].

- F-4 landing gear
- F-4 Vari-ramp louvers (magnesium with titanium screen in place with stainless steel wire)
- AIM -9 missile nose cone
- Epoxy cast fiberglass - remove paint and leave primer on.
- A-7 spar, 7075-T6
- A-7, station 490 bulkhead fitting, 7075-T-6
- MER/TER bomb rack, 7075-T73
- A-7 wheel, 2014-T61
- 1820 Engine gear box housing magnesium alloy
- Dirt/grease removed from casting sections of F-4 landing gear
- Engine blades and vanes
- F-4 wing folder stabilizer
- C-118 Al-clad wing surfaces
- Fiberglass radome
- Sealant coated door
- Carbon coated (engine exhaust) fairing
- S-3 Nose radome
- S-3 Wing fairing
- A-6 Vertical fin cap
- EA-6 Rudder access panel
- F-4 Vertical fin radome
- F-4S Airframe
- P-3, A-3, A-6, S-3 landing gear, arresting hooks, wheels, fairings, cylinders, barrels, housing, shanks, pistons, side brakes, GSE screens, drag struts, HSE covers, lower links, arms, latch bars, yoke assembly, pinions, etc.
- ADF antenna - Polyplus 30-40, 35psi
- B-747 Wing panel, without removing black conductive coating
- B-737 Inboard aft flap - Polyplus 30-40, 40 psi
- B-737 Rudder
- Spinner cones with anti-erosion paint
- 7075-T6
- 7075-T-76; 7075-T-73
- 2014-T-6
- 2024-T4 - Polyextra 30-40, 30-40 psi
- A281-T4 (magnesium alloy)

7.4 West German Research

An attempt was made to acquire West German Air Force research material through CAB Inc. in Seattle WA. However, CAB Inc. considers this material proprietary and not for public release.

8.0 OBSERVATIONS

Throughout the course of this task, collection efforts were focused on gathering as much information on PMB as possible. In categorizing and compiling the data, several observations were made and impressions formed regarding PMB technology and published information on the subject. The following paragraphs document these observations and impressions, and may suggest areas of interest warranting further investigation.

It is unusual that a search spanning in-depth phone calls, letters, site visits, over 630 computer data bases and two technical research firms yielded only enough information to fill one 4-inch file. A body of knowledge has been developed; however, most of this knowledge resides in the private sector. Private sector users, media suppliers and PMB equipment manufacturers will not release information they consider proprietary or sensitive in nature. Government collection of information on PMB should be an ongoing effort until the necessary body of knowledge is developed.

The PMB community is a closed one and patents are few. In order to continue to develop a body of technical information available for public scrutiny, it may be advisable for the Government to institute an independent, in-depth PMB testing program.

New media are appearing on the market. Some of this media may not perform adequately, or may present safety and hazards different from the media currently being used. Testing of all new media is essential.

Performance oriented military procurement specifications have not been developed for either the plastic media or the blasting equipment. Military specifications could enhance competition among suppliers, may increase the pace of technological advancements, and could result in decreasing the cost of PMB operations.

The search uncovered conflicting information concerning the amount of hazardous waste generated by PMB, and the cost of disposing of this waste. Further economic investigations and studies are warranted in order to correctly determine all of the economic factors and correctly assess the cost savings.

Safety and health concerns over dust explosiveness, particulate concentrations, and dust toxicity are not clearly resolved. Continued data collection and more testing is necessary.

Appropriate standards may not exist for dust explosiveness, particulate concentrations, and dust toxicity. Safety and health standards specifically applicable to PMB need to be either identified or developed.

Data on the long-term effects of PMB on aircraft surfaces has not been obtained. Careful monitoring of the aircraft in the PMB program would yield vital information on the safety of the PMB process.

PMB is proving to be a cost effective method of paint removal with many benefits. More research by Government and industry will further enhance PMB technology, making PMB truly the "wave of the future".

BIBLIOGRAPHY

Reports

1. Acurex Corporation. Reduction of Total Toxic Organics Discharges and VOC Emissions from Paint Stripping Operations Using Plastic Bead Cleaning, by C. D. Wolback and C. McDonald. May 1986.

2. Air Force Wright Aeronautical Laboratories. Evaluation of the Effects of a Plastic Bead Paint Removal Process on Properties of Aircraft Structural Materials, AFWAL-TR-85-4138, UNCLASSIFIED, by Sidney Childers, David C. Watson, Patricia Stumpff and Jon Tirpak. December 1985.

3. Anonymous. Koppers Blast Cleaning Media. Not dated. (Evaluation of Koppers Media at various facilities and on various substrates)

4. Anonymous. Preliminary Economic Analysis of Plastic Media Blasting at NARF Pensacola. 28 March 1984.

5. Anonymous. Technical Aspects of Paint Removal Using Koppers Plastic Blast Cleaning Media. Not dated.

6. Assistant Secretary of Defense. 1984 Annual Environmental Protection Summary. 1984.

7. Aviation Week. Dry Stripping Cuts Hazardous Waste Materials. 3 March 1986.

8. Bell Helicopter, TEXTRON. Stripping Paint from Rotor Blades Using Plastic Blasting Media. 4 November 1985. (Interoffice memorandum)

9. Boeing Aircraft. Manufacturing Development Report - Composite Paint Stripping Development, by W. Egan. 4 April 1985.

10. Bullington, John D. "Plastic Media Blast Best for Stripping," Mantech Journal, Volume 10/Number 4/1985. (Corrosion Under Attack)

11. CH_2M Hill. Industrial Processes to Reduce Generation of Hazardous Waste at DOD Facilities, Phase 2 Report - Evaluation of 18 Case Studies - UNCLASSIFIED, by T. E. Higgins. Prepared for U.S. Army Corp of Engineers. July 1985.

12. CH_2M Hill. Industrial Processes to Reduce Generation of Hazardous waste at DOD Facilities, Phase 1 Report - Evaluation of 40 Case Studies - UNCLASSIFIED, by T. E. Higgins. Prepared for U.S. Army Corp of Engineers. February 1985.

13. Corpus Christi Army Depot. The Environmental Impact of Plastic Media Blasting at Corpus Christi Army Depot, by John Bullington and Randy Williams. Not dated. (Probably late 1984 to early 1985)

14. Corpus Christi Army Depot. Training Guide for: Plastic Media Blasting. Not dated.

15. Desoto, Inc. Material Safety Data Sheets. 14 April 1986.

16. DC-9 Component Parts - Removed From Aircraft. Time Comparison Charts. Not dated. (Test data from either Republic Airlines or United Airlines)

17. G.A.G. "The Stripper," Business and Commercial Aviation. September 1985.

18. Gardner, Joe. "Abrasive Blast Cleaning - A Viable Alternative to Chemical Stripping Operations." February 1985. (SAE Technical Paper Series)

19. Grumman Aerospace Corp. Department of the Navy Report - Automated Painting and Stripping Project, 6th Quarterly Report, Project WBS-235. Not dated.

20. Hockenberry. "Plastic Media Blasting." 14 March 1986. (Article for publication in Boeing Vertol Company's newsletter, Transitions)

21. Midway Supply Company. GSA Contract No. GS-00F-79342. Not dated. (Cites media authorized for procurement under GSA Contract)

22. Military Specification (Unnumbered). Synthetic Blast Cleaning Media for the Removal of Paint and Surface Contaminants From Military Aircraft and Support Equipment. Not dated.

23. Naval Air Rework Facility, Alameda. Summary of Reports on Plastic Media Blasting, Lab Report #286-016, by A. Viera. Not dated.

24. Naval Air Rework Facility, Alameda. Surface Finish Removal From Advanced Composites Prior to Repair and Refinishing, by H. Panciera. Not dated.

25. Naval Air Rework Facility, Cherry Point. Trip Report Number 057-85, Coating and Removal Systems Conference, by G. L. Arthur. 16 April 1985.

26. Naval Air Rework Facility, Jacksonville. The Study of the Effect of Blasting with Plastic Media on Cracked Aircraft Parts, Lab Report No. 2-84, by R. H. Wheat. 20 July 1984.

27. Naval Air Rework Facility, North Island. Preliminary Report on Plastic Media Paint Stripping From Graphite/Epoxy Surfaces, by Terry Gee, NESO. 19 March 1984.

28. Naval Air Rework Facility, North Island. Preliminary Report on Plastic Media Paint Stripping From Metallic Surfaces, by Doug King, NESO. 23 April 1984.

29. Naval Air Rework Facility, North Island. Status Report on Plastic Media Paint Strip (F-4S) Engineering Report No. 002-85, by Terry Gee and Doug King, NESO. 1985

30. Naval Air Rework Facility, Pensacola. Coating Removal Via Plastic Media Blasting, Laboratory Analysis of Physical Effects on Aircraft Materials, by B. N. Reaves, K. Sanders, D. Knapp and R. McSwain, NESO. 18 July 1984.

31. Naval Air Rework Facility, Pensacola. Laboratory Analysis Report P79-84, Evaluation of Koppers Plastic Blast Cleaning Media, by B. N. Reeves. 16 February 1984. (Enclosure to NAVAIREWORKFAC letter 343/0042/BNR dated 24 February 1984)

32. Naval Air Rework Facility, Pensacola. PMB Workshop, Equipment Status Report. 30 October 1985.

33. Naval Aviation Logistics Center, Patuxent River. OSH Considerations for Design of a Plastic Media Blasting Program for Naval Air Rework Facilities, by John Deloach. 25 October 1985.

34. Ogden Air Logistics Center, Hill Air Force Base, Utah. Industrial Hygiene Evaluation, Bead Blast, Building 223, by Maynard G. Moody, Lt Col, USAF. 10 October 1985. (Internal Report)

35. Ogden Air Logistics Center, Hill Air Force Base, Utah. Mechanical Paint Removal Process - Interim Report on Stripping Paint from the First F-4E Prototype at Hill AFB, Utah on 31 July 1984, by Robert A. Roberts OO/ALC/MABEB. 21 January 1985.

36. Ogden Air Logistics Center, Hill Air Force Base, Utah. Mechanical Paint Removal System - Special Report on Plastic Impact Cleaning Media, by Robert A. Roberts OO-ALC/MABEB. Not dated. (Enclosure to Naval Aviation Logistics Center letter 332C/4800/16491 dated 6 September 1983)

37. Ogden Air Logistics Center, Hill Air Force Base, Utah. Plastic Material Blasting - PMB - Interim Report on Stripping Paint from the Second F-4E Prototype at Hill AFB, Utah on 20 May 1985, by Robert A. Roberts OO-ALC/MABEB. 20 May 1985.

38. Ogden Air Logistics Center, Hill Air Force Base, Utah. PRAM Program Final Report, PRAM Project Paint Stripping of F-4 Aircraft and Component Parts Using Mechanical Methods, Project Number OO-143, by Project Officer Tom Byers. 11 August 1986.

39. Ogden Air Logistics Center, Hill Air Force Base, Utah. Test Coupons for PRAM Project OO-143, Metallurgical Report 2070-70-83, by Fred Seppi, Met Lab/NDT Branch. 21 March 1983.

40. Pauli and Griffin Company. Unsolicited Proposal for "Plastic Reclaimable Abrasive Machines." (PRAM), by Robert B. Dowgin. Not dated.

41. Pioneer Laboratory. Toxicity Reports. 15 June 1985.

42. Plastic Media Team Relationships. Not dated. (Diagram identifying DoD activities involved in PMB)

43. Republic Airlines. "Experimental Process Cuts Painting Time Almost in Half," Republic's OurLine, Volume 2, Number 10, 13 May 1985.

44. Republic Airlines. Various dates. (Various Reports and Data Received from Republic Airlines)

45. Roberts, Robert A. "Paint Removal Through Plastic Bead Blasting - The Sensible Way." 18 February 1985. (SAE Technical Paper Series).

46. Shattuck, Dennis. "Dry Stripping Technique Reduces Preparation Costs," Aero Magazine. February 1986.

47. Union Carbide Corporation Testing and Research Service. Minimum Explosion Concentration and Size Distribution Analysis of IG-251, Report 3-TRS-19/453, by D. R. Lorentz and S. M. Chambers. 2 October 1985. (Purchase Order Number 7255-B)

48. United Airlines. Pauli and Griffin Plastic Media Evaluation MOC, 30-31 July 1985, by Charles Owens. 07 August 1985

49. U.S. Environmental Protection Agency, by Charles H. Darvin and Roger C. Wilmoth, and Acurex Corporation by D. Wolbach and C. McDonald. Comparative Study of the Use of Plastic Media Blasting for Paint Stripping. Not dated. (Marked "For Technical Review Only - Not for Publication")

50. U.S. Plastic and Chemical Corporation. Summary Report and Brochure. Not dated. (Marketing Material for Koppers Blast Cleaning Media)

51. U.S. Plastics and Chemical Corporation (est). Synopsis of Testing Performed by U.S. Military Facilities Evaluating U.S. Plastic and Chemical Corporation Plastic Abrasives. 30 May 1984.

52. Zimmerle, Jerome R. "Paint Stripping By Plastic Media Blasting," The Military Engineer, Number 509, pg. 491. August 1986.

53. Zimmerle, Jerome R. "Safety and Health for Plastic Media Blasting." Techdata Sheet, NAVFAC 71-026, 9057102. Not dated.

Letters

54. Cashdollar, Kenneth L. (Bureau of Mines, Pittsburgh Research Center) letter to C. Pavlik, (Hill AFB), of 20 March 1985. (Explosability Tests of Plastic Media)

55. Chief of Naval Material letter to Chief of Naval Operations, 5100 Ser 04F/4201, of 29 November 1984. Subj: Rationale for making the determination on the stringency of ANSI Z9.4a-1981.

56. Chief of Naval Material letter to Commander, Naval Air Systems Command, 5100 Ser 04F2/4119 of 19 October 1984. Subj: Variance From Organic Abrasive Blasting Standard.

57. DuPont (R.B. Young) letter to Engineering Management Concepts (Chris Oakland), of 18 August 1986. (Data on DuPont abrasives including thermosetting unfilled product)

58. DuPont (R.B. Young) letter to Naval Air Development Center (Ken Clark), of 29 April 1986. (Plastic media data, including hardness vs performance)

59. Fazio, Vic, Member of Congress, letter to Carl Shafer, Director of Environmental Policy, Office of the Assistant Secretary of Defense of 7 November 1984. (Plastic Media Stripping of Aircraft)

60. Naval Air Rework Facility, Alameda. Code 342.1 Internal Memorandums of 10 February 1984 and 22 March 1984. Subj: Progress Reports #1 and #2 on Plastic Media Blasting. (Prepared by H. Panciera)

61. Naval Air Rework Facility, Alameda letter to Naval Aviation Logistics Center, 3963 Ser 64120/( ), of (not dated). Subj: Explosability Hazard of Plastic Media Blasting.

62. Naval Air Rework Facility, Jacksonville (Code 342) memorandum to NAVAIR Engineering Support Officer Code 07, Ser Code 342:RHW:bp of 5 April 1984. Subj: Progress Report on Paint Removal With Plastic Media.

63. Naval Air Rework Facility, North Island. Code 34117 Internal Memorandum of 17 May 1985. Subj: Mechanical Testing Request/Report (Prepared by M.R. Poirier)

64. Naval Air Rework Facility, North Island. Code 610 Internal Memorandum of 27 January 1984. Subj: Composite Compatible Paint Stripping Equipment Procurements.

65. Naval Air Rework Facility, North Island. Code 610C Trip Report Ser 610C/JML:lp of 3 August 1984.

66. Naval Air Rework Facility, Pensacola letter to Naval Air Systems Command, N04790 Ser 342/0103:BNR of 29 August 1984. Subj: Paint Removal by Plastic Media Blasting.

67. Naval Air Rework Facility, Pensacola letter to Naval Air Systems Command 4790 Ser 342/0124:BNR. Subj: NAVAIR Workshop On Paint Removal Using Plastic Media Blasting, 29 and 30 October 1985. (Enclosure is minutes of subject workshop)

68. Naval Air Systems Command letter to Chief of Naval Material, 5100 Ser AIR-09E2/509 of 13 Nov 1984. Subj: Variance From Organic Abrasive Blasting Standard.

69. Naval Air Systems Command letter to Distribution, 4790 Ser AIR-4111C9/515 of 13 June 1984. Subj: Aircraft Paint Removal - Plastic Bead Method, Minutes of April 11, 12 Meeting.

70. Naval Air Systems Command letter to Naval Air Rework Facility, Pensacola, 5100 Ser AIR-09E2/087 of 27 November 1985. Subj: Organic Abrasive Blasting.

71. Naval Air Systems Command letter to Naval Aviation Logistics Center, 5100 Ser AIR-09E2/515 of 14 November 1984. Subj: Organic Abrasive Blasting.

72. Naval Aviation Logistics Center. Code NALC 04 Internal Memorandum of 13 April 1984. Subj: Report on Plastic Media Blasting Meeting at NAVAIR 11 APR-12 APR 84.

73. Naval Construction Battalion Center letter to Engineering Management Concepts Ser L04/MON/AB/jv of 29 April 1986. (Enclosure 1 is Statement of Work: Gathering Data On Plastic Media Blasting)

74. Ogden Air Logistics Center, Hill Air Force Base, Utah. Statement of Work - Removal of Paint from Aircraft with Plastic Media, PRAM Project 00-143, AFLC # 22983-01, by Robert A. Roberts (Project Engineer). 1 November 1983.

75. Pauli and Griffin (Larry Carr) letter to Jerry Zimmerle (NCEL) of 8 January 1986. (PRAM instruction package for dry stripping of military aircraft).

76. Shafer, Carl, Director, Environmental Policy, Office of the Assistant Secretary of Defense letter to Vic Fazio, Member of Congress of 27 November 1984. (Plastic Media Stripping of Aircraft, Potential DoD Savings of $100 million annually)

77. United Airlines (Charles E. Owens) letter to Aviation Equipment Maintenance Magazine (Karl D. Forth) Ser C-00-13-68/56 of 13 August 1985. (Fiberglass substrates, savings in man hours, and recommended applications)

78. USAF Occupational and Environmental Health Laboratory, Brooks AFB, Texas. Abstract - Health Hazard Evaluation for Paint Removal Using Plastic Media Robins AFB, Georgia, by Major Randall C. Ostaat, USAF, BSC. Not dated.

79. U.S. Plastic and Chemical Corporation (George Duhnkrack) letter to Naval Air Station, North Island (Douglas King) of 19 July 1984. (Blast media data package)

80. Zlochower, Isaac (Bureau of Mines, Pittsburgh Research Center) letter to Jerry Zimmerle (NCEL), of 12 August 1986. (Summary of Results, Explosability Testing of Plastic Blast Media)

Brochures

81. Aerolyte Systems. Not dated. (Equipment specifications, fixed installations, system descriptions and applications)

82. Blast*It*All. Not dated. (Equipment specifications, fixed installations, system descriptions and applications)

83. Caber, Inc. Dry Stripping Systems. Not dated. (Equipment specifications)

84. Farr Company. Equipment specifications, and engineering drawings, for Tenkay Aspirated Dust Collection Systems, 1984. (Units sold to Hill AFB)

85. Federal Supply Service (General Services Administrator). Authorized Federal Supply Schedule Pricelist (Catalog) Synthetic Plastic Abrasive Blast Media Effective 19 May 1986 to 18 May 1988.

86. Midway Supply Company. Aircraft Paint Removal. Not dated. (Marketing material on Koppers/US Media)

87. Pauli and Griffin Aeronautical Products Division. PRAM Series Plastic Reclaimable Abrasive Machines Brochures. Not dated.

88. Pauli and Griffin Company Customers for PRAM Systems. 21 April 1986. (Customer list)

89. Schmidt Manufacturing, Inc. The Schmidt Dry Stripping System Portable Units. March 1985. (Brochure)

90. U.S. Plastic and Chemical Corporation (U.S. Technology Corporation). Dry Stripping Media. Not dated. (Brochure)

91. Zero Manufacturing Company. Custom Designed Plastic Media Blast Room. Plant tour and briefing, 13 and 14 May 1986.

APPENDIX A

DATA SEARCH PROCESS DOCUMENTATION
October 1986

CALLS MADE:

PERSON	COMPANY	COMMENTS
6/20/86		
GARY BIGGERS	NEESA	Interested in the study. Installs blasting facilities
ALICE VIERA	NARF-Alameda	Will submit reports listed in summary
WARD DABNEY	United Airlines	Will forward Plastic Media Blasting (PMB) data as soon as it arrives
BILL PETERS	Republic Airlines	Currently using PMB and will prompty forward data available
6/24/86		
JERRY BLAHUT	N.M. Research Institute	Exchanged addresses and discussed ideas and involvement with PMB
7/10/86		
DEAN HANCOCK	Particle Measurement	Established relations and exchanged monitoring ideas
7/11/86		
DAYLE CONRAD	NARF-Norfolk	Stated had no data on PMB
GEORGE DUHNKRACK	U.S. Plastics	A technician will be responding to the request letter
7/14/86		
ANDY DENMARK	N.C. SCI & TECH CTR	Started Data Search
7/15/86		
JOHN BULLINGTON	Corpus Christi Army Depot	Forwarding data in upcoming days
MARK KOGEO	NARF-San Diego	Have no data
ALICE VIERA	NARF-Alameda	Will send the reports before the end of next week
WARD DABNEY	United Airlines	Finishing response to letter dated 5/23/86

CALLS MADE: (continued)

PERSON	COMPANY	COMMENTS
7/15/86		
CAPT. RAY PETERS	Tyndall AFB	No data, but referred New Mexico Research Institute
JERRY BLAHUT	N.M. Research Institute	Will send information
7/16/86		
BRIAN MARSHALL	CH_2M Hill	T.E. Higgins will send data upon return from vacation
KELLEY HOWARD	OSHA	Discussed explosivity of dust
7/17/86		
BRIAN MARSHALL	CH_2M Hill	Provided the NTIS number of their report
8/5/86		
JOHN BULLINGTON	Corpus Cristi Army Depot	Will send data 8/6/86
8/7/86		
KEN CASHDOLLAR	Bureau of Mines	Will send data to Zimmerle in two weeks, 8/21/86
JOHN ULRICH	CAB	Uncooperative. All their information was proprietary
JEFF NELSON	Empire	Submitting company brochures
LARRY HESS	Blast-It-All	Will send company brochures
8/15/86		
ROBERT YOUNG	DuPont	Will send letter
8/19/86		
J.M. LELAND	NARF-North Island	CAB had information on West German Research

LETTERS SENT:

PERSON	COMPANY	COMMENTS
6/23/86		
TOM BYERS	Hill AFB	A Letter was distributed to the
JOHN BULLINGTON	Corpus Christi Army Depot	people listed, informing them a
NORIS REEVES	NARF-Pensacola	data study was being conducted
MARK KOGEO	NARF-San Diego	and would appreciated any infor-
DAYLE CONRAD	NARF-Norfolk	mation concerning PMB

LETTERS SENT: (continued)

PERSON	COMPANY	COMMENTS
6/23/86		
ALICE VIERA	NARF-Alameda	
BILL PETERS	Republic Airlines	
GEORGE DUHNKRACK	U.S. Plastics & Chemical Corporation	
T.E. HIGGINS	CH_2M Hill	
KEN CASHDOLLAR	Bureau of Mines	
RAY PETERS	Air Force Research Ctr	
JOHN DELOACH	Naval Aviation Logistics Center	
6/24/86		
JERRY BLAHUT	N.M. Research Institute	Submitted 6/23/86
7/11/86		
BRUCE THOMPSON	BOEING-Vertol	Submitted 6/23/86
G.L. ARTHUR	NARF-Cherry Point	Submitted 6/23/86

DATA SENT:

PERSON	COMPANY	COMMENTS
7/17/86		
SECRETARY	NTIS	A copy of report by CH_2M Hill was sent

LETTERS RECEIVED:

PERSON	COMPANY	COMMENTS
7/7/86		
BILL PETERS	Republic Airlines	Received various PMB data
7/25/86		
JERRY BLAHUT	N.M. Research Institute	Received data on PMB equipment
ALICE VIERA	NARF-Alameda	Received data listed in summary

DATA RECEIVED:

PERSON	COMPANY	COMMENTS
8/5/86 NTIS	U.S. Dept. of Commerce	Received CH_2M Hill reports
8/11/86 T.R. POTTER	North Carolina	Received list of data found
8/14/86 SCHMIDT MANUFACTURING		Data will be sent
8/15/86 JOHN BULLINGTON	Corpus Christi Army Depot	Copies of reports generated at CCAD,

APPENDIX B

General Applications of Plastic Media

Item	Media Type	Comments
Aircraft Nose Cones	Polyextra 40 psi 20/30	Removes paint down to surface without damage to fiberglass
Aircraft Landing Gear (Heat stressed steel)	Polyplus 50 psi 16/20	Able to remove surface coatings down to anodize without removing anodize
Die Castings (Zinc, aluminum)	Polyplus 50 psi 20/30	Used to remove flash from parts without affecting critical surface dimensions
Aircraft Engine Components (Aluminum, exotic metals)	Polyplus 40 psi 20/30	Used to deburr critical components while maintaining .04 in. tolerance
Actuator Assembly (Magnesium)	Polyplus 40 psi 20/30	Able to clean assembly in 1.5 min. vs standard time of 2.4 hrs. with chemicals; no need to disassemble
Surface Sealants (Polysulfide, teflon dry with film)	Type III 50 psi 16/20	Readily removes various sealants with no damage to substrates
Capacitors (Epoxy encapsulation)	Polyplus 30 psi 20/30	5 to 10 times as effective as agri-media; low breakdown rate; very little dust
Auto Bodies (Fiberglass, Sheet metal)	Polyextra Polyplus	Paint can be blasted off without need to to mask glass, rubber, or chrome surfaces

General Applications of Plastic Media, Continued

Item	Media Type	Comments
Military Aircraft (Aluminum, magnesium, titanium, fiberglass, carbon/graphite composite)	Polyextra Polyplus Type III	Used to remove surface coatings and buildup without damage to substrate; replacement of toxic chemical solvents
Clear Optical Sensors (Epoxy encapsulation)	Polyextra 25 psi 20/30	Only media able to deflash and remove resin bleed without need to mask individual encapsulations
Tire Molds (Aluminum, Steel)	Type III 40 psi 30/40	Able to remove surface buildup without damaging mold surfaces
Computer Housing Panel (Aluminum)	Polyplus 40 psi 30/40	Able to remove thread shavings from drilled holes without causing surface distortion
Helicopter Components (Carbon/Graphite)	Type III 30 psi 30/40	Removes polyurethane paint without marring or removing composite substrate
Hydraulic Connection (Steel)	Polyplus 40 psi 20/30	Removes paint and surface residue without need to disassemble component
Axial Lead Diodes (Epoxy encapsulation)	Polyplus 24 psi	Polyplus: 29,000/hr at 24 psi results in 100 % clean vs Walnut shell: 12,000/hr at 40 psi results in 96% clean
Copper Armature Wires (Polyamide coating)	Polyplus 50 psi 20/30	Able to remove polyamide coating without damage to copper wiring; aluminum oxide caused rapid oxidation to occur

DISTRIBUTION LIST

DTIC Alexandria, VA
GIDEP OIC, Corona, CA
NAVFACENGCOM Code 03, Alexandria, VA
NAVFACENGCOM - CHES DIV. Code FPO-1PL, Washington, DC
NAVFACENGCOM - LANT DIV. Library, Norfolk, VA
NAVFACENGCOM - NORTH DIV. Code 04AL, Philadelphia, PA
NAVFACENGCOM - PAC DIV. Library, Pearl Harbor, HI
NAVFACENGCOM - SOUTH DIV. Library, Charleston, SC
NAVFACENGCOM - WEST DIV. Library (Code 04A2.2), San Bruno, CA
PWC Code 101 (Library), Oakland, CA; Code 123-C, San Diego, CA; Code 420, Great Lakes, IL; Library (Code 134), Pearl Harbor, HI; Library, Guam, Mariana Islands; Library, Norfolk, VA; Library, Pensacola, FL; Library, Yokosuka JA; Tech Library, Subic Bay, RP