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An Investigation Conducted by:
Acurex Corporation
Mountain View, CA 94039

USERS GUIDE FOR THE CONVERSION OF NAVY PAINT SPRAY BOOTH PARTICULATE EMISSION CONTROL SYSTEMS FROM WET TO DRY OPERATION

ABSTRACT This guide provides users with instructions and cost evaluation information for converting the water curtain particulate emission control system currently used on many Navy painting facilities to dry filter operation. Engineering and logistical issues are addressed, and example design plans are provided. Construction and operating permit requirements mandated by regulatory agencies, such as air pollution control districts and fire departments, are discussed. Cost estimates that may be used to perform comprehensive cost evaluation analyses are provided. In addition, sample calculations that illustrate how to use the cost data are included.

NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043

METRIC CONVERSION FACTORS

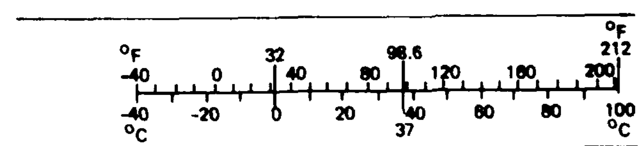
Approximate Conversions to Metric Measures

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

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

Approximate Conversions from Metric Measures

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



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This guide provides users with instructions and cost evaluation information for converting the water curtain particulate emission control system currently used on many Navy painting facilities to dry filter operation. Engineering and logistical issues are addressed, and example design plans are provided. Construction and operating permit requirements mandated by regulatory agencies, such as air pollution control districts and fire departments, are discussed. Cost estimates that may be used to perform comprehensive cost evaluation analyses are provided. In addition, sample calculations that illustrate how to use the cost data are included.

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FOREWORD

This work was jointly sponsored by the Naval Civil Engineering Laboratory and the EPA Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, as part of the Naval Facilities Engineering Command program to minimize the hazardous waste generated by paint spray booths operated by the Navy. The particulate emission control (PEC) devices installed in Navy spray booths, being predominantly of the wet scrubber (water-wall) configuration, are responsible for the production of large amounts of noxious wastewater and gelatinous paint sludge, both forming during the removal of paint overspray aerosol from exhausted booth ventilation air. The feasibility of changing out such PEC equipment with dry filter systems was shown in earlier work. The dry filter system was demonstrated to furnish: (1) equivalent performance against the wet PEC (VOCs are not significantly removed by either configuration), (2) in most cases, complete avoidance of hazardous waste formation, and (3) lower O&M costs and longer booth service life.

Follow-on work consisted of the preparation of the present users guide which is intended to facilitate, at the activity level, wet to dry PEC system conversions. This construction guide-document will thus help promote, in a timely manner, Navy's 1992 goal of reducing by at least 50% the hazardous waste it now generates.

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SUMMARY

USERS GUIDE FOR THE CONVERSION OF NAVY PAINT SPRAY BOOTH PARTICULATE EMISSION CONTROL SYSTEM FROM WET TO DRY OPERATION

Introduction

The water curtain particulate emission control system used on many paint spray booths is a major source of hazardous waste. It is possible to eliminate this waste generation problem by converting the booth to use a dry filter particulate emission control system. Proper conversion requires planning prior to actual facility modification. Planning and preparation requirements for conversion of typical spray booths are discussed in this Users Guide. The Users Guide is designed to address modifications of naval facility spray booths; however, the basic engineering requirements discussed are applicable to other Department of Defense installations, and to commercial industrial facilities.

This Users guide is the result of work sponsored by the United States Navy Civil Engineering Laboratory (NCEL), and the United States Environmental Protection Agency (EPA) Air and Energy Engineering Research Laboratory.

Background

The United States Navy (USN) and the EPA are exploring methods to reduce the quantity of hazardous waste generated from naval and industrial painting facilities. A target of these efforts is an emission control system that uses a water curtain to remove particulate overspray from the booth exhaust.

The large volume of contaminated waste generated by the water curtain particulate emission control system contains paint particles, solvents, and flocculating and coagulating agents. The water must be treated and the hazardous constituents removed before it can be discharged. The sludge material resulting from proper treatment of the waste water is considered a hazardous waste, and requires disposal in a environmentally safe manner. One option to reduce these waste generation problems is to convert the paint booths to dry operation which can result in a number of significant benefits. They include:

- Lower disposal costs
- Lower energy costs
- Less system deterioration due to rusting
- Greater reliability and maintainability
- Improved worker environment

Users Guide Organization

The Users Guide is divided into three parts. Part I discusses the classification and characterization of Navy and similar commercial paint booths. Part II contains step-by-step conversion instructions and a guideline construction work package. Permitting processes and waste disposal issues are also presented in Part II. Part III presents cost estimate data that may be used to perform a conversion. Sample calculations illustrating how the cost data should be used are also provided in Part III.

CONTENTS

CONTENTS (CONCLUDED)

FIGURES

FIGURES (CONCLUDED)

TABLES

TABLES (CONCLUDED)

Table **Page**

METRIC CONVERSION FACTORS

Readers more familiar with the metric system may use the following factors to convert the non-metric units in the report to metric units.

English units	Multiply by	To Obtain
in	2.54	cm
ft	0.305	m
ft^2	0.0929	m^2
ft^3	0.0283	m^3
gal	3.79	liter
hp	0.746	kW
lb	0.454	kg

GLOSSARY OF TERMS

Air Supply Duct(s)	The duct(s) through which fresh make-up air is supplied to the paint booth. The duct(s) are generally equipped with forced draft fans
BACT	Best Available Control Technology
Crossdraft Booth	A booth in which the ventilation air flows horizontally
Discounted Payback Period	Time required to accrue sufficient present value savings to offset the investment cost.
DOHS	Department of Health Services
Downdraft Booth	A booth in which the ventilation air flows vertically
Exhaust Duct(s)	The duct(s) through which contaminated paint booth air is vented to the outside. The duct(s) are generally equipped with induced draft fans
Face Velocity	The linear velocity of air flow through a filter
IWTP	Industrial Waste Treatment Plant
Laydown	Procedures and space allocated for equipment maintenance and/or alteration
NADEP	Naval Aviation Depot
NAVFAC P-442	Naval Facilities Engineering Command P-442 Economic Analysis Handbook
NPV	Net present value
NSPS	New Source Performance Standards: Federal standards that specify pollutant emission control requirements
NSY	Naval Ship Yard
O&M	Operating and Maintenance
Particulate Capacity	The maximum quantity of overspray particulate that a filter retains
Particulate Removal Efficiency	The percent of overspray particulate captured by a filter
PECS	Particulate Emission Control System
Resistance to Airflow	The pressure differential across a filter due to the filter media and the paint overspray particulate collected in the media

SECTION 1

INTRODUCTION

This Users Guide is the culmination of work performed for the United States Navy's Naval Civil Engineering Laboratory (NCEL) under the auspices of the United States Environmental Protection Agency's (EPA's) Air and Energy Engineering Research Laboratory (AEERL). The work was performed under EPA Contract No. 68-02-4285 WA 2/026. This Users Guide presents step-by-step instructions for the conversion of water curtain particulate emission control systems currently used on most Navy paint spray booths to dry filter operation. In addition, cost estimate information is provided for the purposes of performing cost/benefit evaluations for the proposed conversion. The cost/benefit information presented was prepared according to NAVFAC P-442 procedures.

1.1 BACKGROUND

The Navy is currently exploring the possibility of reducing the quantities of hazardous waste generated in many industrial Navy processes. One hazardous waste generating source targeted for waste minimization efforts is the particulate emission control system (PECS) used on nearly every Navy paint spray booth. The most common PECS utilizes a water curtain to remove paint overspray particulate from the booth exhaust.

The large volume of contaminated wastewater generated by the water curtain PECS contains paint particulate, solvents, and in some cases, flocculating and coagulating agents. The wastewater must be treated and the hazardous constituents removed (often at great cost to the generating facility) before it may be discharged to a municipal treatment plant.

The waste minimization option that the Navy is exploring is the replacement of water curtain PECSs with dry filter systems at Navy painting facilities. Dry filter systems are capable of controlling particulate emissions from paint booths with the same high efficiency associated with water curtain systems.

The conversion of PECSs from wet to dry operation will result in a number of benefits, such as:

- Paint booth hazardous waste disposal costs are eliminated or significantly reduced.
- The energy demand for operating dry filter systems is lower than for water curtain systems.
- Unlike water curtain systems, which tend to rust, dry filter systems do not deteriorate with age if properly maintained.

- The reliability, availability and maintainability of dry filter systems are generally as high or higher than those of water curtain systems.

- The working conditions are often greatly improved due to the elimination of water curtain sump odors.

Water curtain systems generate large quantities of contaminated wastewater which, as described previously, must be disposed of as hazardous waste. However, dry filter PECSs generate spent filter media that is caked with paint solids. These spent filters are generally not classified as hazardous waste, and may therefore be disposed of at a municipal landfill. Thus, a significant reduction in operating costs may be achieved in the conversion of PECS from wet to dry operation. The reduction in waste disposal costs, combined with the lower energy requirement of dry filter systems, results in far lower paint booth operating costs.

An additional advantage of dry filter PECSs is that the low pressure drop across the system facilitates the integration of a VOC emission control device at the paint booth exhaust. This is important because increased pressure is being placed on Navy painting facilities by local, state, and federal agencies to significantly reduce VOC emissions. It is important to note that neither water curtain nor dry filter systems are capable of reducing VOC emissions from a paint spray booth.

1.2 OBJECTIVE

The objective of this effort was to provide guidance for the conversion of water curtain PECSs to dry filter operation by producing a Users Guide that may be used by Navy and industrial personnel.

1.3 APPROACH

The production of this Users Guide was accomplished in three phases. Phase I was the classification and characterization of Navy paint spray booths. Phase II was the development of construction work packages for the conversion of two principal types of paint spray booths. Phase III was the development of a cost evaluation strategy that may be used to perform a cost/benefit analysis of the proposed conversion.

To generate a Users Guide applicable to the conversion of all practical sizes and types of Navy paint spray booths, a thorough understanding of painting operations occurring at Navy activities was necessary. This information was obtained by conducting a survey of all painting facilities located on Navy Ship Yard (NSY) and Naval Aviation Depot (NADEP) activities. Based on this information, the Navy paint spray booth population was classified into two general types: crossdraft and downdraft. Conversion strategies for these two categories were then developed. In addition, generalized construction work packages for the two classifications were developed. Finally, cost/benefit analysis information was gathered, and economic analysis calculations were performed.

1.4 USERS GUIDE ORGANIZATION

In Section 2, the Navy paint spray booth survey results are presented. Included in this Section is a discussion of the paint booth classification parameters.

General conversion issues and system design elements relevant to both paint booth categories are addressed in Section 3. Step by step conversion instructions for each category are also presented in Section 3. The instructions are accompanied by guideline construction work packages.

Permitting processes and waste disposal issues are presented and discussed in Section 4. This section includes a discussion of local, state and federal waste disposal regulations and permitting procedures for selected areas, and fire and building permits.

The final section contains tabulations and detailed descriptions of installation and operating costs associated with the conversion of water curtain PECSs to dry filter operation. The data is presented such that the user may easily perform the cost/benefit analysis of a PECS conversion for virtually any booth. Included in the cost/benefit analysis section are three examples that illustrate how an economic evaluation is performed. The examples were selected based on the Navy paint booth survey results, and represent all practical sizes and operations of Navy painting facilities.

SECTION 2

NAVY PAINT BOOTH CHARACTERISTICS

2.1 SURVEY DESCRIPTION

The Navy operates many paint spray booths at NSY and NADEP activities across the United States. For the purposes of this Users Guide, it was necessary to characterize and classify this spectrum of paint booths. To develop the required classification system, a complete survey of the types, quantities, and duty cycles of NSY and NADEP paint booths was performed. The survey was conducted by sending a questionnaire to Navy personnel cognizant of paint shop operations at every NSY and NADEP activity in the United States. A copy of the questionnaire supplied for each booth is presented in Figure 1.

2.2 SURVEY RESULTS

The results of the paint booth survey are presented in Tables 1 and 2. Most of the Navy booths are relatively small crossdraft facilities, although some large downdraft booths are also used.

Based on the survey results and preliminary retrofit design analyses, Navy paint booths were divided into two major categories: crossdraft and downdraft. The motivation for this classification scheme is: (1) retrofit procedures and requirements for crossdraft booths are independent of booth size; and (2) downdraft booth configurations vary significantly, and require a more general discussion. This classification scheme is discussed in more detail in Section 3.

The information presented in Tables 1 and 2 was also used to select representative examples of Navy painting operations for the purpose of developing sample cost/benefit evaluation calculations. For each of these operations, parameters such as duty cycles and wastewater treatment methods were selected based on the results of the paint booth survey. These sample calculations are presented in Section 5.

SURVEY FORM FOR PAINT BOOTHS HAVING WATER CURTAIN SYSTEMS ONLY

Booth location (i.e. building or hangar number)

Approximate booth dimensions (w x l x h) and orientation (i.e. is it completely enclosed, or are one or more sides open?):

This booth is a [crossdraft downdraft] facility (circle one). If a downdraft facility, where are the water sumps located? (i.e. above or below floor level, along the sides of the booth, under the entire floor, etc.)

On average, how many shifts per day is this booth operated?

On average, approximately how much paint is used per week in this booth?

What is a reasonable estimate of the transfer efficiency of the paint application system used in this booth?

Are all the coatings applied in this booth air dried? If not, approximately what percentage of the coatings are not air dried?

Are any chemicals or coagulants added to the sump system in this booth? If so, approximately how much and how often is each chemical added?

Approximately what is the sump volume & how often is the sump drained?

Approximately how much time is required to drain the sump system, muck out the sludge that collects on the sump bottom, and refill the system?

Please describe the wastewater treatment method employed (if any) to process the sump system effluent (i.e. all the water is drummed and shipped as hazardous waste, or the sump water is drained and sent to an IWTP, and the sludge from the sump bottom is drummed and shipped as hazardous waste, etc.).

How many drums of hazardous waste that must be properly disposed of are generated as a result of this treatment method? What is the composition of this waste (i.e. water only, sludge only, sludge + water, etc)

What types of equipment are painted, and what is the average size (i.e. dimensions) of the equipment?

In what Air Quality Management District is this Activity located?

Figure 1. Questionnaire mailed to NSY and NADEP paint booth operators.

TABLE 1. NSY PAINT SPRAY BOOTH SURVEY RESULTS

Activity	Booth Dimension (ft)	Number of Booths	Paint Booth Type	Paint Booth Duty Cycle (shifts/day)	Paint Usage Rate (gal/week)	Paint Curing Method	Sump Maintenance Schedule	Wastewater Treatment Method	Waste Generation Rate (drums/yr•booth)
Charleston NSY	12x14x14	1	Crossdraft	1	20	Air dried	Once/yr	Water & sludge are	15
	14x35x8	1	Crossdraft	1	20	Air dried	Once/yr	drummed & shipped	10
	20x15x20	1	Crossdraft	1	20	Air dried	Once/yr	as haz. waste	34
Long Beach NSY	NI	NI	NI	NI	NI	NI	NI	NI	NI
Mare Island NSY	17x21x3	6	Downdraft	1	3	Air dried	Once/mo	Water drained to	3
	11x16x6.5	1	Crossdraft	1	1	Air dried	Twice/mo	IWTP; sludge is	1
	5x8x6.5	1	Crossdraft	1	1	Air dried	Twice/mo	drummed & shipped	1
	5x8x6.5	1	Crossdraft	1	1	Air dried	Twice/mo	as haz. waste	1
Norfolk NSY	4x20x6.5	4	Crossdraft	2	20	Air dried	Once/yr	Water drained to IWTP;	1
	12x15x8	1	Crossdraft	1	15	Air dried	Once/mo	sludge is haz. waste	2
Pearl Harbor NSY	13X12.5X8.5	1	Crossdraft	1	1	Air dried	1 - 4/mo	Water drained to IWTP;	1
	25x9	1	Crossdraft	1	20	Air dried	Twice/yr	sludge is haz. waste	1
Philadelphia NSY	20x10x8	2	Crossdraft	2	50	Air dried	Once/mo	Wastewater is drained;	24
	10x13x10	2	Crossdraft*	1	4	Air dried	Once/3 mo	sludge is drummed and	2
	15.5x10x8	1	Crossdraft*	1	8	Air dried	Twice/mo	shipped and hazardous	12
	14x18x7.5	1	Crossdraft*	1	5	Air dried	Once/3 mo	waste	<1
Portsmouth NSY	8x10x9	1	Crossdraft*	1	5	Air dried	Weekly	Water drained to sewer sludge is haz. waste	>1+
Puget Sound NSY	6x8x10	1	Crossdraft	1	10	Air dried	Once/yr	Water drained to IWTP;	2
	9x9x10	1	Crossdraft	1	40	Air dried	NI	sludge is drummed &	NI
	10x10x7	1	Crossdraft	1	2	Air dried	Twice/yr	shipped as haz. waste	1
	10x10x8	1	Crossdraft	1	7	Air dried	Once/2 mo	"	1
	16x13x8	1	Crossdraft	1	20	Air dried	Once/3 mo	"	5
	18x12x12	1	Crossdraft	2	20	Air dried	Twice/yr	"	6
	20x60x20	1	Crossdraft	2	75	Air dried	Twice/yr	"	6
Total:		33							91

To convert the english units to metric, conversion factors are presented at the beginning of this document
NI: No Information
* This data determined from additional information supplied by Navy activity
+ Actual sludge generation rate is probably much higher

TABLE 2. NADEP PAINT SPRAY BOOTH SURVEY RESULTS

Activity	Booth Dimension (ft)	Number of Booths	Paint Booth Type	Paint Booth Duty Cycle (shifts/day)	Paint Usage Rate (gal/week)	Paint Curing Method	Sump Maintenance Schedule	Wastewater Treatment Method	Waste Generation Rate (drums/yr•booth)
Alameda NADEP	6.5x10x7	2	Crossdraft*	1	5	Most aired	Twice/yr	Water & sludge are	4
	12.5x14x8	1	Crossdraft*	1	2	Air dried	Once/mo	shipped as haz. waste	13
	13x7.5x7	2	Crossdraft*	1	3	Air dried	Twice/yr	Water is sent to IWTP;	2
	7x16x8	4	Crossdraft*	1	10	Air dried	Twice/yr	sludge is drummed &	2
	12.5x13x8	1	Crossdraft*	1	10	Aired,baked	Once/yr	shipped as haz. waste	3
	9.5x25x6.5	2	Crossdraft*	1	3	Air dried	Once/yr	"	7
	5x48x7	1	Crossdraft*	1	30	Air dried	Twice/yr	"	20
	5x46x7	1	Crossdraft*	1	30	Air dried	Twice/yr	"	20
	15x31.5x15	1	Crossdraft*	1	5-6	Air dried	Once/2 mo	"	10
Cherry Point NADEP	10x20x10	2	Crossdraft	2	20	Air dried	Once/wk	Water drained to IWTP;	24
	20x10.5x10	1	Downdraft	2	70	Air dried	Once/4 mo	sludge is haz. waste	NI
Jacksonville NADEP	9x12x8	2	Crossdraft	2	NI	NI	Twice/yr	Water is sent to IWTP;	NI
	5x8x8	1	Crossdraft	2	NI	NI	Twice/yr	sludge is drummed &	NI
	35x15x30	1	Downdraft	2	NI	NI	Twice/yr	shipped as haz. waste	NI
Norfolk NADEP	7x8x10	1	Crossdraft	1	15+/-	10% Aired	NI	Water is sent to IWTP;	6+/-*
	7x8x12	2	Crossdraft	1	15+/-	10% Aired	NI	sludge is drummed &	6+/-*
	12x8x8	1	Crossdraft	2	20	95% Aired	Once/3 mo	shipped as haz. waste	4
	6x8	1	Crossdraft	1	7	Air dried	Once/3 mo	"	1
	4x12x20	1	Crossdraft*	2	10	10% Aired	Once/3 mo	"	NI
	7x30x12	1	Crossdraft*	2	10	10% Aired	Once/3 mo	"	NI
	12x14x40	1	Crossdraft*	2	10	10% Aired	Once/3 mo	"	NI
	40x75x130	4	Downdraft	2	60-80	Air dried	Once/3 mo	"	32
Pensacola NADEP	8x8x19	1	Downdraft	1	30	Air dried	NI	Water is sent to IWTP;	6+
	8x18x9	1	Downdraft	1	30	Air dried	NI	sludge is drummed &	6+
	4x6x6	1	Crossdraft*	1	30	Air dried	NI	shipped as haz. waste	1+
	9x21x10	1	Crossdraft	1	14	Air dried	Once/6 wks	"	5+
	10x24	1	Crossdraft	1	80	Air dried	Once/6 wks	"	6+
	8x12x8	1	Crossdraft	1	16	Air dried	Once/6 wks	"	1+
	10x54x10	1	Crossdraft	1	16	Air dried	Once/6 wks	"	6+
	10x30x10	1	Crossdraft	1	16	Air dried	Once/6 wks	"	4+
	10x15x15	1	Crossdraft	1	75	Air dried	Once/6 wks	"	6+
	15x24x15	2	Crossdraft	1	80	Air dried	Once/6 wks	"	6+
	50x90X36	1	Downdraft	1	391	Air dried	Once/6 wks	"	10+
San Diego NADEP	14.5x14.5x3	8	Crossdraft	2	3	50% Aired	NI	NI	NI
Total:		54							227

To convert the english units to metric, conversion factors are presented at the beginning of this document
NI: No information
* This data determined from additional information supplied by Navy activity
\+ Actual sludge generation rate is probably much higher

SECTION 3

GUIDELINE CONSTRUCTION WORK PACKAGE

In this section, step by step instructions for converting the water curtain PECS of two types of paint booths is presented. In subsection 3.1, general issues common to both types of paint booths are discussed. In subsections 3.2 and 3.3, step-by-step instructions and information specific to each type of booth are presented.

The two types of water curtain paint spray booths for which retrofit packages are developed are crossdraft and downdraft. These booths are distinguished by the direction in which ventilation air flows through them. For each type of booth, general retrofit requirements are independent of booth size and duty cycle. Thus, construction work packages for these two types of booths are presented without reference to booth size or operations.

In general, the crossdraft booth is the easiest and least expensive booth to convert. It is also the most common water curtain booth operated at Navy activities. For this reason, conversion of the crossdraft type booth is discussed first and perhaps in greater detail than the downdraft type booth.

The operating and waste disposal permits that are required before installation of the dry filter system are not discussed in this section, rather they are presented in detail in Section 4.

3.1 GENERAL CONVERSION ISSUES AND INSTRUCTIONS

The proper conversion of a paint spray booth must take into consideration general system issues, such as the characteristics and applicabilities of dry filter systems available on the market, as well as general design issues, such as the fan size and required dry filter surface area. These issues and system design elements are addressed in this subsection, and will be referred to in subsequent discussions in which specific paint booth conversion instructions are provided.

3.1.1 Dry Filter System Selection

The first step in converting a paint booth PECS from wet to dry operation is to select the appropriate filtration system. There are many types of dry filter PECSs available on the market; depending on the situation, some are more applicable than others. In selecting the appropriate filter system, a number of issues, such as paint booth duty cycles and paint usage rates, must be considered. However, before these issues are discussed, a brief description of the various filter types and characteristics is provided. Further information is provided in Appendix A.

3.1.1.1 Filter Types and Characteristics

There are four principal types of filters currently used: fiberglass cartridges, multilayer honeycombed paper rolls or pads, accordion-pleated paper sheets, and cloth rolls or pads. Qualitative characteristics of each type of filter are summarized in Table 3. The performance of these filter types is characterized by three basic parameters: particulate capacity, resistance to air flow, and particulate removal efficiency. Fiberglass cartridge filters are characterized by low capital equipment and installation costs, reasonable particulate capacities, and high particulate removal efficiencies. Replacement filters are fairly expensive per square foot, and the downtime associated with filter replacement is quite high compared to other systems. Fiberglass cartridge filters are generally installed in crossdraft booths that are used less than one shift per day.

Multilayer honeycombed paper roll type filters are characterized by moderate installation costs, fairly high particulate capacities, and moderate to high particulate removal efficiencies. Replacement costs per square foot are fairly low, and the downtime associated with their replacement is also low. This type of filter may be used in either light, moderate, or high production rate booths. The honeycombed paper filters are also available in pads; however, the downtime associated with pad replacement is fairly high, thus the rolls are recommended.

Cloth filter rolls are characterized by moderate installation costs, high particulate capacities, and relatively high particulate removal efficiencies. Replacement costs per square foot are low, and the downtime associated with their replacement is quite low. These types of filters may be used in either light, moderate, or high production rate booths. The pressure differential across a clean cloth filter is higher than for the other filter types discussed, therefore upgrading of the fan motor may be required if this system is installed. The capital outlay for a replacement motor is generally justified by the savings accrued from the low filter replacement rate.

TABLE 3. DRY FILTER SYSTEM CHARACTERISTICS

	Filter Characteristics			
Filter Type	Particulate Capacity	Removal Efficiency	Cost	Replacement Time
Fiberglass Cartridge	Moderate	High	High	High
Honeycombed Paper	High	High	Low	Low
Cloth	High	High	Low	Low
Pleated Paper	Low	Low	High	Low

Accordion pleated paper filters are characterized by low to moderate installation costs and per square foot replacement costs, moderate capacities, and moderate to low removal efficiencies. The downtime associated with filter replacement is low, thus they may be used in virtually any type of paint spray booth. Despite the fact that the particulate removal efficiency of this type of filter is low, it should adequately control emissions from most Navy paint booths.

For all systems described above, filter replacement is required when the maximum rated pressure differential across the filter face is reached. This maximum rated pressure differential is specified by the manufacturer, and varies from system to system. The differential pressure across the filter should be monitored daily, if not continuously. Filter manufacturers sell manometers that measure the pressure differential across the filter media.

3.1.1.2 Selection Criteria

The critical paint booth operating parameters that must be considered when selecting a dry filter system are:

- The paint booth usage rate (i.e the number of shifts per day the booth is used, and the average amount of time the booth remains inactive).
- The average transfer efficiency of the paint application system (this transfer efficiency is defined as the pounds of paint applied on the workpiece divided by the total pounds of paint used, and is generally reported as a percent. It is a function of the target geometry, the type of coating, and the application method).
- The average quantity of paint used per day.
- The characteristics of the paint used.
- The applicable emission regulations.

The paint booth usage rate should be considered when determining how much downtime may be tolerated for filter replacement. For example, the throughput rate for a booth used less than one shift per day will not be affected by the downtime required to replace filters that take a relatively long time to deploy (such as fiberglass cartridges). However, the throughput rate for a booth operated two shifts per day may be significantly affected by downtime due to filter replacement if such a system were installed. In this case, it would be better to install a cloth or honeycombed paper roll type filter.

The average transfer efficiency and paint usage rate can be combined to determine the paint overspray rate, which defines the rate at which the particulate capacity of the dry filter is reached. This, in turn, determines the filter replacement schedule. Filter systems for booths that are used heavily should have fairly high particulate capacities, (such as the cloth roll filters) despite the fact that capital and installation costs for such systems may be higher. The equation used to calculate the filter replacement is:

$$\begin{bmatrix}\text{Paint Usage}\\ \text{Rate (gal/hr)}\end{bmatrix} \times \begin{bmatrix}1 - \begin{matrix}\text{Transfer}\\ \text{Efficiency}\end{matrix}\end{bmatrix} \times \begin{bmatrix}\begin{matrix}\text{Filter}\\ \text{Capacity}\end{matrix} \ (\text{gal/ft}^2)\end{bmatrix}^{-1} = \begin{matrix}\text{Number of square feet of}\\ \text{filter reaching maximum}\\ \text{capacity per hour}\end{matrix}$$

Paint characteristics are important in determining the compatibility of the paint used with the dry filter system. For example, the particulate size distribution of the paint overspray should be matched with the filter media, otherwise surface clogging or insufficient emission control may result. When the general type of filter system has been selected (i.e., fiberglass cartridge vs. pleated paper) the manufacturers and vendors should be consulted to determine which filter of the type selected is optimal. Many manufacturers will perform tests to determine filter-paint compatibilities, if paint samples are supplied to them.

Emissions regulations must be considered in selecting the appropriate filter system. Issues pertaining to emissions regulations are discussed in more detail in Section 4, and Appendix A. Included in Section 4 is a list of names, addresses and phone numbers of the appropriate regulatory agencies for every NSY and NADEP within the U.S. It is advisable to refer to the local air pollution regulatory agency to ensure compliance with applicable air emission requirements.

3.1.2 General Engineering Design Issues and Instructions

The second step involved in converting a paint booth PECS is to determine the filter surface area required for adequate ventilation and optimal particulate removal. This is a function of the required volumetric flowrate through the booth and the design filter face velocity.

The volumetric flowrate through the booth is calculated by multiplying the linear air flowrate through the booth by the cross-sectional area of the booth perpendicular to the flow. According to Occupational Safety and Health (OSHA) regulations defined in 29 CFR 1910.94, the required design linear air flowrate, or velocity, through a paint spray booth upstream of the object being painted is 100 ft per minute (fpm). For a margin of safety, 125 fpm is generally used as the design criterion. The converted booth must be designed to accommodate this flowrate.

The required filter surface area is obtained by dividing the volumetric flowrate by the design filter face velocity. The design filter face velocity is specified by the manufacturer, and defines the optimal flowrate at which the filter operates to remove particulate. The design filter face velocity varies significantly depending on the type of filter, thus the filter system to be installed must be specified before this calculation is performed.

The next step is to evaluate fan system operation to determine if fan modifications are required. This is done by summing up the total airflow resistance (in inches of water column [inches w.c.] at a given volume flowrate) experienced by the forced draft supply fan(s) in the booth air supply duct(s) and the induced draft fan(s) in the booth exhaust duct(s) Many cross draft booths have only exhaust fan(s), and do not have air supply fan(s). The airflow resistances are due to the presence of the loaded paint filters (generally on the order of 0.5 inches w.c. for all but the cloth type, which ranges from 1 to 2 inches w.c. or more), the exhaust duct work (on the order of 0.5 inches w.c. or more), the water curtain baffle system, inlet air filters, and any other flow obstructions.

After the total fan resistance is calculated, the operating efficiency curve of the supply and exhaust fans currently in place must be consulted to determine whether or not the fan system is capable of delivering the required volume flowrate (as described above). The fans may require some alteration to ensure adequate ventilation. Generally, exhaust duct fan systems require downsizing rather than upgrading, because the flow resistance of a dry filter PECS is often lower than the flow resistance of a water curtain PECS. This results in a lower electricity demand after conversion. However, fan downsizing does not necessarily imply fan replacement.

If it appears a slightly more powerful fan system is required, it is advisable to remove the baffles located in the exhaust plenum of the water curtain PECS prior to installation of the new fan system. These baffles are an integral part of the water curtain PECS because they generate the actual water curtain; however, they contribute a considerable friction loss to the exhaust flow. If the existing fan capacity is slightly low, the removal of the baffles may be all that is required to meet ventilation flowrate requirements. Removal of the baffle system requires more sheet metal work, however. Alternatively, replacement of the fan motor with one of slightly high horsepower is possible, rather than replacement of the entire fan system.

If the induced draft exhaust fan capacity is too high, and replacement is required, removal of the baffles may allow the installation of a fan motor having a lower power rating than would be required if the baffles were not removed. This results in considerable energy savings. The alternative is to install a damper in the exhaust duct upstream of the exhaust fan. However this solution results in unnecessarily high energy usage.

To ensure uniform ventilation in a converted crossdraft booth, the filters must be evenly distributed across the exhaust face. In this way, the air flow through the booth is laminar with few eddy currents. By replacing a water curtain PECS with an evenly distributed, dry filter PECS, ventilation through the booth can be improved, because the air flow into a water curtain PECS is not evenly distributed across the exhaust face.

As with all dry filtration systems, partial blinding of the filter media will occur as the quantity of overspray collected increases. Blinding will occur in those filter sections in front of which frequent painting occurs. However, this should not cause any ventilation problems, provided that these filters are replaced when the maximum design pressure differential across them is reached.

3.1.3 Shutdown/Access/Laydown Arrangements

Shutdown time will vary depending on the type of filter system installed, the type of booth being modified, how extensive the required repairs and modifications are, and the manpower and resources available to carry out the work. For example, a 12 ft by 20 ft booth may be completely modified in 3 to 5 days, provided that little or no sheetmetal repair work is required, there is ample draw from the exhaust fan, and the water curtain baffles do not require removal. However, a 30 ft by 60 ft downdraft facility with significant corrosion damage could take many weeks to renovate, especially if only three or four people are available to perform the required modifications.

There is one rule of thumb available to estimate the amount of time the paint booth will be out of commission. This rule can be applied only if no complications (i.e., fan replacement, rust damage repair, etc.) exist, and the frame only requires attachment. The installation of the filter support frame provided by the filter manufacturer is a relatively small operation, and should average between 8 and 12 hours per 100 ft^2 of filter surface area.

Most sections of the booth requiring modification are accessed within the booth. It is only when excessive corrosion damage to exterior booth walls is present that external access may become necessary. This issue must be considered on a case-by-case basis.

For crossdraft booths, the inside of the booth should suffice for all laydown requirements. The frame supporting the filter system wall may be assembled inside the booth, or may be delivered to the booth fully assembled at the time that the system is to be installed. For the conversion of a downdraft booth, a relatively large area near the booth must be identified for the stockpiling of necessary equipment and material. In addition, a temporary site for the storage of discarded equipment and materials may be required. After the floor grating is covered and sealed, the inside of the booth may be used for all laydown arrangements.

3.2 SPECIFIC INFORMATION AND STEP-BY-STEP INSTRUCTIONS FOR THE CONVERSION OF A CROSSDRAFT PAINT SPRAY BOOTH

3.2.1 General Discussion

The primary feature of the crossdraft booth is that fresh ventilation air passes horizontally through the booth, picking up paint overspray particulate and solvent vapors. The ventilation air is exhausted through a PECS located along the wall opposite the air intake face. A crossdraft booth may be entirely enclosed and equipped with intake air dust filters, or it may be partially enclosed with short sidewalls and a roof section to prevent overspray into adjacent areas. The retrofit requirements for both types are the same, because the volumetric flowrate through the PECS before conversion is the same as after conversion.

3.2.2 Crossdraft System Conversion Procedures

Step 1: Perform Equipment Audit

Prior to selecting a dry filter system or contacting filter vendors, a complete equipment audit must be performed to determine booth system characteristics. Information regarding booth equipment, its condition, and its operating parameters should be obtained in as much detail as possible. The parameters and items of interest are:

- Booth dimensions.
- Booth manufacturer.
- Booth manufacturer specifications and drawings.
- The current condition and structural integrity of booth (i.e., rust damage and fan corrosion).
- Exhaust fan manufacturer.
- Exhaust fan selection curves.
- Exhaust fan horsepower and electrical rating (voltage, AC or DC, phase, amperage, etc.).
- Exhaust fan rating as installed (air flow [in cfm] at what pressure rating [in inches w.c.]).
- The pressure drop (in inches w.c.) across the existing PECS baffle system, both with and without the water scrubber system in operation.
- The measured air flow (in cfm) and measured vacuum (in inches of w.c.) just upstream of the exhaust fan when operating the booth in its present normal mode (doors closed, water curtain on, etc.).

In addition to the equipment audit, site-specific permit issues should be addressed at this time. A discussion of the permit processes that must be considered is provided in Section 4.

Step 2: Select the appropriate dry filter system

Filter system options and selection criteria are discussed in Section 3.1 and Appendix A. After characterizing paint spray booth operations in terms of filter system compatibility, and reviewing information gathered from the relevant permitting agencies, evaluate the criteria discussed in Section 3.1, and select the appropriate dry filter system.

Step 3: Select a filter system supplier

After tentatively selecting one of the four filter types, filter system suppliers should be contacted to discuss merits of each manufacturer's design, installation services, and price. After selecting a supplier, obtain all performance information concerning the filter brand selected, such as particulate loading capacities, recommended face velocities, and the pressure differential across the clean filter.

Many filter manufacturers will perform filter-paint compatibility tests to evaluate particulate removal efficiencies and filter loading capacities. This service should be used after tentative selection of the most applicable filter type.

It is a good idea to contact and/or visit paint booths in which the filter media recommended by the vendor is installed. In this way, filter replacement procedures may be observed, and the downtime associated with filter replacement can be accurately assessed. In addition, a site visit affords the opportunity to obtain information regarding advantages and limitations of the system selected from a source other than the vendor.

Step 4: Design of the retrofit package

After selecting and characterizing the filter system to be installed, the retrofit package must be designed. The information obtained from the filter system vendor must be combined with the equipment audit and permit requirement information collected in previous steps to perform the calculations (for filter surface area and fan sizing) discussed in Section 3.1. Some of the issues and questions that may arise in evaluating the information and performing the calculations are:

- What is the condition of the existing booth? Does it require extensive sheetmetal replacement?
- Is the fan oversized? Can it be easily downsized to reduce operating costs by installing a smaller motor?
- Is the exhaust fan in good condition, and does it have the capacity for the dry filter PECS selected?
- Will the existing baffle system need to be removed?

Based on the evaluation and calculation results, the retrofit package containing equipment lists and explicit directions for the required site modifications must be generated. The package may contain specification drawings that the vendor will use to supply the filter frame system, and construction workers (electricians, sheet metal workers, etc) will use to properly install the system. The package should include any required alterations to the fan system and the booth structure.

Generalized diagrams of the type that may be included in the retrofit package are provided in Figures 2 and 3. Figure 2 illustrates a typical crossdraft water curtain paint booth of unspecified dimensions to be converted. Figure 3 illustrates the same booth retrofit for dry filter operation.

The retrofit package must include directions for constructing a support frame onto which the supplier's filter support unit will mount. This support frame is usually a sheetmetal wall, spanning the booth from wall to wall and from floor to ceiling (although it may not need to be as high as the ceiling). The sheetmetal wall must have one or more rectangular openings in it. The manufacturer's filter support unit will attach across the rectangular opening(s).

The directions in the construction work package should indicate the size of each opening, and attachment points and mounting hardware requirements. It is important to interface closely with the vendor in designing the filter support system, because the vendor has considerable experience in constructing easily installed systems having uniform flow.

Step 5: Installation of the dry filter PECS

Before the dry filter system may be installed, the existing booth must be prepared. Water sumps and piping must be drained, and contaminated water and sludge must be disposed of in a safe and legal manner. It may be necessary to scrape or sandblast portions of the structure to remove excessive paint build-up.

It is good practice to remove all existing piping, pumps and drain lines at this time to prevent their accidental future use. After this general clean-up, the entire booth should be thoroughly inspected for corrosion and other forms of damage. It is possible that previously undetected corrosion damage will be found during this inspection. If necessary, the modifications specified in the retrofit package should be changed to include major repairs to areas severely damaged by rust. Minor rust and corrosion damaged areas should be cleaned and treated with a rust preventative, and small pits or holes covered with a patch.

After the inspection and minor repair work are concluded, the major booth alterations indicated in the specification retrofit package must be performed. These include the replacement of corroded sections with structural steel or sheet metal, removal of baffle systems, fan system modifications, and installation of the filter support frame. When fully refurbished, the external shell of the booth should be as air tight as possible to allow maximum fan and particulate removal efficiency.

This retrofit work may be performed either by the vendor, an outside contractor, or in-house labor. If there is significant corrosion damage to the booth or fans, or if fan and/or fan motor replacement is required, it may be too involved or too costly to have the vendor install the system, thus contractor or in-house labor may be optimal.

All that remains is to install the dry filter PECS. The dry filter system may be installed either by the vendor, contractor, or in-house labor. If in-house or contractor labor is to be used, the filter manufacturer will provide standard installation drawings and instructions for their product.

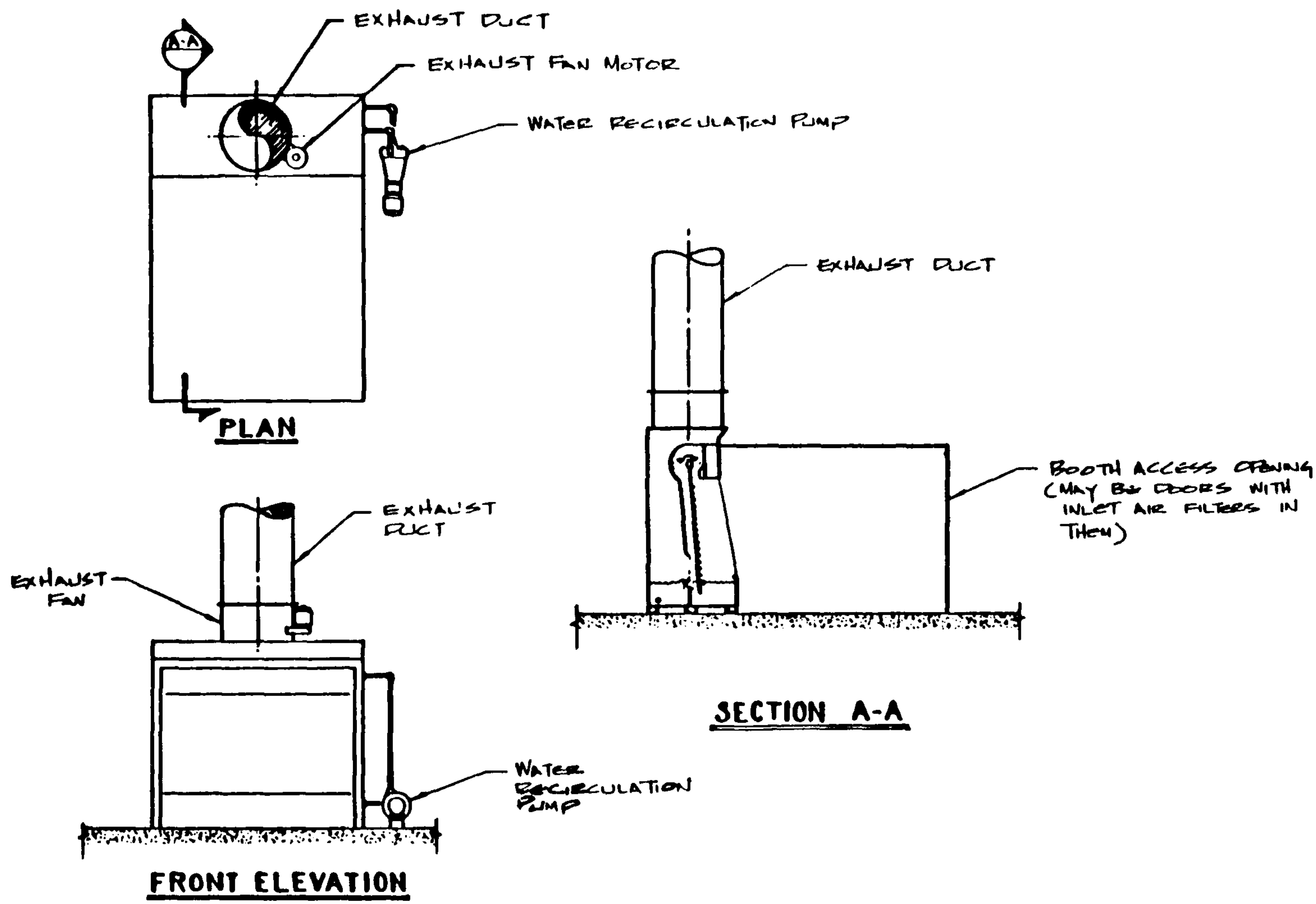

Figure 2. Diagram of a typical crossdraft paint spray booth equipped with a water curtain PECS.

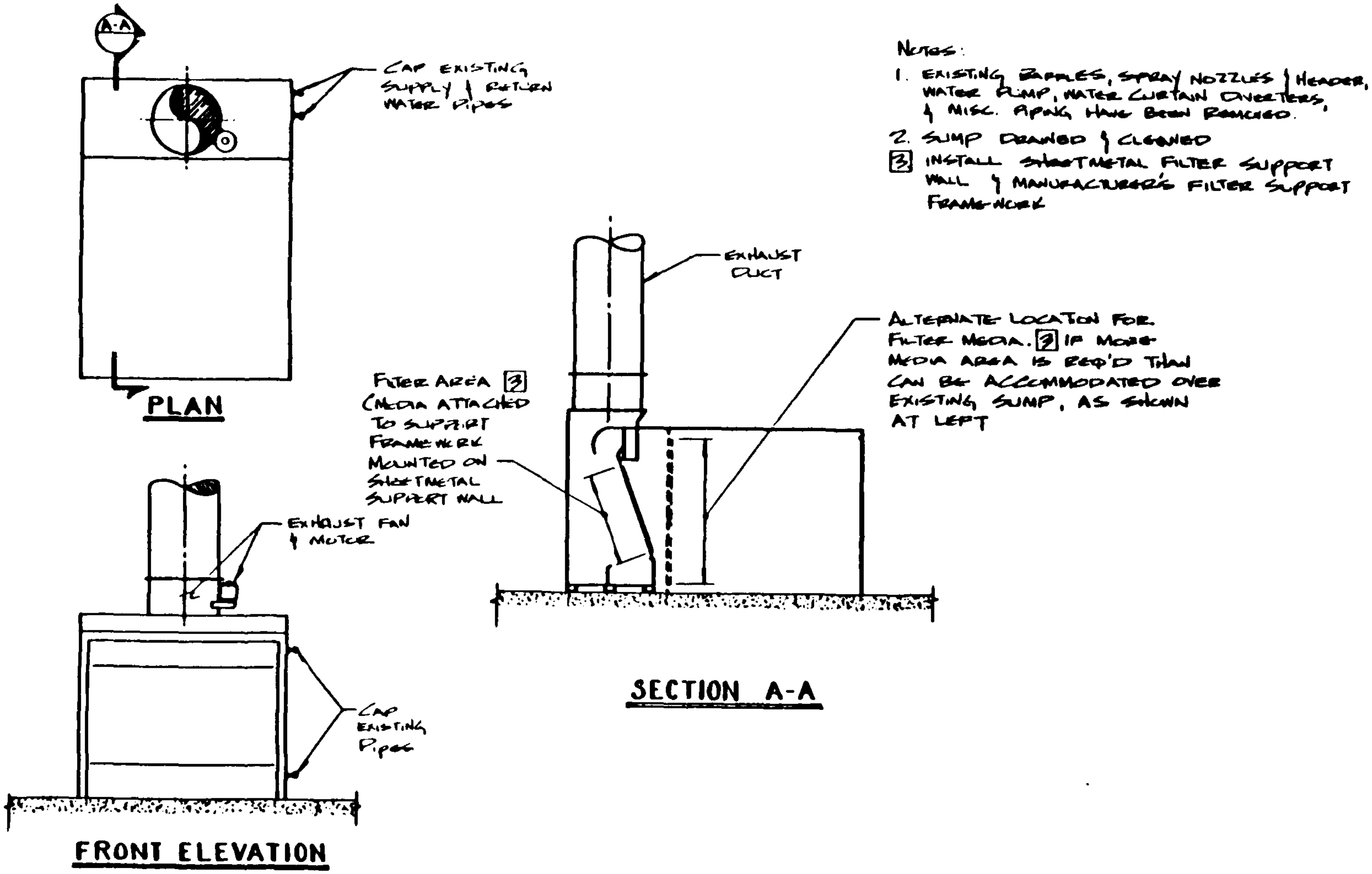

Figure 3. Diagram of a retrofit crossdraft paint spray booth equipped with a dry filter PECS.

3.3 SPECIFIC INFORMATION AND STEP-BY-STEP INSTRUCTIONS FOR THE CONVERSION OF A DOWNDRAFT PAINT SPRAY BOOTH

3.3.1 General Discussion

Downdraft paint spray booths are generally larger than crossdraft booths (often 1700 ft^2 of floor space or more). The primary feature of the downdraft booth is that fresh ventilation air flows vertically downward through the booth picking up paint overspray particulate and solvent vapors. Downdraft booths vary significantly from site to site, however the entire floor surface of the booth is generally a grating through which the ventilation air passes.

The area below the grating is a water sump into which a large portion of the overspray particulate settles. The ventilation air containing the particulate not deposited in the sump is drawn through baffled water spray scrubbers located in the side walls of the booth. Paint particulate is scrubbed from the air, which is then vented outside (note: the scrubber system does not remove solvent vapors).

In general, downdraft booths are entirely enclosed, with intake air dust filters and supply fans mounted on the roof. In addition, exhaust fans are often roof-mounted. Conversion of downdraft booths, while considerably more difficult than crossdraft booths, can be quite cost effective. Conversion of this type of booth must be considered on a case-by-case basis, but certain guidelines apply and will be covered in as much detail as possible.

3.3.2 Downdraft System Conversion Procedures

Step 1: Perform Equipment Audit

Prior to selecting a dry filter system or contacting filter vendors, a complete equipment audit must be performed to determine booth system characteristics. Information regarding booth equipment, its condition, and its operating parameters should be obtained in as much detail as possible. The parameters and items of interest are:

- Booth dimensions.
- Booth equipment manufacturer.
- Does the booth floor consist of a grating over a sump?
- Booth manufacturer specifications and drawings.
- The location of the baffled water spray scrubber system (i.e., on the side of the booth), as well as the accessibility of the system (i.e., is it easily accessed and is it accessed from inside or outside the booth).
- The current condition and structural integrity of the equipment (i.e., rust damage and fan corrosion).
- Supply and exhaust fan manufacturer.
- Supply and exhaust fan horsepower and electrical rating (voltage, AC or DC, phase, amperage, etc.).

- Supply and exhaust fan rating as installed (air flow [in cfm] at what pressure rating [in inches w.c.]).

- Supply and exhaust fan selection curves.

- The pressure drop (in inches w.c.) across the existing PECS baffle system, both with and without the water scrubber system in operation.

- The measured air flow (in cfm) and measured vacuum (in inches w.c.) just upstream of the exhaust fan when operating the booth in its present normal mode (doors closed, water curtain on, etc.).

In addition to the equipment audit, site-specific permit issues should be addressed at this time. A discussion of the permit processes that must be considered is provided in Section 4.

Step 2: Select the appropriate dry filter system

Filter system options and selection criteria are discussed in Section 3.1 and Appendix A. After characterizing paint spray booth operations in terms of filter system compatibility, and reviewing information gathered from the relevant permitting agencies, evaluate the criteria discussed in Section 3.1, and select the appropriate dry filter system.

Step 3: Select a filter system supplier

After tentatively selecting one of the four filter types, filter system suppliers should be contacted to discuss merits of each manufacturer's design, installation services, and price. After selecting a supplier, obtain all performance information concerning the filter brand selected, such as particulate loading capacities, face velocities, and the pressure differential across the clean filter. Filter manufacturers will perform filter-paint compatibility tests to evaluate particulate removal efficiencies and filter loading capacities. This service should be used after tentative selection of the most applicable filter type.

It is a good idea to contact and/or visit paint booths in which the filter media recommended by the vendor is installed. In this way, filter replacement procedures may be observed, and the downtime associated with filter replacement can be accurately assessed. In addition, a site visit affords the opportunity to obtain information regarding advantages and limitations of the system selected from a source other than the vendor.

Step 4: Design of the retrofit package

After selecting and characterizing the filter system to be installed, the retrofit package must be designed. The information obtained from the filter system vendor must be combined with the equipment audit and permit requirement information collected in previous steps to perform the calculations (for filter surface area and fan sizing) discussed in Section 3.1. Some of the issues and questions that may arise in evaluating the information and performing the calculations are:

- What is the condition of the existing booth and equipment? Is extensive sheetmetal work required?

- Are the fans oversized? Can they be easily downsized to reduce operating costs by installing smaller motors?

- Are the supply and exhaust fans in good condition, and do they have the capacities required for the dry filter PECS selected?

Based on the evaluation and calculation results, the retrofit package containing equipment lists and explicit directions for the required site modifications must be generated. The package may contain specification drawings that the vendor will use to supply the filter frame system, and construction workers (electricians, sheet metal workers, etc.) will use to properly install the system. The package should include any required alterations to the fan system and the booth and equipment structures.

Generalized diagrams of the type that may be included in the retrofit package are provided in Figure 4 and 5. Figure 4 illustrates a typical downdraft water curtain paint booth of unspecified dimensions to be converted. Figure 5 illustrates the same booth retrofit for dry filter operation.

Note that the plenum and sump chamber located below the floor grates in Figure 4 have been sealed off in Figure 5 to prevent the possibility of paint booth air escaping into the chamber. If this area is not sealed off, a stagnant zone under the booth floor will develop in which solvent laden air may accumulate. This can result in a potentially explosive environment.

The chamber located under the floor grating should be sealed off in the following manner: steel plates must be welded together over the grating to provide a vapor tight cover over the existing water sump. The plates will be supported by the grating (which will bear their full load), thus the steel plates need not be very thick—1/8 inch should suffice. The plates should extend across the area under the scrubber housings, and be supported from below along the sides of the booth to provide a floor for the dry filter PECS. The plates installed along the sides do not support much load other than the PECS, thus 1/8 inch should suffice. Where the floor plates border walls or equipment, a thorough caulking is advised to prevent the build-up of solvent vapors.

As illustrated in Figure 5, each exhaust plenum structure has three solid walls that are joined to the steel plate floor noted above, and are connected to the exhaust duct. The fourth wall, which faces the booth interior, is actually a door that swings upward in front of the filters to allow easy access during filter replacement. The door ensures that the flowrate through the booth is maintained at 100 fpm in the vicinity and well below the breathing zone of the paint booth operator(s). Furthermore, the filter frame is placed so as to ensure that flow through the filter system is uniform and unobstructed

Unlike crossdraft systems (which have few variations), downdraft systems vary significantly. For example, one type has sumps and grates located only along the sides of the booth. Retrofitting this type of booth requires that only the side grates be covered with welded plates and sealed off. Another type of downdraft booth is equipped with water curtain sumps that are located above ground. For this type of booth, no floor modifications are necessary, however removal of the sumps is required. Despite the differences in floor systems, most, if not all downdraft booths may be equipped with a hinged door to facilitate filter replacement.

The retrofit package must include directions for constructing a support frame onto which the supplier's filter support unit will mount. This support frame is usually a sheetmetal wall, spanning the length of the booth walls from the floor to the required filter height. The sheetmetal wall must have rectangular openings in which to attach the manufacturer's filter support unit.

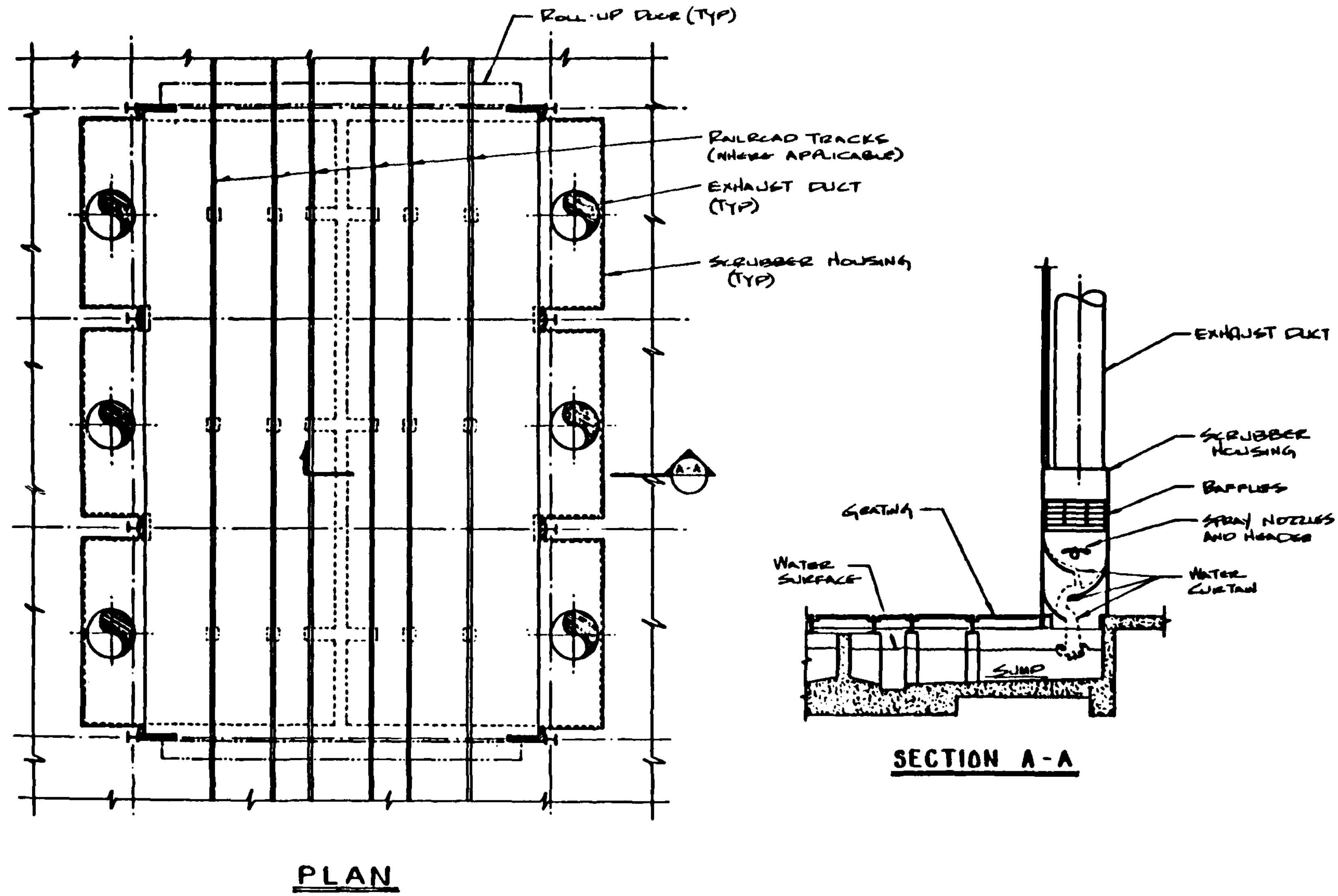

Figure 4. Diagram of a downdraft paint spray booth equipped with a water curtain PECS.

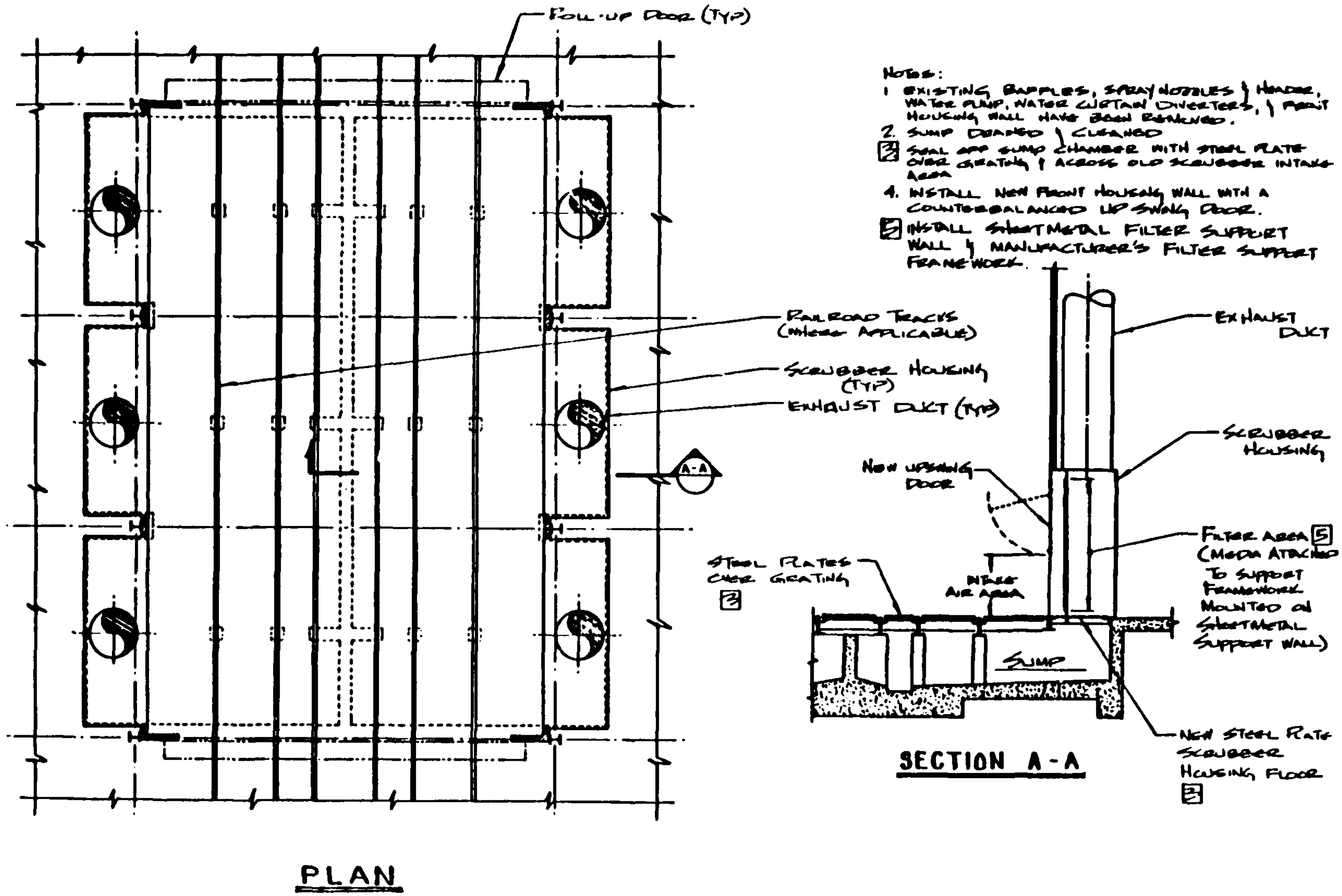

Figure 5. Diagram of a retrofit downdraft paint spray booth equipped with a dry filter PECS.

The directions in the retrofit construction work package should indicate the size of the support frame, attachment points and mounting hardware requirement. It is important to interface closely with the vendor in designing the filter support system, because the vendor has considerable experience in constructing easily installed systems having uniform flow.

Step 5: Installation of the Dry Filter PECS

Before the dry filter system may be installed, the existing booth must be prepared. Water sumps and piping must be drained and contaminated water and sludge must be disposed of in a safe and legal manner. It may be necessary to scrape or sandblast portions of the structure to remove excessive paint build-up. It is good practice to remove all existing piping, pumps and drain lines at this time to prevent their accidental future use.

After this general clean-up, the entire booth, scrubber housing and ductwork should be thoroughly inspected for corrosion and other forms of damage. It is possible that previously undetected corrosion damage will be found during this inspection. If necessary, the modifications specified in the retrofit package should be changed to include major repairs to areas severely damaged by rust.

After this inspection, a decision should be made as to whether portions of the existing baffle and spray scrubber housing can be utilized in the construction of the new system. In addition, all piping, pumps, electrical equipment and water curtain baffles must be removed from the housings. If portions of the existing housings do not fit into the new design, or if they are damaged beyond repair, they must be removed and disposed of. If existing housings are to be reused, minor rust and corrosion damaged areas should be cleaned and treated with a rust preventative, and small pits or holes covered with a patch. Large corroded areas, or areas severely damaged, should be removed and replaced with new structural steel or sheetmetal.

After the inspection and minor repair work are concluded, the major booth alterations as indicated in the specification retrofit package must be performed. These include the filter housing structure retrofit and repair, fan system modifications, installation of the welded floor, and installation of the filter support frame. When fully refurbished, the external shell of the filter housing should be as air tight as possible to allow maximum fan and particulate removal efficiency.

This work may be performed either by the vendor, an outside contractor, or in-house labor. If there is significant corrosion damage to the filter housing or fans, or if fan and/or fan motor replacement is required, it may be too involved or too costly to have the vendor install the system, thus contractor or in-house labor may be optimal.

All that remains is to install the dry filter PECS. The dry filter system may be installed either by the vendor, contractor, or in-house labor. If in-house or contractor labor is to be used, the filter manufacturer will provide standard installation drawings and instructions for their product.

SECTION 4

PERMITTING PROCESSES

There are several permits from local, state and federal agencies that may be required prior to paint booth modification. The types of permits generally required concern air emissions from the booth, building, fire and safety codes, and waste disposal regulations. Each of these topics are discussed fully in this section.

4.1 AIR EMISSIONS REGULATORY AGENCY PERMIT PROCEDURES AND INFORMATION

4.1.1 Permitting Procedures

In general, when a paint booth is modified in some way, a modification permit or permission to construct the modifications must be obtained from the appropriate air emissions regulatory agency. However, permitting processes for paint spray booth modifications vary significantly from state to state, as well as district to district.

For example, in the State of Hawaii, paint spraying operations that utilize an enclosed paint booth are exempt from the air pollution permit system (provided that the booth is not part of a major stationary source, or subject to Federal New Source Performance Standards [NSPS]). Thus, a permit may not required for the modifications outlined in this Users Guide, although the State of Hawaii Department of Health should be informed. However, paint booth operators in the Los Angeles area are required to submit a Permit to Construct application, as well as a Spray Booth Summary form to operate a modified paint booth.

It is the responsibility of the Navy activity to contact the appropriate regulatory agency, and determine whether or not a modification permit is required. A list of appropriate regulatory agencies is provided in the following subsection.

Whenever a paint booth modification is being considered, it is best to inform the appropriate regulatory agency well in advance of any modifications. In addition, if a permit application is required, it should be submitted and approval obtained before modifications are installed. Generally, operating permits for modified spray booths need only be obtained from one air emissions regulatory agency, thus multiple permits from local, state and federal agencies are not required.

The primary concern of the regulatory agency issuing the modification permit is whether or not the modifications will cause an increase in particulate or organic air emissions. The particulate removal efficiencies of dry filter PECSs are as high or higher than those for water curtain systems. Furthermore, neither system is capable of controlling VOC emissions. Thus, it is important to stress on the application that the proposed paint booth modifications will not result in an increase in emissions from the booth.

The information presented in this section is based on the assumption that the paint booth targeted for modification is already permitted for operation with a water curtain PECS, thus only a permit for modification is required. This distinction is critical, because if the booth is not permitted (and the regulatory agency does not know of its existence), then considerable effort may be required to obtain an operating permit.

If the booth requires an operating permit from the appropriate air emissions regulatory agency, but does not yet have one, it is advisable to terminate booth operations, and contact the agency immediately. The booth operator will probably be allowed to complete the modifications prior to submitting an operations permit application. Please note, this statement is applicable only to booth operators that have not yet obtained a required operating permit from an air emissions regulatory agency. In regard to unpermitted booths, be aware of the fact that many regulatory agencies require that all painting (and probably booth modification) activities cease in unpermitted booths until operating permits have been obtained.

The information requested in modification permit applications is generally concerned with the location of the paint booth, the quantity of paint used per day, the VOC content of the paint used, the workpieces to be coated, the type of PECS in place, etc. The information supplied on the modification permit application should be the same as the information supplied in the original permit application already on file at the agency, with the exception of the PECS modification.

The focus of this section is only on permitting processes involved with converting PECSs from wet to dry operation. Some air emission regulatory agencies currently consider requiring the use of best available control technologies (BACT) to control VOC emissions from paint booths. This action is generally being considered as applicable to new sources (i.e. nonpermitted paint booths), and booth modifications that result in an increase in VOC emissions. Fortunately, the conversion of PECSs from wet to dry operation does not fall into this category. The status of permitted booths may change in the future. This Users Guide does not address permitting issues and procedures involved in complying with BACT requirements for the control of VOC emissions. Such an analysis is extremely complicated and out of the scope of this project.

4.1.2 Air Emissions Regulatory Agency Information for NSYs and NADEPs Located in the United States

The appropriate regulatory agencies that should be contacted for procedural advice and permit applications are given in this section for all the NSYs and NADEPs in the United States. The addresses and telephone numbers included in this section are valid as of September 1, 1989.

In general, the staff members of these agencies are easily contacted for advice and information by telephone or in writing. This service should be taken advantage of for a variety of reasons. For example, the permit process can be greatly simplified by knowing all the factors and requirements involved. In addition, if it is perceived by the regulating agency that the facility requesting the permit is willingly giving information, the agency may be more inclined to expedite the permit application process.

Military Activity	Air Emissions Regulatory Agency
Pearl Harbor NSY Pearl Harbor, HI	State of Hawaii Department of Health Environmental Permits Branch P.O. Box 3378 Honolulu, HI 96801 (808) 548-6410
Alameda NADEP Alameda, CA Mare Island NSY Mare Island, CA	Bay Area Air Quality Management District 939 Ellis Street San Francisco, CA 94109 (415) 771-6000
Long Beach NSY Long Beach, CA	South Coast Air Quality Management District 9150 Flair Drive El Monte, CA 91731 (818) 572-6200
North Island NADEP San Diego, CA	San Diego County Air Pollution Control District 9150 Chesapeake Dr San Diego, CA 92123-1095 (619) 694-3307
Puget Sound NSY Bremerton, WA	Puget Sound Air Pollution Control Agency 200 West Mercer Street, Room 205 Seattle WA 98119 (206) 296-7330
Pensacola NADEP Pensacola, FL	State of Florida Department of Environmental Regulation Northwest District 160 Governmental Center Pensacola, FL 32501-5794 (904) 436-8300
Jacksonville NADEP Jacksonville, FL	Bio-Environmental Services Division Dept. of Air & Water Pollution Control 421 West Church Street, Suite 412 Jacksonville, FL 32202 (904) 630-3210

Cherry Point NADEP Cherry Point, NC	Department of Natural Resources Division of Environmental Management 1424 Carolina Avenue Farish Building Washington, NC 27889 (919) 946-6481
Charleston NSY Charleston, SC	Department of Air Pollution Control Trident District 2470 Air Park Road North Charleston, SC 29418 (803) 554-5533
Norfolk NSY Norfolk, VA Norfolk NADEP Norfolk, VA	Department of Air Pollution Control Region 6 2010 Old Greenbriar Road, Suite A Chesapeake, VA 23320-2168 (804) 424-6707
Philadelphia NSY Philadelphia PA	Department of Environmental Resources Bureau of Air Quality Control 1875 New Hope Street Norristown. PA 19401 (215) 270-1920
Portsmouth NSY Kitterey, ME	Department of Environmental Protection Bureau of Air Quality Control State House, Station 17 Augusta, ME 04333 (207) 289-2437

4.1.3 Paint Booth Modification Permit Application Processes in Two Target Areas

Paint booth modification permit application processes vary significantly across the country. Because it is not feasible to evaluate the permit application process for every NSY and NADEP activity, two representative areas have been selected for in-depth evaluation. The two areas selected are: Long Beach, CA, which is under the jurisdiction of the South Coast Air Quality Management District (SCAQMD), and Norfolk VA, which is under the jurisdiction of Region VI of the Commonwealth of Virginia, State Air Pollution Control Board (SAPCB). Descriptions of the permit procedures required in these two areas, as well as copies of the required permit applications, are provided.

Case 1: SCAQMD Paint Booth Modification Permit Procedures

The Los Angeles area was selected because it has one of the most stringent permitting processes in the country. For modifications of paint booths that are already permitted to operate in the Los Angeles Area, the SCAQMD requires that Form 400A (Application for

Permit to Construct) be submitted. In addition, supplemental information requested in Form 400-C-1 (Paint Booth Summary) must be included with Form 400A. Instructions for the completion of Form 400A is provided in Form 400B. Copies of these forms are provided in Figures 6 through 11.

A $250.00 filing fee must be included with each application. In addition, a permit evaluation fee will be levied on the permit requestor. The fee amount varies, and normally depends on the electric power capacity (hp) of the fans in the converted system. Normally, the electrical capacity of the water pumps would be included in this calculation, however the water pumps will not be present in the converted system.

In addition to these forms, the SCAQMD requires that modification plans, specifications and drawings be submitted in duplicate. Equipment location drawings are required that indicate property locations related to streets and adjacent properties, exhaust stack locations and discharge directions. In addition, paint booth locations on the property must be indicated, as well as their relationships to all adjacent buildings and parking lots within 300 feet not located on the property.

Detailed booth drawings are also required in which booth dimensions, size and shapes of booth openings, and sizes and locations of booth vents and fans are indicated. Detailed information concerning the air pollution control equipment must also be furnished. Structural design calculations and details are not required. If standard equipment is installed, the manufacturers catalog describing the air pollution control equipment may be submitted to fulfill this requirement.

It should be noted that most or all of the information requested should have already been supplied to the SCAQMD to obtain the original operating permit. Thus, assuming that the paint booth operator has a copy of the original permit application, most of the work required to complete the application has been done. The only additional effort involves updating the PECS description and facility diagrams.

The SCAQMD evaluates permit applications for paint booth modifications based on compliance with Rule 481. This rule stipulates:

(a) A person shall not use or operate any spray painting or spray coating equipment unless one of the following conditions is met:

(1) The spray coating equipment is used inside a controlled enclosure which is approved by the Executive Officer. Any control enclosure for which an application for permit for new construction, alteration, or change of ownership or location is submitted after the date of adoption of this rule shall be exhausted only through filters at a design face velocity not less than 100 ft per minute nor greater than 300 ft per minute, or through a water wash system designed to be equally effective for the purposes of air pollution control.

(2) Coatings are applied with electrostatic and/or airless spray equipment.

(3) A method of application or control is used which has an effectiveness equal to or greater than the equipment specified in subsection (a)(1) or (a)(2) of this rule.

Section (b) discusses painting operations that are exempt from this rule. Navy painting operations do not come under any of the listed categories.

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
9150 Flair Drive El Monte, CA 91731
APPLICATION FOR PERMIT TO CONSTRUCT AND PERMIT TO OPERATE AND EXCAVATE AND FOR PLANS REQUIRED BY THE EXECUTIVE OFFICER

CO.ID. ______
IF YOU HAVE AN EXISTING PERMIT ENTER ID NUMBER IF NO PERMIT LEAVE BLANK

FOR FEE INFORMATION AND SMALL BUSINESS EXEMPTION SEE REVERSE SIDE

PLEASE TYPE OR PRINT

SCAQMD USE: SEC | TS | ID NUMBER (FOR NEW CO. ONLY)

1A PERMIT TO BE ISSUED TO
BUSINESS LICENSE NAME OF ORGANIZATION THAT IS TO RECEIVE PERMIT

1B
NAME (OR NAMES) OF OWNER OR PRINCIPAL PARTNERS DOING BUSINESS AS (DBA) ABOVE ORGANIZATION

2A MAILING ADDRESS
NUMBER STREET CITY OR COMMUNITY STATE
2B ZIP CODE

3A EQUIPMENT LOCATION (IF SAME ENTER "SAME")
NUMBER STREET CITY OR COMMUNITY ZIP
3B NEAREST INTERSECTING STREET

4A CONTACT PERSON (INITIAL & NAME)
4B CONTACT PHONE NO. (AREA & NO.) (   )

5 APPLICATION IS HEREBY MADE FOR PERMIT TO OPERATE THE FOLLOWING EQUIPMENT

6 IF THIS EQUIPMENT HAD A PREVIOUS WRITTEN PERMIT STATE NAME OF CORPORATION COMPANY OR INDIVIDUAL OWNER THAT OPERATED THIS EQUIPMENT AND STATE PREVIOUS AIR POLLUTION CONTROL DISTRICT PERMIT NUMBER
NAME PREVIOUS PERMIT NUMBER

7 PERMIT APPLICATION FOR EQUIPMENT
NEW CONSTRUCTION ☐
ALTERATION ☐
CHANGE OF LOCATION ☐
REINSTATE NON-PAYMENT P/O FEES DUE ☐
CHANGE OF OWNERSHIP ☐
EXISTING EQUIPMENT IN OPERATION WITHOUT PRIOR PERMIT ☐
CHANGE OF CONDITIONS ☐

8 TYPE OF ORGANIZATION
CORPORATION ☐
PARTNERSHIP ☐
INDIVIDUAL OWNER ☐
LOCAL GOV'T AGENCY ☐
STATE AGENCY ☐
FEDERAL AGENCY ☐
UTILITY ☐

9 ESTIMATED COST OF EQUIPMENT OR ALTERATION
BASIC EQUIPMENT $ ______ AIR POLLUTION CONTROL EQUIPMENT $ ______

10 FOR THE NEW CONSTRUCTION ALTERATION TRANSFER OF OWNERSHIP OR LOCATION WHAT IS
ESTIMATED STARTING DATE? ______ ESTIMATED COMPLETION DATE? ______

11 GENERAL NATURE OF BUSINESS
12 PRINCIPAL PRODUCT

13 DO YOU CLAIM CONFIDENTIALITY OF DATA?
YES ☐ NO ☐
IF YES STATE NATURE OF DATA ON SEPARATE SHEET

14 NORMAL OPERATING HOURS OF SUBJECT EQUIPMENT
HOURS/DAY ______
DAYS/WEEK ______
WEEKS/YEAR ______

15 HAS A CEQA DOCUMENT BEEN PREPARED FOR THIS PROJECT? YES ☐ NO ☐
15A ARE ALL COMPANIES FACILITIES IN CALIFORNIA IN COMPLIANCE WITH AIR POLLUTION RULES? YES ☐ NO ☐

16 SIGNATURE OF RESPONSIBLE MEMBER OF ORGANIZATION
17 OFFICIAL TITLE OF SIGNER

18 TYPED OR PRINTED NAME OF SIGNER
19 PHONE NO
20 DATE

SCAQMD USE
SIC NO | EQUIP CAT NO _ _ _ _ _ _/_ _ | SCH/STP
APPLICATION NO | PERMIT NO | TYPE B OR C | WORK UNITS A/C P/O | ASSIGNMENT UNIT ENGR | CLASS I III IV
VALIDATION | FILING FEE $ | CHECK OR MONEY ORDER NUMBER

Form 400A PRIOR VERSIONS NOT VALID (Continued on Reverse)

SEE REVERSE FOR FEES REQUIRED UPON FILING

Figure 6. SCAQMD Paint Spray Booth Permit Form 400A (Front).

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Filing Fees

Except as noted following, a $250 filing fee must accompany each application for Permit to Construct/Operate

1. For small businesses the filing fee is $160. The small business declaration form below must be completed in order to be considered a small business
2. Each application for change of ownership requires a $110 transfer fee.
3. All applicants, including state, local governmental and public districts, must pay a permit evaluation fee. Such fees are in addition to filing fees and change of ownership fees.

SEE APPLICATION INSTRUCTIONS FORM 400-B FOR ADDITIONAL INSTRUCTIONS
Call (818) 572-6212 for assistance
SUPPLEMENTAL DATA FORMS REQUIRED

Special supplemental data forms must be completed for. BOILERS, LIQUID HEATERS, DEGREASERS, DRY CLEANING EQUIPMENT, OVENS, SPRAY BOOTHS, STORAGE TANKS, ABRASIVE BLASTING OPERATION and PRINTING and DRYING SYSTEM

MAKE CHECK PAYABLE TO "SOUTH COAST AQMD"
MAIL APPLICATION TO SOUTH COAST AQMD
9150 Flair Drive
El Monte, CA 91731

SMALL BUSINESS DECLARATION

In order to be considered a small business as specified in Regulation XIII, this form must be completed. *If not a small business, do not complete this form*

A "Small Business" is a business which is independently owned and operated and meets the following criteria, or if affiliated with another concern the combined activities of both concerns shall meet these criteria:

The number of employees is 10 or less; and
the total gross annual receipts are $500,000.00 or less

I hereby certify, under penalty of perjury, that the business enterprise containing the emission source(s) for which an SCAQMD Permit to Construct or Permit to Operate is being applied herein qualifies as a SMALL BUSINESS based on compliance with the definition above

Signature of Applicant	Date	Telephone Number

Printed or Typed Signature	Company Name

State law requires that we inform you about the Office of Permit Assistance. The Office of Permit Assistance is a state agency which is available to assist you and provide information relating to the permit approval process at the state and local level. Call (916)322-4245 for information

89399 01 Revised 5/89

Figure 7. SCAQMD Paint Spray Booth Permit Form 400A (Back).

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
SPRAY BOOTH SUMMARY

(SEE OTHER SIDE FOR INSTRUCTIONS)

ONE COPY OF THIS FORM MUST BE FILLED OUT COMPLETELY FOR EACH BOOTH AND MUST ACCOMPANY THE APPLICATION FOR PERMIT, FORM 400-A.

1 BUSINESS LICENSE NAME OF CORPORATION, COMPANY, INDIVIDUAL OWNER OR GOVERNMENTAL AGENCY UNDER WHICH APPLICATION (FORM 400-A) IS SUBMITTED

2 BOOTH MANUFACTURER, MODEL NUMBER & SERIAL NUMBER (SEE ITEM 2 ON REVERSE SIDE)

3 BOOTH TYPE AND OUTSIDE DIMENSIONS AUTOMOTIVE ☐ FLOOR ☐ BENCH ☐
CONVEYORIZED YES ☐ NO ☐ WIDTH X ______ LENGTH X ______ HEIGHT ______

4 EXHAUST FAN DATA
MANUFACTURER ______ NO OF FANS ______ FAN HP ______ FAN DIAMETER ______ NO OF FAN BLADES ______

5 EXHAUST CONTROL
EXHAUST FILTERS ☐ NO OF FILTERS ______ SIZE OF EACH FILTER ______ WIDTH X ______ LENGTH X ______ THICK ______
WATERWASH ☐ PUMP HP ______ PUMP CAPACITY IN GALLONS/MIN ______
OTHER ☐ ______
MANOMETER OR DRAFT GAUGE INSTALLED YES ☐ NO ☐

6 PLANT LOCATION
RESIDENTIAL ☐ RESIDENTIAL - COMMERCIAL ☐ COMMERCIAL ☐ COMMERCIAL - INDUSTRIAL ☐ INDUSTRIAL ☐
DISTANCE OF EXHAUST TO PROPERTY LINE ______ FT

7 ARTICLE SPRAYED
AUTOMOBILE ☐ METAL ☐ PLASTIC ☐ WOOD ☐ OTHER ☐ ______

8 METHOD OF APPLICATION a ☐ AIR ATOMIZATION b ☐ PRESSURE ATOMIZATION (AIRLESS) c ☐ COMBINED AIR AND AIRLESS
d ☐ HVLP (HIGH VOLUME LOW-PRESSURE) e ELECTROSTATIC 1 ☐ AUTOMATIC 2 ☐ AIR 3 ☐ DISC 4 ☐ MANUAL
5 ☐ AIRLESS f ☐ OTHER ______

9 DISPOSITION OF SPRAYED ITEMS
AIR DRIED ☐ OVEN DRIED OR BAKED ☐
LENGTH OF TIME IN MINUTES BETWEEN COATING AND BAKING
MAX TIME ______ MIN TIME ______ AVG TIME ______

10 IDENTIFY ALL COATINGS AND SOLVENTS APPLIED IN THIS BOOTH

*TYPE OF COATING AND SOLVENT	VOLATILE ORGANIC COMPOUNDS (VOC), LB/GAL OR GRAM/LITER	AVG AMOUNT USED IN ONE DAY GALLONS
ENAMEL		
LACQUER		
STAIN		
HI SOLID		
WATER BORNE		
POWDER		
ADDED THINNER		
CLEAN-UP SOLVENT		
SURFACE PREPARATION SOLUTION		
OTHER ______		

MAXIMUM AMOUNT OF COATINGS(S) USED IN THIS EQUIPMENT IN ANY ONE DAY= GALLONS
MAXIMUM AMOUNT OF CLEAN-UP SOLVENT USED IN THIS EQUIPMENT IN ANY ONE DAY= GALLONS
MATERIAL SAFETY DATA SHEETS (MSDS) FOR ALL COATINGS AND SOLVENTS MUST BE INCLUDED. MSDS MUST INCLUDE PERCENTAGES OF ALL COMPONENTS IN THE COATING(S)

SIGNATURE OF RESPONSIBLE PERSON	NAME	TITLE
	TYPED	DATE

FORM 400 C 1 Rev. 11 88

Figure 8. SCAQMD Paint Spray Booth Permit Form 400-C-1 (Front).

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
APPLICATION INSTRUCTIONS FOR SPRAY BOOTHS

FILL OUT REVERSE SIDE AND RETURN WITH YOUR APPLICATION, FORM 400-A

The proper filing fee, as indicated on Form 400-A, Application For Permit To Construct and Permit To Operate, must accompany each application. Checks or money orders should be made payable to the South Coast Air Quality Management District.

With each application for permit to construct and permit to operate any type of spray booth, the following data, specifications, plans and drawings must be submitted.

1 EQUIPMENT LOCATION DRAWING. The drawing or sketch submitted must be to scale (suggested scale 1 inch = 100 feet, accuracy of measurements to the nearest 5 feet will be satisfactory) and must show at least the following:
   a The property involved and outlines and heights of all buildings on it. Identify property lines plainly.
   b Location and identification of the spray booth on the property, showing vent or stack.
   c Location of the property with respect to streets and all adjacent properties. Identify adjacent properties. Show location of all buildings and automobile parking lots outside the property that are within 350 feet of the booth. Identify all such buildings (as residence, apartment house, machine shop, warehouse, etc.), specifying height of each building (number of stories). Identify parking lots. Indicate direction (north) on the drawing. Show booth stack and indicate direction of discharge.

2 DRAWING OF BOOTH. (See NOTE below.) Supply an assembly drawing, dimensioned and to scale, in plan, elevation and as many sections as are needed to show clearly the following:

   a Over-all width, height and length of the booth.
   b Size and shape of openings or doors.
   c Size and location of vents and fan.
   d Details of any additional air pollution control device. Show as many detail drawings as are needed to indicate clearly how the control device operates, showing particularly the path of the air through the control section. If water is used, state the amount of water sprayed (gallons per minute), number of spray heads and the amount of chemical additive used in the water (if any), naming the chemical used.

3 Composition of all coatings and thinners used must be provided in sufficient detail to show the status of this booth relative to Rule 442. It is the applicant's responsibility to supply this information with the application for authority to construct and permit to operate or insure that it is submitted by the coatings and thinner suppliers directly to the Air Quality Management District. In either case, assurance is given that the information will remain confidential.

4 STACK/EXHAUST EMISSIONS DATA

   a Mass emissions rate and stack concentration of air pollutants
   b Stack diameter
   c Stack height above ground level
   d Exhaust temperature
   e. Exhaust velocity
   f. Exhaust flow rate (volumetric)
   g Buildings whose wakes may affect the plumes of the stack
   h Dimensions of the buildings identified above
   i Maximum concentration of air pollutants for any averaging times of concern and any receptors of concern

NOTE: Structural design calculations and details are not required. When standard commercial equipment is to be installed, the manufacturer's catalog describing the equipment may be submitted in lieu of the parts of Item 2 that it covers. All information required above that the catalog does not contain must be submitted by the applicant. ADDITIONAL INFORMATION MAY BE REQUIRED.

After permit to construct or to install is granted for any equipment, deviations from the approved plans are not permissible without first securing additional approval for the changes from the Engineering Division.

Further information or clarification concerning permits can be obtained by writing or calling the Permit Application Receiving Unit Headquarters: 9150 Flair Drive, El Monte, CA 91731, (818) 572-6212, or Colton: 1280 Cooley Drive, Suite C, Colton, CA 92324, (714) 877-4677.

Form 400-C-1 *(Continued on reverse side)* 11/88

Figure 9. SCAQMD Paint Spray Booth Permit Form 400-C-1 (Back).

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
GENERAL INFORMATION FOR FORM 400-A
APPLICATION FOR PERMIT TO CONSTRUCT AND PERMIT TO OPERATE

A Use one application Form 400-A for each permit unit of basic equipment and one application Form 400-A for each permit unit of air pollution control equipment. Call (818) 572-6212 for assistance.

B Except as noted following, every applicant filing for a permit shall pay a filing fee of $250 for each application.

1 The filing fee for small businesses is $160 for each application. In order to be considered a small business, the "Small Business Declaration" must be completed on the reverse of application Form 400-A.

2. The filing fee for change of ownership is $110 for each application filed when there has been no change in operation and a permit to operate had previously been granted and has not otherwise expired. Applications by the new owner should be submitted before the date of transfer of the equipment.

3. All applicants including Federal, State, local governmental agencies and public districts must pay an Engineering Analysis Fee for equipment requiring a permit to construct or operate.

C If an application for a permit is canceled, the filing fee shall not be refunded nor applied to any subsequent application, unless it is determined that such application is not required pursuant to District Rules.

D Permit fees will be determined by the District in accordance with Rule 301.1 and 301.2. These fees shall be paid by the applicant within 30 days of notification or the permit will be canceled.

E Every application must be signed by a responsible member of the organization that is to operate the equipment. Each application must be filled out completely.

F File application (1 copy) with filing fee and one copy of plans at District headquarters:

South Coast AQMD
9150 Flair Drive
El Monte, CA 91731

INCOMPLETE APPLICATIONS ARE NOT ACCEPTABLE

G The Permit Processing Engineer may require more information to complete his evaluation.

H. A copy of SCAQMD Rules and Regulations or notice of any proposal to adopt or amend a rule or regulation may be obtained from

Office of Public Advisor
South Coast AQMD
(818) 572-6283

SUPPLEMENTAL DATA FORMS REQUIRED

Special supplemental data forms must be completed for: BOILERS, LIQUID HEATERS, DEGREASERS, DRY CLEANING EQUIPMENT, OVENS, SPRAY BOOTHS, STORAGE TANKS, ABRASIVE BLASTING OPERATION and PRINTING and DRYING SYSTEM

MAKE CHECK PAYABLE TO "SOUTH COAST AQMD"

Form 400-B   See reverse for excerpts from Rules and Regulations   1/89

Figure 10. SCAQMD Paint Spray Booth Permit Form 400B (Front).

EXCERPTS FROM RULES AND REGULATIONS

RULE 201. Permit to Construct. A person shall not build, erect, install, alter or replace any equipment, the use of which may cause the issuance of air contaminants or the use of which may eliminate, reduce or control the issuance of air contaminants without first obtaining written authorization for such construction from the Executive Officer. A permit to construct shall remain in effect until the permit to operate the equipment for which the application was filed is granted or denied, or the application is cancelled.

RULE 202. Temporary Permit to Operate.

(a) New Equipment - A person shall notify the Executive Officer before operating or using equipment granted a permit to construct. Upon such notification, the permit to construct shall serve as a temporary permit for operation of the equipment until the permit is granted or denied. The equipment shall not be operated contrary to the conditions specified in the permit to construct.

(b) Altered Equipment - The permit to construct granted to modify equipment having a valid permit to operate shall serve as a temporary permit for operation of the equipment until a new permit to operate is granted or denied. The altered equipment shall not be operated contrary to the conditions specified in the permit to construct. A person must notify the Executive Officer when construction of the modification has been completed.

(c) Existing Equipment - When an application for permit to operate is filed for existing equipment, the application shall serve as a temporary permit for operation of the equipment. If the equipment was previously operated under permit and has not been altered, it shall not be operated under a temporary permit contrary to the conditions specified in the previous permit to operate.

RULE 203. Permit to Operate. A person shall not operate or use any equipment, the use of which may cause the issuance of air contaminants or the use of which may reduce or control the issuance of air contaminants, without first obtaining a written permit from the Executive Officer or except as provided in Rule 202. The equipment shall not be operated contrary to the conditions specified in the permit to operate.

RULE 204. Permit Conditions. To assure compliance with all applicable regulations, the Executive Officer may impose written conditions on any permit. Commencing work or operation under such a permit shall be deemed acceptance of all the conditions so specified.

RULE 205. Cancellation of Applications. An application for a permit shall be cancelled and a permit to construct shall expire two years from the date of filing of the application unless an extension of time has been approved by the Executive Officer.

RULE 212. Standards for Approving Permits.

(a) The Executive Officer shall deny a permit to construct or permit to operate, except as provided in Rule 204, unless the applicant shows that the equipment, the use of which may cause the issuance of air contaminants, or the use of which may eliminate, reduce or control the issuance of air contaminants, is so designed, controlled, or equipped with such air pollution equipment that it may be expected to operate without emitting air contaminants in violation of Sections 41700 or 41701 of the State Health and Safety Code or of these rules.

(b) If the Executive Officer finds that the equipment has not been constructed in accordance with the permit and provides less effective air pollution control than the equipment specifited in the permit to construct, he shall deny the permit to operate.

Figure 11. SCAQMD Paint Spray Booth Permit Form 400B (Back).

After the permit application has been submitted, the District will evaluate the request in reference to applicable sections of SCAQMD Regulations II (permits), IV (prohibitions), IX (standards of performance for new stationary sources), X (national emissions standards for hazardous air pollutants), and XIII (new source review).

Based on the above discussion, any of the three modification analyses presented in Section 5 should be acceptable to the SCAQMD, thereby making the permit evaluation process straightforward. The completed permit application, filing fee, and required drawings should be mailed to the address listed in Section 4.1.2.

Case 2: Virginia SAPCB Paint Booth Modification Permit Procedures

The Commonwealth of VA Department of Air Pollution Control, Region VI was selected for evaluation because there are two large Navy activities located in this region. This Region has very specific laws regarding the modification of paint spray booths, which depend primarily on when the booth was installed.

Paint booths that were in existence before 1972 should already be registered with the control agency, and require neither an operating permit, nor a modification permit. However, a registration update will be required before any modifications are made to the booth.

Paint booths that were installed during or after 1972 should already have an operating permit. In order to modify such a booth, a modification to the permit must be made.

If the booth is not permitted, and the control agency is not aware that the booth exists, the agency should be notified immediately, and a permit application should be submitted. A permit may or may not be required, depending on the size of the operation.

Applications for registration updates and permit modifications require that State Air Pollution Control Board (SAPCB) Form 7, section E-1 and E-3, be completed and submitted to the Regional Office of the Department of Air Pollution Control. Copies of Form 7, Section E-1 and form 7, Section E-2 are provided in Figures 12 through 17, respectively.

4.2 HEALTH, SAFETY AND BUILDING PERMITS

The following is a listing of facility permits (in addition to those required by air pollution control and waste disposal agencies) that are usually required by city, county and/or special district agencies:

- Building Permit
- Fire Permit
- Plumbing Permit
- Electrical Permit
- Health and Safety Permit

In most areas, the local Building Department will issue a single permit package which will cover building, fire, plumbing, electrical, and health and safety permits. This agency is in

COMMONWEALTH of VIRGINIA

STATE AIR POLLUTION CONTROL BOARD

For Agency Use Only		
Date Received	Received by	Sec. Completed
Register Source as		E1
Location		E2
Acknowledgement Sent; Date	By	E3
SIC Code:	Plant Registration Number:	E4
UTM Coordinates:		E5
County	City	Grid Number
Plant ID	Height Above MSL (ft)	

SECTION E-1 GENERAL INFORMATION

Reason for Registration

- ☐ Existing
- ☐ Change of Ownership Or Location
- ☐ Permit Application New Source
- ☐ Registration Update
- ☐ Permit Application Modification
- ☐ Other (Specify) ____________

Company and Division Name		Date of Submittal
Mailing Address	County	Number of Employees at Site
City or Town / State	Zip Code	Property Area at Site
Person to Contact on Air Pollution Matters	Title	Telephone Number

Exact Source Location, include name of locality (County or City)

Major Activity at Source Location

- ☐ Manufacturing
- ☐ Hospital or Laboratory
- ☐ Retail or Wholesale Store
- ☐ Warehouse
- ☐ Office Building
- ☐ Residential or Apts.
- ☐ School or Church
- ☐ Other (specify) ____________
- ☐ Hotel or Motel

Do You Handle or Discharge any of the Following Materials?

- ☐ Mercury
- ☐ Antimony
- ☐ Cadmium
- ☐ Asbestos
- ☐ Arsenic
- ☐ Pesticides and/or Radioactive Compounds (list) ____________
- ☐ Beryllium
- ☐ Chlorine
- ☐ Vinyl Chloride
- ☐ Bromides
- ☐ Lead
- ☐ Fluorides

Type or Print Name of Owner or Certifying Company Official	Title
Signature	Date

SAPCB Form 7 (Section E-1—Page 1)
(Rev. 3/77)

Figure 12. Commonwealth of Virginia SAPCB Form 7(Section E.1 Pg1).

COMMONWEALTH OF VIRGINIA
State Air Pollution Control Board

Person Completing Form	Date	Registration Number

SECTION E-1 GENERAL INFORMATION (Cont.)

List the Products Manufactured and/or Services Performed at This Facility.

List the Standard Industrial Classification (SIC) Codes for Your Operation.

IF THIS FORM IS BEING USED BY A NEW OR MODIFIED SOURCE AS AN APPLICATION FOR A PERMIT TO CONSTRUCT AND/OR MODIFY AND OPERATE, PLEASE COMPLETE THE SECTION BELOW AND E-1, PAGES 3, 4 and 5 IF APPLICABLE AND OTHER REQUIRED SECTIONS.

PURSUANT TO THE PROVISIONS OF THE REGULATIONS FOR THE CONTROL AND ABATEMENT OF AIR POLLUTION OF THE COMMONWEALTH OF VIRGINIA, APPLICATION IS HEREBY MADE FOR AUTHORITY TO CONSTRUCT AND/OR MODIFY AND OPERATE THE EQUIPMENT OF FACILITY DESCRIBED ON THE ATTACHED PERMIT FORMS.

(COMPLETE APPLICABLE ITEMS – ESTIMATE DATES)

MILESTONES	STARTING DATE	COMPLETING DATE
Site Selection		
Design and Specifications		
Construction Contract Let		
New Source Construction		
Modification of Existing Equipment		
Final Source Emission Testing		
Transfer of Location		
Transfer of Ownership		

IF THIS FACILITY HAS BEEN PREVIOUSLY REGISTERED BY THE STATE AIR POLLUTION CONTROL BOARD, PLEASE LIST THE REGISTRATION NUMBER ASSIGNED BY THE BOARD

REGISTRATION NUMBER

SAPCB FORM 7 Section E-1—Page 2

Figure 13. Commonwealth of Virginia SAPCB Form 7(Section E.1 Pg2).

COMMONWEALTH OF VIRGINIA
State Air Pollution Control Board

SECTION E 3 PROCESSING AND MANUFACTURING OPERATIONS

Company Name	Company Address		Registration Number
Facility Operating Schedule ____ Hours/Day ____ Days/Week ____ Weeks/Year	Information For Calendar Year 19___	Person Completing Form	Date

Reference Number	Process or Operation Name	Maximum Rated Capacity* Tons/Hour	Normal Feed Input		Number of Emission Points into Air	Normal Product Output	
			Tons / Hour	Tons / Year		Tons / Hour	Tons / Year

* If Units Other Than Tons Are Used, Specify Units

SAPCB Form 7 (Section E 3-Page 1)
(Rev. 8/78)

Figure 14. Commonwealth of Virginia SAPCB Form 7(Section E.3 Pg1).

COMMONWEALTH OF VIRGINIA
State Air Pollution Control Board

Person Completing Form	Date	Registration Number

SECTION E 3 PROCESSING AND MANUFACTURING OPERATIONS

Reference Number	Stack or Exhaust Data					Air Pollution Control Equipment			
	Stack Height Feet	Inside Exit Diameter Feet	Exit Gas Velocity Feet/Minute	Exit Gas Volume ACFM **	Exit Gas Temperature Degrees F	Manufacturer and Model Number	Type (Use Codes 1*)	Collection Efficiency	
								Design	Actual

** ACFM = Actual Cubic Feet per Minute

1* Air Pollution Control Equipment Identification Codes

1. Settling Chamber
2. Cyclone
3. Multic, clone
4. Cyclone Scrubber
5. Orifice Scrubber
6. Mechanical Scrubber
7. Venturi Scrubber
8. Mist Eliminator
9. Electrostatic Precipitator
10. Baghouse (Fabric Filter)
11. Catalytic Afterburner
12. Director Flame Afterburner
13. Packed Tower
14. Carbon Adsorption
15. Refrigerant Condenser
16. Refrigerated Liquid Scrubber
99. Other (Specify)

For Wet Scrubbers, List Gallons per Minute Water Flow and Inches Water Pressure Drop Across Scrubber, If Known.

SAPCB Form 7 (Section E 3 - page 2)
(Rev 8/78)

Figure 15. Commonwealth of Virginia SAPCB Form 7(Section E.3 Pg2).

COMMONWEALTH OF VIRGINIA
State Air Pollution Control Board

Person Completing Form	Date	Registration Number

SECTION E-3 PROCESSING AND MANUFACTURING OPERATIONS

Reference Number	Emission Rates (List Emissions in Tons per Year and Pounds per Hour and Identify Units)					Basis of Emission Estimates	Names of Compounds Emitted from Process
	Particulates	Sulfur Oxides	Carbon Monoxide	Volatile Organic Compounds	Nitrogen Oxides		

Figure 16. Commonwealth of Virginia SAPCB Form 7(Section E.3 Pg3).

COMMONWEALTH OF VIRGINIA
State Air Pollution Control Board

Person Completing Form	Date	Registration Number

SECTION E 3 PROCESSING AND MANUFACTURING OPERATIONS

Reference Number	% of Annual Throughput by Season				Normal Operating Schedule			(FOR AGENCY USE ONLY)
	December . . . February	March . . . May	June . . . August	September . . . November	Hours/Day	Days/Week	Weeks/Year	

Figure 17. Commonwealth of Virginia SAPCB Form 7(Section E.3 Pg4).

a position to advise the design engineer regarding applicable regulations with which the retrofit design must comply.

Most local building departments utilize standard, nationally accepted codes such as the Uniform Building Code, Uniform Plumbing Code, National Fire Code, National Electric Code, etc. However, in some areas, state or local codes may be used. It is therefore important to obtain information pertaining to relevant building codes before the design package is completed.

4.3 DISPOSAL OF SPENT FILTER MEDIA

4.3.1 General Requirements

Requirements for disposing of the spent filter media vary from state to state. However, if the paint collected on the filter media is thoroughly dry when removed for disposal (i.e. the solvents have volatilized off the filter), it is very likely that the filter waste is nonhazardous, and may therefore be disposed of at a municipal landfill. The results of the paint booth survey indicate that virtually all paints used in Navy paint booths are air dried. Thus, the waste filters from these booths are probably thoroughly dry. Prior to disposal, the spent filter media should remain in the paint booth until it is dry to the touch.

Each Navy activity has the responsibility of determining whether or not state or local laws permit disposal of spent filter media at municipal landfills. In addition, permission to dispose of the spent filters may also be required from the municipal landfill that accepts the waste.

When requesting permission to dispose of the filter waste from the relevant state or local agency, it is imperative that the agency personnel understand that no solvents remain on the filter, and no solvent vapors are emitted from the filter. Thus, they should not present a flammability or ground water contamination problem. Once this has been established with the waste disposal facility and/or regulatory agency, permission for disposal at a municipal landfill should be easily attained.

4.3.2 Filter Waste Disposal Information For NSYs and NADEPs Located Across the United States

The appropriate regulatory agencies that may be contacted for procedural advice concerning disposal of spent filter waste are given in this section for all the NADEPs and NSYs in the United States. The addresses and telephone numbers included in this section are valid as of September 1, 1989.

In general, the staff members of these agencies may easily be contacted for advice and information by telephone or in writing. This service should be taken advantage of for a variety of reasons. For example, the disposal process can be greatly facilitated by knowing all the factors and requirements involved.

Navy Activity	**Waste Disposal Regulatory Agency**
Pearl Harbor NSY Pearl Harbor, HI	City and County of Honolulu Department of Public Works, Refuse Division Chief of Engineering 650 South King Street Honolulu, HI 96813 (808) 523-4775
Alameda NADEP Alameda, CA Mare Island NSY Mare Island, CA Long Beach NSY Long Beach, CA North Island NADEP San Diego, CA	State of California Department of Health Services Alternate Technologies Section Toxic Substances Control Division 714/744 P Street P.O. Box 942732 Sacramento, CA 94234-7320 (916) 322-3670
Pensacola NADEP Pensacola, FL Jacksonville NADEP Jacksonville, FL	Department of Environmental Regulation Environmental Administration of Hazardous Waste Regulations Twin Towers Office Building 2600 Blair Stone Road Tallahassee, FL 32399-2400 (904) 488-0300
Cherry Point NADEP Cherry Point, NC	Division of Health Services Solid and Hazardous Waste Management Branch Department of Solid Waste P.O. Box 2091 Raleigh, NC 27602 (919) 733-0692
Puget Sound NSY Bremerton, WA	Department of Ecology Solid and Hazardous Waste Program NW Regional Office 4350 150 Avenue NE Redmond, WA 98052 (206) 867-7053

Portsmouth NSY Kitterey, ME	Department of Environmental Protection Bureau of Oil and Hazardous Materials State House, Station 17 Augusta, ME 04333 (207) 289-2651
	State of New Hampshire Department of Environmental Services Hazardous Waste Management Division 6 Hazen Drive Concord, NH 03301-6509 (603) 271-2942
Philadelphia NSY Philadelphia PA	Department of Environmental Resources Bureau of Waste Management P.O. Box 2063 Harrisburg, PA 17120 (717) 787-7382
Norfolk NSY Norfolk, VA Norfolk NADEP Norfolk, VA	Department of Waste Management Monroe Building, 11th Floor 101 N. 14 Street Richmond, VA 23219 (804) 225-2667
Charleston NSY Charleston, SC	Bureau of Solid and Hazardous Waste Management 2600 Bull Street Columbia, SC 29201 (803) 734-5200

4.3.3 Filter Waste Disposal Processes in Three Target Areas

It is out of the scope of this project to determine the laws pertaining to waste classification for every NSY and NADEP activity, thus three states have been selected for a review of their waste disposal policies regarding spent filter media. The states selected are California, Virginia, and Florida.

Case 1: California Waste Disposal Regulations

The State of California Department of Health Services policy regarding the disposal of spent filters is the same as that used for the disposal of empty paint cans. The paint can disposal policy requires that the cans be drained so that only a thin, completely dry film of paint remains. In addition, the cans must not emit toxic or ignitible vapors, nor be mixed with any other hazardous materials. If these conditions are met, the paint cans are classified as nonhazardous waste.

Accordingly, if the spent filters are completely dry before disposal, and they do not emit toxic or ignitable vapors, they are classified as nonhazardous waste in the State of California. As such, they may be disposed of at a municipal landfill, with the approval of the State Regional Water Quality Control Board.

Information was obtained from the State Regional Water Quality Control Board pertaining to spent filter disposal requirements in the Los Angeles area. Information from the Los Angeles Region IV office (which has jurisdiction over Los Angeles and Ventura Counties) was obtained. The Region IV office allows waste that is classified as nonhazardous by the Department of Health Services (DOHS) to be landfilled without need for prior approval. However, the particular landfill that takes the waste may require that a letter be obtained by the waste generator from the water quality control board certifying that the waste may be landfilled.

In some regions of California, the local air quality control agency requires that municipal landfills be monitored for VOC emissions. Landfills in these areas may therefore be hesitant to permit disposal of the spent filters at their facility. When petitioning the landfill facility to accept the filter wastes, it is important to stress that the filters are thoroughly dry and therefore do not emit any VOCs or toxic compounds into the atmosphere.

Case 2: Virginia Waste Disposal Regulations

The Commonwealth of Virginia Department of Waste Management does not consider filter waste generated in painting operations as hazardous, if and only if the filters are dry, and are not emitting VOC vapors. Thus, such filters may be disposed of at a municipal landfill. The primary objective of this requirement is to prevent the disposal of flammable waste in the municipal landfill.

The commonwealth of Virginia requires that, prior to disposing of dry filter waste in a permitted municipal solid waste landfill, the landfill receive written permission from the Executive Director to accept this waste from the generator. This requirement is in accordance with Part VIII of the Virginia Solid Waste Management Regulations. Before the approval is received, some testing of the waste filters may be required. If testing is required, an environmental contractor should be contacted to collect and analyze a waste filter sample for leachable hazardous metals, as well as solvent vapor emissions.

The leachability (or EP toxicity) test may be required for filter waste containing toxic metals such as lead or chrome. However, it is very unlikely that toxic metals leach out of Navy paint booth filter waste, because the coatings used in Navy operations are specially formulated for stability and long life, even under extreme conditions. Furthermore, if the filters are thoroughly dry before they are disposed of, solvent vapor emissions from them should be negligible. For these reasons, any required test results will probably be negative, which would result in the waste filters being classified as nonhazardous.

Case 3: Florida Waste Disposal Regulations

The State of Florida Department of Environmental Regulations stipulates that some analytical testing of representative filter waste samples be performed before the waste is classified as nonhazardous. The tests required focus on the leachability and ignitibility characteristics of the filter waste. For reasons discussed above, the test results will probably be negative, thereby allowing the waste filters to be classified as nonhazardous.

SECTION 5

COST/BENEFIT ANALYSIS

To perform an accurate cost/benefit analysis of a particular process, the process under consideration must be well defined and characterized. In addition to the information collected during the design of the construction work package, a cost/benefit analysis of the conversion must consider a number of operating procedures, such as:

- The quantity of hazardous waste generated annually
- The percentage of paints used that are air dried
- The paint overspray rate
- The wastewater treatment system

These parameters are important in evaluating the costs and benefits of PECS conversion because they define the installation and operating costs associated with the booth before and after conversion.

A general description of the economic analysis performed in this Section is provided in Subsection 5.1. The analysis was conducted according to procedures outlined in the Naval Facilities Engineering Command P-442 Economic Analysis Handbook (NAVFAC P-442). All costs reported in Section 5 are in the format specified in the NAVFAC P-442 document.

In Section 5.2, costs incurred in converting a water curtain PECS to dry filter operation and operating costs associated with both water curtain and dry filter systems, are presented. These costs are itemized and described in detail. In addition, system reliability, availability, and maintainability are discussed.

Section 5.3 provides examples of how the information presented in Sections 5.1 and 5.2 is used to perform an economic evaluation of the paint spray booth conversion option. In this section, sample economic evaluations of the conversion option for three different paint spray booths are presented. The booth characteristics assumed in these examples were selected based on the Navy paint booth survey results, and represent all practical sizes and types of Navy booths currently in use.

5.1 ECONOMIC ANALYSIS TECHNIQUES

The techniques used in the economic evaluation of converting a Navy paint spray booth PECS from wet to dry operation were drawn from the NAVFAC P-442 document. The three steps outlined in NAVFAC P-442 that are involved in performing an economic evaluation are: (1) the identification and quantification of all one-time and recurring costs in constant and present value dollars, and the development of a cash flow diagram for each alternative; (2) calculation of the savings to investment ratio (SIR); and (3) determination of the discounted payback period. Each of these steps is discussed in general terms for the benefit of readers outside the Navy.

5.1.1 Identification and Estimation of all Costs

The initial step in performing an economic analysis of any proposed system alteration is the identification of all costs, both one-time and recurring, for both the present and proposed systems. The only one-time cost considered in this Users Guide is for the replacement of the water curtain PECS with a dry filter system. The recurring costs considered are: waste treatment and disposal, filter media replacement, utilities, and labor.

After the costs have been identified, the constant dollar value of the costs must be assessed. This information is used to generate cash flow diagrams for both the present system and the proposed conversion.

After completion of the cash flow diagrams, the net present value (NPV) of the recurring operating and maintenance (O&M) costs for both the current and proposed system are then determined over the economic life of the paint booth. For the purposes of this Users Guide, an economic life of 10 years is assumed. This results in a more conservative estimate, because dry filter PECs will last longer than water-certain PECs, which often require replacement or significant repair within 10 years.

To estimate the NPV of the recurring costs, some assumptions must be made regarding cost escalations due to inflation and other factors. In general, if the anticipated rise in O&M costs is the same as the general inflation rate (assumed to be 5 percent), a 10 percent discount factor may be applied to calculate the NPV. This is the rate applied to all costs presented in this Users Guide, with the exception of wastewater and sludge disposal costs.

Future wastewater and sludge disposal costs will not vary at the same rate as inflation. Thus, an adjusted escalation rate calculation was performed to determine the NPV of wastewater and sludge disposal costs over the requisite 10-year economic life. This calculation was performed according to the NAVFAC P-442 document procedures, and is discussed in greater detail in Section 5.2.

5.1.2 Calculation of the Savings to Investment Ratio

The second step in comparing the economics of a proposed system alteration is to calculate the savings to investment ratio (SIR), which is defined as the amount of savings accrued by each dollar of investment. It is mathematically defined as:

$$SIR = \frac{\text{Net Present Value (Savings)}}{\text{Net Present Value (Investment)}}$$

The NPV (savings) is obtained by subtracting the NPV of the recurring costs for the proposed system from the NPV of the recurring costs for the current system. As discussed above, these costs are calculated over the economic life of the installation. The NPV (savings) is the total amount of money (in present value dollars) that will be saved if the proposed system is installed. The NPV (investment) is the total one-time costs incurred to install the proposed system in present value dollars. For the proposed alternative to be cost-effective, the SIR must be greater than 1.

5.1.3 Determination of the Discounted Payback Period

The final step in performing an economic evaluation is to determine the discounted payback period, which is the time required to accrue sufficient present value savings to offset the investment cost. The discounted payback period is determined by calculating the accrued year by year savings, and comparing this result to the initial investment in present value dollars. The point at which the two are equal defines the payback period. For all of the analyses presented in this section, Table C in Appendix C of the NAVFAC-P442 document was used to determine the discounted payback period.

5.2 IDENTIFICATION AND ESTIMATION OF PECS CONVERSION COSTS

As described previously, the only one-time cost considered in this economic evaluation is the cost incurred to install the dry filter system. The NPV of recurring costs for waste disposal, filter media replacement, utilities, and labor have been tabulated over the 10-year economic life of the booth. These one-time and recurring costs are presented and discussed separately in this section, and are referred to frequently in Section 5.3.

5.2.1 Retrofit System Installation Cost

The dry filter system installation costs can only be evaluated after all the preliminary efforts (such as the equipment audit and selection of a general filter type) on the construction work package are complete. At that time, estimates of installation costs (such as fan downsizing or replacement, sheetmetal repair, and filter frame acquisition and installation) can be derived using Table 4. Please note that many of the costs presented in Table 4 are the same for downdraft and crossdraft systems. The exception is the floor grate modification cost, which is applicable only to downdraft systems.

TABLE 4. CAPITAL AND INSTALLATION COSTS OF CONVERTING WATER CURTAIN PECS'S TO DRY FILTER OPERATION

Construction Item	Cost in Current Dollars
Fan replacement:	
(0-5,000 cfm)	$180/1,000 cfm
(5,000-15,000 cfm)	$100/1,000 cfm
(15,000-20,000 cfm)	$80/1,000 cfm
(20,000-25,000 cfm)	$68/1,000 cfm
(5,000-15,000 cfm)	$60/1,000 cfm
Fan Motor Replacement:	
(0-1 HP)	$300
Additional HP (ea)	$20
Major Sheetmetal Repair	$15.74/sq. ft.
Minor Sheetmetal Repair	$8.80/sq. ft.
Grate floor covering	$22.32/sq. ft.
Cartridge Filter Frame	$9.76/sq. ft.
Paper Filter Frame	$9.47/sq. ft.
Cloth Filter Frame	$10.38/sq. ft.
Pleated Filter Frame	$7.31/sq. ft.

The costs provided in Table 4 are in present value dollars, and may be considered valid through 1990. In addition, due to the large number of filter system manufacturers, the filter frame costs listed in Table 4 are approximate.

5.2.2 Water Curtain And Dry Filter System Operating Costs

The operating costs for both the dry filter and water curtain systems have been tabulated in present value dollars over the economic life of the booth according to the description given in 5.1.1. For the constant dollar value (which is necessary to develop a cash flow diagram), refer to the costs reported for 1989. The operating costs have been divided into five categories: replacement filter costs, filter waste disposal costs, wastewater and sludge disposal costs, utility costs, and labor costs.

Replacement Filter Costs

The filter replacement costs associated with the honeycombed paper, cloth, pleated paper, and fiberglass cartridge type filters are presented in Tables 5, 6, 7, and 8, respectively. The costs presented in each of these tables were derived in the following manner:

- A transfer efficiency of 30 percent was assumed
- Values for the filter capacity and cost per square foot (in current dollars) were obtained from the filter manufacturer
- A range of paint usage rates from 5 gallons per day to 50 gallons per day was selected based on the survey results
- The estimated transfer efficiency is multiplied by the applicable usage rate and divided by the filter capacity to obtain the number of square feet of filter that reaches the maximum capacity limit per day. (Note, this value does not imply that a certain square footage of filter requires replacement per day, rather it is a tool for calculating filter depletion rates).
- The depletion rate (square feet per day) is then multiplied by the cost per square foot to obtain the cost per day incurred due to filter depletion
- To determine the frequency of filter replacement, simply divide the filter surface area (obtained by following the procedures outlined in Section 3) by the depletion rate to determine the number of days between filter replacement

If the actual paint usage rate for a given booth is not represented in the range presented in the tables, the filter replacement costs may be interpolated between the paint usage rates that most closely match the actual usage rate. In addition, the time unit specified for the paint usage rates in Tables 5 through 8 (days) may be changed to months or weeks, however, the replacement costs will also reflect this change. For example, for a paint usage rate of 50 gal per week, the present value cloth filler replacement costs for 1989 will be $28.00 per week.

Filter Disposal Costs

Because nearly all the paints used by the Navy are air dried coatings, the spent filters are also air dried and should not emit solvent vapors upon removal from the booth. It is

TABLE 5. PRESENT VALUE OF HONEYCOMBED PAPER FILTER REPLACEMENT COST OVER THE 10 YEAR ECONOMIC LIFE OF THE PAINT BOOTH

	Present Value Filter Replacment Costs ($/day)[a]					
	Paint Usage Rates					
Year	5 gal/day	10 gal/day	20 gal/day	30 gal/day	40 gal/day	50 gal/day
1989	$3.25	$6.50	$13.00	$19.50	$26.00	$32.50
1990	$2.95	$5.91	$11.82	$17.73	$23.63	$29.54
1991	$2.69	$5.37	$10.74	$16.11	$21.48	$26.85
1992	$2.44	$4.88	$9.76	$14.65	$19.53	$24.41
1993	$2.22	$4.44	$8.88	$13.31	$17.75	$22.19
1994	$2.02	$4.03	$8.07	$12.10	$16.14	$20.17
1995	$1.83	$3.67	$7.33	$11.00	$14.67	$18.33
1996	$1.67	$3.33	$6.67	$10.00	$13.33	$16.67
1997	$1.51	$3.03	$6.06	$9.09	$12.12	$15.15
1998	$1.38	$2.75	$5.51	$8.26	$11.02	$13.77
1999	$1.25	$2.50	$5.01	$7.51	$10.01	$12.52
Total	$23.21	$46.42	$92.84	$139	$186	$232

a: Assuming a base cost of $.26/sq. ft. and a transfer efficiency of 30%

TABLE 6. PRESENT VALUE OF CLOTH ROLL FILTER REPLACEMENT COST OVER THE 10 YEAR ECONOMIC LIFE OF THE PAINT BOOTH

	Present Value Filter Replacment Costs ($/day)[a]					
	Paint Usage Rates					
Year	5 gal/day	10 gal/day	20 gal/day	30 gal/day	40 gal/day	50 gal/day
1989	$2.80	$5.60	$11.20	$16.80	$22.40	$28.00
1990	$2.55	$5.09	$10.18	$15.27	$20.36	$25.45
1991	$2.31	$4.63	$9.25	$13.88	$18.51	$23.14
1992	$2.10	$4.21	$8.41	$12.62	$16.82	$21.03
1993	$1.91	$3.82	$7.65	$11.47	$15.29	$19.12
1994	$1.74	$3.48	$6.95	$10.43	$13.90	$17.38
1995	$1.58	$3.16	$6.32	$9.48	$12.64	$15.80
1996	$1.44	$2.87	$5.74	$8.62	$11.49	$14.36
1997	$1.31	$2.61	$5.22	$7.83	$10.44	$13.05
1998	$1.19	$2.37	$4.75	$7.12	$9.49	$11.86
1999	$1.08	$2.16	$4.31	$6.47	$8.63	$10.78
Total	$20.00	$39.99	$79.99	$120	$160	$200

a: Assuming a base cost of $.28/sq. ft. and a transfer efficiency of 30%

TABLE 7. PRESENT VALUE OF PLEATED PAPER FILTER REPLACEMENT COST OVER THE 10 YEAR ECONOMIC LIFE OF THE PAINT BOOTH

Year	Present Value Filter Replacment Costs ($/day)[a] — Paint Usage Rates: 5 gal/day	10 gal/day	20 gal/day	30 gal/day	40 gal/day	50 gal/day
1989	$14.67	$29.33	$58.67	$88.00	$117.33	$146.67
1990	$13.33	$26.66	$53.33	$79.99	$106.66	$133.32
1991	$12.12	$24.24	$48.48	$72.71	$96.95	$121.19
1992	$11.02	$22.03	$44.06	$66.10	$88.13	$110.16
1993	$10.01	$20.03	$40.05	$60.08	$80.11	$100.14
1994	$9.10	$18.20	$36.41	$54.61	$72.82	$91.02
1995	$8.27	$16.55	$33.10	$49.64	$66.19	$82.74
1996	$7.52	$15.04	$30.08	$45.13	$60.17	$75.21
1997	$6.84	$13.67	$27.35	$41.02	$54.69	$68.37
1998	$6.21	$12.43	$24.86	$37.29	$49.72	$62.15
1999	$5.65	$11.30	$22.60	$33.89	$45.19	$56.49
Total	$105	$209	$419	$628	$838	$1,047

a: Assuming a base cost of $.88/sq. ft. and a transfer efficiency of 30%

TABLE 8. PRESENT VALUE OF FIBERGLASS CARTRIDGE FILTER REPLACEMENT COST OVER THE 10 YEAR ECONOMIC LIFE OF THE PAINT BOOTH

Year	Present Value Filter Replacment Costs ($/day)[a] — Paint Usage Rates: 5 gal/day	10 gal/day	20 gal/day	30 gal/day	40 gal/day	50 gal/day
1989	$5.08	$10.16	$20.32	$30.48	$40.65	$50.81
1990	$4.62	$9.24	$18.47	$27.71	$36.95	$46.18
1991	$4.20	$8.40	$16.79	$25.19	$33.58	$41.98
1992	$3.82	$7.63	$15.26	$22.90	$30.53	$38.16
1993	$3.47	$6.94	$13.88	$20.81	$27.75	$34.69
1994	$3.15	$6.31	$12.61	$18.92	$25.22	$31.53
1995	$2.87	$5.73	$11.46	$17.20	$22.93	$28.66
1996	$2.61	$5.21	$10.42	$15.63	$20.84	$26.05
1997	$2.37	$4.74	$9.47	$14.21	$18.95	$23.68
1998	$2.15	$4.31	$8.61	$12.92	$17.22	$21.53
1999	$1.96	$3.91	$7.83	$11.74	$15.65	$19.57
Total	$36.28	$72.57	$145	$218	$290	$363

a: Assuming a base cost of $.45/sq. ft. and a transfer efficiency of 30%

therefore assumed that the filters may be disposed of at a municipal landfill, and the costs associated with their disposal are negligible.

Waste Disposal Costs

The waste disposal costs associated with a particular water curtain system depend on a number of variables such as the waste treatment method (if any) and the type of waste disposed of. These parameters are not mutually exclusive. Navy activities that have access to municipal or onsite industrial wastewater treatment plants (IWTPs) often drain the supernatant wastewater to the IWTP, where it is treated at negligible cost. The sludge collected on the bottom of the sump is periodically removed and disposed of as hazardous waste at considerable cost.

Navy activities that do not have access to an IWTP generally dispose of the entire contents of the sump (the wastewater and the sludge) as hazardous waste. The presence of significant quantities of water in the waste reduces the density and, to some extent, the disposal cost per volume. However, the total volume of waste generated is very high.

The waste disposal costs per 55 gallon drum are presented in Table 9. These values are tabulated in present value dollars for each type of waste described above. To calculate the disposal costs per year, the user should multiply the number of drums generated per year by the waste disposal costs for the particular type of waste generated.

The costs presented in Table 9 were calculated in a manner slightly different from the other costs reported in this section. The costs were calculated based on a 0 percent inflation rate for disposal services over the next four years, and a standard 5 percent inflation rate over the remaining 6 years. These estimates may seem extremely optimistic; however they were obtained through conversations with waste disposal company marketing strategists. Increasing competition and improved disposal techniques were cited as reasons for the near-term price stabilization. Information from marketing strategists regarding future prices is generally not forthcoming, and this information may be questionable. However, by assuming the zero percent escalation rate over the next four years, the costs estimated are made more conservative. A differential cost escalation rate calculation was performed according to NAVFAC P-442 procedures to obtain the costs presented in Table 9.

TABLE 9. SLUDGE AND/OR WASTEWATER DISPOSAL COSTS

	Present Value Waste Disposal Costs ($/drum)	
Year	Liquid & Sludge	Sludge Only
1989	$200	$300
1990	$182	$273
1991	$165	$248
1992	$150	$225
1993	$143	$215
1994	$137	$205
1995	$131	$196
1996	$125	$187
1997	$119	$179
1998	$114	$170
Total	$1,466	$2,199

Utility Operating Costs

The utility costs associated with operating water pumps (for water curtain systems) and exhaust fans (for both types of PECSs) are presented here. The costs of replacement water for the water curtain system cannot be calculated accurately, because booth operators "top off" the sumps weekly, if not daily. Thus, water consumption rates cannot be accurately quantified. At any rate, the cost of replacement water is considered negligible.

The daily operating costs for a water pump or exhaust fan of a particular rated horsepower are presented in Table 10. Note that these costs are broken down for industrial and commercial users, because electricity costs for industrial users are generally much lower than for commercial users. The Table 10 base year costs per kWhr assumed for the industrial and commercial users are $0.045 and $0.067, respectively. The costs reported are per 8-hour shift, thus if the booth is operated 2 shifts per day, the dollars reported in Table 10 should be doubled.

After preliminary work on the construction work package is complete, the information pertaining to the exhaust fan and water pump power ratings is combined with the information presented in Table 10 to calculate annual electrical operating costs before conversion. Electrical operating cost estimates of the converted system are also obtained from this table.

Labor Costs

The labor costs associated with maintaining dry filter and water curtain PECSs are presented and discussed here separately.

The labor costs per square foot to replace the spent filter media depend primarily on the type of filter employed. For example, as discussed in Section 3, fiberglass cartridge filters require much more time to replace than most other filter types. The labor costs for filter replacement are tabulated in Table 11. These costs were obtained by multiplying the replacement time for each filter type (in hours per 100 ft^2) by a labor rate of $17.00 per hour. The replacement time for each type of filter was obtained from manufacturer estimates, and assumes easy access to the filter face. The $17.00/hr labor rate was calculated assuming an hourly wage of $9.00 (typical for a wage grade [WG] level 3 employee in the San Francisco area in 1989), and an overhead and G&A load of 90 percent. This loading may appear low; however, the work is performed at a government facility, thus the overhead contribution is small.

The labor costs involved in draining and maintaining water curtain PECSs are presented in Table 12. Note that the maintenance requirements for the crossdraft and downdraft booths are very different; downdraft system maintenance is more involved, because it includes removing the grate and cleaning out somewhat inaccessible parts of the sump system. In addition, the grate itself requires periodic cleaning and occasional sand blasting to remove the accumulated overspray particulate. Crossdraft sump maintenance procedures are more straightforward.

In Table 12, the sump clean out costs are presented per drum of waste produced, and the grate cleaning costs are presented per square foot of floor surface. Actual labor costs for sump maintenance can be calculated by multiplying the number of waste drums generated in the cleaning process by the cost per drum to fill. The labor rate used in Table 12 is the same as that used in Table 11.

The numbers presented in Table 12 were derived for removing sludge accumulated at the bottom of the sump, and are based on the assumption that the wastewater from the sump

TABLE 10. ELECTRICAL OPERATING COSTS AS A FUNCTION OF HORSEPOWER

Present Value Electrical Operating Cost Per Shift ($/day)

Year	5 HP		10 HP		15 HP		20 HP		30 HP		40 HP	
	Industrial User	Commercial User	Industrial User	Commercial User	Industrial User	Commercial User	Industrial User	Commercial User	Industrial User	Commercial User	Industrial User	Commercial User
1989	$1.35	$2.01	$2.70	$4.02	$4.05	$6.03	$5.40	$8.04	$8.09	$12.07	$10.79	$16.09
1990	$1.23	$1.83	$2.45	$3.66	$3.68	$5.48	$4.90	$7.31	$7.36	$10.97	$9.81	$14.63
1991	$1.11	$1.66	$2.23	$3.32	$3.34	$4.99	$4.46	$6.65	$6.69	$9.97	$8.92	$13.29
1992	$1.01	$1.51	$2.03	$3.02	$3.04	$4.53	$4.05	$6.04	$6.08	$9.06	$8.10	$12.08
1993	$0.92	$1.37	$1.84	$2.75	$2.76	$4.12	$3.68	$5.49	$5.53	$8.24	$7.37	$10.99
1994	$0.84	$1.25	$1.67	$2.50	$2.51	$3.74	$3.35	$4.99	$5.02	$7.49	$6.70	$9.99
1995	$0.76	$1.13	$1.52	$2.27	$2.28	$3.40	$3.04	$4.54	$4.57	$6.81	$6.09	$9.08
1996	$0.69	$1.03	$1.38	$2.06	$2.07	$3.09	$2.77	$4.13	$4.15	$6.19	$5.53	$8.25
1997	$0.63	$0.94	$1.26	$1.87	$1.89	$2.81	$2.51	$3.75	$3.77	$5.62	$5.03	$7.50
1998	$0.57	$0.85	$1.14	$1.70	$1.71	$2.56	$2.29	$3.41	$3.43	$5.11	$4.57	$6.82
1999	$0.52	$0.77	$1.04	$1.55	$1.56	$2.32	$2.08	$3.10	$3.12	$4.65	$4.15	$6.20
Total	$9.63	$14.36	$19.26	$28.73	$28.90	$43.09	$38.53	$57.45	$57.79	$86.18	$77.06	$115

TABLE 11. LABOR COSTS ASSOCIATED WITH FILTER REPLACEMENT

Year	Present Value Labor Costs For Replacing Dry Filter Media (dollars/square foot)			
	Cartridge Filters	Honeycombed Paper Filters	Non-Woven Cloth Filters	Pleated Paper Filters
1989	$0.071	$0.054	$0.065	$0.034
1990	$0.064	$0.049	$0.059	$0.031
1991	$0.059	$0.045	$0.053	$0.028
1992	$0.053	$0.041	$0.049	$0.026
1993	$0.048	$0.037	$0.044	$0.023
1994	$0.044	$0.034	$0.040	$0.021
1995	$0.040	$0.031	$0.036	$0.019
1996	$0.036	$0.028	$0.033	$0.017
1997	$0.033	$0.025	$0.030	$0.016
1998	$0.030	$0.023	$0.027	$0.014
1999	$0.027	$0.021	$0.025	$0.013
Total	$0.506	$0.389	$0.461	$0.243

TABLE 12. LABOR COSTS ASSOCIATED WITH SUMP SYSTEM MAINTENANCE

Year	Present Value Sump Maintenance Labor Costs (Sludge Removal Only)		
	Downdraft		Crossdraft
	Sump ($/drum)	Grates ($/sq ft)	Sump ($/drum)
1989	$51.00	$0.85	$34.00
1990	$46.36	$0.77	$30.91
1991	$42.14	$0.70	$28.09
1992	$38.31	$0.64	$25.54
1993	$34.82	$0.58	$23.21
1994	$31.65	$0.53	$21.10
1995	$28.77	$0.48	$19.18
1996	$26.15	$0.44	$17.44
1997	$23.77	$0.40	$15.85
1998	$21.61	$0.36	$14.41
1999	$19.64	$0.33	$13.10
Total	$364	$6.07	$243

is treated at an IWTP. This is because little or no labor is required to drain the water from the sump.

No attempt has been made to estimate the cost impacts of having the booth remain idle during system maintenance. These costs are a function of the number of painters affected (who are essentially out of work during that time), workpiece throughput, and system accessibility. In some cases, this may not be a real cost, because the painters may be utilized for cleaning out the sump, or they may be transferred to other booths, along with the pieces that would normally be painted in the booth undergoing maintenance.

5.2.3 System Reliability, Availability, and Maintainability

The dry filter systems discussed in this document have low failure rates if properly planned, installed, and operated. Failure is defined here as the inability of the system to adequately control particulate emissions while simultaneously maintaining product quality and providing a safe working environment for the paint booth operator.

Because there are many dry filter system manufacturers and distributors, the availability of the filter types discussed in this User's Guide is very high. The number of participants in this market is on the increase, thus installation and operating costs may decrease and availability increase in the future.

The maintainability of dry filter systems in general cannot be assessed; rather it is more productive to evaluate each system individually in terms of the booth operating conditions. This issue is addressed insofar as possible by providing filter replacement labor cost estimates ($\$/ft^2$) for each type of filter. In addition, filter depletion rates (ft^2/day) can be estimated from Tables 5 through 8 by dividing the filter replacement cost ($/day) by the base filter cost ($\$/ft^2$). These two quantities (filter depletion rates and filter replacement labor costs) must be combined to determine the annual labor costs associated with the dry filter replacement.

5.3 ECONOMIC EVALUATION EXAMPLES: THE APPLICABILITY OF THE CONVERSION OPTION FOR THREE DIFFERENT PAINT SPRAY BOOTHS

In this section, three examples are presented in which step-by-step instructions for performing an economic evaluation are provided. The purpose of these examples is to illustrate how the information presented in Section 5.2 may be used to determine the economic feasibility of converting a water curtain paint spray booth to dry filter operation.

In each example, a description of the physical and operating characteristics of the booth are provided. The characteristics were selected based on the results of the Navy paint booth survey. The examples provided do not represent specific booths, rather each example represents a general class of booths.

5.3.1 Conversion of a Small Crossdraft Paint Booth

The first example discusses the economic conversion of a small crossdraft paint spray booth that has a light duty cycle.

5.3.1.1 Paint Booth Characterization Before and After Conversion

The current physical and operating characteristics of the booth are:

- The booth is 9 ft wide, 9 ft high, and 10 ft long
- The booth is used less than one shift per day
- The average paint usage rate is 10 gal per week
- The average transfer efficiency is 30 percent
- Sump maintenance occurs once per month
- Wastewater from the sump is drained to an IWTP at negligible cost; sludge collected at the bottom of the sump is drummed and disposed of as hazardous waste
- Three drums of sludge are generated per year
- The air flowrate through the booth is approximately 10,500 cfm (125 linear fpm) x (9 ft width) (9 ft height)
- The water curtain pressure drop is 0.8 inch w.c. due to the baffle system and spray curtain
- The power ratings of both the exhaust fan and the water pump are 5 hp. The Navy activity is considered an industrial user, therefore lower electricity rates apply.
- There is no major sheetmetal rust or damage problem; however, 20 ft^2 of minor sheetmetal work is required

Because of the operating characteristics of the booth, the dry filter system selected for installation is of the honeycombed paper variety. The decision was made not to remove the water curtain baffles. The pressure drop from the PECS is therefore reduced from 0.8 inch w.c. to 0.5 inch w.c. (it is assumed that the baffles contribute 0.4 inch w.c., and the filter system contributes 0.1 inch w.c.). It is calculated that the fan motor may be downsized to 3 hp, and replacement of the fan or motor is not necessary.

The required air flowrate through the booth will remain the same (10,500 cfm), and the clean face velocity of the dry filter system is assumed to be 200 linear fpm. The minimum required surface area is therefore approximately 55 ft^2. The filters are available in widths of 45 inches (or 3.75 ft), thus the filter surface area must be at least 7.5 ft wide and 7.3 ft high. For simplicity, it is assumed that the filter surface area is 7.5 by 7.5, or 56 ft^2.

5.3.1.2 Identification and Estimation of Costs

The above system evaluation results, combined with the information provided in Tables 4 through 12, is used to estimate PECS conversion costs and operating costs for both the current and proposed systems. The cost estimations are obtained as follows:

PECS Conversion Cost

The cost per square foot to install a honeycombed paper filter system is provided in Table 4. If 56 ft^2 of filter area is required, the cost to install the system is $530 (56 ft^2 x $9.47/$ft^2$). In addition, approximately 20 ft^2 of minor sheetmetal work is required. This work will cost approximately $176 ($8.8/ft^2 x 20 ft^2). The total cost to install the paper filter system is approximately $706 ($530 + $176).

Utility Costs

The utility costs before and after conversion must be considered separately using Table 10. Before conversion, two 5-hp motors are required to operate the paint booth. An industrial user operating a 10-hp unit such as this for one shift per day requires $2.70 worth of electricity per day, or $702 per year in constant dollars ($2.70 per day in 1989 x 260 days per year). The NPV of the electrical operating cost for the current system over the economic life of the booth is $5,007 ($19.26 per day x 260 days per year).

After conversion, the electricity required is for the operation of one 3-hp motor. An industrial user operating a 3 hp unit one shift per day requires $0.81 worth of electricity per day, or $211 per year in constant dollars ($0.81 per day in 1989 x 260 days per year). The NPV of the electrical operating cost for the converted system over the economic life of the booth is $1,502 ($5.78 per day x 260 days per year).

Waste Treatment Costs

The only waste treatment cost of concern in this example is that associated with disposal of the sludge collected at the bottom of the sump, after the supernatant liquid is drained. The sludge disposal cost may be calculated from information presented in Table 9, under the column entitled "Sludge only." The water curtain system in this example generates 3 drums of sludge per year; this results in an annual waste treatment cost in constant dollars of $900 ($300 per drum in 1989 x 3 drums per year). The NPV of the waste treatment cost over the economic life of the booth is $6,597 ($2,199 per drum x 3 drums per year).

Equipment Costs

As discussed in Section 5.2, the only equipment cost considered is for the replacement of spent filter media. Replacement costs for the filter type selected (honeycombed paper) may be calculated from information presented in Table 5. For a paint usage rate of 10 gal per week, $6.50 worth of filter media is depleted per week. This results in an annual filter cost in constant dollars of $338 ($6.50 per week in 1989 x 52 weeks per year). The NPV of the filter replacement cost over the economic life of the booth is $2,413 ($46.42 per week x 52 weeks per year).

Labor Costs

As with the utility cost calculations, the labor utility costs before and after conversion must be considered separately using Tables 11 and 12.

Before conversion, the labor cost incurred is for draining and cleaning the water curtain sump. Table 12 presents labor costs per drum generated; in this example, three drums of sludge waste are generated per year. This results in an annual labor cost in constant dollars of $102 ($34 per drum in 1989 x 3 drums per year). The NPV of the labor cost for the current system over the economic life of the booth is $729 ($243 per drum x 3 drums per year).

After conversion, the labor cost incurred is for spent filter media replacement. Table 11 presents labor costs per square foot of filter replaced. A parameter that must be calculated is the filter depletion rate (or number of square feet of filter surface area depleted per week) which is obtained from Table 5 by dividing the filter replacement cost in dollars per week by the base cost per square foot. In this example, the depletion rate is 25 ft^2 per week ($6.50 per week/$0.26 per ft^2). This depletion rate results in an annual labor cost in constant dollars of $70 ($0.054 per ft^2 in 1989 x 25 ft^2 per week x 52 weeks per year). The NPV of the labor cost for the dry filter system over the economic life of the booth is $505 ($0.389 per ft^2 x 25 ft^2 per week x 52 weeks per year).

A summary of the one-time and recurring costs calculated in this section is presented in Table 13.

5.3.1.3 Development of Cash Flow Diagrams for the Current and Proposed Systems

The one-time and recurring costs calculated in constant dollars in Section 5.3.1.2 are used to generate cash flow diagrams for the current and proposed systems. The recurring costs must be summed separately for each system to determine annual recurring costs in constant dollars.

TABLE 13. SUMMARY OF ONE-TIME AND RECURRING COST ESTIMATES FOR A SMALL CROSSDRAFT BOOTH BEFORE AND AFTER CONVERSION

RECURRING COSTS

	Water Curtain System		Dry Filter System	
Item	Annual Constant Dollar Cost ($)	NPV of 10 Year Life Cycle Cost ($)	Annual Constant Dollar Cost ($)	NPV of 10 Year Life Cycle Cost ($)
Utilities	$702	$5,007	$211	$1,502
Waste Treatment	$900	$6,597	$0	$0
Labor	$102	$729	$70	$505
Materials	$0	$0	$338	$2,413
Total	$1,704	$12,333	$619	$4,420

ONE-TIME COSTS

Item	Cost ($)
Equipment & Installation	$530
Sheetmetal Work	$176
Total	$706

The cash flow diagram for maintaining the status quo with the water curtain system is presented in Figure 18. Note that no one-time cost is included in this diagram. The recurring cost ($1,704) in constant dollars is obtained by summing the recurring utility, waste treatment and labor costs ($702, $900, and $102, respectively) in constant dollars calculated in Section 5.3.1.2.

The cash flow diagram for the conversion option is presented in Figure 19. The one-time cost included in the diagram is from the purchase and installation of the dry filter PECS. The recurring cost ($619), in constant dollars, associated with the dry filter system is obtained by summing the recurring utility, filter media and labor costs ($211, $338, and $70, respectively) in constant dollars calculated in Section 5.3.1.2.

5.3.1.4 Calculation of the Savings to Investment Ratio

The SIR is calculated by taking the difference between the NPV of the recurring costs of the present and proposed systems, and dividing the resultant by the total investment cost. The NPV of the recurring costs of the current water curtain system is $12,333. This value is obtained by summing the NPV of the recurring utility, waste treatment, and labor costs associated with the water curtain system ($5,007, $6,597, and $729, respectively) calculated in Section 5.3.1.2.

The NPV of the recurring costs of the proposed dry filter system is $4,420. This value is obtained by summing the NPV of the recurring utility, filter media, and labor costs associated with the water curtain system ($1,502, $2,413, and $505, respectively) calculated in Section 5.3.1.2.

The total investment cost for the dry filter system selected in this example is $706. The SIR is therefore 11.2. Based on this result, installation of the proposed dry filter system is a very economical alternative.

5.3.1.5 Determination of the Discounted Payback Period

The discounted payback period for this example is determined by referring to Table C found on page C-4 of the NAVFAC P-442 document. This table is used because the savings accrued each year is constant (except for the fact that waste disposal costs will remain stable over the first four years; this however will serve only to shorten the payback period, and is therefore not considered relevant), and there is no lead time between system installation and usage. With an SIR of 11.1 and an economic life of 10 years, the payback period for the proposed alternative is less than 1 year.

5.3.2 Conversion of a Large Crossdraft Paint Booth

The second example discusses the economic conversion of a large crossdraft paint spray booth having a moderate duty cycle.

5.3.2.1 Paint Booth Characterization Before and After Conversion

The current physical and operating characteristics of the booth are:

- The booth is 15 ft wide, 10 ft high, and 20 ft long
- The booth is used one shift per day

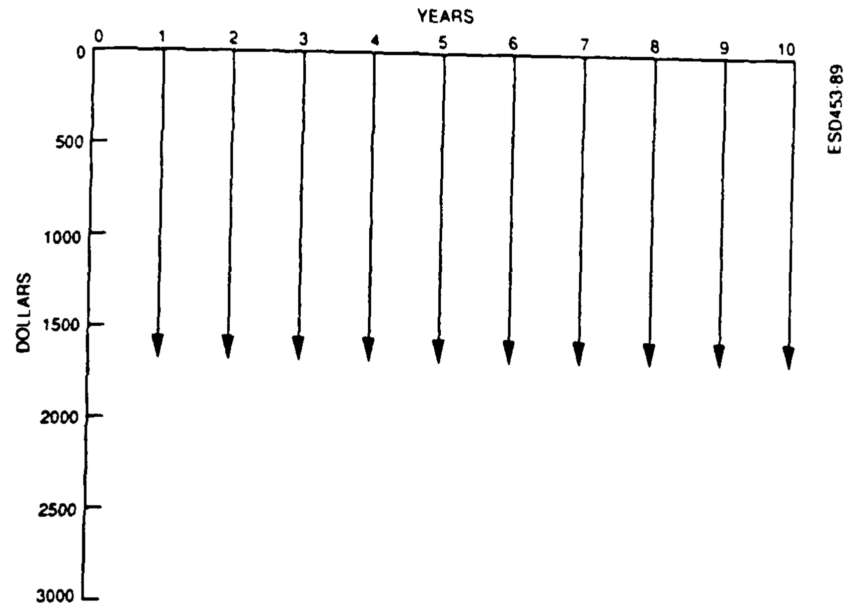

Figure 18. Cash flow diagram: current operation of a small crossdraft booth.

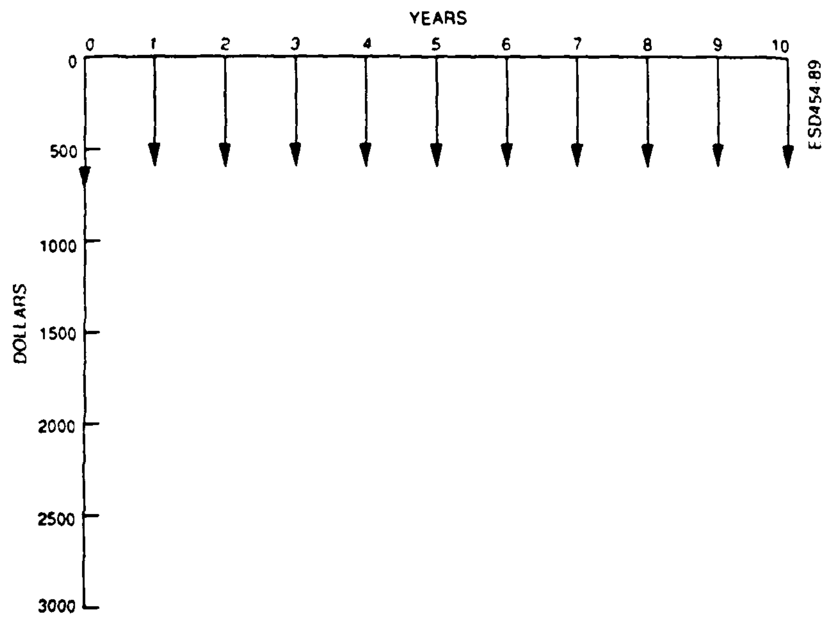

Figure 19. Cash flow diagram: proposed operation of a small crossdraft booth.

- The average paint usage rate is 20 gal per week
- The average transfer efficiency is 30 percent
- Sump maintenance occurs once every 2 months
- Wastewater from the sump is drained to an IWTP at negligible cost; sludge collected at the bottom of the sump is drummed and disposed of as hazardous waste
- Six drums of sludge are generated per year
- The flowrate through the booth is 18,750 cfm (125 linear fpm) x (10 ft high) x (15 ft wide)
- The pressure drop across the water curtain PECS is 1.3 inches w.c. due to the baffles, water curtain, etc.
- The power ratings of the exhaust fan and water pumps are 10 and 7.5 hp, respectively. The Navy activity considered an industrial user, therefore lower electricity rates apply.
- 20 ft^2 of major sheetmetal modification and repair work is needed to remove the water curtain baffles, and prepare the site for installation of the dry filter system

Because of the operating characteristics of the booth, a cloth filter replacement system is selected. The high pressure drop (1.25 inches w.c.) associated with the cloth filter requires removal of the water curtain baffles from the booth exhaust duct. After the baffle system is removed, the pressure drop across the proposed cloth filter system is the same as that for the water curtain system. Thus, no alteration of the exhaust fan system is required.

After conversion, the volume flowrate through the booth must remain at 18,750 cfm. Assuming a cloth filter clean face velocity of 200 linear fpm, the minimum required filter surface area is 94 ft^2. Cloth filters are available in widths of 3 ft, thus the resulting dry filter surface area should have dimensions of 8 ft by 12 ft. The actual surface area is therefore 96 ft^2.

5.3.2.2 Identification and Estimation of Costs

The one-time and recurring costs for the current and proposed systems in this example are estimated in a manner similar to that presented in Section 5.3.1.2. The calculation results for this example are summarized in Table 14.

5.3.2.3 Development of Cash Flow Diagrams for the Current and Proposed Systems

The one-time and recurring costs calculated in constant dollars in Section 5.3.2.2 are used to generate cash flow diagrams for the current and proposed systems. The recurring costs must be summed separately for each system to determine annual recurring costs in constant dollars.

The cash flow diagram for maintaining the status quo with the water curtain system is presented in Figure 20. Note that no one-time cost is included in this diagram. The recurring cost ($3,232) in constant dollars is obtained by summing the recurring utility, waste treatment

TABLE 14. SUMMARY OF ONE-TIME AND RECURRING COST ESTIMATES FOR A LARGE CROSSDRAFT BOOTH BEFORE AND AFTER CONVERSION

RECURRING COSTS

Item	Water Curtain System		Dry Filter System	
	Annual Constant Dollar Cost ($)	NPV of 10 Year Life Cycle Cost ($)	Annual Constant Dollar Cost ($)	NPV of 10 Year Life Cycle Cost ($)
Utilities	$1,228	$8,766	$702	$5,007
Waste Treatment	$1,800	$13,194	$0	$0
Labor	$204	$1,458	$135	$958
Materials	$0	$0	$582	$4,159
Total	$3,232	$23,418	$1,419	$10,124

ONE-TIME COSTS

Item	Cost ($)
Equipment & Installation	$996
Sheetmetal Work	$314
Total	$1,310

and labor costs ($1,228, $1,800, and $204, respectively) in constant dollars calculated in Section 5.3.2.2.

The cash flow diagram for the conversion option is presented in Figure 21. The one-time cost included in the diagram is from the purchase and installation of the dry filter PECS. The recurring cost ($1,419) in constant dollars associated with the dry filter system is obtained by summing the recurring utility, filter media and labor costs ($702, $582, and $135, respectively) in constant dollars calculated in Section 5.3.2.2.

5.3.2.4 Calculation of the Savings to Investment Ratio

The SIR is calculated by taking the difference between the NPV of the recurring costs of the present and proposed systems, and dividing the resultant by the total investment cost. The NPV of the recurring costs of the current water curtain system is $23,418. This value is obtained by summing the NPV of the recurring utility, waste treatment, and labor costs associated with the water curtain system ($8,766, $13,194, and $1,458, respectively) calculated in Section 5.3.2.2.

The NPV of the recurring costs of the proposed dry filter system is $10,124. This value is obtained by summing the NPV of the recurring utility, filter media, and labor costs associated with the water curtain system ($5,007, $4,159, and $958, respectively) calculated in Section 5.3.2.2.

The total investment cost for the dry filter system selected in this example is $1,310. The SIR is therefore 10.1. Based on this result, installation of the proposed dry filter system is a very economical alternative.

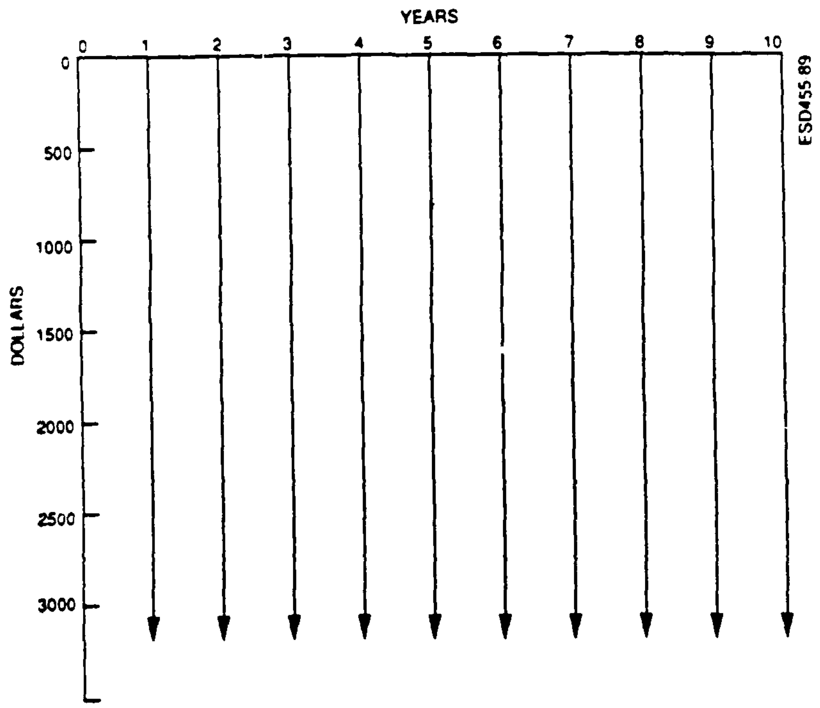

Figure 20. Cash flow diagram: current operation of a large crossdraft booth.

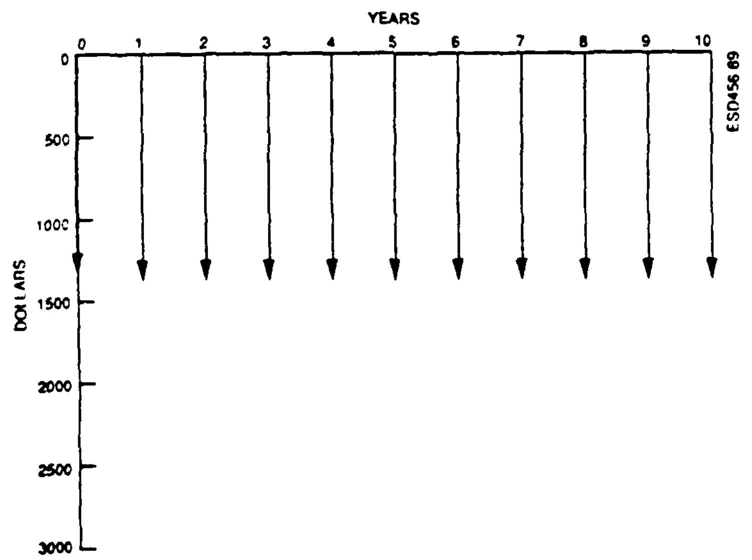

Figure 21. Cash flow diagram: proposed operation of a large crossdraft booth.

5.3.2.5 Determination of the Discounted Payback Period

The discounted payback period for this example is determined by referring to Table C found on page C-4 of the NAVFAC P-442 document. With an SIR of 10.1 and an economic life of 10 years, the payback period for the proposed alternative is less than 1 year.

5.3.3 Conversion of a Large Downdraft Paint Booth

The third example discusses the economic conversion of a large downdraft paint spray booth having a fairly heavy duty cycle.

5.3.3.1 Paint Booth Characterization Before and After Conversion

The current physical and operating characteristics of the booth are:

- The booth is 20 ft wide, 25 ft high, and 40 ft long
- The booth floor consists of a large grate covering the water curtain sump
- There are four exhaust ducts, each drawing overspray from a 20 ft by 10 ft area (approximately)
- The flowrate through each exhaust duct is 25,000 cfm (125 linear fpm) x (10 ft width) (20 ft length), and each exhaust fan is rated at 20 hp
- There are four water pumps, each rated at 7.5 hp, that circulate water from the sump
- The Navy activity is considered an industrial user, therefore lower electrical rates apply
- The pressure drop across the water curtain PECS is 2.0 inches w.c. due to presence of baffles, underground ducting, etc.
- The booth is used one and one-half shifts per day
- The average paint usage rate is 70 gal per week
- The average transfer efficiency is 30 percent
- Sump maintenance occurs three times per year
- Wastewater from the sump is drained to an IWTP at negligible cost; sludge collected at the bottom of the sump is drummed and disposed of as hazardous waste
- The grates are cleaned once per year
- Twenty-five drums of sludge are generated per year
- 120 ft^2 of major sheetmetal modification and repair work is needed to remove the water curtain baffles, and prepare the site for installation of the dry filter system

Because of the operating characteristics of the booth, a cloth filter replacement system is selected. The pressure drop associated with the cloth filter (1.25 inches w.c.) is considerably less than that associated with the water curtain PECS (because the baffles will be removed), thus the exhaust fans can be downgraded to 15 hp each. This requires the replacement of the fan motors, because downsizing in this case is not possible.

After conversion, the volume flowrate through each exhaust duct must remain at 25,000 cfm. Assuming a cloth filter clean face velocity of 210 linear fpm, the minimum required filter surface area associated with each exhaust fan is 119 ft^2. Cloth filters are available in widths of 3 ft, thus the resulting dry filter surface area associated with each fan should have dimensions of 20 ft by 6 ft.

5.3.3.2 Identification and Estimation of Costs

The one-time and recurring costs for the current and proposed systems in this example are estimated in a manner similar to that presented in Section 5.3.1.2. The results are summarized in Table 15.

5.3.3.3 Development of Cash Flow Diagrams for the Current and Proposed Systems

The one-time and recurring costs calculated in constant dollars in Section 5.3.3.2 are used to generate cash flow diagrams for the current and proposed systems. The recurring costs must be summed separately for each system to determine annual recurring costs in constant dollars.

The cash flow diagram for maintaining the status quo with the water curtain system is presented in Figure 22. Note that no one-time cost is included in this diagram. The recurring constant dollar cost ($21,026) is obtained by summing the recurring utility, waste treatment and labor constant dollar costs ($11,571, $7,500, and $1,955, respectively).

The cash flow diagram for the conversion option is presented in Figure 23. The one-time cost included in the diagram ($27,044) is from the purchase and installation of the dry filter PECS ($4,980), replacement of the exhaust fan motors ($2,320), major sheetmetal repair work ($1,888) and installation of the floor grate covering ($17,856). The recurring constant dollar cost ($8,825) associated with the dry filter system is obtained by summing the recurring utility, filter media and labor constant dollar costs ($6,314, $2,038, and $473, respectively).

5.3.3.4 Calculation of the Savings to Investment Ratio

The NPV of the recurring costs of the current water curtain system is $151,576. This value is obtained by summing the NPV of the recurring utility, waste treatment, and labor costs associated with the water curtain system ($82,645, $54,975, and $13,956, respectively) calculated in Section 5.3.3.2.

The NPV of the recurring costs of the proposed dry filter system is $63,003. This value is obtained by summing the NPV of the recurring utility, filter media, and labor costs associated with the water curtain system ($45,088, $14,559, and $3,356, respectively) calculated in Section 5.3.3.2.

As discussed in Section 5.3.3.3, the total investment cost for the dry filter system selected in this example is $27,044. The SIR is therefore 3.6. Based on this result, installation of the proposed dry filter system is a very economical alternative.

TABLE 15. SUMMARY OF ONE-TIME AND RECURRING COST ESTIMATES FOR A LARGE DOWNDRAFT BOOTH BEFORE AND AFTER CONVERSION

RECURRING COSTS

Item	Water Curtain System		Dry Filter System	
	Annual Constant Dollar Cost ($)	NPV of 10 Year Life Cycle Cost ($)	Annual Constant Dollar Cost ($)	NPV of 10 Year Life Cycle Cost ($)
Utilities	$11,571	$82,645	$6,314	$45,088
Waste Treatment	$7,500	$54,975	$0	$0
Labor	$1,955	$13,956	$473	$3,356
Materials	$0	$0	$2,038	$14,559
Total	$21,026	$151,576	$8,825	$63,003

ONE-TIME COSTS

Item	Cost ($)
Fan Motor Replacement	$2,320
Equipment & Installation	$4,980
Major Sheetmetal Work	$1,888
Floor Grate Covering	$17,856
Total	$27,044

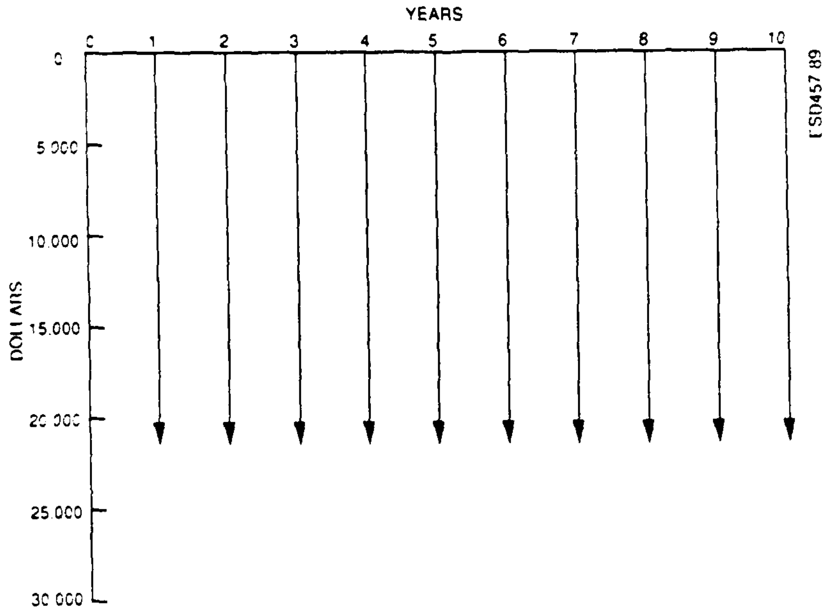

Figure 22. Cash flow diagram: current operation of a large downdraft booth.

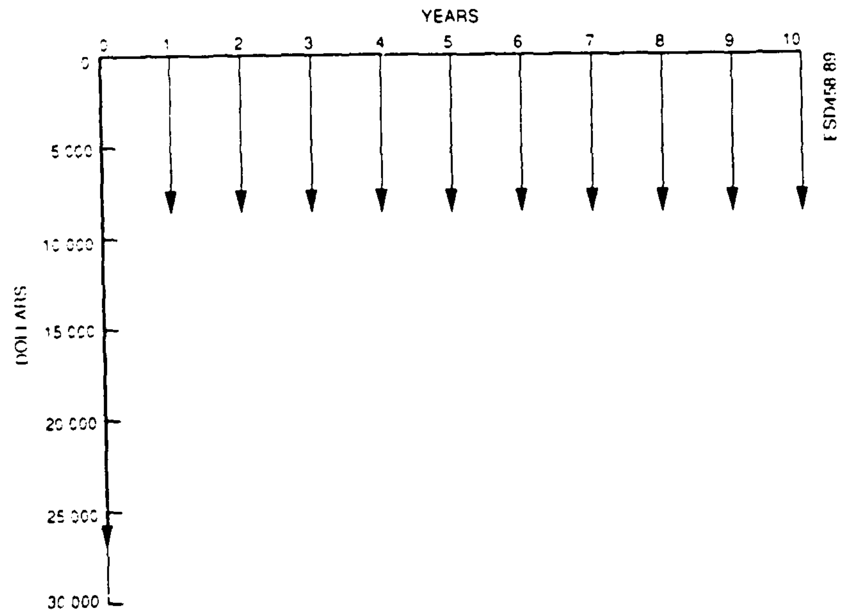

Figure 23. Cash flow diagram: proposed operation of a large downdraft booth.

5.3.2.5 Determination of the Discounted Payback Period

The discounted payback period for this example is determined by referring to Table C found on page C-4 of the NAVFAC P-442 document. With an SIR of 3.6 and an economic life of 10 years, the payback period for the proposed alternative is slightly less than 2 years.

APPENDIX A

DRY FILTER SYSTEM CHARACTERISTICS

General and specific characteristics of most dry filter systems currently available on the market are presented in this Appendix.

A-1 GENERAL DRY FILTER CHARACTERISTICS

All dry filter systems operate on the same principle: particulate laden air drawn into the filter is forced to rapidly change directions as it flows around the filter media. The particulate, having more inertia than the surrounding air, impacts on the filter media and is removed from the air flow. Dry filter systems operate in much the same way as mist eliminators.

The characteristics of all dry filter systems that affect performance are particulate capacity, resistance to airflow, and particulate removal efficiency.

Particulate Capacity

Particulate capacity of the filter is the quantity of overspray particulate that the filter is able to retain before replacement is required. The filter reaches maximum particulate capacity when the pressure drop across it exceeds the design value specified by the manufacturer.

Resistance to Airflow

Minimizing the resistance to airflow through the filter is necessary to maintain the required volume flowrate through the booth. Ideally, dry filters operate with little flow resistance until the particulate capacity is reached. This is generally not the case however, because airflow resistance increases as the quantity of particulate captured by the filter increases.

Particulate Removal Efficiency

Particulate removal efficiency is a measure of how effectively the filter removes paint particulate from spray booth exhaust. It is generally expressed as the percent of overspray removed from the airflow. The removal efficiency is primarily dependent on the particulate size, the spacing between obstructions presented by the filter media, and the velocity of air that passes through the filter.

Small particles remain entrained longer than large particles because they are better able to follow the flow of air around obstructions presented by the filter media. By tightly packing the filter media, small particles are removed more efficiently; however the filter may quickly become clogged. The air velocity also affects particulate removal efficiency; the higher the flowrate, the higher the particulate inertia, and, correspondingly, the more likely the particulate is to impact the filter media.

A-2 DRY FILTER TYPES

There are four principal filter types: fiberglass cartridge, multilayered honeycombed paper, accordion-pleated paper, and cloth filters. Although each type is presented separately, there are dry filter systems available in which one or more types of filters are combined. For example, one filter manufacturer markets a system in which a honeycombed paper filter and a cloth filter are combined for higher removal efficiency and particulate capacity.

Fiberglass Cartridge Filters

This type of filter finds widespread use due to low capital equipment and installation costs, reasonable particulate capacities, and high particulate removal efficiencies. However, filter replacement costs are relatively high. The filter media is composed of thin, closely packed fiberglass filaments, and is generally encased in a cardboard frame held in place by an easily assembled metal support structure. Cartridge sizes are approximately 20 inches long, 20 inches high and 1 inch deep. The primary advantage to this type of filter is the associated low installation cost.

There are several disadvantages to this type of filter. When filter changeout is required, each cartridge must be individually replaced. This can result in considerable downtime if the booth is heavily used, because of the high filter replacement rate. The support structure is generally not built so that the filters fit tightly in the frame. Thus, as the filters become clogged and airflow resistance through them increases, significant leakage of contaminated exhaust air around the cartridges occurs.

Fiberglass cartridge filters are best deployed in booths that have light duty cycles (less than one shift per day).

Multilayered Honeycombed Paper Roll or Pad Filters

Moderate capital equipment and installation costs and low filter replacement costs, fairly high particulate capacities, and reasonably high particulate removal efficiencies characterize the multilayered honeycombed paper filter systems. The filter media is composed of thin, loosely connected paper strips that are combined to form a multilayered honeycomb pattern. The paint booth exhaust flows through the strips, which become covered with paint overspray.

Honeycombed paper filters are available in pads or rolls; however the rolls require significantly less time to replace. This is because the pads must be installed individually, and are normally placed in two layers to increase particulate emission control. In addition, the price per square foot is higher for pads than rolls.

Accordion Pleated Paper Sheet Filters

Low to moderate installation and operating costs, moderate capacities, and moderately low particulate removal efficiencies are associated with accordion-pleated paper sheet filters. The media is composed of layers of pleated paper attached at the folds. The paint booth exhaust air flows through staggered rows of perforations which honeycomb the layers of paper. A schematic diagram illustrating how these filters operate is given in Figure A-1. (Reference 2).

The advantage of pleated paper filters is that they are quickly and easily replaced. The downtime associated with pleated paper filters replacement is somewhat less than with cloth or

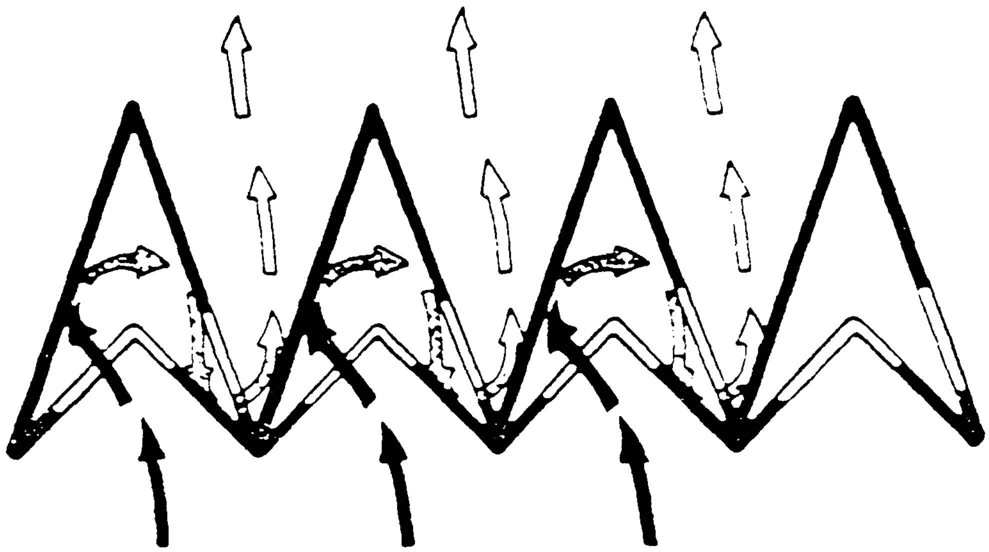

Figure A-1. Schematic Diagram Illustrating the Pleated Paper Filtration Process multilayered honeycombed paper rolls, and significantly less than with pad or cartridge type filters.

The primary disadvantage of the pleated paper filter is that the particulate removal efficiency is low compared to the other filter types. However, the control capabilities of this type of filter should be sufficiently high to maintain most, it not all, Navy paint booths in compliance with applicable regulations. In addition, difficulties may arise if they are used in areas of constant, high humidity, or if significant quantities of water based paints are used. The presence of excess moisture can cause the filter media to sag and allow unfiltered air to be emitted.

Cloth Filters

A variety of cloth filters are available on the market. The operating costs associated with these filters are low; however installation costs may be slightly higher than for other filter types. Cloth filter removal efficiencies and capacities are both high. Filter media is composed of specially designed woven or nonwoven cloth. It is available in thicknesses ranging from 0.25 to 1 inch, and in pads or rolls up to 400 ft in length.

Cloth roll filters have several distinct advantages over other types of filters. They are generally less expensive per square foot than other filters. One manufacturer claims that the capacity of their cloth roll filter is four times higher than that of pleated paper filters, and replacement filters cost one half as much. The cloth filter may therefore require much less frequent replacement. In addition, particulate removal efficiencies are high. The downtime associated with cloth roll filter replacement is significantly less per square foot than that required to replace cartridge and pad filters.

Another advantage of cloth roll filters is that they may be automatically deployed. In an automatic deployment system, the pressure differential across the filter is continuously monitored. When it reaches the limit specified by the manufacturer, clean filter media is unrolled from the top to replace used filter media, which is collected on a roll at the bottom. The advantage of automatic versus manual deployment is that the filter is changed only when necessary, not when the filter appears dirty. This reduces operating and filter disposal costs, and eliminates most of the downtime associated with filter replacement. It should be noted, however, that there have been reports that the automatic deployment system does not operate satisfactorily.

The primary disadvantage of cloth roll filter systems is that installation costs may be higher than for other systems, especially if an automatic deployment system is installed. The pressure differential associated with this type of filter is often higher than for the other type of filters, and may require upgrading or replacement of the fan motor.

These higher installation costs are often mitigated by the lower replacement filter costs and a significant reduction in downtime required for filter replacement. Automatically deployed filters are most suitable to high production booths (two or more shifts per day), while manually deployed systems are suitable for all booths, regardless of booth duty cycles.

A.3 Determination of Minimum Required Particulate Removal Efficiency

A.3.1 Compliance With Emissions Regulations

To determine whether or not the selected filter is capable of complying with local air pollution control regulations, the following analysis should be done:

- **Step 1**: Multiply the density of the paint (in lbs per gallon) by the percent solids content (approximately 50 percent for military paints), one minus the transfer efficiency (approximately 70 percent), the paint usage rate (in gallons per paint cycle); and divide this quantity by the air flowrate through the booth. Convert the results to tne metric system (mg per cubic meter). This yields the particulate concentration of particulate emitted.

- **Step 2**: Determine the allowable particulate emission concentration, which is generally reported in mg per cubic meter. This is accomplished by contacting the appropriate air pollution control agency listed in Section 4.

- **Step 3**: Divide the allowed emission rate by the calculated actual emission rate, subtract this quantity from one, and multiply by 100. The result is the minimum required removal efficiency for the filter system selected to maintain the facility in compliance.

A sample calculation is provided below. The values used for paint density, transfer efficiency, and solids content are fairly representative of military coating operations. The duty cycle (50 gallons per day) was selected to illustrate what may be considered a "worst case scenario," in which high particulate concentrations are encountered. The flowrate is fairly low for a booth with such a high production rate; however it was selected also for the purpose of illustrating a worst case situation.

Step 1:

$$\frac{[9\ \text{lb}]}{\text{gal}} \times \frac{[50\ \text{gal}]}{8\ \text{hr}} \times \frac{[0.5\ \text{lbs solids}]}{[1\ \text{lb paint}]} \times 0.70 \times \frac{1\ \text{hr}}{[1{,}200{,}000\ \text{ft}^3]} = \frac{0.000016\ \text{lb}}{[\text{ft}^3]}$$

(convert to metric units)

$$\frac{[0.000016\ \text{lb}]}{\text{ft}^3} \times \frac{\text{ft}^3}{0.028\ \text{m}^3} \times \frac{1\ \text{kg}}{[2.2\ \text{lb}]} \times \frac{[10^6\ \text{mg}]}{\text{kg}} = \frac{[266\ \text{mg}]}{[\text{m}^3]}$$

Step 2: For the Los Angeles area, the particulate concentration limit is 123 mg/m3, which is probably one of the lowest emission limits in the country. For a reasonable safety margin assume the limit is 100 mg/m^3.

Step 3:

$$1 - \frac{\frac{100\ \text{mg}}{\text{m}^3}}{\frac{266\ \text{mg}}{\text{m}^3}} = 0.62 \times 100 = 62\%\ \text{removal efficiency is required.}$$

The removal efficiency of the pleated paper filter should be high enough to meet this requirement.

A.3.2 Other Removal Efficiency Requirements

If the paint spray booth to be converted is also a target for future VOC emission control requirements, the particulate removal efficiency of the proposed dry filter system (as well as the current water curtain system) may be critical. This is because some VOC emission control systems (i.e., carbon adsorption and catalytic incineration) cannot tolerate any appreciable amount of particulate present in the process flow. For this and other reasons, these systems are often not recommended for use in controlling VOC emissions from military painting operations. However, if a VOC emission control device is to be installed on the booth, the minimum required particulate removal efficiency issue should be carefully considered.

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NAVFACENGCOM Code 03, Alexandria, VA; Code 03T (Essoglou), Alexandria, VA; Code 04A, Alexandria, VA; Code 04A1, Alexandria, VA; Code 04A3, Alexandria, VA; Code 051A, Alexandria, VA; Code 083, Alexandria, VA; Code 09M124 (Lib), Alexandria, VA; Code 163, Alexandria, VA; Code 1645B, Alexandria, VA; Code 1651, Alexandria, VA; Code DS02, Alexandria, VA
NAVFACENGCOM - CHES DIV. FPO-1PL, Washington, DC
NAVFACENGCOM - LANT DIV. Code 403, Norfolk, VA; Code 405, Norfolk, VA
NAVFACENGCOM - NORTH DIV. CO, Philadelphia, PA; Code 04, Philadelphia, PA; Code 04AL, Philadelphia, PA; Code 114 (Rhoads), Philadelphia, PA; Code 1142/MPL, Philadelphia, PA
NAVFACENGCOM - PAC DIV. Code 09P, Pearl Harbor, HI; Library, Pearl Harbor, HI
NAVFACENGCOM - SOUTH DIV. Code 0525, Charleston, SC; Code 406, Charleston, SC; Library, Charleston, SC
NAVFACENGCOM - WEST DIV. 09P/20, San Bruno, CA; Code 04A2.2 (Lib), San Bruno, CA; Code 04B, San Bruno, CA; Code 09B, San Bruno, CA; Code 102, San Bruno, CA; Code 405, San Bruno, CA; Code 408.2 (Jeung) San Bruno, CA; Pac NW Br Offc, Code C/50, Silverdale, WA; Pac NW Br Offc, Dir, Silverdale, WA
NAVFACENGCOM CONTRACTS AROICC, Cherry Point, NC; AROICC, Coleville, CA; AROICC, Quantico, VA; AROICC, San Vito, Italy; Code 922, Everett, WA; DROICC, Adak, AK; DROICC, Rota, Spain; Mid Pac, OICC, Pearl Harbor, HI; OICC (Code 04A), Madrid, Spain; OICC NW, Code 114NW, Silverdale, WA; OICC, Guam; OICC, Nea Makri, Greece; OICC/ROICC, Virginia Beach, VA; PWO, Moffett Field, CA; ROICC (Code 495), Portsmouth, VA; ROICC, Columbus, OH; ROICC, Corpus Christi, TX; ROICC, Crane, IN; ROICC, Keflavik, Iceland; ROICC, Point Mugu, CA; ROICC, Portsmouth, NH; ROICC, Warminster, PA; SW Pac, OICC, Manila, RP; Trident, OICC, St Marys, GA; Whidbey Is, AROICC, Oak Harbor, WA
NAVFUEL DET OIC, Yokohama, Japan
NAVHOSP CO, Millington, TN; Hd, Fac Mgmt, Camp Pendleton, CA; PWO, Camp Lejeune, NC; SCE (Knapowski), Great Lakes, IL; SCE, Great Lakes, IL; SCE, Long Beach, CA; SCE, Pensacola, FL; SCE, Yokosuka, Japan
NAVMARCORESCEN LTJG Davis, Raleigh, NC
NAVMEDCOM NWREG, Fac Engr, PWD, Oakland, CA; NWREG, Head, Fac Mgmt Dept, Oakland, CA; SCE, Jacksonville, FL; SWREG, Code 35, San Diego, CA; SWREG, SCE, San Diego, CA
NAVMEDRSCHINSTITUTE Code 47, Bethesda, MD
NAVMEDRSCHU Three, PWO, Cairo, Egypt
NAVOCEANCOMCEN Code EES, Guam, Mariana Islands
NAVOCEANO Library, Bay St Louis, MS
NAVORDSTA Indian Head DET, McAlester, OK; MDS-25, Louisville, KY; PWO, Louisville, KY
NAVPACEN Dir, San Diego, CA
NAVPETRES Director, Washington DC
NAVPGSCOL E. Thornton, Monterey, CA
NAVPHIBASE PWO, Norfolk, VA; SCE, San Diego, CA
NAVRADSTA Whidbey Is, PWO, Oak Harbor, WA
NAVSAFECEN CO, Norfolk, VA
NAVSCOLCECOFF Code C35, Port Hueneme, CA
NAVSEA DET NISMF Pearl Harbor, Director, Waipahu, HI
NAVSEACENPAC Code 950, San Diego, CA
NAVSECGRU Code G43, Washington, DC
NAVSECGRUACT PWO (Code 40), Edzell, Scotland; PWO, Adak, AK; PWO, Sabana Seca, PR; PWO, Sonoma, CA
NAVSECSTA Code 60, Washington, DC; Code N70, Washington, DC
NAVSHIPREPFAC SCE, Subic Bay, RP; SCE, Yokosuka, Japan
NAVSHIPYD Carr Inlet Acoustic Range, Bremerton, WA; Code 108.1, Pearl Harbor, HI; Code 202.5 (Library), Bremerton, WA; Code 420, Long Beach, CA; Code 440, Portsmouth, NH; Code 440.1 (R. Schwinck), Long Beach, CA; Code 440.7, Charleston, SC; Code 444, Philadelphia, PA; Code 903, Long Beach, CA; Mare Island, Code 106.4, Vallejo, CA; Mare Island, Code 202.13, Vallejo, CA; Mare Island, Code 401, Vallejo, CA; Mare Island, Code 421, Vallejo, CA; Mare Island, Code 440, Vallejo, CA; Mare Island, Code 457, Vallejo, CA; Mare Island, PWO, Vallejo, CA; Norfolk, Code 106, Portsmouth, VA; Norfolk, Code 380, Portsmouth, VA; Norfolk, Code 411, Portsmouth, VA; Norfolk, Code 440, Portsmouth, VA; Norfolk, Code 450-HD, Portsmouth, VA; PWO (Code 400), Long Beach, CA; PWO, Bremerton, WA; PWO, Charleston, SC; PWO, Portsmouth, NH

SPCC PWO (Code 08X), Mechanicsburg, PA
SUBASE PWO, Groton, CT
SUPSHIP Tech Library, Newport News, VA
TRIREFFAC Bangor, Code 213, Bremerton, WA
US DEPT OF INTERIOR BLM, Engrg Div (730), Washington, DC
US GEOLOGICAL SURVEY J Bales, Raleigh, NC; Marine Geology Offc (Piteleki), Reston, VA
US GOVT PRINTING OFFC Library Prgms Svcs, SLLC, Washington, DC; Supt Docs, SLLA, Washington, DC; Supt Docs, SLLA, Washington, DC
USAF RGNHOSP SGPB, Fairchild AFB, WA; SGPM, Fairchild AFB, WA
USCINCPAC Code J44, Camp HM Smith, HI
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USNA Mech Engrg Dept (Power), Annapolis, MD; PWO, Annapolis, MD; Rsch Dir, Annapolis, MD; Sys Engrg (Tuttle), Annapolis, MD
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CALIFORNIA Nav & Ocean Dev (Armstrong), Sacramento, CA
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CLEVELAND STATE UNIVERSITY CE Dept (Akinmusuru), Cleveland, OH
CORNELL UNIVERSITY Library, Ithaca, NY
DAMES & MOORE Library, Los Angeles, CA
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UNIVERSITY OF CALIFORNIA CE Dept (Mitchell), Berkeley, CA
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