PARTS WASHING ALTERNATIVES STUDY
UNITED STATES COAST GUARD

by

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ABSTRACT

This report has been written to assist the United States Coast Guard (USCG) industrial managers in determining the most cost effective and environmentally acceptable parts washing alternatives for their specific applications. An evaluation was conducted on four different cleaners from three different Coast Guard facilities to determine economic and environmental impacts for the parts washing applications. This evaluation considered only USCG related impacts, with the USCG facilities as the analysis boundary. The three facilities chosen for the study were Aviation Training Center (ATC), Mobile, Alabama; Air Station Cape Cod (ASCC), Falmouth, Massachusetts; and Support Center New York (SCNY), Governors Island, New York. ATC and ASCC parts washing applications focused on cleaning contaminated parts from aviation operations; SCNY parts washing applications were directed at cleaning contaminated parts from seafaring vessels. The evaluation of alternative parts cleaners included the following categories: process description; environmental, safety and health impacts; cost analysis; and the material and emission reduction opportunities. The methodology used in this study can be employed to complete evaluations on other parts cleaners. The following parts cleaners were evaluated; Bio Seven, Penatone 724, Safety-Kleen 105, and Brulin 815 GD. All four cleaners are effective cleaners for the specific applications described in this evaluation. Bio Seven is an on-site recycled aqueous parts cleaner that has minimal apparent health effects and is currently being tested to qualify to military specifications. Penatone 724 is a non-recycled petroleum distillate that meets the military classification of a PD 680 type II parts cleaner but possess potential personnel and environmental concerns. Safety-Kleen 105 is a full service recycled petroleum solvent; but has potential long term hazardous waste liability concerns. Brulin 815 GD has apparent minimal health and environmental concerns, but must be heated to 140°F - 160°F for effective cleaning.

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WORKSHEETS

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INTRODUCTION

An evaluation was conducted on techniques and chemicals used to clean parts at Coast Guard facilities located at the Aviation Training Center (ATC), Mobile, Alabama; Air Station Cape Cod (ASCC), Falmouth, Massachusetts; and Support Center New York (SCNY), Governors Island, New York. The objective of this evaluation was to provide decision-making guidance for the United States Coast Guard industrial managers to choose cost effective parts cleaning chemicals that have minimum environmental and safety impacts. The alternative chemicals evaluated were categorized for each location:

TABLE 1. CHEMICAL TYPE AND APPLICATION

CHEMICAL	LOCATION	CATEGORY
Bio Seven	ATC	On-Site Recycle, Aqueous - Mild
Penatone 724	ATC	Non-Recycle, Petroleum Distillate
Safety-Kleen 105	ASCC	Full Service Recycle, Petroleum Solvent
Brulin 815 GD	SCNY	Non-Recycle, Aqueous Alkaline

The evaluation includes a limited inventory analysis, impact analysis, improvement analysis, and cost analysis for each alternative. The inventory analysis identifies and quantifies energy, process material requirements, atmospheric emissions, waterborne emissions, solid and hazardous waste, and other releases from the parts cleaning process. The impact analysis addresses environmental and human health impacts from the use of the parts cleaners. The improvement analysis introduced opportunities to reduce environmental releases, energy consumption and material use in the parts cleaning process. A cost analysis of the cleaning alternative evaluated provides a financial descriptive report that can aid in cleaner selection.

APPROACH

PROCEDURE FOR EVALUATING USCG PARTS WASHING ALTERNATIVES

A. BACKGROUND

A system evaluation is a tool for identifying the environmental burdens and evaluating the associated impacts caused by a product, process, or service. The decision to perform a system evaluation usually is based on the following objectives:

- Establish a baseline of information on a system's overall resource use, energy consumption, and environmental impacts
- Identify stages within the process where a reduction in resource use and emissions might be achieved
- Compare the system inputs and outputs associated with alternative products, processes, or activities
- Guide the development of new activities, processes, or products toward a net reduction of resource requirements and emissions

A system evaluation should provide independent determinations of environmental and economic impacts for each product, process, or service evaluated. The level of that determination will be dependent on available information and desired results. A basic system evaluation should include:

Process Description: Identification and quantification of energy and resource use and environmental releases to air, water, and land.

Environmental, Safety and Health Issues: Characterization and assessment of the environmental impacts.

Material and Emission Reduction Opportunities and Cost Analysis: The evaluation of opportunities to reduce environmental and economic burdens.

The process description begins with a conceptual goal definition phase to define both the purposes for performing the evaluation and the scope of the analysis. An inventory procedure is then employed and data are gathered. The data are incorporated into a model to determine the environmental, safety and health impacts and to assist in the cost analysis. Finally, results are analyzed to determine improvements that will reduce material usage, environmental burdens and the associated cost.

The main focus of the USCG parts washing alternatives study was to develop a procedure for assessing and comparing parts cleaners. This was accomplished by evaluating the chemical cleaners selected by the USCG and detailing the method used to obtain the operating practices and cost for each.

The first step in initiating the study is to identify the evaluation team. It is imperative that the goals, scope, and all assumptions inherent in the evaluation be clear to the participants. The evaluation team should have technical knowledge of the process, as well as knowledge of the current production operations and the personnel involved. Team members for this evaluation included engineers, machinists, technicians, repair maintenance personnel, knowledgeable department personnel such as production operator(s), and material experts.

B. PROCEDURE

The following outline was used to collect the information for the evaluation of the parts washing alternatives. The outline is presented in a format that allows for further evaluations to be conducted on other parts washing processes and is divided into the following sections: process description; environmental, safety and health; cost analysis; material and emission reduction; and conclusion.

PROCESS DESCRIPTION:

The main elements of the process description are the process location, summary of operations performed, equipment, process controls, products, input materials, and the waste streams affected.

Preliminary information for the parts washing process is developed using worksheet 1. Information on the process location should include:

- Geographical location of the Facility or Base
- Principal function of the Facility or Base
- Duties performed at the Facility or Base
- Location of the Parts Cleaning Stations within the Facility or Base

Obtaining information on the parts washing station will allow the evaluation team to assess possible state or local regulatory concerns, understand the needs of the process technician, and define the process boundary. The process boundary should be based on the objective of the evaluation. The boundary may be established around the parts washing station, or the boundary could extend to the building where parts washing is conducted, or the USCG facility.

The process description should include a chronological sequence of the parts washing process that begins from the time the contaminated parts come into the washing station until the clean parts leave the washing station. A detailed description of the cleaning procedure used by the technician will be important in identifying potential areas for operation improvements. The "product" in this evaluation is the cleaned part.

After the completion of worksheet 1, a process flow diagram should be developed. The flow diagram should track all input and output materials from the time they enter the process boundary until they leave. A sample flow diagram is shown in worksheet 2 for the parts washing process.

Inputs should include the cleaner for the station and all physical factors that go into the cleaning of the part. Some of these factors are the energy to heat the solution, personal protective equipment, dilution materials, rinses, wipe down material, air drying, etc.

Outputs are the direct result of the inputs. Outputs should be divided into separate groups. These groups could include air emissions released through the process, liquid effluent and solid waste that cross the designated boundary, personal protective equipment (i.e., gloves, face

Parts Washing Process Preliminary Information

Location:

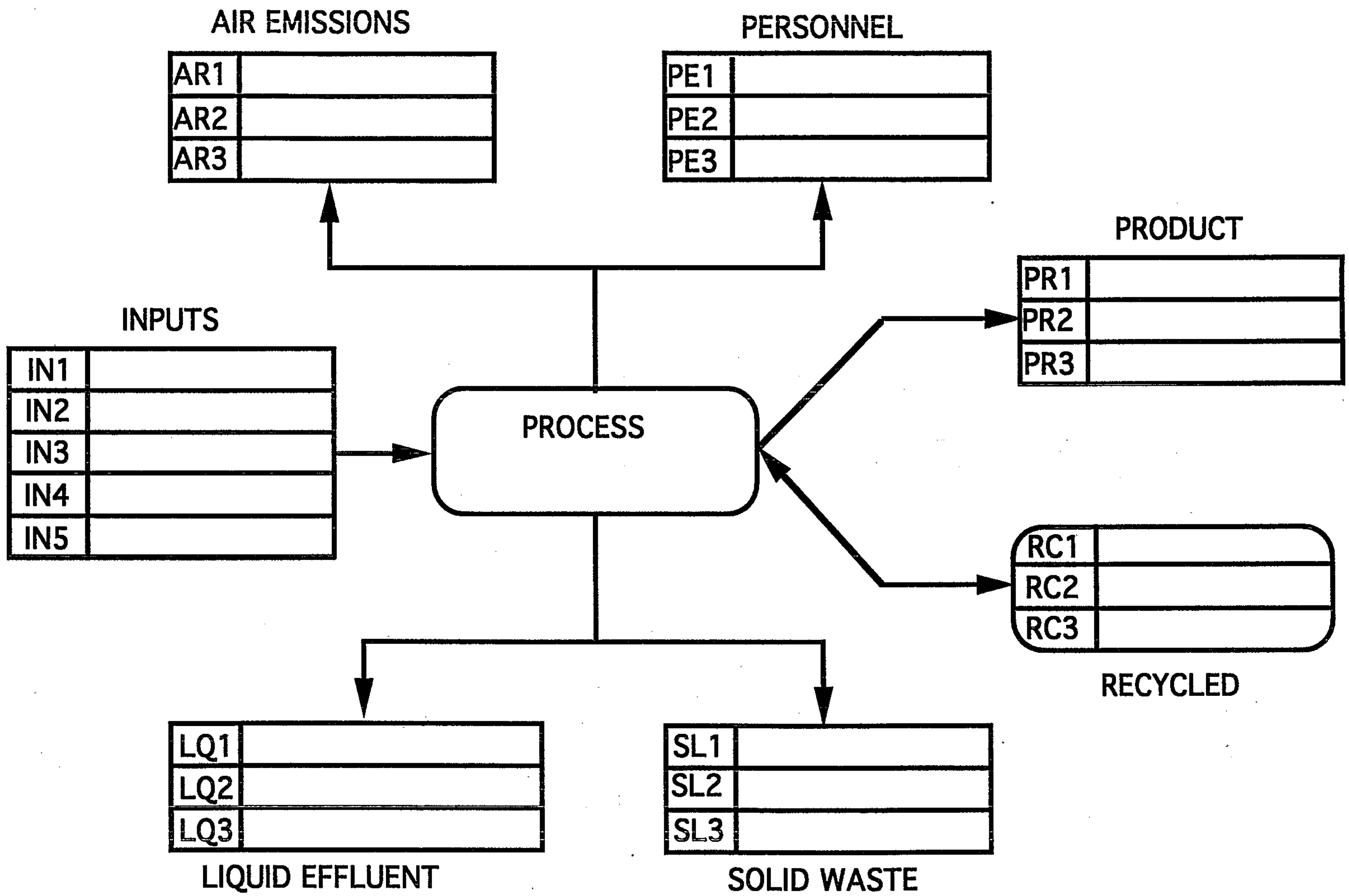
Process Boundary:

Process Description:

Product of Process:

Worksheet 1. Parts Washing Process Description

FLOW DIAGRAM FOR PARTS WASHING



Worksheet 2. Flow Diagram for Parts Washing

shields, respirators, etc.) used to complete the task, recycled material(s), and the product.

After the flow diagram has been developed, a material balance can be tabulated. Worksheet 3 is an example of a tabular material balance of the inputs and outputs for all streams associated with the parts washing process. The first step in developing a material balance is determining a "basis" to be used, which is a unit of measure to ensure equal comparison of alternatives. A basis may be a period of time, or a given mass of material associated with the process. In the selection of a basis, it is important to consider the material being processed, the questions to be answered from the evaluation, and the type and quality of available data.

The annual mass of parts decontaminated was used for the basis in the USCG parts washing evaluation. The material balance is a summation of the total quantity of input material to a process and the output to the environment, another process, or conversion into product. The total inputs should equal the total outputs for the process.

ENVIRONMENTAL, SAFETY AND HEALTH IMPACTS:

After completing the description of the parts washing process, it is important to evaluate the potential environmental, safety and health (ESH) impacts, and associated regulatory requirements of the chemical cleaner.

A good source of information regarding the ESH impacts in using the cleaner can be found on the material safety data sheet (MSDS). The MSDS details hazardous ingredients contained in the cleaning solutions, flammability/combustibility, corrosiveness, exposure limits, required protective equipment, and other factors that must be addressed when using the cleaner.

The state and local regulatory requirements should be verified with appropriate agency offices. State regulatory requirements as a minimum must conform to federal regulations, but can be more restrictive. Typical areas to check for increased state requirements include:

- Definitions of a hazardous waste
- Requirements for manifesting before shipment
- Allowable emission rates or effluent discharges for the process
- Permitting requirements for emissions to the various media (air, water, and soil)

Each state has its own guidelines that detail the requirements necessary to maintain regulatory compliance. These guidelines could include provisions to obtain an operating permit for the cleaning station. The MSDS may also contain some possible federal and state regulatory requirements for using the cleaner.

MATERIAL BALANCE FOR CHEMICAL CLEANERS

Material Description	Annual Input (lbs.)	Annual Total Output (lbs.)		TOTAL RELEASES (Units: lbs)									
			PR1 PRODUCT	AR1 AIR EMISSIONS	AR2 AIR EMISSIONS	LQ1 LIQUID EFFLUENT	LQ2 LIQUID EFFLUENT	LQ3 LIQUID EFFLUENT	SL1 SOLID WASTE	SL2 SOLID WASTE	SL3 SOLID WASTE	PE1 PERSONAL PROTECTIVE EQUIPMENT	RC1 RECYCLED MATERIAL
TOTAL													

Worksheet 3. Material Balance Sheet

COST ANALYSIS:

With the quantified numbers from the material balance and ESH impacts identified, a cost for using the cleaner can be determined. In worksheet 4, the cost analysis is divided into the following sections:

- Material Acquisition - The actual chemical purchases and any initial start-up cost should be included. The costs for these acquisitions are typically derived from purchase records or receipts.
- Identify and Quantify Inputs and Outputs - Items from the material balance should be addressed. Include energy usage and water consumption. Certain items (i.e., parts, air emissions, etc.) may not have a cost factor.
- ESH Impacts - Include the cost for personal protective equipment, sewer discharge costs, operating permits, physical examinations, etc.

If assumptions or calculations were used in the cost analysis, the documentation should be attached to the worksheet. For aqueous cleaners a sewer discharge cost would normally be accounted for in the cost section. In this evaluation we were unable to obtain direct sewage cost and found that most sewage cost were incorporated into the price of the water.

MATERIAL AND EMISSION REDUCTION OPPORTUNITIES:

A diagramming tool for option identification helps generate pollution prevention ideas. It is useful to conduct a brainstorming session with people who know the parts washing process to group ideas under similar pollution prevention categories. It also ensures that all pollution prevention categories are considered. Worksheet 5 is a diagraming tool for option generation that list the six primary categories to consider. The categories may change according to specific requirements.

After pollution prevention options have been generated, the options are described in worksheet 6. Multiple pollution prevention options may be identified in a successful evaluation. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Since detailed evaluation of technical and economic feasibility is usually costly, the proposed options should be screened to identify those that deserve further evaluation. The screening process serves to eliminate suggested options that appear marginal, impractical, or inferior without a detailed and more costly feasibility study.

The preliminary screening procedure should consider the following questions:

- Is implementation of the option cost effective?
- What is the principal benefit of the option?
- What is the expected change in the type or amount of waste generated?
- Does it use existing technology?
- What kind of development effort is required?
- Will implementation be constrained by time?

COST ANALYSIS FOR CHEMICAL CLEANERS

DESCRIPTION	COST PER UNIT	TOTAL COST	
		START-UP	RECURRING
Material Acquisition			
Identify and Quantify Inputs and Outputs			
ESH Impacts			

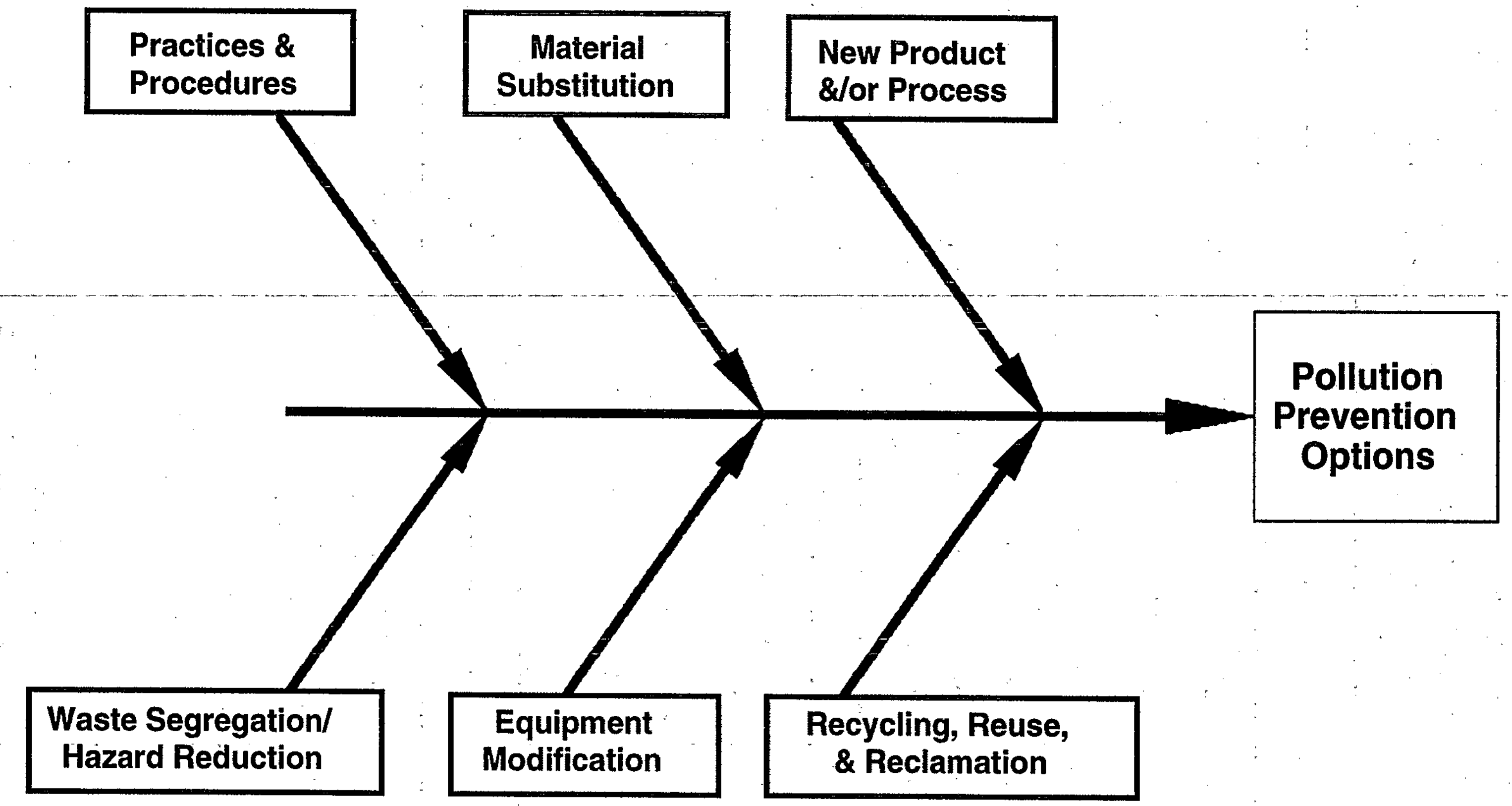
Total Start-Up Cost __________

Total Annual Recurring Cost __________

Worksheet 4. Cost Analysis for Cleaners

Material and Emission Reduction

Option Generation



Worksheet 5. Option Generation

Material and Emission Reduction
Option Description

Option Name and Description
(Include input materials and products affected)

Option No. ____________ **Consider:** O Yes O No

____
____
____
____

Practices & Procedures ☐ Waste Segregation/Hazard Reduction ☐
Material Substitution ☐ Equipment Modification ☐
New Product &/or Process ☐ Recycling, Reuse, & Reclamation ☐

Option No. ____________ **Consider:** O Yes O No

____
____
____
____

Practices & Procedures ☐ Waste Segregation/Hazard Reduction ☐
Material Substitution ☐ Equipment Modification ☐
New Product &/or Process ☐ Recycling, Reuse, & Reclamation ☐

Option No. ____________ **Consider:** O Yes O No

____
____
____
____

Practices & Procedures ☐ Waste Segregation/Hazard Reduction ☐
Material Substitution ☐ Equipment Modification ☐
New Product &/or Process ☐ Recycling, Reuse, & Reclamation ☐

Worksheet 6. Option Description

- Does the option have a dependable performance record?
- Will the option affect product, employee health, or safety?
- What are the upstream or downstream impacts if implemented?

The results of the screening process will be a list of options that are candidates for more detailed technical and economic evaluations.

Cost evaluation of the pollution prevention options identified in worksheet 6 is listed in worksheet 7. The cost evaluation is beyond the scope of this study, but is presented to provide a method to compare and contrast the pollution prevention options. The three major cost categories in worksheet 7 are: Implementation Costs, Incremental Operating Costs, and Incremental Intangible Costs.

An evaluation of the options considered is most easily accomplished and documented by using a simple matrix for scoring and ranking. The evaluation matrix listed in worksheet 8 provides a means to quantify the important criteria that affect the parts washing process and is a quick visual representation of the factors affecting various waste minimization and pollution prevention options. These considerations include: economic viability, including capital cost, operating cost, waste management cost and return on investment; change in the type or amount of waste generated liability issues; technical feasibility; avoided costs; effect on product; employee health and safety; permits, variances, and regulatory compliance; releases and discharges to all media; and implementation feasibility. The options should be prioritized for implementation based on their ranking within the matrix. The rational for selection or weighing of scores should be included.

CONCLUSION:

The procedure used in developing, assessing and choosing a waste minimization and pollution prevention option can be used to compare similar processes. A summarization of the information obtained from the worksheets should be presented in a brief report. Decisions on improvement options should be based on the conclusions developed in the evaluation. It is important to attempt to gather all the data that can affect the process and clearly summarize recommendations.

Material and Emission Reduction

Option Cost Evaluations

CATEGORY	Option No.	Option No.	Option No.
Implementation Costs			
Purchased Equipment			
Installation			
Materials			
Utility Connections			
Engineering			
Development			
Start up / Training			
Administrative			
Other.			
Other			
Total Implement. Cost			
Incremental Operating Savings / (Costs)			
Change in Raw Mat'ls			
Change in Utilities			
Change in Labor			
Change in Disposal			
Other			
Other			
Annual Operating Savings / (Costs)			
Incremental Intangible Savings / (Costs)			
Permits and Fees			
Future Liabilities			
Other			
Other			
Annual Intangible Savings / (Costs)			
TOTAL ANNUAL SAVINGS / (COSTS)			
PAYBACK PERIOD			

Worksheet 7. Option Cost Evaluations

OPTION EVALUATION FOR PARTS WASHING

CATEGORY	Weight (1) 'W'	Option No. ☐ Scale (2) 'S'	'WxS'	Option No. ☐ Scale (2) 'S'	'WxS'	Option No. ☐ Scale (2) 'S'	'WxS'
Economic							
Waste Generation							
Implementation Period							
Employee Health & Safety							
Improved Operation/ Product							
Regulatory Compliance							
Other							
Subtotal							
Likelihood of Technical Success (Multiplier)		X		X		X	
Likelihood of Useful Results (Multiplier)		X		X		X	
Total							
Rank							

1. The numerical value of the weight must be determined by the review team and should be from 0 (none) to 10 (high)
2. Scale each category from 0 (none) to 10 (high)

Worksheet 8. Evaluation Matrix

PARTS CLEANING ASSESSMENTS

GENERAL FORMAT

Four parts cleaners were chosen for the alternatives study. The cleaners were selected from three different Coast Guard facilities. The facilities chosen consisted of two aviation centers; ATC Mobile, Alabama and ASCC Falmouth, Massachusetts, and one marine and ground support facility; SCNY Governors Island, New York. The different functions of the sites selected allowed for a broad study of the alternative parts cleaners.

Aviation cleaning requirements are different from those of a marine and ground support facility. Because of the complexities of an aircraft, it is necessary to divide aviation cleaning into three distinct categories. Category one includes tires and wheels of the aircraft. Category two includes engine components, and category three is general aviation equipment. A cleaner must be qualified by the USCG within a specific category for aviation cleaning.

The alternatives in the study include a full-service recycled cleaner (Safety-Kleen 105), an on-site recycled cleaner (Bio Seven), and two non-recycled cleaners (Penatone 724 and Brulin 815 GD). These cleaners were selected because of their high usage level and different chemical constituents. Safety-Kleen 105 and Penatone 724 have been qualified by the USCG to military specifications for parts cleaning in all three aviation categories. Bio Seven is used to clean category two and three aviation parts and is currently being tested to qualify to military parts cleaning specifications. Table 2 delineates these cleaners and classifies them by category and usage.

TABLE 2. CLEANER CATEGORY AND APPLICATION

CHEMICAL	CATEGORY	APPLICATION
Safety-Kleen 105 (SK)	Full Service Recycle: Petroleum Distillates	Aviation: Category one, two and three
Penatone 724 (PE)	Non-Recycle: Petroleum Distillates	Aviation: Category one, two and three
Bio Seven (BI)	On-Site Recycled: Aqueous - Mild	Aviation: Category two and three
Brulin 815 GD (BR)	Non-Recycle: Aqueous - Alkaline	Marine and Ground Support: No restrictions

This report presents each parts washing cleaner in a similar format. This type of information provides a consistent approach to studying the alternative cleaners and developing comparison trends. The format is divided into two main sections: (1) a discussion and (2) supporting documentation. The discussion provides a qualitative approach to analyzing the alternative cleaners. This section presents: (1) the step-by-step procedure used in parts cleaning, (2) environmental impacts or possible health and safety risks associated with the cleaner, (3) identifiable costs associated with using the cleaner, (4) a material and emission reduction opportunity assessment, and (5) summarized conclusion of the parts cleaning process. The supporting documentation describes the parts cleaning activity in quantitative terms and is comprised of a process description, process flow diagram, material balance, calculations used to derive numerical data, cost analysis, and material and emission reduction options for the process.

Labor cost associated with the cleaning process is not presented in this report. It was the opinion of the review team that there were no significant deviations in the amount of effort expended on the task of cleaning the part; therefore, this parameter would not be a deciding factor for the selection of an alternative cleaner in this study.

Each of the four cleaners evaluated had different applications, therefore a comparison of total costs for the cleaners should be avoided. The total cost for a specific cleaner will vary depending on the type and quantity of parts that are cleaned, geographical location, and facility preferences.

USCG AVIATION TRAINING CENTER MOBILE, ALABAMA

The USCG Aviation Training Center is located at Bates Field, adjacent to the Mobile, Alabama Municipal Airport. The ATC was commissioned in 1966 to provide centralized comprehensive training to USCG personnel in the operation of fixed wing and rotary wing aircraft. The facility also has fixed wing search and rescue responsibilities. Five hundred personnel operate the facility on a 24-hour basis. Three types of aircraft are maintained in operation: the Dauphin Helicopter (HH-65), the Jayhawk Helicopter (HH-60), and the Falcon Jet (HU-25). Duties performed include cleaning, maintenance and repair of structural, mechanical, and electrical components, and rescue and survival gear. There are approximately 20 aircraft operated at this facility.

The ATC has the capability to address the majority of repair needs for each airframe design. Each type of aircraft has its own maintenance and repair shop. The engine repair shop facilities are shared by multiple types of aircraft.

The maintenance, repair and engine shop facilities have the capability to clean a wide variety of aircraft and engine parts. Bio Seven, a mild aqueous cleaner, and Penatone 724, a petroleum distillate, are routinely used in the parts cleaning process at these facilities.

BIO SEVEN

PROCESS DESCRIPTION:

The ATC has three separate parts cleaning stations using the cleaner Bio Seven. Each station contains a 55-gallon polyethylene parts washing tank that is designed to hold approximately 36 gallons of cleaning solution. These solutions are 50/50 mixtures of Bio Seven and potable water. The cleaning solution is heated in the holding tank to the temperature range of 96°F to 104°F and is continuously recirculated as parts are being washed. The contaminants that are typically cleaned from the parts consist of grease, oil, dirt, and hydraulic fluid. These contaminants are removed from the parts by vigorous manual brushing. As the contaminants are removed from the parts, they are washed away with the cleaning solution into the enclosed section of the tank. After cleaning, the parts are rinsed with clean potable water to remove any residual cleaning solution. Rinsing is done at a separate location, and rinsate is discharged to the sewer. The parts cleaning procedure is complete when the technician dries the part with a hand wipe cloth or disposable wipe towel.

The contaminants separate from the cleaning solution in the holding tank due to density differences. Petroleum products float to the top of the cleaning solution where they can then be easily removed. Dirt and other contaminants that are heavier than water sink to the bottom of the holding tank. In theory, the operator would not have to change out the cleaning solution since the contaminants being cleaned from the parts are immiscible. In practice, the contaminants may dissolve in the cleaning solution or could become entrained with the contaminants, reducing the potential cleaning capability. Bio Seven has been used for 10 months and ATC maintenance personnel indicate that the solution has maintained cleaning effectiveness and has not yet been changed out.

The petroleum waste generated from the parts cleaning process is collected by a private contractor. The contractor comes on site every month and extracts the waste from the three stations. Approximately one half of an inch (1/2 gallon) of petroleum contaminants are removed from the cleaning solution at each station. The contractor discharges the waste into a holding tank located on-site, known as the oil bowser. The waste is characterized as ignitable hazardous waste by RCRA regulations (40 CFR section 261.21). This ignitibility gives the waste a high fuel value that can be used for heat recovery. The ATC has an existing contract with a hazardous waste disposal company for removal and incineration of waste fuels from the oil bowser. The waste is then shipped to a cement kiln were it is used as an alternative fuel source for heat generation. The ATC receives 3 cents for every gallon that is shipped off for fuel burning.

ENVIRONMENTAL, SAFETY AND HEALTH ISSUES:

Bio Seven is a clear, free-flowing surfactant with a slight rose odor. The material safety data sheet (MSDS) for the solution does not list any hazardous ingredients. Bio Seven is comparable to petroleum-based solvents in cleaning versatility and possesses high solubility in water. Bio Seven is biodegradable, non-toxic and under normal use there are no apparent health hazards. It is non-flammable and will not support combustion. In Alabama, hand wipe towels with Bio Seven and contaminants are disposed as a non-hazardous solid waste. The liquid effluent is discharged to the sewer.

There are no requirements in the MSDS calling for personal protective equipment when the Bio Seven solution is used. However, the USCG requires that all technicians wear protective gloves and eye glasses whenever they are engaged in the process of cleaning parts.

COST ANALYSIS:

The total purchase cost for the three Bio Seven cleaning stations at the ATC was $2,538 ($846 each). Purchase of the stations included the installation and start-up. Once the station is purchased, it becomes the property of the purchaser. Efforts are underway to qualify the Bio Seven parts cleaning process to a military specification. A specification is important in that it informs a user that the chemical substance to be employed for a specific job has been found to be satisfactory in its cleaning ability and that there will be no harmful side affects to the material being cleaned. Station ownership becomes a minor issue for the USCG in the event that the Bio Seven does not qualify with the military specifications necessary to clean parts. In the event Bio Seven does not qualify, the tanks could use cleaners that have the necessary military specifications for parts cleaning.

The cost of the Bio Seven solution is $15 per gallon and is purchased in a 55-gallon drum at a total cost of $825. On average, the total annual electrical cost for heating the three wash stations is estimated at $198. The water usage for the process consists of general washing, rinsing the part, and makeup for the working solution. The cost of the annual water usage for the three stations is less than $100. Annual contract cost for the monthly removal of petroleum contaminants is $1440.

Another incurred cost is the purchase of personal protective equipment. The approximate annual cost for the gloves and eye protection for the three stations is $241.

MATERIAL AND EMISSION REDUCTION OPPORTUNITIES:

The annual loss of the cleaning solution is about 25%, primarily due to "drag-out" and evaporation. Drag-out is the liquid residual on the part after it has been removed from the cleaning station. The water and cleaning solution from the rinsing process could be captured and utilized as make-up for the losses incurred by drag out and evaporation.

CONCLUSIONS:

The ATC is presently using Bio Seven as a test solution for cleaning engine components and general aviation parts. Bio Seven is designated as a test solution because at the time of this report it does not have a military specification. Plans are in progress to classify the cleaner as a Navy soap. This classification would qualify the cleaner to the Mil-C-85570, type II specification when approval has been granted.

One concern with the use of Bio Seven is the potential to cause hydrogen embrittlement. Hydrogen embrittlement is the degradation of high strength steels, such as aluminum and magnesium, that are used as bearings and bolts on aircraft wheels.

Bio Seven is a viable cleaner for aviation parts cleaning categories two and three (engine components and general aviation equipment). Bio Seven should not be used to clean category one (tires and wheels) aviation parts until its potential to cause hydrogen embrittlement has been determined.

BIO SEVEN
Preliminary Information

Location:

USCG Aviation Training Center (ATC), Mobile, Alabama. There are approximately twenty fixed wing and rotary wing aircraft that include; HH-65, HU-25. Each of the aircraft has its own maintenance and repair shop facilities.

Process Boundary:

The system boundary for the evaluation was established around the parts washer.

Process Description:

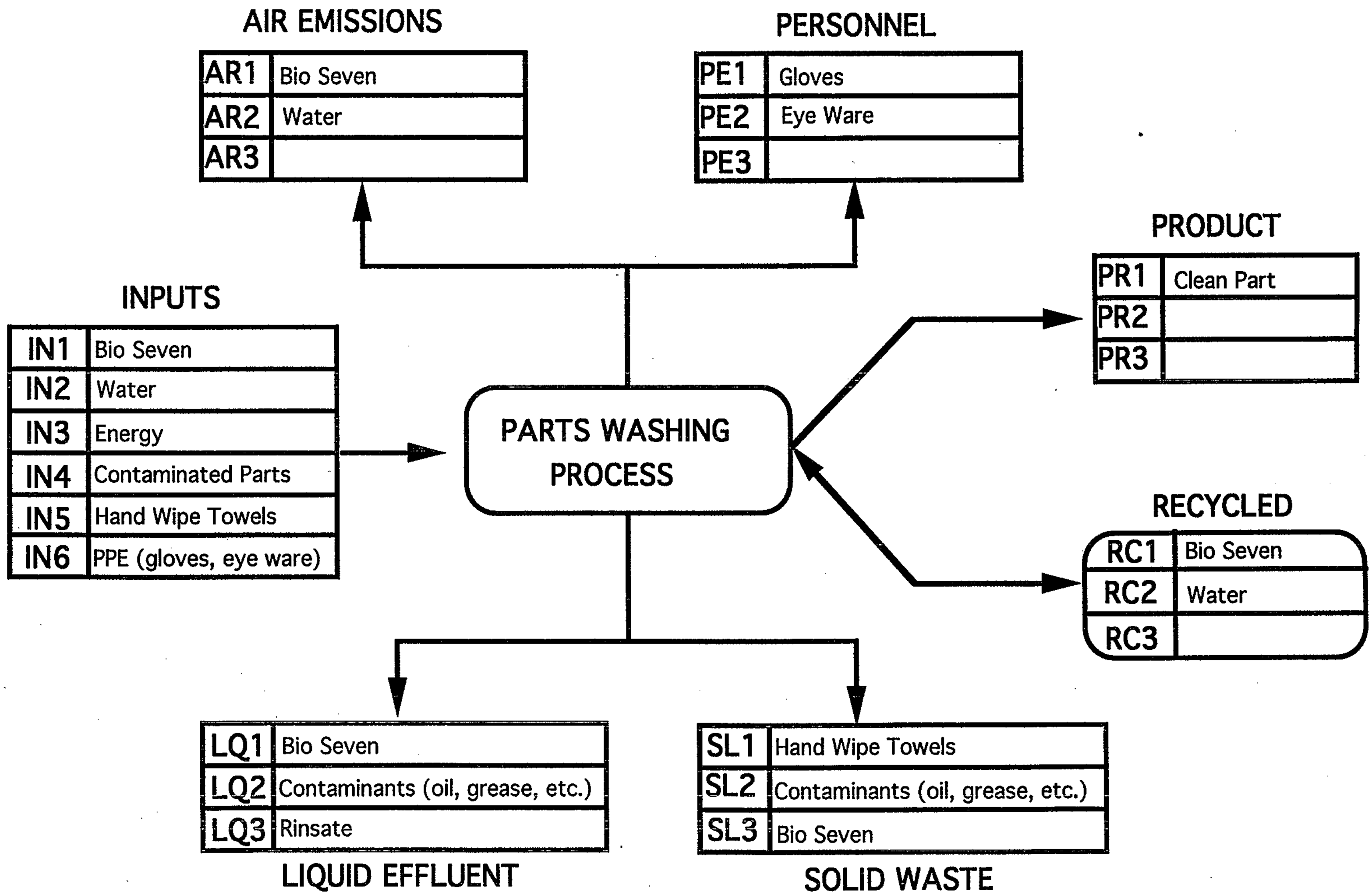
The ATC has three separate parts cleaning stations using the cleaner Bio Seven. Each station contains a 55-gallon polyethylene parts washing tank that is designed to hold approximately 36 gallons of cleaning solution. These solutions are 50/50 mixtures of Bio Seven and potable water. The cleaning solution is heated in the holding tank to the temperature range of 96 °F to 104 °F and is continuously recirculated as parts are being washed. The contaminants that are typically cleaned from the parts consist of grease, oil, dirt, and hydraulic fluid. These contaminants are removed from the parts by vigorous manual brushing. As the contaminants are removed from the parts, they are washed away with the cleaning solution into the enclosed section of the tank. After cleaning, the parts are rinsed with clean potable water to remove any residual cleaning solution. Rinsing is done at a separate location, and rinsate is discharged to the sewer. The parts cleaning procedure is complete when the technician dries the part with a hand cloth.

Product of Process:

Clean Aviation Parts (Category two and three)

Worksheet BI-1. Parts Washing Process Description

FLOW DIAGRAM FOR CHEMICAL CLEANERS
BIO SEVEN



Worksheet BI-2. Flow Diagram for Parts Cleaners

MATERIAL BALANCE FOR CHEMICAL CLEANERS

BIO SEVEN

Material Description	Annual Input (lbs.)	Annual Total Output (lbs.)	PR 1 Product	TOTAL RELEASES (Units: lbs) AR 1 Air Emission	AR 2 Air Emission	LQ 1 Liquid Effluent	LQ 2 Liquid Effluent	LQ 3 Liquid Effluent	SL 1 Solid Waste	SL 2 Solid Waste	SL 3 Solid Waste	PE 1 PPE	PE 2 PPE	RC 1 Recycled Material
Bio Seven	488	488		120		8					8			352
Water	30,034	30,034			2,170			27,414						450
Contaminated Parts	373	373	300				71			2				
Hand Towels	200	200							200					
Gloves	50	50										50		
Eye Ware	2.5	2.5											2.5	
TOTAL	31,147.5	31,147.5	300	120	2,170	8	71	27,414	200	2	8	50	2.5	802

Worksheet BI - 3. Material Balance Sheet

BIO SEVEN - SUPPORTING CALCULATIONS

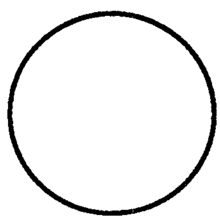
Calculations for the annual liquid and air emissions from the Bio Seven parts washing process:

1. Approximately 0.25 inch petroleum waste level accumulation every month for each cleaning station

   (0.25 inch/month) * (12 months/year) = 3 inches per year

   (3 parts washing stations) * (3 inches/year) = 9 inches per year

2. Determine the volume:



Drum Area = πr^2 = $\pi(0.75 \text{ feet})^2$ = 1.767 ft^2

|- 1.5 ft. - |

Volume = (0.75 ft) * (1.767 ft^2) = 1.33 ft^3

Volume = (1.33 ft^3) * (7.48 gallons/ft^3) = 9.9 gallons ≈ 10 gallons

3. Specific gravity for the petroleum waste is 0.85

   (10 gal.) * (0.85 sp. gr.) * (8.34 pounds/gal.) = 70.89 ≈ 71 pounds (sent to oil bowser)

4. Based on operational information, 2 pounds of contaminants are entrained in the hand wipe towels

Total Contaminants per year = (71 + 2) pounds = 73 pounds

Air emissions are the results of two processes: (1) Make-up for the Bio Seven parts washing solution, and (2) the rinsing of the part after using the Bio Seven parts washing solution.

The following breakdown of air emissions is based on information obtained from the operators at ATC.

(1) Make-Up for the Parts Cleaner due to drag-out and evaporation losses:

Bio Seven Air Emissions ≈ 25% of the annual usage

488 lbs * 0.25 = 122 lbs air emissions

Water air emissions ≈ 40%

688 lbs * 0.40 = 275 lbs air emissions

(2) Rinse Water evaporation

Water air emissions ≈ 0.06%

(30,034 - 275) * 0.06 = 1895 lbs

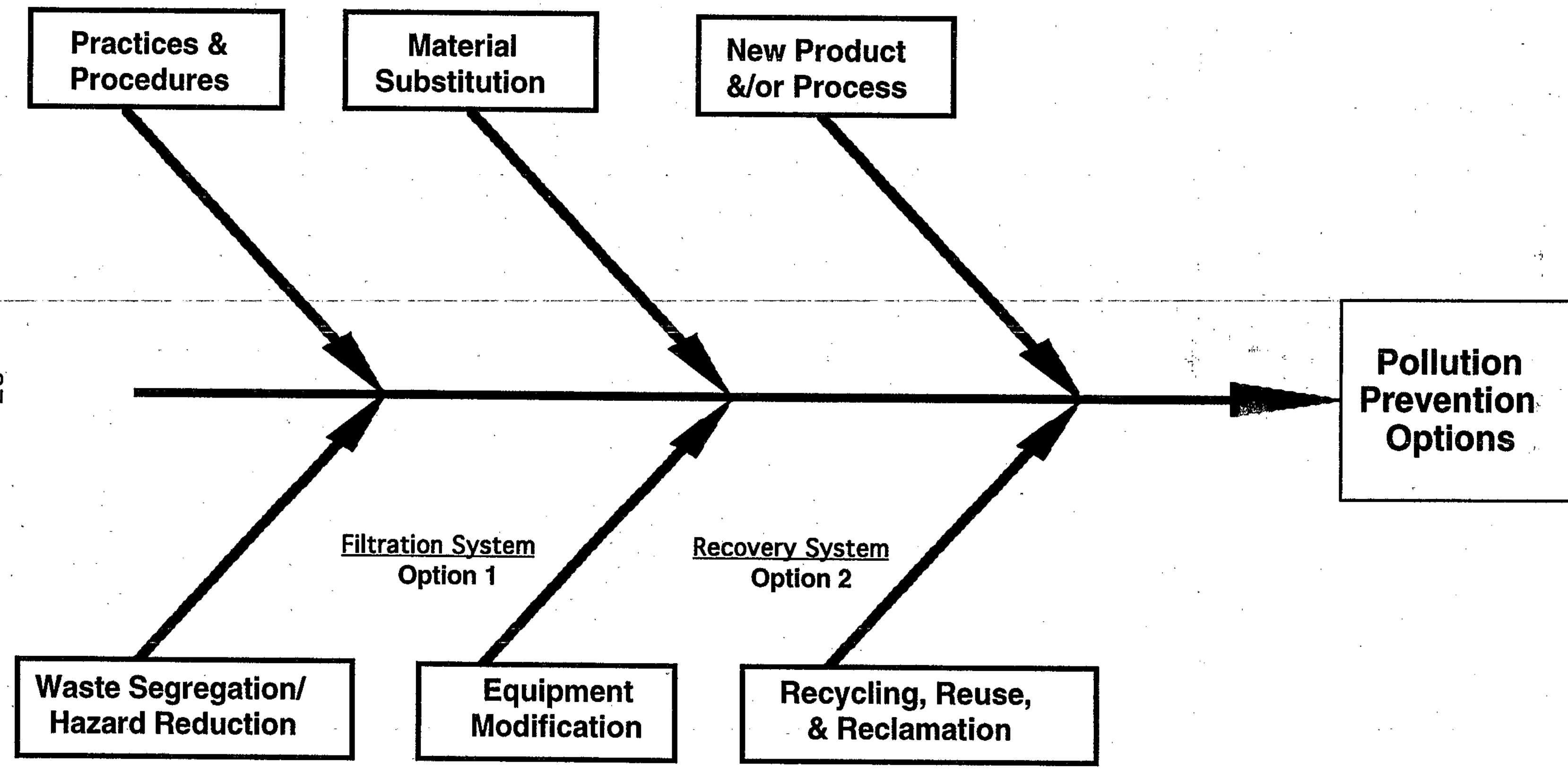
COST ANALYSIS FOR CHEMICAL CLEANERS
BIO SEVEN

DESCRIPTION	COST PER UNIT	TOTAL COST START-UP	TOTAL COST RECURRING
Material Acquisition			
Cleaning Stations	3 Stations at $846 each	$2,538	
Bio - 7 Initial Acquisition	488 pounds at $1.69 per pound	$825	
Bio - 7 Annual Usage	136 pounds per year Bio-7		$225
Inputs and Outputs			
Energy	2640 kWh @ $0.075/KWH for Mobile, Alabama		$198
Water Usage	3,600 gallons ($0.03/gallon)		$100
Parts Processed	300 pounds per year		N/A
Recycled Cleaner	802 pounds per year		N/A
Atmospheric Emissions	2,290 pounds per year* (no permit required)		N/A
Liquid Effluent			
Petroleum Contaminants	10 gallons (71 lbs) per year sold at $0.03/gal.		(-$0.30)
Solid Waste			
Hand Wipe Towels	200 pounds per year (Non-Hazardous)		$400
Petroleum Contaminants	2 pounds per year (trapped in the towel)		N/A
Contract Cost	$120 per month		$1,440
* Calculated from make-up requirements			
Ecological and Human Health/Safety Impacts			
PPE (Gloves)	500 pairs per year (50 pounds/year)		$140
PPE (Eye ware)	12 pairs per year (2.5 pounds/year)		$20
Special Precautions	N/A		N/A
Total Start-Up Cost		$3,363	
Total Annual Recurring Cost			$2,523
Start-Up Cost per Cleaning Station		$1,121	
Annual Recurring Cost per Cleaning Station			$841

Worksheet BI - 4. Cost Analysis for Cleaners

BIO SEVEN

Material and Emission Reduction Option Generation



Worksheet BI-5. Option Generation

BIO SEVEN

Material and Emission Reduction Option Description

Option Name and Description
(Include input materials and products affected)

Option No. ONE **Consider:** ● Yes ○ No

Insert a filtration system into the existing cleaning unit to remove the heavier contaminants, i.e. dirt.

Practices & Procedures ☐	Waste Segregation/Hazard Reduction ☐
Material Substitution ☐	Equipment Modification ■
New Product &/or Process ☐	Recycling, Reuse, & Reclamation ☐

Option No. TWO **Consider:** ● Yes ○ No

Capture effluent loses in drag-out using a recovery system. Return the drag-out to the cleaning system to serve as make-up.

Practices & Procedures ☐	Waste Segregation/Hazard Reduction ☐
Material Substitution ☐	Equipment Modification ☐
New Product &/or Process ☐	Recycling, Reuse, & Reclamation ■

Worksheet BI-6. Option Description

BIO SEVEN
OPTION EVALUATION

CATEGORY	Weight (1) 'W'	Option No. 1 Scale (2) 'S'	Option No. 1 'WxS'	Option No. 2 Scale (2) 'S'	Option No. 2 'WxS'	Option No. Scale (2) 'S'	Option No. 'WxS'
Economic	8	6	48	4	32		
Waste Generation	8	8	64	6	48		
Implementation Period	4	6	24	10	40		
Employee Health & Safety	10	2	20	2	20		
Improved Operation/ Product	6	4	24	2	12		
Regulatory Compliance	10	0	0	0	0		
Other							
Subtotal			180		152		
Likelihood of Technical Success (Multiplier 0 TO 1)		X	1	X	0.8	X	
Likelihood of Useful Results (Multiplier 0 TO 1)		X	0.8	X	0.8	X	
Total			144		97		
Rank			1		2		

1. The numerical value of the weight must be determined by the review team and should be from 0 (none) to 10 (high)
2. Scale each category from 0 (none) to 10 (high)

Worksheet BI-8. Evaluation Matrix

PENATONE 724

PROCESS DESCRIPTION:

Penatone 724 is currently being used in two separate parts cleaning processes. The first process uses Penatone 724 in an aerosol canister to spot clean various contaminated parts; the second process is the complete immersion or saturation of the contaminated part with the cleaning solvent. Approximately 80 percent of the Penatone 724 is in the immersion and saturation procedure with the remaining 20 percent used for aerosol cleaning. Typical contaminants that are cleaned from the parts consist of grease, oil, dirt, and hydraulic fluid. The Penatone 724 is distributed from a single location. This centralization allows for a controlled chemical distribution and less waste of the cleaning solvent.

In the aerosol cleaning process, an aerosol canister is filled with the cleaning solvent from the distribution area. The aerosol canister, known as "Sure-Shot®", comes in two different sizes, 32 ounce and 16 ounce. Once the aerosol canister has been filled with the cleaning solvent, it is then charged with compressed air that has been filtered to remove any particulate matter. The portable canister allows cleaning while the parts are installed on aircraft or after minor disassembly. The cleaning solvent is sprayed directly on the contaminated part and then wiped clean with a disposable hand wipe towel. The aerosol canisters can be refilled and reused indefinitely. About 98 percent of the Penatone 724 used in the aerosol process evaporates and becomes an air emission. The remainder is assumed to be mixed with the contaminants on the hand wipe towels. These emission numbers are based on operator experience.

In the immersion cleaning process, the contaminated part is completely immersed or saturated with the Penatone 724. Larger volumes of the cleaning solvent (1 to 2 gallons) are placed into a container and then transported from the chemical distribution center to the cleaning area. The contaminated part is dipped into the container for complete immersion or the cleaning solvent is cascaded over the part. The cleaned part is then dried with a hand wipe towel. About 17 percent of the Penatone 724 is evaporated or dragged out during the cleaning and drying process. A small amount (approximately 2 percent) is assumed to be mixed with the contaminants on the wipe towel.

There are two primary wastes that are generated when using Penatone 724; hand wipe towels and spent liquid waste. The used hand wipe towels are landfilled as a non-hazardous waste. Under the Federal Resource Conservation and Recovery Act (RCRA) laws and the State of Alabama RCRA laws, the hand wipe towels do not exhibit characteristics of a hazardous waste (40 CFR Part 261, Subpart C). The towels would be a hazardous waste if saturated with the solvent, but the towels normally do not contain a significant quantity of the solvent due to operational practices and evaporation. The second waste generated is the spent Penatone 724 from the cleaning process. The spent cleaning solvent containing the waste oils from aircraft engines, gear boxes, and hydraulic fluids is disposed of in the same holding tank (oil bowser) as the petroleum waste from the Bio Seven process.

Penatone 724 is classified as a combustible (not flammable) liquid. The difference between flammability and combustibility is temperature. Flammable liquids have flash points below 100°F and combustible liquids flash points at or above 100°F. The flashpoint is simply the temperature at which a liquid gives off vapors that can be ignited under specified laboratory conditions. The flashpoint of Penatone 724 is 160°F compared to the more flammable cleaner methyl ethyl ketone (MEK), which has a flashpoint of 28°F.

ENVIRONMENTAL, SAFETY AND HEALTH ISSUES:

Penatone 724 is a clear water-white blend of aliphatic hydrocarbons (classified as 100% volatile organic compounds) and is a combustible material. Regulatory agencies respond two these two conditions by requiring a system of warnings and controls. The Occupational Safety and Health Administration (OSHA) has classified the ingredients in Penatone 724 as a hazardous combustible material. Penatone 724 contains no reportable Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) materials and is considered non-hazardous under RCRA. In the Superfund Amendments and Reauthorization Act (SARA) Title III, sections 311 and 312, Penatone 724 is categorized as an acute health and fire hazard and is not a reportable chemical under section 313.

TABLE 3. PENATONE 724 REGULATORY REQUIREMENTS

OSHA	29 CFR 1910.1200; Combustible Material
RCRA	40 CFR 260, Subpart D; Non-Hazardous Waste
TSCA	Ingredients are listed on the inventory
CERCLA	Contains no reportable materials
SARA, Title III	
section 311, 312	Hazard Categories: Acute Health, Fire
section 313	Contains no reportable ingredients

The company recommends that the user of this product contact local authorities to determine if there may be other local reporting requirements.

The exposure limits for the use of Penatone 724 have not been established by OSHA or any other regulatory agency. The supplier recommends that an exposure limit be set at 300 ppm for an 8-hour timeframe. The volatility of the cleaning solvent requires personal protective equipment (gloves, glasses, etc.) be utilized. Small amounts of the liquid could be drawn into the body by handling , inhalation, or swallowing resulting in adverse health effects. Solvent resistant gloves are recommended for situations in which prolonged skin exposure is expected. Ventilation is not needed under normal use conditions. For enclosed areas, or where large amounts of the product are being used, the use of fans or other mechanical ventilation is recommended.

COST ANALYSIS:

The cost of the Penatone 724 solvent is $5.55 per gallon. ATC purchases one hundred gallons of the cleaning solvent at a cost of $555 on an annual basis. The aerosol dispensing canisters, "Sure Shot®", were a one time purchase for total cost of $1,390. This purchase included twenty 16 oz aerosol canisters at $43 per canister and ten 32 oz aerosol canisters at $53 per canister.

The cost of the hand wipe towels used to dry the parts is $1,200 annually. This includes the purchase and disposal of the towels. Penatone 724 emissions released into the atmosphere at the ATC do not have an associated cost factor. ATC is paid 3 cents per gallon for the spent solvent.

The total annual cost for personal protective equipment is approximately $268. This cost includes the purchase and disposal of solvent resistant gloves, eye protection, and respirator cartridges when necessary.

MATERIAL AND EMISSION REDUCTION OPPORTUNITIES:

Penatone 724 contains volatile organic compounds (VOC) at a concentration level of 780 grams per liter of solution. Because of the volatility of the cleaning compound, much of the solution is lost through evaporation. Alabama does not currently restrict the amount of VOCs allowed to be dissipated into the environment from this type of cleaning process. States such as California and New Jersey have regulations to reduce VOC emissions such as: (1) best available control technology (BACT) be implemented to control emissions or (2) a usage permit with fees based on the amount of releases into the atmosphere.

An alternative to the current immersion cleaning procedure would be to employ a parts cleaning station for the cleaning solvent. The station would be designed for the containment of the solvent with a cover to reduce losses through evaporation. The parts cleaning station would give the cleaning solvent a longer usage life and significantly reduce environmental releases.

CONCLUSIONS:

Penatone 724 is qualified to PD 680 type II military specifications as a parts cleaner. Penatone 724 can clean in all three aviation parts cleaning categories (engine components, general aviation equipment, and tires and wheels).

Concerns about using the cleaning solvent focus on the potential environmental, safety and health impacts.

PENATONE 724
Preliminary Information

Location:
USCG Aviation Training Center (ATC), Mobile, Alabama. There are approximately twenty fixed wing and rotary wing aircraft that include; HH-65, HU-25. Each of the aircraft has its own maintenance and repair shop facilities.

Process Boundary:
The system boundary was defined as two separate beginning points, one for the aerosol cleaner and the other for the immersion process, but both having the same ending point with the outputs contained within the facility.

Process Description:
Penatone 724 is currently being used in two separate processes. The first process uses the cleaner in an aerosol canister to spot clean various contaminated parts; the second cleaning process is the complete immersion of the contaminated parts in the cleaner.

Typical contaminants consist of grease, oil, dirt, and hydraulic fluid

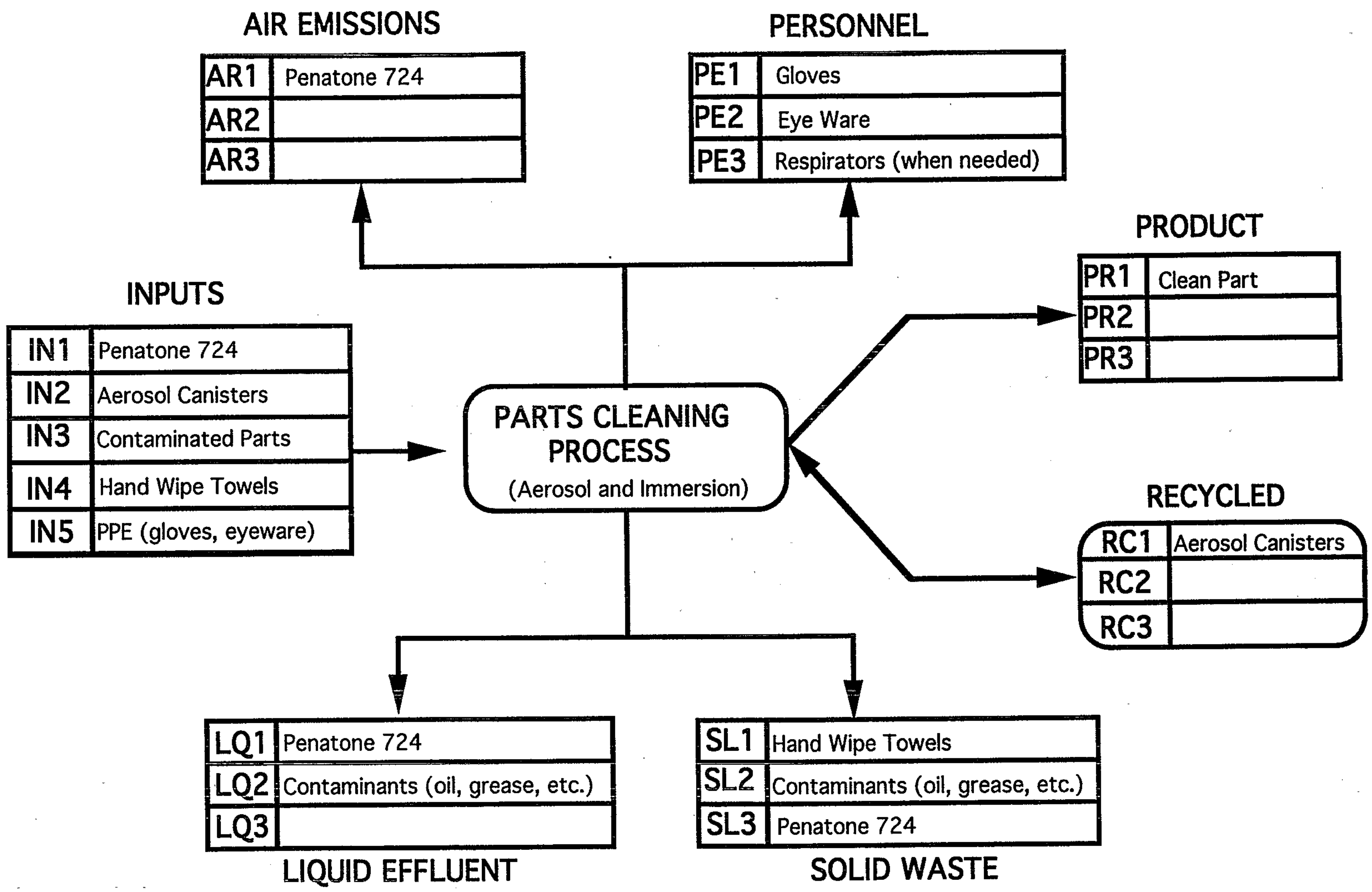
The aerosol canister is filled with the cleaning solvent and the pressurized with compressed air that has been filtered to remove particulate. The cleaning solvent is sprayed directly on the contaminated parts then wiped clean with a disposable towel. The canister can be reused after the solvent has been completely dissipated.

In the immersion process the contaminated parts are completely immersed or saturated with the cleaning solvent. The cleaned part is dried using disposable towels.

Product of Process:
Clean Aviation Parts (All Categories)

Worksheet PE-1. Parts Washing Process Description

FLOW DIAGRAM FOR CHEMICAL CLEANERS PENATONE 724



Worksheet PE-2. **Flow Diagram for Parts Cleaning**

MATERIAL BALANCE FOR CHEMICAL CLEANERS

PENATONE 724

Material Description	Annual Input (lbs.)	Annual Total Output (lbs.)	PR 1 Product	TOTAL RELEASES (Units: lbs) AR 1 Air Emissions	LQ 1 Liquid Effluent	LQ 2 Liquid Effluent	SL 1 Solid Waste	SL 2 Solid Waste	SL 3 Solid Waste	PE 1 Personal Protective Equipment	PE 2 Personal Protective Equipment	PE 3 Personal Protective Equipment	RC 1 Recycled Material
Penatone 724	651	651		206	432				13				
Aerosol Canisters	30	30											30
Contaminated Parts	1,150	1,150	1,000			142		8					
Hand Wipe Towels	600	600					600						
Gloves	70	70								70			
Eye Ware	2.5	2.5									2.5		
Respirators	10	10										10	
TOTAL	2,513.5	2,513.5	1,000	206	432	142	600	8	13	70	2.5	10	30

Worksheet PE - 3. Material Balance Sheet

PENATONE 724 - SUPPORTING CALCULATIONS

Based on 100 gallons of Penatone usage per year Calculate the chemical breakdown per media i.e. air, land, and water:

1. Calculate pounds (lbs) per year:
   given: Specific Gravity of Penatone 724 = 0.78

   (100 gallons) * (0.78 Sp. Gr.) * (8.34 lbs/gallon) = 650.52 lbs ≈ 651 lbs

2. Usage between aerosol and immersion process was obtained from maintenance personnel at ATC Mobile, Alabama

Aerosol	= (0.20) * (651 lbs) =	130.2 lbs
Immersion	= (0.80) * (651 lbs) =	520.8 lbs
Penatone 724 Annual Usage		651 lbs

3. Air Emissions were based on operational experence

Aerosol	= (0.98) * (130.2 lbs) =	127.6 lbs
Immersion	= (0.15) * (520.8 lbs) =	78.1 lbs
Penatone724 Annual Air Emissions		205.7 lbs

4. Liquid Effluent was based on operational experence

Aerosol	= (0.00) * (130.2 lbs) =	0 lbs
Immersion	= (0.83) * (520.8 lbs) =	432.3 lbs
Penatone 724 Annual Liquid effluent		432.3 lbs

5. Solid Waste was based on operational experence

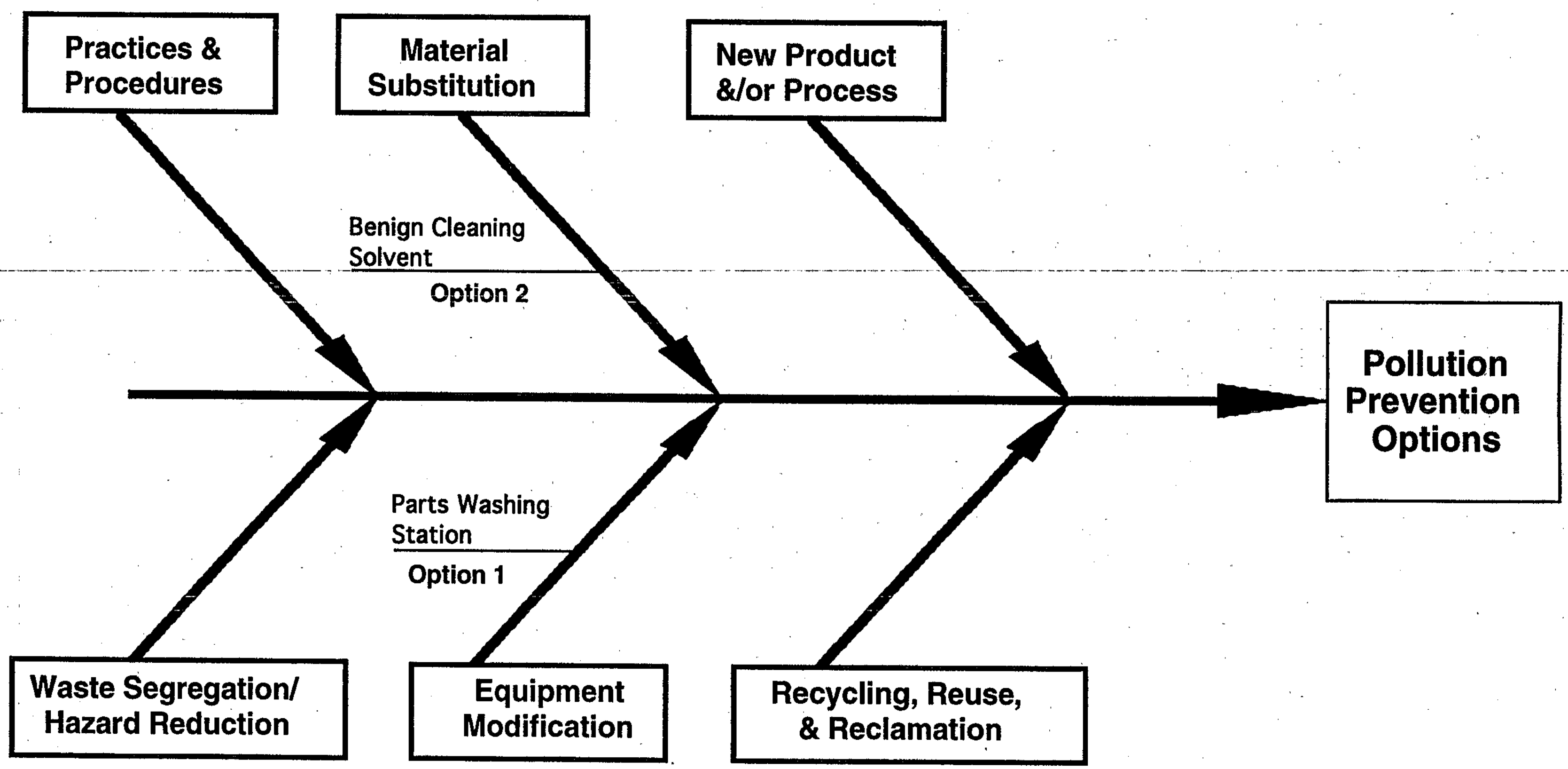
Aerosol	= (0.02) * (130.2 lbs) =	2.6 lbs
Immersion	= (0.02) * (520.8 lbs) =	10.4 lbs
Penatone 724 Annual solid Waste		13 lbs

COST ANALYSIS FOR CHEMICAL CLEANERS
PENATONE 724

DESCRIPTION	COST PER UNIT	TOTAL COST START-UP	TOTAL COST RECURRING
Material Acquisition			
Penatone 724 Acquisition	651 pounds at $0.85 per pound	$555	
Penatone 724 Annual Usage	651 pounds at $0.85 per pound		$555
Aerosol Canisters (reusable)	twenty 16 oz at $43 per canister	$860	
	ten 32 oz at $53 per canister	$530	
Input and Output			
Parts Processed	1,000 pounds per year		N/A
Atmospheric Emissions	206 pounds per year (no permit required)		N/A
Liquid Effluent			
Penatone 724	66 gallons (432 lbs) per year sold at $0.03/gal.		(-$1.98)
Contaminants	21 gallons (142 lbs) per year sold at $0.03/gal.		(-$0.63)
Solid Waste			
Hand Wipe Towels	600 pounds per year (Non-Hazardous)		$1,200
Penatone 724	13 pounds per year (trapped in the towel)		N/A
Contaminants	8 pounds per year (trapped in the towel)		N/A
Ecological and Human Health/Safety Impacts			
PPE (Gloves)	700 pairs per year (70 pounds per year)		$200
PPE (Eye ware)	12 pairs per year (2.5 pounds per year)		$20
PPE (Respirators)	Organic Vapor Cartridges (6 cartridges/year)		$48
Total Start-Up Cost		$1,945	
Total Annual Recurring Cost			$2,020

Worksheet PE - 4. Cost Analysis for Cleaners

PENATONE 724
Material and Emission Reduction
Option Generation



Worksheet PE-5. Option Generation

PENATONE 724
Material and Emission Reduction
Option Description

Option Name and Description
(Include input materials and products affected)

Option No. ONE **Consider:** ● Yes ○ No

Employ a parts washing station that would reduce losses of the solvent. The parts cleaning station would give the cleaning solvent a longer usage life and significantly reduce environmental releases.

Practices & Procedures ☐ Waste Segregation/Hazard Reduction ☐
Material Substitution ☐ Equipment Modification ■
New Product &/or Process ☐ Recycling, Reuse, & Reclamation ☐

Option No. TWO **Consider:** ● Yes ○ No

Switch to a more environmentally benign parts cleaning solvent

Practices & Procedures ☐ Waste Segregation/Hazard Reduction ☐
Material Substitution ■ Equipment Modification ☐
New Product &/or Process ☐ Recycling, Reuse, & Reclamation ☐

Worksheet PE-6. Option Description

PENATONE 724
OPTION EVALUATION

CATEGORY	Weight (1) 'W'	Option No. [1] Scale (2) 'S'	'WxS'	Option No. [2] Scale (2) 'S'	'WxS'	Option No. [ ] Scale (2) 'S'	'WxS'
Economic	8	6	48	4	32		
Waste Generation	8	6	48	8	64		
Implementation Period	4	8	32	2	8		
Employee Health & Safety	10	6	60	8	80		
Improved Operation/ Product	6	8	48	6	36		
Regulatory Compliance	10	2	20	8	80		
Other							
Subtotal			256		300		
Likelihood of Technical Success (Multiplier 0 TO 1)		X	0.8	X	0.6	X	
Likelihood of Useful Results (Multiplier 0 TO 1)		X	0.8	X	0.8	X	
Total			164		144		
Rank			1		2		

1. The numerical value of the weight must be determined by the review team and should be from 0 (none) to 10 (high)
2. Scale each category from 0 (none) to 10 (high)

Worksheet PE-8. Evaluation Matrix

USCG AIR STATION
CAPE COD, MASSACHUSETTS

The USCG Air Station Cape Cod is part of a multi-service group located at the Otis Air Force Base, Massachusetts. The ASCC was established in 1970 and is blended within the confines of a base that supports elements of the Air Force, National Guard, Army Reserve Units, and various other Federal Agencies.

The ASCC operates six Falcon Jets (HU-25) and four Jayhawk Helicopters (HH-60) out of two large hangers. The mission of the ASCC is to provide enforcement of the federal laws and treaties upon the high seas and waters subject to the jurisdiction of the United States. The ASCC has the capabilities to respond to medium range search and rescue missions, support short range navigational aid, and provide surveillance in marine environmental protection.

The ASCC has the capability to address the majority of repair needs for each airframe design and ground support equipment. The maintenance, repair and engine shop facilities have the capability to clean a wide variety of aircraft and engine parts. Safety-Kleen 105 cleaning solvent is the predominant choice for the parts washing process.

SAFETY-KLEEN 105

PROCESS DESCRIPTION:

The ASCC has five separate parts washing stations using the cleaner Safety-Kleen 105. Three of the cleaning stations are located in the aircraft maintenance hanger, one cleaning station is in the ground services equipment garage, and one cleaning station is located at the base auto hobbies shop.

Each parts washing station has approximately 30 gallons of the cleaning solvent in a holding tank located below the parts washing basin. The cleaning solvent is pumped from the holding tank, through a discharge tube, onto the part, and drains back into the holding tank. The technician removes the contaminants by holding the part under the discharge tube and scrubbing or rubbing the part with a brush or gloved hand. Typical contaminants consists of grease, oil, dirt, and hydraulic fluid. The contaminants drain into the holding tank along with the cleaning solution.

The part does not require any rinsing or further use of different chemicals to complete the cleaning process. The part is wiped down with a disposable hand towel or an absorbent cloth material to remove traces of contaminants and solvent. The towels and cloths are disposed of by the USCG in a designated 55 gallon container for waste rags. The State of Massachusetts considers that the waste generated from this cleaning process is hazardous. This classification includes the cleaning solvent and the towels or cloths that are used to remove the contaminants, requiring a hazardous waste manifest for disposal.

ASCC has an existing contract with the Safety-Kleen Corporation for the parts cleaning stations. Safety-Kleen Corporation is responsible for the handling of the cleaning solvent and the liquid waste resulting from the cleaning process. They are also responsible for the maintenance of the cleaning stations, which includes periodic checks of the operability of the station and the replenishing or complete exchange of the cleaning solvent. Safety-Kleen comes on-site every ten weeks to meet the requirements of the contract. A Safety-Kleen repersentative personnel complete the hazardous waste manifest and transfer the waste off the ASCC facility to a Safety Kleen recycling facility.

ENVIRONMENTAL, SAFETY AND HEALTH ISSUES:

Safety-Kleen 105 is a clear-green liquid with a characteristic hydrocarbon odor. The chemical ingredients of this cleaning solvent include petroleum distillates, and trace quantities of perchloroethylene (PCE) and 1,1,1-trichloroethane (TCA). According to the MSDS, Safety-Kleen 105 is a combustible cleaner with a flash point of 105°F. The decomposition and combustion products of Safety-Kleen 105 may be toxic. Safety-Kleen 105 vapors are heavier than air and may travel great distances to ignition sources and flash back. The material may be sensitive to static discharge, which could result in fire or explosion.

Regulatory information states that the product poses the following physical and health hazards as defined in 40 CFR Part 370:

- Immediate (Acute) health hazard
- Delayed (Chronic) health hazard
- Fire hazard

Safety Kleen 105 is subject to the requirements of section 311 and 312 of Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986. It is not subject to requirements of Title III of SARA Section 313 because the PCE and TCA are present in trace quantities only. Safety Kleen 105 is considered to be a hazardous material in Massachusetts and is not for sale or use in California.

TABLE 4. SAFETY KLEEN 105 REGULATORY REQUIREMENTS

OSHA	29 CFR 1910.1200; Combustible Material
TSCA	Ingredients are listed on the inventory
CERCLA	Contains no reportable materials
SARA, Title III	
section 311, 312	Hazard Categories: Acute Health, Fire
section 313	Contains De Minimis amounts of PCE and TCA

Eye contact with liquid or exposure to vapors may cause mild to moderate irritation. Skin contact may cause redness, dryness, cracking, burning, or dermatitis. Inhalation or ingestion may have central nervous system effects and cause nausea, vomiting, and in severe cases, death.

Personal protective equipment should include gloves to prevent contact with skin and chemical goggles. The cleaning station should provide process enclosure or local ventilation to maintain concentration of the vapor or mist below applicable exposure limits.

COST ANALYSIS:

The contract with Safety-Kleen Corporation is $4,000 per year. The contract provides the cleaning solvent, maintenance of the cleaning stations and disposal of the spent solvent. A separate cost is incurred for hand wipe towels, $400 per year for purchase and disposal. Emissions released into the atmosphere from the use of Safety-Kleen 105 do not result in a cost at the ASCC because the emissions are not regulated by Massachusetts.

Another cost associated with the use of this product is the personal protective equipment; glasses and gloves, which is approximately $340 per year for purchase and disposal.

MATERIAL AND EMISSION REDUCTION OPPORTUNITIES:

Safety Kleen 105 has environmental and heath risks associated with usage. Aqueous cleaners could be a viable candidate for this cleaning operation based on the findings in this study. ASCC should use the experience gained at ATC and SCNY to implement aqueous cleaners such as Bio Seven and Brulin 815 GD.

Attempts by the technician should be made to limit the amount of splashing or spilling of the cleaning solvent. This can be accomplished by allowing the clean part to drip dry above the parts washing basin and using only enough Safety-Kleen 105 to remove the contaminants for the part.

Efforts should be taken to extend the operational life of Safety-Kleen 105. By extending the life of the solvent, ASCC can revise the existing contract with Safety Kleen Corporation to reduce solvent change-out and decrease the annual cost for the cleaning solvent. A review of parts cleaned should be conducted to reduce the contaminant load on the solvent.

CONCLUSIONS:

Safety-Kleen 105 is qualified to clean all three aviation categories (engine components, general aviation equipment, and tires and wheels).

Potential long-term liability for the Coast Guard could result with continued use of this parts cleaner. If Safety-Kleen Corporation uses poor practices in the recycling process, under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the

United States Coast Guard could be responsible for paying any incurred cost to remediate the resulting environmental contamination. Even though Safety Kleen Corporation completes the hazardous waste manifests, USCG is on record for the purchase and generation of the solvent waste.

The single source for the product and service, Safety-Kleen Corporation, could potentially lead to product cost increases or product shortages. If Safety-Kleen Corporation decides to stop production, ASCC would incur the cost associated with accelerated replacement with a new product.

SAFETY KLEEN 105
Preliminary Information

Location:

The USCG Air Station Cape Cod (ASCC) is located at Otis Air National Guard Base, Falmouth, Massachusetts. The ASCC operates six HU-25 Falcon jets and four HH-60 Jayhawk helocopters. The ASCC has the capabilities to respond to medium range search and recue and provide law enforcement.

Process Boundary:

The boundary was established around the Safety Kleen parts washing station.

Process Description:

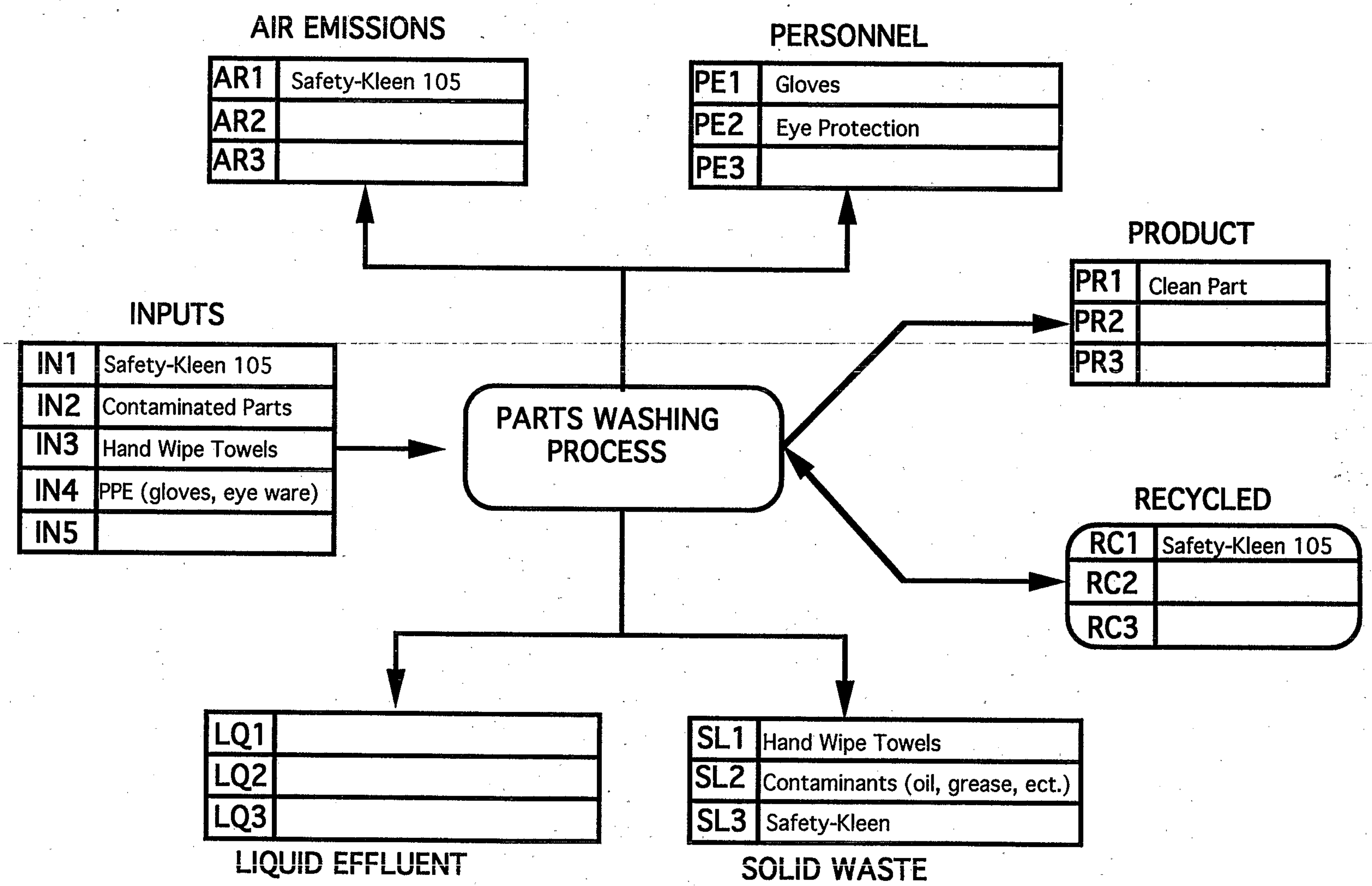
The ASCC has five separate parts washing stations using Safety Kleen 105. Each station has approximately 30 gallons of the cleaning solvent in a holding tank located below the parts washing basin. The non-heated cleaning solvent is continuously recirculated via a pump into the parts washing basin when in operation. The technician removes the contaminants (grease, oil, carbon, etc.) by scrubbing or rubbing with a brush or gloved hand. The contaminants become suspended in the solution. The part is wiped down with disposable towels or absorbant cloth material.

Product of Process:

Clean Aviation Parts (All Categories)

Worksheet SK-1. Parts Washing Process Description

FLOW DIAGRAM FOR CHEMICAL CLEANERS
SAFETY KLEEN 105



Worksheet SK-2. Flow Diagram for Parts Cleaning

MATERIAL BALANCE FOR CHEMICAL CLEANERS

SAFETY-KLEEN 105

Material Description	Annual Input (lbs.)	Annual Total Output (lbs.)	PR 1 Product	TOTAL RELEASES (Units: lbs) AR 1 Air Emissions	LQ 1 Liquid Effluent	LQ 2 Liquid Effluent	SL 1 Solid Waste	SL 2 Solid Waste	SL 3 Solid Waste	PE 1 Personal Protective Equipment	PE 2 Personal Protective Equipment	RC 1 Recycled Material
Safety-Kleen 105	4,337	4,337		172					3			4,162
Contaminated Parts	2,219	2,219	2,000					219				
Hand Wipe Towels	300	300					300					
Gloves	100	100								100		
Eye Ware	5	5									5	
TOTAL	6,961	6,961	2,000	172			300	4	3	100	5	4,162

Worksheet SK - 3. Material Balance Sheet

SAFETY-KLEEN 105 - SUPPORTING CALCULATIONS

Calculations for Safety-Kleen 105 based on information from Hazardous Waste Manifests

Known:

(1) Amount of Safety-Kleen 105 manifested = 4381 pounds (lbs) per year

(2) Safety-Kleen Corporation visited the site every 10 weeks

(3) Safety-Kleen parts cleaning stations contain a 30 gallon tank for the solvent

(4) Specific gravity of cleaner is 0.8

Based on Operational Experience

(1) Tanks have an average volume of 25 gallons of solvent

(2) 5 % solid waste

(3) Losses of cleaner are: 2% entrainment in hand wipe towel, and 98% by evaporation

Total Safety-Kleen:

[(5 stations * 25 gallons per station)/(10 weeks)] * [(52 weeks)/(year)] = 650 gallons/yr

[(650 gallons)/yr] * [(0.8)/(1)] * [(8.34 lbs)/(gallon water)] ≈ 4,337 lbs per year

Solid Waste Calculation:

From waste manifest [(4381 lbs)/(yr)] * (0.05 solid waste) = 219 lbs/yr solid waste

Safety-Kleen Recycled:

4,337 lbs/yr - 219 lbs/yr = 4,162 lbs/yr recycled

Change Out 4,337 lbs/yr

Recycled - 4,162 lbs/yr

Losses 175 lbs/yr (this is a combination of 146 lbs/yr evaporation and 26 lbs/yr dragout)

Towel losses	=	(175 lbs/yr)	*	(0.02)	=	3 lbs/yr
Air Emissions	=	(175 lbs/yr)	*	(0.98)	=	172 lbs/yr

COST ANALYSIS FOR CHEMICAL CLEANERS
SAFETY-KLEEN 105

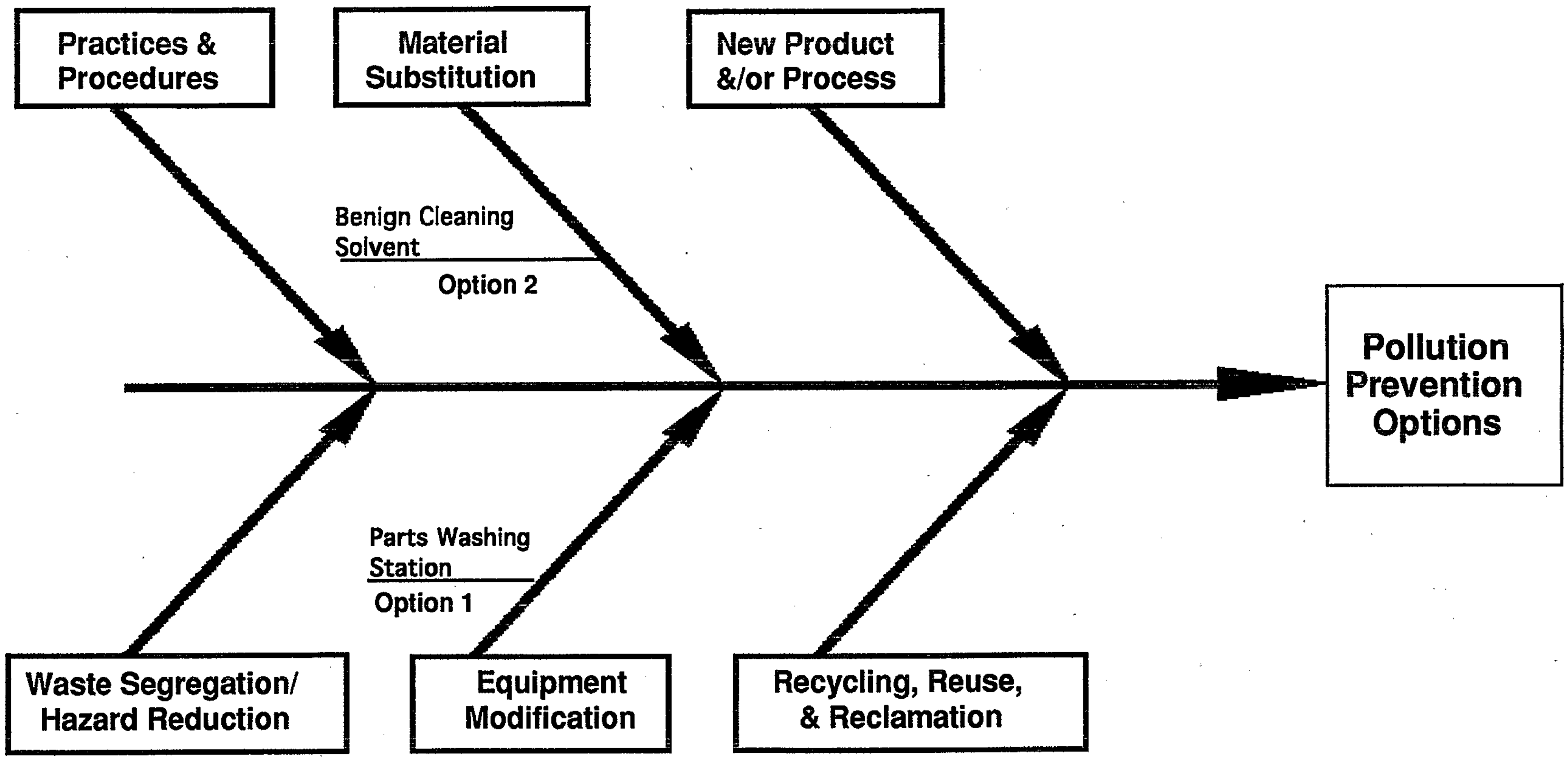
DESCRIPTION	COST PER UNIT	TOTAL COST START-UP	TOTAL COST RECURRING
Material Acquisition			
Safety-Kleen 105 Recycled (5 Cleaning Stations Included)	Under Contract with Safety-Kleen	$4,000	
Safety-Kleen 105 Recycled	Under Contract with Safety-Kleen		$4,000
Identify and Quantify			
Contaminated Parts Processed	2,000 pounds per year		N/A
Atmospheric Emissions	146 lbs/yr Safety Kleen 105 (no permit required)		N/A
	26 lbs/yr Safety Kleen 105 (drag-out losses)		N/A
Liquid Effluent			
Safety-Kleen 105	4,162 pounds per year (recycled)		*
Contaminants	219 pounds per year		*
Solid Waste			
Hand Wipe Towels	300 pounds per year (Non-Hazardous)**		$400
Safety-Kleen	3 pounds per year (trapped in the towel)		N/A
Contaminants	4 pounds per year (trapped in the towel)		N/A
Ecological and Human Health/Safety Impacts			
PPE (Gloves)	60 pairs per year (100 lbs/yr) @ $4/pair**		$240
PPE (Eye ware)	10 face shields per year (5 lbs/yr) @ $8/pair**		$100
Total Start-Up Cost		$4,000	
Total Annual Recurring Cost			$4,740
Start-Up Cost per Station		$800	
Annual Recurring Cost per Station			$948

* Cost are covered in the contract with Safety Kleen

** Purchase and Disposal

Worksheet SK - 4. Cost Analysis for Cleaners

SAFETY KLEEN 105
Material and Emission Reduction
Option Generation



Worksheet SK-5. Option Generation

SAFETY KLEEN 105
Material and Emission Reduction
Option Description

Option Name and Description
(Include input materials and products affected)

Option No. ONE **Consider:** ● Yes ○ No

Employ a parts washing station that would reduce the losses of the solvent through evaporation or drag-out.

- Practices & Procedures ☐
- Material Substitution ☐
- New Product &/or Process ☐
- Waste Segregation/Hazard Reduction ☐
- Equipment Modification ■
- Recycling, Reuse, & Reclamation ☐

Option No. TWO **Consider:** ● Yes ○ No

Switch to a more environmentally benign cleaning solvent.

- Practices & Procedures ☐
- Material Substitution ■
- New Product &/or Process ☐
- Waste Segregation/Hazard Reduction ☐
- Equipment Modification ☐
- Recycling, Reuse, & Reclamation ☐

Worksheet SK-6. Option Description

SAFETY KLEEN 105
OPTION EVALUATION

CATEGORY	Weight (1) 'W'	Option No. 1 Scale (2) 'S'	'WxS'	Option No. 2 Scale (2) 'S'	'WxS'	Option No. Scale (2) 'S'	'WxS'
Economic	8	6	48	4	32		
Waste Generation	8	6	48	8	64		
Implementation Period	4	4	16	2	8		
Employee Health & Safety	10	6	60	8	80		
Improved Operation/ Product	6	6	36	6	36		
Regulatory Compliance	10	4	40	8	80		
Other							
Subtotal			248		300		
Likelihood of Technical Success (Multiplier 0 TO 1)		X	0.8	X	0.6	X	
Likelihood of Useful Results (Multiplier 0 TO 1)		X	0.8	X	0.8	X	
Total			159		144		
Rank			1		2		

1. The numerical value of the weight must be determined by the review team and should be from 0 (none) to 10 (high)
2. Scale each category from 0 (none) to 10 (high)

Worksheet SK-8. Evaluation Matrix

U.S. COAST GUARD SUPPORT CENTER NEW YORK
GOVERNORS ISLAND, NEW YORK

Governors Island is located off the southern tip of Manhattan and is accessible primarily by a Coast Guard operated ferry. The island encompasses 175 acres and consists solely of Coast Guard facilities which are grouped together under the name Support Center New York. The island, which serves as a support center for Coast Guard activities conducted within the New York area and for tenant commands located on the island, is the home port for a number of Coast Guard vessels. There are 22 different commands represented on the island which are given support from the center. A total of 20 Coast Guard ships are tended to at the support center. The list of ships includes high endurance cutters, buoy tenders, bay class icebreakers, harbor tugs, search and rescue utility boats, and ferry boats.

The industrial facility located within the confines of the base is responsible for the majority of the parts from the tenant ships and ground support vehicles being cleaned. The facility also has an internal contract with the Coast Guard Supply Center at Baltimore, Maryland, to inspect and rebuild patrol boat engines. Brulin 815 GD parts cleaner is the predominant choice for the parts washing process.

BRULIN 815 GD

PROCESS DESCRIPTION:

Brulin 815 GD is currently being used in the industrial motor repair shop for the removal of contaminants from ship and ground support vehicle parts. The parts cleaning solution is a mixture of 20 to 50 percent Brulin 815 GD in potable water and is contained in an insulated 1,200 gallon capacity tank. The percentage of Brulin 815 GD in the potable water is important in that the higher the concentration the better removal efficiency of heavy contaminants (grease, high viscosity oil). The cleaning solution is maintained at a temperature of 140°F to 160°F by use of an electrical coil located inside the tank.

The contaminated parts to be cleaned are placed in a metallic basket and then lowered into the tank by a mechanical hoist. The cleaning solution is not agitated in the tank and there is no manual brushing on the contaminated parts by the technician to stimulate the removal of the contaminants. The contaminated parts soak in the cleaning solution for periods of four to twelve hours.

Common contaminants removed from the parts include scale, carbon, grease, and paint. There is no filtration device used for the separation of the contaminants from the cleaning solution. The contaminants are usually entrained in the cleaning solution and tend to settle to the bottom of the tank forming a sludge. The accumulated sludge is removed from the tank on an annual basis. The waste sludge is considered hazardous in the State of New York and is transferred off-site by contracted personnel.

Cleaned parts are removed from the tank and steam cleaned with a water and surfactant (Blue Giant) mixture to further enhance cleanliness. This process generates contaminant waste (approximately 27 pounds per year), which is collected in an oil-water separator. The contaminant waste is placed in a designated container for storage and then transferred off the island. The liquid effluent from the steam cleaning is allowed to be discharged into the sewer system without a permit.

After the cleaning procedure, the part is allowed to air dry or is dried using a disposable cloth. The cloth towel may be disposed of as non-hazardous waste.

ENVIRONMENTAL, SAFETY AND HEALTH ISSUES:

Brulin 815 GD is a blue-green blend of detergents, alkaline builders and inhibitors that possesses a mild odor. It is distributed as a concentrate with a pH level of 12, with a typical dilution pH of 9. Brulin 815 GD is bio-degradable, contains no phosphates, and is completely soluble in water. Blue Giant is considered a non-toxic water soluble cleaner. Both formulations list no hazardous ingredients in the MSDS and are non-flammable. Direct eye contact and prolonged or repeated skin contact may cause irritation. The use of personal protective equipment consisting of gloves and protective eye ware should be utilized.

Brulin 815 GD is considered by environmental agencies to be a relatively benign solution and requires minimal environmental monitoring. The working solution posses no significant health threats and is relatively safe to use. Efforts should be taken to ensure that the discharge of the cleaner into the sewer system does not require any pretreatment by local water treatment facilities.

COST ANALYSIS:

The start-up cost for the Brulin 815 GD parts washing alternative was approximately $3,448. This cost included modifications to the existing tank in the industrial motor repair shop and all chemical acquisitions. Included in the start-up was the energy cost for heating the tank to its working temperature of 150°F.

The total annual cost for the purchase of the Brulin 815 GD cleaner at Governors Island was $1,293 ($9.40 per gallon). The majority of the Brulin 815 GD losses were incurred from the removal of the sludge. Other losses of the cleaner were from evaporation and drag-out. The Blue Giant surfactant used in the steam cleaning process cost $800 ($8 per gallon). Governor Island used approximately 3,600 gallons of water are used annually at a cost of $216 ($0.06 per gallon). Water consumption for parts cleaning includes the losses through evaporation, drag-out, and sludge removal and use for the rinsing procedure. The cost to heat the Brulin 815 GD solution throughout the year has been estimated through engineering calculations. These calculations incorporate conductive heat losses. Energy cost for maintaining the cleaners heat at 150°F was estimated at $6,849 for the year.

Disposal of the sludge from the island costs $0.61 per pound for a total cost of $610. Emissions released into the atmosphere from the use of Brulin 815 GD and Blue Giant are assumed not to result in a cost. Other incurred costs include the use of personal protective equipment, consisting of gloves and face shields at $96 per year and three bales of the disposable cloth towels used to dry the parts at a cost of $99 per year.

MATERIAL AND EMISSION REDUCTION OPPORTUNITIES:

A possible material reduction opportunity for the Brulin 815 GD parts cleaning process would be to establish a continuous filtration system to separate the contaminants from the working solution. Approximately 575 pounds (64 gallons) of Brulin 815 GD is used to make-up the losses incurred through the removal of the sludge from the parts washing tank. This is about 47 percent of the total annual usage of the Brulin 815 GD parts cleaner. A cost savings of $600 would result from the elimination of Brulin 815 GD in the sludge. The total weight for the sludge could be reduced by 75 percent with the separation of the cleaner from the contaminants. This reduction would have a cost savings of $458 annually. The "mucking" out the tank and removal of the sludge would be reduced to every three years. The total savings associated with the use of a continuous filtration unit, including any water losses, would be almost $1,100 annually.

An evaluation should be conducted to assess the need to use the surfactant Blue Giant as a follow-up cleaner to the Brulin 815 GD parts washing procedure. Steam rinsing only should have the same cleaning effects as steam cleaning with the surfactant mixture, resulting in an annual cost savings of $800.

CONCLUSIONS:

The industrial motor repair shop at Governors Island has cleaned over 60,000 pounds of contaminated parts with the Brulin 815 GD solution. The cleaner has proven to be effective at removing contaminants from the various ship and ground support parts located on the island.

Important factors in using the Brulin 815 GD as a parts cleaner is the solution temperature, concentration, and soaking time. Operational experience indicates that the Brulin 815 GD to be an efficient parts cleaner at SCNY, the temperature must be at least 150°F with the concentration of Brulin greater than 20 percent and a soaking time of at least 4 hours if there is no agitation.

According to tests performed by Scientific Material International Inc., Brulin 815 GD showed no hydrogen embrittlement, no visible cracking to titanium alloys, and was proven to be safe on most metals including steel and aluminum. Brulin 815 GD contains no "butyl" or petroleum solvents and is effective as a hot tank degreaser.

BRULIN 815 GD
Preliminary Information

Location:
SCNY, Governors Island is located off the southern tip of Manhattan and is accessible primarily by a Coast Guard operated fairy. Nine Coast Guard Cutters, 4 Ferry Boats, and 7 small boats are home ported at this facility.

Process Boundary:
The industrial facility located within the confines of the base is responsible for cleaning the majority of marine parts. The boundary was established within this facility and dealt specifically with the cleaning tank and the secondary steam cleaning for marine parts.

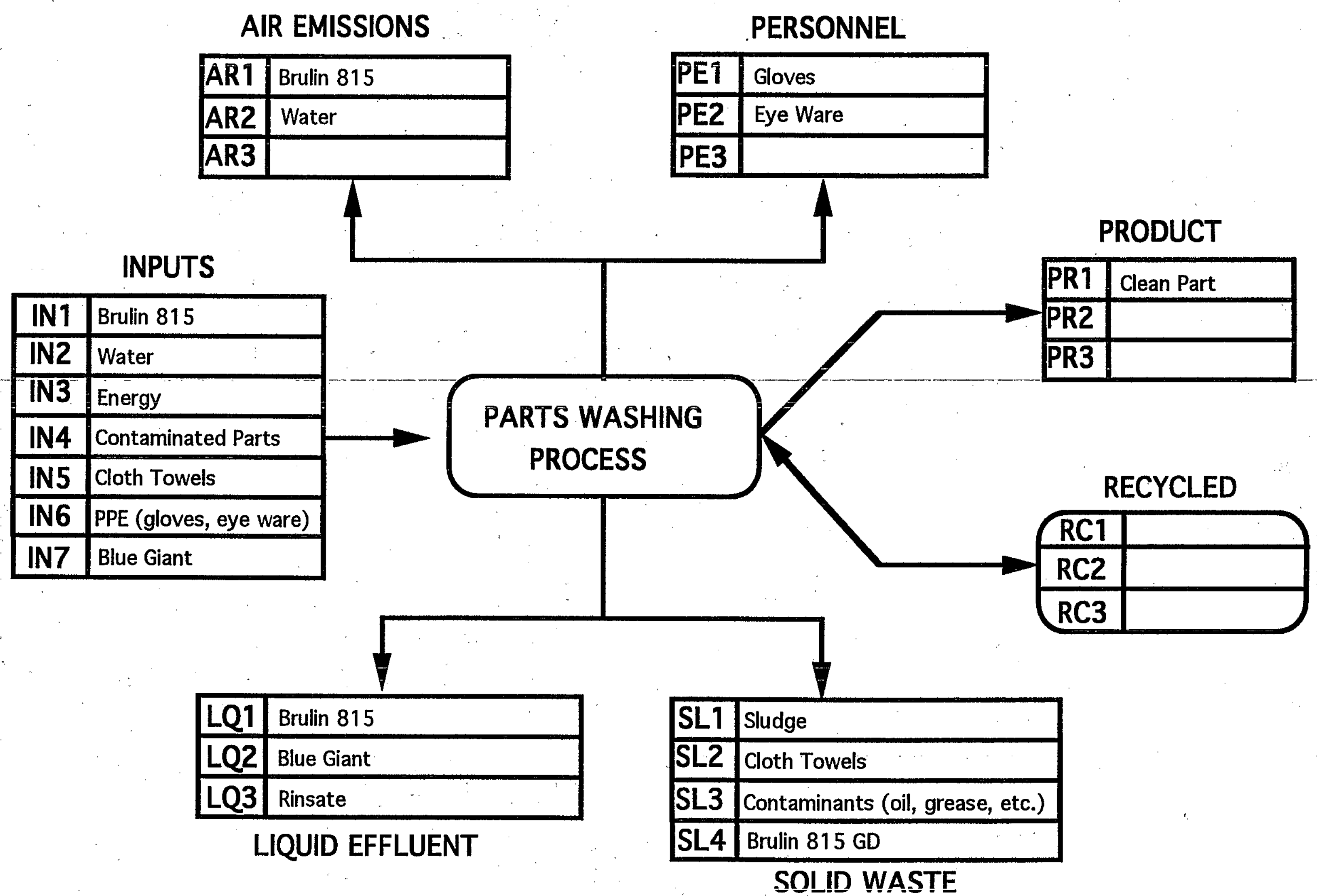
Process Description:
The parts cleaning solution is a mixture of 20 to 50 percent Brulin in potable water that is contained in an insulated 1,200 gallon capacity tank. The cleaning solution is heated to 150 degrees Fahrenheit. The contaminated part is placed into the tank by a mechanical hoist and left for periods of four hours or greater. There is no manual brushing on the contaminated parts by the technician. The cleaning solution is not agitated. Common contaminants removed from the marine parts include scale, carbon, grease, and paint. There is no filtration device used for the separation of the contaminants from the cleaning solution.

After the parts are removed from the cleaning tank they are steam washed with a surfactant (Blue Giant) and water mixture. The parts are allowed to air dry or dried using a disposable paper towel.

Product of Process:
Clean Marine Parts (No restrictions)

Worksheet BR-1. Parts Washing Process Description

FLOW DIAGRAM FOR CHEMICAL CLEANERS
BRULIN 815 GD



Worksheet BR-2. Flow Diagram for Parts Cleaners

MATERIAL BALANCE FOR CHEMICAL CLEANERS

BRULIN 815 GD

Material Description	Annual Input (lbs.)	Annual Total Output (lbs.)	PR 1 Product	TOTAL RELEASES (Units: lbs) AR 1 Air	AR 2 Air	LQ 1 Liquid Effluent	LQ 2 Liquid Effluent	LQ 3 Liquid Effluent	SL 1 Solid Waste	Make-Up for Sludge Losses	SL 2 Solid Waste	SL 3 Solid Waste	SL 3 Solid Waste	PE 1 PPE	PE 2 PPE
Brulin 815 GD	1,228	1,228		547		99			450	125			7		
Blue Giant	900	900					900								
Water	30,024	30,024			2,502			27,097	300	125					
Contaminated Parts	60,280	60,280	60,000						250			30			
Cloth Towels	300	300									300				
Gloves	20	20												20	
Eye Ware	3	3													3
TOTAL	92,755	92,755	60,000	547	2,502	99	900	27,097	1,000	250	300	30	7	20	3

Worksheet BR - 3. Material Balance Sheet

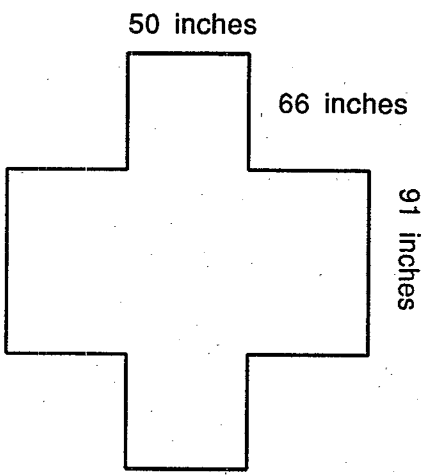
HEAT LOSS CALCULATIONS:

(1) Specific Heat of cleaning solution = $C_p \approx 1$ Btu/lb -°F

(2) Ambient air temperature 72°F

(3) Tank size 1,200 gallon capacity

Tank Calculations



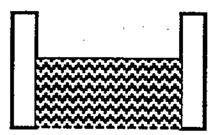
a. Total Tank Area

(50") * (66") * (91")* (1 ft³/1728") ≈ 174 ft³

b. Total Tank Volume

(174 ft³) / (0.1337 ft³/gal) = 1,300 gal

c. Clearance of 5 inches from top of tank to the cleaning solution



Clearance Volume = 98.5 gallons

Volume of Brulin 815 Gd in Tank = (1,300 - 98.5) ≈ 1,200 gallons

Step 1: Heat tank from ambient temperature (72°F) to working temperature (150°F)

$q = mCp\Delta T$

q = heat

m = mass = (1,200 gal)*(8.34 lbs/gal) = 10,008 lbs

Cp = Specific Heat = 1 Btu/lbs-°F

ΔT = Change in Heat = (150°F - 72°F) = 78°F

q = 780,624 Btu

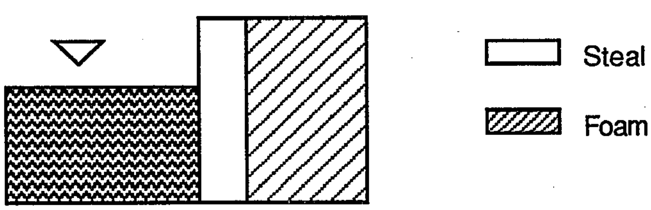
1 Btu ≈ $2.93071 * 10^{-4}$ kWH

kWh = (780,624 Btu) * ($2.93071 * 10^{-4}$ kWH/Btu) = 228.78 kWH

Cost = (228.78 kWH) * ($0.17)/(kWH) = $38.82

Step 2: Conduction losses from operations

Tank is constructed of two materials: (1) Steal .75 inch thick, and (2) foam insulation 1 inch thick



q = heat

A = Area

ΔT = Temperature change

R = Thermal Resistance

B = Thickness of Material

K = Thermal Conductivity

$$q = \Delta T/R$$

$$R = R_{st} + R_f$$

Where $_{st}$ = Steel

$_f$ = Foam

$$R = \frac{B}{KA} \quad \text{therefore}$$

$$R = B_{st}/K_{st}A + B_f/K_fA$$

Calculate losses from tank sides:

A = 119 ft^2

B_{st} = 0.0625 ft

K_{st} = 26.2 Btu/ft-h-°F

B_f = 0.08333 ft

K_f = 0.08 Btu/ft-h-°F

Assume ΔT = 70°F

R_{st} = $2 * 10^{-5}$ °F/Btu

R_f = $8.75 * 10^{-3}$ °F/Btu

R = $8.77 * 10^{-3}$ °F/Btu

$$q = (70°F)/(8.77*10^{-3}°F/Btu) = 7979 \text{ Btu} = 2.33 \text{ kWh}$$

Hours per year (Tank is not heated for two weeks for sludge removal)

(2.33 kWh) * ($0.17) * (8400 hours/yr) = <u>$3,327 per year</u>

Step 3: Calculate losses from tank bottom

Assume concrete thickness of 1 foot

B_c = 1 ft — $_c$ = concrete

K_c = 0.54 Btu/ft-h-°F

B_{st} = 0.0625 ft

K_{st} = 26.2 Btu/ft-h-°F

A = 40 ft^2

Assume ΔT = 70°F

q = 1725 Btu

Annual kWh cost = <u>$751</u>

Step 4: Calculate losses from tank top

Follow the same procedure used for the tank sides and the tank bottom

q = 1.94 kWh

Cost = (1.94 kWh) * ($ 0.17) * (8400 hrs/yr) = $2.770 per year

Total cost to heat tank per year = $ 6.887

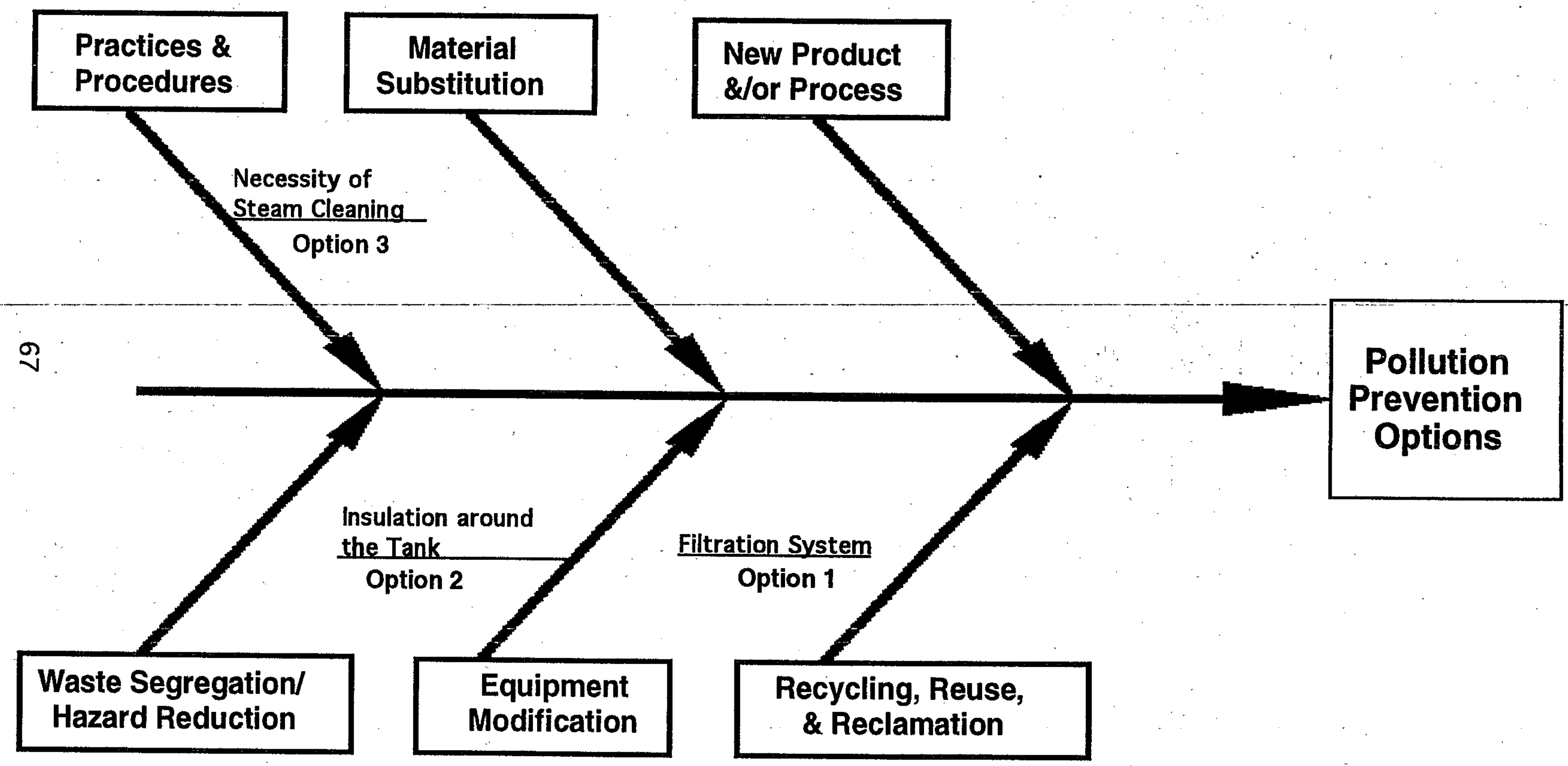
COST ANALYSIS FOR CHEMICAL CLEANERS
BRULIN 815 GD

DESCRIPTION	COST PER UNIT	TOTAL COST START-UP	TOTAL COST RECURRING
Material Acquisition			
Cleaning Station		$2,000	
Brulin 815 GD Acquisition	150 gallons (1,345 lbs) @ $9.40 per gallon	$1,410	
Brulin 815 GD Usage	137 gallons (1,228 lbs) @ $9.40 per gallon		$1,293
Blue Giant Usage	100 gallons (900 lbs) @ $8.00 per gallon		$800
Identify and Quantify			
Energy	40,512 kWh @ $0.17/kWh	$38	$6,849
Water Usage	Estimated 3,600 gallons ($0.06/gallon)		$216
Parts Processed	60,000 pounds per year		N/A
Atmospheric Emissions	3049 pounds per year (no permit required)		N/A
Solid Waste			
Sludge*	1000 pounds per year $.61/lbs (Hazardous)		$610
Disposable Cloth Towels	3 Bales per year @ $33 per bale		$99
Petroleum Contaminants	27 pounds per year (oil/water seperator)		N/A
Petroleum Contaminants	3 pounds per year (trapped in the towel)		N/A
Ecological and Human Health/Safety Impacts			
PPE (Gloves)	12 pairs per year (20 lbs/yr) @ $4/pair		$48
PPE (Eye ware)	6 face shields per year (2.5 lbs/yr) @ $8/pair		$48
Total Start-Up Cost		$3,448	
Total Annual Recurring Cost			$9,963

* Mixture of contaminants (250 lbs), Brulin 815 GD (450 lbs), and Water (300 lbs)

Worksheet BR - 4. Cost Analysis for Cleaners

BRULIN 815 GD
Material and Emission Reduction
Option Generation



Worksheet BR-5. Option Generation

BRULIN 815 GD
Material and Emission Reduction
Option Description

Option Name and Description
(Include input materials and products affected)

Option No. ONE　　**Consider:** ● Yes　○ No

Establish a continuous filtration system to separate the contaminants from the working solution.

Practices & Procedures	☐	Waste Segregation/Hazard Reduction	☐
Material Substitution	☐	Equipment Modification	■
New Product &/or Process	☐	Recycling, Reuse, & Reclamation	☐

Option No. TWO　　**Consider:** ● Yes　○ No

Increase the amount of insulation surrounding the cleaning tank to reduce heat loss.

Practices & Procedures	☐	Waste Segregation/Hazard Reduction	☐
Material Substitution	☐	Equipment Modification	■
New Product &/or Process	☐	Recycling, Reuse, & Reclamation	☐

Option No. THREE　　**Consider:** ● Yes　○ No

Investigate the necessity of steam cleaning the parts following the Brulin 815 GD parts washing procedure.

Practices & Procedures	■	Waste Segregation/Hazard Reduction	☐
Material Substitution	☐	Equipment Modification	☐
New Product &/or Process	☐	Recycling, Reuse, & Reclamation	☐

Worksheet BR-6. — Option Description

BRULIN 815
OPTION EVALUATION

CATEGORY	Weight (1) 'W'	Option No. 1 Scale (2) 'S'	Option No. 1 'WxS'	Option No. 2 Scale (2) 'S'	Option No. 2 'WxS'	Option No. 3 Scale (2) 'S'	Option No. 3 'WxS'
Economic	8	6	48	8	64	6	48
Waste Generation	8	8	64	6	48	8	64
Implementation Period	4	4	16	6	24	8	32
Employee Health & Safety	10	6	60	0	0	0	0
Improved Operation/ Product	6	8	48	4	24	0	0
Regulatory Compliance	10	4	40	0	0	0	0
Other							
Subtotal			276		160		144
Likelihood of Technical Success (Multiplier 0 TO 1)		X	0.8	X	1	X	1
Likelihood of Useful Results (Multiplier 0 TO 1)		X	0.8	X	1	X	1
Total			177		160		144
Rank			1		2		3

1. The numerical value of the weight must be determined by the review team and should be from 0 (none) to 10 (high)
2. Scale each category from 0 (none) to 10 (high)

Worksheet BR-8. Evaluation Matrix

REFERENCES

1. Vigon, B.W., et al., Life Cycle Assessment: Inventory Guidelines and Principles, EPA - 600/R-92/245, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1993

2. Perry, J.H. (ed): "Chemical Engineers Handbook," 6th ed., McGraw-Hill, New York, 1984

3. McCable, Smith, and Harriott (ed): "Unit Operations of Chemical Engineering," 4th ed., McGraw-Hill, New York, 1985

4. Himmelblau, D.M. (ed): "Basic Principles and Calculations in Chemical Engineering," 5th ed., Prentice Hall, New Jersey, 1989