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Waste Minimization Program

Air Force Plant 78

Prepared for:

U.S. Air Force System Command
Aeronautical Systems Division/PMD
Wright-Patterson, AFB, OH 45433

Contract -F09603-84-G-1462-SC01

The Earth Technology Corporation

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This report presents the findings of an assessment of hazardous waste minimization opportunities at Air Force Plant 78. This assessment was based upon a site investigation at the manufacturing plant, discussions with operators and subsequent analyses. Recommendations are made regarding methods to reduce the volume of hazardous waste disposed.

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This report was prepared by the Earth Technology Corporation under Contract Number F09603-84-G-1462-SC01 for the AFSC, Aeronautical Systems Division (ASD/PMD). Mr. Charles H. Alford was the Project Officer for ASD/PMD. Mr. Richard R. Pannell was Program Manager and Mr. Brian J. Burgher, P.E., Mr. Douglas Hazelwood and Mr. Eric Hillenbrand were principal investigators for The Earth Technology Corporation.

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1.0 INTRODUCTION

This report presents the findings of an assessment of waste minimization opportunities at Air Force Plant 78 in Brigham City, Utah. It is part of the Waste Minimization Program being conducted by the Air Force Systems Command, Aeronautical Systems Division/Facilities Management Division (ASD/PMD) for eight (8) Government-Owned, Contractor-Operated (GOCO) facilities to promote prudent waste management by exploiting opportunities to limit land disposal, reduce costs and conserve resources.

A project team completed a site investigation of Morton Thiokol, Inc. operations during the week of September 16, 1985 to review facility operations and discuss opportunities for waste reduction with plant engineering staffs. Based upon this investigation and subsequent analyses, this report presents the status of current waste generation and minimization programs and recommends other potential methods for reducing current waste volumes. Tables of waste volumes before and after minimization have been prepared to provide an indication of planned and projected waste reduction through system modifications. Finally, recommendations for implementation of opportunities which could further reduce waste generation and disposal are provided.

1.1 BACKGROUND

Interest in waste minimization has long been promoted by Federal legislation, including the Federal Water Pollution Control Act Amendments of 1972, the Energy Policy and Conservation Act of 1975 and the Used Oil Recycling Act as well as DOD directives such as AFR 78-22 and DODD 19-14. More recently, the impetus for waste minimization has become even stronger. The reauthorization of RCRA includes bans on landfilling of certain waste types and a requirement for certification that waste minimization is being conducted by hazardous waste generators. Similarly, DOD has issued directives requiring zero land disposal of solvents by October, 1986 through its Used Solvent Elimination Program.

ASD/PMD anticipated these developments and initiated programs in 1983 to address these issues. A preliminary identification of resource conservation and recovery activities and opportunities was included in an environmental audit program conducted in 1983 for fifteen (15) facilities. ASD/PMD contracted a further study of resource conservation and recovery opportunities at eleven (11) GOCO facilities in 1984. This effort resulted in a preliminary assessment of opportunities for industrial and non-industrial (i.e., solid or municipal) waste streams.

The methodology for this effort relied primarily on data acquired during the environmental audit program conducted in 1983 supplemented with conversations and information exchanges between the study team and GOCO contractor personnel. The results of this investigation were an indication of the areas where resource conservation and recovery opportunities appeared to be most substantial, and the areas where opportunities were not promising. Through application of a consistent methodology, facilities with substantial opportunities and measures warranting further investigation were identified.

The 1984 study demonstrated that plant operators were implementing methods that could substantially reduce waste generation volumes and raw material requirements to reduce their waste management costs and potential liabilities associated with waste land disposal. However, other opportunities for waste minimization were identified which appeared both technically and economically feasible, but were not being implemented.

In light of the findings of these studies and the new certification requirements of RCRA, ASD/PMD is adopting a Waste Minimization Program. This program is promoting prudent waste management by exploiting opportunities to reduce costs and conserve resources. It is intended to establish for ASD/PMD the status of progress in this area, and to demonstrate facility advances in alternate waste management methods. In addition, it is expected that new opportunities determined to be infeasible in the past will be identified for possible implementation.

1.2 OBJECTIVES

The ASD/PMD Waste Minimization Program is designed to promote waste management opportunities which reduce the reliance on land disposal by GOCO facilities and which result in increased efficiency in the utilization of resources. As part of this program, this study has the following objectives:

1. Define the status of waste generation and existing minimization measures at AFP 78.

2. Support feasible alternatives identified at AFP 78 by Morton Thiokol.

3. Identify and evaluate new opportunities not being implemented by Morton Thiokol.

4. Stimulate technology transfer between AFP 78 and other Air Force GOCO facilities as well as with other DOD installations.

5. Continue to increase the awareness of the importance of waste minimization.

6. Provide information needed to confidently certify that waste minimization is being employed at AFP 78 to satisfy RCRA requirements and DOD directives.

2.0 CONCLUSIONS AND RECOMMENDATIONS

Air Force Plant 78, located near Brigham City, Utah, is operated by Morton Thiokol, Inc. Operations at AFP 78 cover 1,515 acres and employ approximately 2,000 employees on 3 shifts. Adjacent to AFP 78 are an additional 17,863 acres of land owned by Thiokol. Operations at AFP 78 center around the production of Trident and Peacekeeper solid fuel propulsion units.

Thiokol generates significant quantities of wastes as a result of machining, mixing, grinding, casting, surface coating, inspection and related activities. It is estimated that 7.0 million pounds of waste and wastewaters are generated at AFP 78 annually. The bulk of these wastes (90 percent) are treated or disposed on-site at a low cost. Approximately 672,000 lb/yr of wastes are sent off-site for recycling or disposal, generating revenues of approximately $522,000/yr.

Measures now in place at AFP 78 are resulting in significant reductions in off-site disposal requirements. At present, no additional measures have been funded or approved to reduce AFP 78's use of off-site recycling and disposal. Additional measures are being investigated to achieve reductions of up to 15 percent in off-site disposal and recycling.

2.1 CONCLUSIONS

This section presents a summary of the waste minimization measures being incorporated at AFP 78, as well as alternatives being considered as part of an ongoing waste minimization program and alternatives requiring further investigation, development or capital resources prior to incorporation. Thiokol has developed a waste management program that has as major objectives:

1. Minimize and reduce hazardous waste generation.

2. Develop hazardous waste management systems that minimize threats to human health and the environment.

3. Achieve the first two objectives in the most practicable economic manner.

The effectiveness of this program is evident in the number of waste minimization measures being investigated for implementation at AFP 78.

A summary of projected 1985 waste volumes, currently planned reductions and additional potential reductions being considered by Thiokol, is provided in Table 2-1. A brief description of waste reduction opportunities is provided in Table 2-2. An analysis of these data result in the following conclusions:

1. Measures now in place at AFP 78 have reduced off-site disposal requirements by approximately 90 percent. These reductions are attributable to the following measures:

   - Approximately 5.5 million lb of wastewater is treated on-site through evaporation and open-pit burning.

   - Approximately 628,000 lb of explosive material is destroyed on-site through open-pit burning.

   - Over 558,000 lb of ammonium perchlorate is sold to off-site recyclers for reuse.

   - Approximately 130,000 lb of waste photographic solution waste is treated on-site to render them non-hazardous and recover saleable silver.

   - Approximately 82,700 lb of methyl chloroform waste is sold to off-site recyclers for reuse.

2. Thiokol is planning to reduce waste generation by approximately 50,000 lb by replacing an existing water-wall painting booth with a dry booth system. This will not impact off-site disposal or treatment rates.

3. Additional opportunities for waste minimization are being studied by Thiokol which could reduce off-site treatment and disposal requirements by 15 percent, including:

   - Hydraulic oil now sold to off-site recyclers and sent off-site for disposal could be reduced by over 20,000 lb through on-site purification.

   - Approximately 80 percent of the 82,000 lb of methyl chloroform waste now sold to off-site recyclers could be eliminated or reused on-site through operational changes, equipment modifications and use of on-site distillation systems.

   - Approximately 4000 lb of Freon could be recovered on-site for reuse through distillation.

TABLE 2-1
AFP 78: MORTON THIOKOL
PROJECTED WASTE DISPOSAL

WASTE STREAM	1985 GENERATION (POUNDS)	1985 LAND DISPOSAL (POUNDS)	PROJECTED LAND DISPOSAL W/PLANNED MINIMIZATION (POUNDS)	PROJECTED LAND DISPOSAL W/PROPOSED MINIMIZATION (POUNDS)
1. Machine Coolant Waste	43,800	43,800	43,800	-
2. Waste Hydraulic Oil	22,500	1,100	1,100	-
3. Methyl Chloroform Waste	82,700	-	-	-
4. Freon TA Waste	4,600	4,600	4,600	550
5. Methyl Ethyl Ketone Waste	5,400	1,800	1,800	-
6. Waste Explosive Material	$1.19x10^6$	-	-	-
7. Photographic Solution Waste	130,000	-	-	-
8. General Plant Wastewater	$5.45x10^6$	-	-	-
9. Paint Booth Wastewater	50,000	50,000	-	-
10. Combustible Organic Waste	1,800	1,800	1,800	-
TOTAL	$6.98x10^6$	103,000	53,100	550
% REDUCTION			48%	99%

TABLE 2-2
AFP 78: MORTON THIOKOL
SUMMARY OF
CURRENT, PLANNED AND PROPOSED
WASTE MANAGEMENT METHODS

WASTE STREAM	PRESENT METHOD	PLANNED CHANGES	PROPOSED CHANGES
1. Machine Coolant Waste	On-site Disposal	None	Evaluate on-site recycling
2. Waste Hydraulic Oil	Off-site recycling and disposal	None	On-site recyclin
3. Methyl Chloroform Waste	Off-site recycling	None	1. Employ minera oil to extend solvent life 2. Install power covers 3. Institute speed control 4. Evaluate on-site re-cycling 5. Evaluate re-placement of old degreaser
4. Freon TA Waste	Off-site disposal	None	Evaluate on-site recycling
5. Methyl Ethyl Ketone Waste	On-site detonation and off-site disposal	None	1. Evaluate on-site recyclin 2. Evaluate use as boiler fue
6. Waste Explosive Material	Off-site recycle and on-site detonation	None	None
7. Photographic Solution Waste	On-site treatment	None	None
8. General Plant Wastewaters	On-site treatment	None	None
9. Paint Booth Wastewater	On-site disposal	Phaseout of waterwall systems	Continue phase-out
10. Combustible Organic Waste	Off-site disposal	None	Evaluate use as boiler fuel

- Over 4000 lb/yr of organic liquids could be used on-site as supplemental boiler fuels.

In addition, on-site wastewater treatment requirements could be reduced by approximately 68,000 lb/yr through the acquisition of a coolant recycling system and switchover of the second M-508 spray booth to a dry system.

2.2 RECOMMENDATIONS

Based on the findings of this waste minimization investigation of Thiokol operations at AFP 78, the following is an inventory of recommendations made with the objective of minimizing current waste disposal.

1. <u>Machine Coolant Waste</u>

   1. Evaluate the economics of on-site recovery through coalescing plate filtration.

2. <u>Waste Hydraulic Oil</u>

   1. Acquire a portable vacuum recovery system to purify hydraulic oils on-site.

   2. Institute an oil maintenance program to recycle (purify) hydraulic oils on a routine basis.

3. <u>Methyl Chloroform Waste</u>

   1. Add mineral oil to degreaser sumps to raise degreaser operating temperature, to minimize preferential boil off of methyl chloroform and maintain the correct solvent/additive balance.

   2. Install and use degreaser covers to prevent atmospheric water vapor condensation on degreaser coils and reduce vapor losses.

   3. Implement step-wise procedures for introducing materials into and removing materials from vapor degreasers (particularly the circular degreaser) to slow the rate of descent and ascent, thereby reducing piston effects.

   4. Evaluate on-site distillative recovery of methyl chloroform.

   5. Evaluate replacement of the old M-508 degreasers to reduce maintenance and solvent expenditures.

4. Freon TA Waste

   1. Evaluate the technical feasibility of on-site distillative recovery of Freon.

5. Methyl Ethyl Ketone Waste

   1. Evaluate the technical and economic feasibility of on-site distillative recovery of MEK.

   2. Evaluate on-site reuse of MEK as fuel if recovery is not feasible.

6. Waste Explosive Material

   1. Consider future implementation of on-site ammonium perchlorate (AP) recovery system if AP resale value increases.

   2. Monitor EPA open-burning regulatory development.

7. Paint Booth Wastewater

   1. Proceed with current plans for changeover of water wall paint booths to dry filter paint booths.

8. Combustible Organic Waste

   1. Evaluate on-site reuse of combustible, nonhalogenated, nonrecycleable, liquid organic wastes as supplemental boiler fuels.

   2. Conduct jar tests to verify waste/fuel oil compatibility.

2.3 ECONOMICS

Table 2-3 summarizes the economics of waste minimization alternatives, developed through this investigation. Economics are order of magnitude estimates only and should not be used in place of detailed engineering estimates which consider contractor labor, engineering and administrative costs and facility specific costs. Estimates are based on standard cost references, vendor quotes or experience with similar capital projects.

TABLE 2-3
AFP 78: MORTON THIOKOL
POTENTIAL WASTE MINIMIZATION ECONOMICS

WASTE	OPTION	CAPITAL COST	ANNUAL O&M COST	INCREASED ANNUAL SAVINGS	PAY
1. Machine Coolant Waste	On-site coolant recycling	$ 7,500	Negl.	$ 2,100	3.5 y
2. Waste Hydraulic Oil	On-site oil recycling	$14,000	Negl.	$ 5,000	2 y
3. Methyl Chloroform Waste	a) Increase sump temperature	$ 0	$ 600	$ 7,400	
	b) Install power covers on all degreasers	$23,000	$ 500	$37,500	0.6 y
	c) Control speed of part descent and ascent	$ 0	$ 0	$ 1,100[1]	-
	d) On-site solvent recovery	$15,500	$ 700	$ 4,200	3.7 y
4. Freon TA Waste	On-site solvent recovery	$ 8,500	$ 70	$ 4,500	2.0 y
5. Methyl Ethyl Ketone Waste	On-site solvent recovery	$ 8,500	$ 50	$ 800	10 yea
6. Combustible Organic Waste	On-site waste reuse as fuel	$ 1,000	$ 60	$ 1,350	0.8 y

1 Estimated minimum annual savings.

3.0 WASTE MINIMIZATION PROGRAM
AFP 78: MORTON THIOKOL

This section provides a description of current waste generation and management practices by waste stream at AFP 78 - Morton Thiokol. A summary of these current practices is provided in Table 3-1. The following subsections present detailed descriptions of each waste stream and current management methods; waste stream material balances (where appropriate); opportunities for waste minimization; system economics; and recommendations for system implementation. Section 3.10 provides an evaluation of the feasibility of using combustible organic liquid wastes as supplemental boiler fuels. This information is provided in support of the conclusions and recommendations summarized in Section 2. Work sheets for each waste stream are included in Appendix B.

3.1 MACHINE COOLANT WASTE

3.1.1 Waste Description and Management Practices

Machining operations at AFP 78 require soluble oil/water emulsion coolants for lubrication and cooling of aluminum parts during metalworking. After prolonged use, coolant degrades as evidenced by ineffective lubrication, rancidity, and free floating tramp oils. When shop operators determine that coolants require replacement (approximately once every 2-3 months), coolant is pumped from machine sumps into 55-gallon drums. The coolants are disposed by draining the waste drums into an evaporation lagoon located on Thiokol property.

Thiokol uses Cimcool and Trimsol brand coolants. A typical makeup of the coolants is:

- 60-90% mineral oil
- 1-5% water
- 5-30% emulsifiers
- 1-20% coupling agents
- 1-10% rust inhibitors
- 0-10% bactericide (generally chlorophenols).

Coolant is mixed with deionized water to a 20:1 (water:oil) ratio. Coolant waste pumped from machine sumps will typically contain this cutting oil/water mixture with 2-3 percent tramp oil and high solids content. Coolant waste will also have reduced concentrations of additives such as emulsifiers and bactericides.

TABLE 3-1
AFP 78: MORTON THIOKOL
WASTE GENERATION RATES AND MANAGEMENT PRACTICES

WASTE	SOURCE/CONTENT	1985 GENERATION RATE (POUNDS)	CURRENT MANAGEMENT PRACTICES	CURRENT COSTS	CHANGES PROJECTED/COMMENTS
1. Machine Coolant Waste	Machining Operations: -95% Water -5% Coolant	(43,800 lbs) 5,250 gal	Collected in drums Drum transport Drained into MTI evaporation pond	Negligible	None
2. Waste Hydraulic Oil	Machining Operations: -Lubricating oils -Water, metal contaminants	(22,500 lbs) 3,000 gal	Collected in drums Drum transport Off-site recycle (95%) Off-site disposal (5%)	Negligible	None
3. Methyl Chloroform Waste	Degreasing Operations: -90% methyl chloroform -10% oil, water & contaminants	(82,700 lbs) 7,520 gal	Collected in drums Drum transport Off-site recycle by OSCO	$5,100 (revenue)	Requested funding for recycling system
4. Freon TA Waste	Degreasing Operations: -88% Freon TA -12% contaminants	(4,600 lbs) 380 gal	Collected in drums Drum transport Off-site disposal	$1,250	None
5. Methyl Ethyl Ketone Waste	Painting Operations: Hand Cleaning Operations: -90% MEK -10% contaminants	(5,400 lbs) 810 gal	Collected in drums Drum transport On-site open pit detonation (66%) Off-site disposal (34%)	N/A*	None
6. Waste Explosive Material	Propellant Manufacturing: -47% ammonium perchlorate -23% composite -propellant -25% XLDB propellant -5% other explosives	$1.2x10^6$ lbs	Collected in bulk On-site open pit detonation (53%) Bulk transport for off-site recycle (47%)	$461,500 (revenue)	None
7. Photographic Solution Waste	Film Processing: -Photographic fixer -5,000 ppm silver -50 ppm cadmium	(130,000 lbs) 15,600 gal	Collected in bulk On-site treatment Silver recycle On-site land disposal of wastewater	$50,000 (revenue)	None

1 Unit costs are provided in Appendix A

TABLE 3-1 (continued)
APP 78: MORTON THIOKOL
WASTE GENERATION RATES AND MANAGEMENT PRACTICES

WASTE	SOURCE/CONTENT	1985 GENERATION RATE (POUNDS)	CURRENT MANAGEMENT PRACTICES	CURRENT COSTS	CHANGES PROJECTED/COMMENTS
8. General Plant Wastewaters	Area Washdown: -99% water -2,000 ppm ammonium perchlorate -5,000 ppm HMX	(5.45×10^6 lbs) 653,000 gal	Bulk Storage Trucked to evaporation ponds Water evaporated on-site Solids burned on-site	Neglibible	None
9. Paint Booth Wastewater	Painting Booths: -Water -Paint solids	(50,000 lbs) 6,000 gal	Drain to evaporation ponds	Negligible	Paint booths to be replaced with dry booths
10. Combustible Organic Waste	Hand Cleaning -70% acetone -13% isopropyl alcohol -12% xylene -4% toluene	(1,800 lbs) 270 gal	Drum storage Drum transport Off-site disposal	$870	None

[1] Unit costs are provided in Appendix A

Thiokol personnel estimate that approximately 300 to 400 gal/yr of undiluted coolants are used at AFP 78. Assuming an average usage of 350 gal/yr of pure coolant and evaporative/dragout losses of 25 percent (based on typical industrial data), net coolant waste generation is estimated to be 43,800 lbs (5,250 gal/yr). On-site disposal costs are reportedly negligible.

3.1.2 Waste Minimization Opportunities

Advances in coolant recovery technology have allowed industrial facilities to greatly extend the life of coolants and thereby reduce costs for new cutting fluid purchases and treatment or disposal costs for coolant waste. Several technologies are commercially available to remove tramp oils and other impurities from coolants so they can be made-up with fresh cutting fluid and reused in machining operations. Two technologies that are most often applied for on-site coolant recovery are coalescing plate filtration and centrifugation. Generally, centrifugation is more effective in separating tramp oils from coolant, but centrifugal units are significantly more expensive (generally 5 to 10 times the cost of plate filtration systems).

Cost savings of $1,050/yr are projected for on-site coolant recovery through plate filtration based on the following assumptions:

1. Operating labor is approximately equivalent to current requirements.

2. Coolant purchases are reduced by 60 percent (based on vendor data).

3. Coolant purchase costs average $10.00/gal (based on vendor quotes).

4. Current waste disposal costs are negligible.

A mobile coalescing plate filtration system suitable for AFP 78's needs would cost approximately $7,500 (based on vendor quotes) resulting in a 3.5 year payback period. A centrifugation system would achieve similar cost savings but would cost approximately $75,000, resulting in a much longer payback of 35 years.

It is anticipated that coolant wastes will be listed as hazardous wastes in the near future. As a result, coolant disposal costs are expected to increase significantly. Assuming a future coolant disposal cost of $0.50/gal (based on typical current off-site coolant disposal costs at other GOCO facilities), annual coolant disposal costs can be estimated to rise to approximately $2,600/yr. On this basis, it appears that a future potential cost savings of approximately $3,650/yr is achievable through on-site coolant recycling. At these savings, system payback could be realized in two years.

3.1.3 Recommendations

It is recommended that Thiokol evaluate the future economics of on-site coolant recovery through coalescing plate filtration. Unless a suitable, low-cost disposal system is established on-site, it appears that on-site coolant recovery will provide an economically attractive alternative to land disposal. It is further recommended that, if such a system is implemented:

1. Use bactericide additives for recovered coolant to achieve greatest useful coolant life.

2. Recover coolant on a routine schedule to minimize degradation and sump clean-out requirements, and improve total coolant life.

3.2 WASTE HYDRAULIC OIL

3.2.1 Waste Description and Management Practices

Hydraulic oils are used at AFP 78 in the machine shop (Building E-517) to provide internal lubrication for mills, presses, shears, lathes and other metalworking equipment. The oils are replaced on a preset schedule every 6 or 12 months. Thiokol personnel estimate that hydraulic oil use averages 200 to 300 gal/month or approximately 22,500 lbs (3000 gal/yr).

It is estimated that 95 percent of the waste hydraulic oils generated (2850 gal/yr) are removed by off-site recycling firms (three firms are currently used by Thiokol). These oils are initially pumped from the machine sumps to 55-gal drums which are eventually drained to a waste oil tank on Thiokol property. The tank is periodically emptied by the recyclers. The recyclers typically remove the waste oil at no cost (or a slight revenue) to Thiokol.

Approximately five percent of the hydraulic oils (150 gal/yr) contain tricresyl phosphate (TCP) and are unsuitable for off-site recycle. Thiokol is currently accumulating all hazardous wastes which require off-site disposal in drums, including TCP hydraulic oils, pending the outcome of negotiations with off-site disposal firms. Based on current typical disposal fees, it is estimated that TCP oil disposal will cost approximately $2.00/gal or $300/yr.

3.2.2 Waste Minimization Opportunities

Advances in oil purification techniques now allow the extended reuse of hydraulic oils. Through the routine removal of impurities, current hydraulic oil use rates and off-site management requirements can be reduced by 90 percent or more. Thiokol currently utilizes cartridge-type oil filtration units to remove solid contaminants from hydraulic oils before they are placed in machines. Occasionally, if excessive oil contamination is detected, oils in the machines are refiltered with this equipment to prevent lubrication failures. Although these cartridge systems do provide some degree of water removal capability, a program designed to maximize hydraulic oil life should employ specialized water-removal equipment.

Advanced oil purification systems typically provide for water removal by exposing a thin film of heated oil to a vacuum. Water as well as volatile hydrocarbons and acids are effectively evaporated from the oils in this manner. Oil use is reduced to the small quantities of oil which are carried out when system filters are replaced (typically 10 percent or less of current use rates). Several system users report achieving oil lifetimes in excess of 10 years.

The economics of on-site oil purification appear favorable. Annual savings of approximately $5,000/yr are projected based on the following assumptions:

1. Oils are purified in-situ using a mobile system approximately once per month.

2. Current oil life is extended by a factor of 10 (based on vendor-supplied data) resulting in a 90 percent decrease in oil purchases.

3. System operating costs are equivalent to existing oil draining, flushing and replacement costs.

4. New hydraulic oil costs average $2.00/gal (based on typical current vendor price quotes).

5. Disposal costs for spent cartridges are approximately $75/drum or $400/yr (based on typical disposal and transportation costs for 300 gal/yr of organic solids).

Based on quoted purification system acquisition costs of $14,000, payback is projected to occur within three years.

3.2.3 Recommendations

It is recommended that Thiokol acquire a portable system for the purification of machine hydraulic oils. The system should be equipped with vacuum purification capability to allow the removal of water, acids and other volatile materials. The unit should also be capable of purifying oils in-situ, i.e., pumping the oil from each machine, through the purification system and directly back into the machine's sump. It is recommended that all hydraulic oils be purified in this manner on a routine basis, preferably once per month. Spent cartridges should be thoroughly drained before disposal and the accumulated oil combined with other plant waste oils for sale to an off-site recycler or use as an alternate boiler fuel.

3.3 METHYL CHLOROFORM WASTE

3.3.1 Waste Generation and Management Practices

Methyl chloroform (1,1,1-trichloroethane) waste is produced at AFP 78 through operation of three vapor degreasers and through use in hand cleaning parts and equipment. Methyl chloroform used in degreasers is removed from degreaser sumps when analyses of samples taken weekly demonstrate that it is unfit for continued service due to depletion or buildup of additives (i.e., acid acceptors, white metal stabilizers) or excess oil or water. Waste solvent is pumped to drums, stored on-site at E-501, and transported off-site in drums for recycling at the Oil and Solvent Process Co. (OSCO) in Henderson, Colorado. Methyl chloroform used in hand cleaning is collected in drums at the point of use. Full waste drums are transported to E-501, stored, and transported off-site for recycling.

Approximately 737,000 lb (67,000 gal) of methyl chloroform is used annually at AFP 78. Of this total use rate, an estimated 82,700 lb (7520 gal) becomes waste and is sent off-site for recycling; the remaining 655,000 lb (59,500 gal) is consumed during use, discarded on solvent-soaked rags, or lost from vapor degreasers through volatilization. Thiokol purchases methyl chloroform for $3.77/gal, or a total cost of $253,000/yr.

Thiokol receives $0.85/gal for methyl chloroform recovered by OSCO. Assuming that the amount of methyl chloroform recovered is 80 percent of the volume sent off-site (based on a 90 percent recovery efficiency and a 90 percent methyl chloroform waste), Thiokol receives $5100/yr in revenue for methyl chloroform waste recycled by OSCO.

The methyl chloroform used in AFP 78's vapor degreasers is Dow Chloroethane VG. The approximate make up of this solvent is:

- o 95.9% - 1,1,1-trichloroethane
- o 0.2% - Acid acceptor
- o 3.5% - White metal stabilizer 1
- o 0.4% - White metal stabilizer 2

The additives used in the formulation impart to the solvent several desired properties. The acid acceptor prevents the buildup of acids in the solvent which would otherwise result in equipment or part corrosion. The white metal stabilizers inhibit corrosion of aluminum and steel. The chemical formulation of these additives is proprietary. The specifications for Thiokol's three vapor degreasers are provided in Table 3-2.

3.3.2 Waste Minimization Opportunities

Several opportunities have been identified for reducing methyl chloroform use and waste generation at AFP 78. These opportunities are discussed below. In addition to the specific measures described in this section, it is noted that two of the three AFP 78 degreasers are over 23 years old and are approaching the end of their useful lives. Replacement with new units, particularly the Circo degreaser which is undersized for the parts required to be cleaned, could achieve significant reductions in solvent use rates. Although replacement cannot be justified solely on the basis of solvent use reductions, maintenance costs for the two older degreasers are likely to increase in the near future to the point where replacement is more attractive than continued maintenance.

3.3.2.1 Operating Practices to Reduce Waste Generation

Records kept by Thiokol identifying the reasons for replacing solvent charges in degreaser sumps indicate that the following are the principle causes of solvent replacement (in order of importance):

1. Excess white metal stabilizer concentrations

2. Excess water (this occurs almost exclusively during the months of April to August)

3. Low acid acceptor concentrations (due to excess water)

4. High oil concentrations.

TABLE 3-2
AFP 78 VAPOR DEGREASER SPECIFICATIONS

TYPE	LOCATION	AGE	SOLVENT VOLUME	CONFIGURATION	OPENING DIMENSIONS	OPENING COVER
Circo	Bldg M-508	23 yr	1,000 gal	Circular	9 ft dia	None
Detrex VS-800S	Bldg M-508	3 yr	115 gal	Rectangular	3 ft x 5 ft	Manual
Detrex VS-800S	Bldg M-605	23 yr	115 gal	Rectangular	3 ft x 5 ft	None

Several operating measures can address these problems and reduce the frequency of solvent changeout. The buildup of metal stabilizer levels in the degreasers is probably due to low concentrations of oils in the degreaser sumps. Dow recommends that boiler sumps contain 8 to 25 percent oil to avoid preferential boil-off of methyl chloroform which results in buildup of stabilizers. Unlike most degreasers, the AFP 78 units are not exposed to high oil-contaminant levels on parts to be cleaned; therefore, the degreaser sumps operate with low oil concentrations. Pure mineral oil can be added directly to the sump to boost the sump's operating temperature. For example, with little or no oil in the sump, methyl chloroform is heated to 165^{o} during operation, vaporizing it at a higher rate than the stabilizers. As the oil concentration in the sump is raised to approximately 25 percent, the temperature also rises and the methyl chloroform and stabilizers are vaporized in correct proportions. Sump temperatures should not be allowed to exceed 174^{o} because this results in rapid degredation of the additives. It is estimated that the control of sump operating temperatures would result in a reduction in the rate of waste disposal of 35 percent, or 2600 gal/yr, for a savings of $7400/yr.

Further reductions can be realized by minimizing the rate of atmospheric water condensation in the degreasers through the use of covers, which prevent significant amounts of warm moist air from entering the units and condensing on the degreaser cooling coils. Because parts placed in the AFP 78 degreasers are usually dry, the majority of the solvent water contamination and accompanying depletion of acid acceptor can be linked to the condensation of water from the air (except for the degreaser in Bldg M-605, which, due to corrosion, experiences periodic leaks in its water jacket). This is confirmed by the fact that excessive water buildup in the solvents usually occurs during warm humid months. The use of degreaser covers can minimize these problems by preventing the inflow of moist air into the unit, except for periods when the top must be open.

To be effective, vapor degreaser covers must be utilized whenever possible. Mechanical covers, such as the hinged cover now on the Bldg M-508 Detrex degreaser, are cumbersome and are typically ignored by operators. Unlike the one existing Detrex cover, covers should open and close in a horizontal motion, so that disturbance of the air/vapor interface is minimized. Typical covers include roll-type plastic covers, canvas curtains and metal guillotine covers. Pneumatic or electrically powered covers with manual controls and automatic cutoffs are recommended. Powering the covers makes them considerably easier to use thereby increasing the liklihood that they will be used. It is estimated that the use of covers would reduce waste generation an additional 15 percent, or 1100 gal/yr. This represents a savings of $3400/yr.

Finally, Thiokol should consider replacing the small rectangular degreaser in M-605 due to its age and poor condition, which has led to leaks in the condenser coils resulting in water contamination of solvent. Replacement with a new degreaser will result in reduced maintenance cost (for repairing corroded coils), a lower frequency of solvent changeout, and reduced vapor losses (assuming the new degreaser is covered).

3.3.2.2 Operating Practices to Reduce Vapor Losses

A large amount of the solvent used at AFP 78 is probably lost through vaporization from degreasers. The U.S. Environmental Protection Agency (EPA) estimates that the average open top vapor degreaser loses 0.5 pounds of solvent per hour per square foot of opening area (Control of Volatile Emissions from Solvent Metal Cleaning, EPA-450/2-77-022). The cumulative annual loss rate for the three AFP 78 vapor degreasers, shown in Table 3-3, is calculated to be 337,000 lb (30,600 gal). This represents approximately one-half of the solvent losses as determined by comparison of purchase and waste disposal records. The remainder of the losses can be attributed to losses resulting from piston effects (described below) and losses during hand-applied cleaning with methyl chloroform. In studies for EPA, Dow has found that diffusion losses from open top vapor degreasers are reduced by 20 to 40 percent by the use of covers. Assuming a 30 percent effectiveness, it is estimated that 9,200 gal/yr of solvent diffusion losses could be prevented through the use of degreaser covers, for a savings of $34,000/yr.

Other vapor losses probably occur due to degreaser operation. Specifically, the large Circo degreaser used to clean mandrils probably loses significant amounts of vapor due to piston effects. Because the mandrils are almost as large as the degreaser opening, they displace a corresponding volume of vapor as they are lowered into the degreaser, and draw vapors out of the degreaser as they are removed. This piston effect can be reduced by introducing materials into and removing materials from the degreaser more slowly. Since the overhead hoist in Bldg M-508 does not have a speed control to allow for a slower continuous descent and ascent, the rate of descent and ascent can be slowed in a stepwise manner by periodically stopping the hoist (e.g., after every 1 foot of descent or ascent into or out of the degreaser) to allow for settling of the vapor blanket. The average entry and exit speeds should be kept below 11 fps. The amount of vapor loss that this would prevent is not known; however, if it were to reduce vapor losses by only one percent, it could save 300 gal/yr, or $1100/yr in solvent purchase costs.

TABLE 3-3
ESTIMATED VAPOR DEGREASER SOLVENT LOSSES
RESULTING FROM VAPOR DIFFUSION

DEGREASER	ANNUAL USAGE[1] (HOURS)	SURFACE AREA (SQ FT)	VAPOR LOSS (LB/YR)	SOLVENT LOSS (GAL/YR)
Circo M-508	8,760	63	275,900	25,100
Detrex M-508	1,870	15	14,000	1,300
Detrex M-605	6,240	15	46,800	4,300
TOTALS	16,900	93	337,000	31,000

[1] Thiokol estimates

3.3.2.3 On-Site Recovery

Implementation of the operating practices discussed above could reduce methyl chloroform waste generation to approximately 41,800 lb (3800 gal). This waste could be recycled on-site for reuse in vapor degreasers. A small distillation unit would be adequate for recycling the total 3800 gal/yr by operating one shift per day. Table 3-4 provides a listing of some of the units commercially available. The recovered solvent should be of sufficient purity to be suitable for reuse in vapor degreasers, but may not be suitable for critical hand cleaning of parts. Generally, recovered solvent does not meet mil specs, but is substantially cleaner than the solvent in the degreasers as they approach one of the turnover (recharge) criteria.

Additionally, spent acid acceptors and other additives can be replenished based upon relativ ly simple analyses, significantly extending solvent life. Several distillation system vendors, such as Baron Blakeslee and Detrex, provide kits which are used to determine the additive levels in recycled methyl chloroform. Based on these test results, additives available from still manufacturers can be added as needed. Operating experience has shown that control of additive levels can extend solvent life by as much as ten times beyond current levels.

As an example, General Electric (GE) has been utilizing a simple distillation system for 7 years to extend the useful life of methyl chloroform in its vapor degreasers at AFP 59. Solvent is removed from the degreasers when pH or specific gravity analyses show that the solvent is outside established acceptance limits. These same limits, which are less stringent than mil specs for new solvents, are applied to the solvents after on-site recycling. If the recycled solvents fail to meet the minimum acceptance limits they are discarded; if they meet the limits they are reused in AFP 59 vapor degreasers. As these solvents are the same as those used by AFP 78 a similar application may be possible.

Operation and maintenance costs for distillation systems are typically in the range of $0.15/gal to $0.20/gal. As these systems are highly automated, very little labor is required for their operation. Simple quality control analyses are generally sufficient to assure the quality of recycled solvents. As an example, GE recycles solvent at AFP 59 utilizing only pH and specific gravity measurements. It should be noted, however, that GE does not attempt to reconstitute spent acid acceptors or metal stabilizers in their recycled solvents. As a result, their recycling program allows an average of three use cycles for degreaser solvents before acid buildup precludes further

TABLE 3-4

TYPICAL SOLVENT DISTILLATION SYSTEM SPECIFICATIONS

MANUFACTURER	UNIT	MAX. SOLVENT BOILING POINT	CAPACITY	COST
Finish Engineering	LS-15	320°F	15 gal/shift	$ 5,030
	LS-55	320°F	55 gal/shift	12,800
Recyclene	R-25	400°F	35 gal/shift	11,900
Venus	SRS-5	320°F	56 gal/shift	10,600
Brighton	7.5 GPH	350°F	60 gal/shift	17,500

use. To further extend solvent life, it would be necessary to periodically rejuvenate solvents with new acid acceptor and metal stabilizers. A maximum reuse program of this type would require additional solvent analyses to determine the necessary additive makeup levels. Assuming analytical costs average $0.20/gal, net O&M costs of $0.40/gal are projected.

The economics of on-site distillative recovery of methyl chloroform at AFP 78 appear favorable. Annual savings of $5,800 are projected based on the following assumptions:

1. Previously described opportunities for waste minimization are successful at reducing waste generation to 3800 gal/yr.

2. Approximately 80 percent of the waste stream is recoverable methyl chloroform (3,400 gal/yr) (based on Thiokol analyses and vendor performance data).

3. Avoided new solvent purchase costs will be $11,500/yr (based on current purchase costs of $3.77/gal).

4. Distillation residues are disposed off-site at a cost of $2400/yr. (based on a 20 percent waste rate and typical off-site disposal costs of $3.20/gal).

5. Current resale revenues of $0.85/gal or $2,600/yr are lost.

6. System operating and maintenance costs will be $0.20/gal or $700/yr (based on vendor estimates).

Based on typical system acquisition costs of $15,500, payback is projected to occur in 3.7 years.

3.3.3 Recommendations

It is recommended that Thiokol evaluate and, depending upon the results of the evaluation, implement the following operational measures to reduce methyl chloroform waste generation and vapor losses:

1. Add mineral oil to degreaser sumps to raise degreaser operating temperature, thereby minimizing preferential boil-off of methyl chloroform and maintaining the correct solvent/additive balance.

2. Install and use power degreaser covers to prevent atmospheric water vapor condensation on degreaser coils and reduce vapor losses.

3. Implement step-wise procedures for introducing materials into and removing materials from vapor degreasers (particularly the circular degreaser) to slow the rate of descent and ascent, reducing piston effects.

Additionally, Thiokol should evaluate implementing an on-site solvent distillative recovery system to recycle waste methyl chloroform. Economics for these recommendations are summarized in Table 3-5. Finally, Thiokol should evaluate replacement of the Bldg M-508 degreasers to reduce maintenance and solvent expenditures.

3.4 FREON TA WASTE

3.4.1 Waste Generation and Management Practices

Freon TA, an azeotrope of Freon TF (trichlorotrifluoroethane) and acetone, is used at AFP 78 for production equipment cleanup and for part and assembly cleaning during propellant casting, rocket motor assembly, and maintenance operations. Waste Freon is collected in drums at the generating location and is then transported to the drum storage area on Thiokol property (Area 186). Freon is disposed of off-site. Analytical data is not available on the composition of waste Freon; however, based upon use, waste Freon is probably a minimum of 98 percent Freon with some contaminants, including other solvents and oil.

Approximately 47,000 lb (3900 gal) of Freon is used annually at AFP 78, most of which is consumed during use (e.g., through volatilization). An estimated 10 percent of the Freon used is collected as waste, or 4600 lb (380 gal).

3.4.2 Waste Minimization Opportunities

Although a relatively small volume waste stream, Freon waste may be able to be economically recycled for reuse on-site due to its relatively high cost. A 15 gal/shift distillation unit, such as one of those discussed in section 3.3.2, would be adequate to recycle all Freon waste generated at AFP 78. However, if the recovered product were not of satisfactory quality for use in hand cleaning parts and assemblies, recycling would not be feasible, as there are no uses on-site for low quality Freon.

The economics of on-site distillative recovery of Freon appear favorable. Annual savings of $4500 are projected based on the following assumptions:

1. Approximately 88 percent of the waste stream is recoverable Freon (340 gal/yr) (based on use and vendor estimates).

TABLE 3-5
SUMMARY OF ESTIMATED ECONOMICS FOR METHYL CHLOROFORM RECOMMENDATIONS

IDENTIFIED OPTION	CAPITAL COST	ANNUAL O&M COST	PROJECTED NET ANNUAL SAVINGS	PAYBACK PERIOD (YEARS)
Sump Temperature Control	$ 0	$ 600	$ 7,400	0
M-508 Circo Power Cover	$15,000	$ 300	$ 30,400	0.5
M-508 Detrex Power Cover	$ 4,000	$ 100	$ 1,900	2.2
M-605-Detrex Power Cover	$ 4,000	$ 100	$ 5,300	0.8
Distillation System	$15,500	$ 5,600	$ 4,800	3.7
TOTAL OF ALL OPTIONS	$38,500	$ 6,700	$ 49,800	0.8

2. Avoided new solvent purchase costs will be $3400/yr (based on an estimated purchase cost of $10.00/gal).

3. Distillation residues are disposed off-site at a cost of $150 yr (based on a 12 percent waste rate and $3.29 gal off-site disposal cost).

4. Current disposal costs of $250/yr are saved (based on an estimated off-site disposal cost of $3.20/gal).

5. System operating and maintenance costs will be $0.20/gal or $70/year.

Based on typical system purchase and installation costs of $8500, payback is projected to occur in two years.

3.4.3 Recommendations

Thiokol should evaluate the technical feasibility of on-site recycling of waste Freon. The ability of on-site distillation systems to produce a Freon product of sufficient quality to be reused on-site should be determined (e.g, by sending a waste sample to a vendor for a test of the recycling unit). If on-site recycling is not technically feasible, Thiokol should investigate off-site recycling of this waste.

3.5 METHYL ETHYL KETONE WASTE

3.5.1 Waste Generation and Management Practices

Methyl ethyl ketone (MEK) is used at AFP 78 for paint and production equipment cleanup and for part cleaning during propellant casting, rocket motor assembly, and maintenance operations. MEK waste from these operations is collected in drums at the generating location and is then transported to either the drum storage area on Thiokol property (Area 186) or the burning area on Thiokol property if contaminated with propellant. Uncontaminated MEK is disposed off-site. Contaminated MEK is disposed on Thiokol property through open-burning.

Analytical data are not available on the composition of waste MEK; however, based upon use, waste MEK probably contains 95 percent MEK with contaminants including paint pigment, other solvents (isopropanol, acetone, and methyl chloroform), oil, ammonium perchlorate, and HMX. Approximately 8700 gal/year of MEK is used annually at AFP 78, of which 5400 lb (810 gal) are disposed of as waste. Of this waste, 3300 lb (500 gal) is explosive-contaminated and must be disposed on-site through open burning. The remaining 2060 lb (310 gal) is not contaminated with explosive and has previously been sent off-site for disposal.

3.5.2 Waste Minimization Opportunities

Waste MEK contaminated with propellants cannot be recycled for reuse due to the unstable nature of the contaminants. The 310 gal/yr of uncontaminated MEK may be able to be recycled on-site for reuse through the use of a small distillation system, although this may not be economically feasible due to the small volume of this waste. Such a system, as described in Section 3.3.2, can recover solvent on-site and is relatively simple to operate. Use of one of the smallest units available (e.g., a capacity of 15 gal/shift) would be sufficient to recover all uncontaminated MEK. While the recycled product may not be of satisfactory quality to reuse in hand cleaning parts and assemblies, it should be suitable for use in cleaning paint guns and other equipment. These systems do not require construction of a special room or building, or other specialized construction, as they are completely self-contained and are equipped with explosion-proof electrical components.

The economics of on-site distillative recovery of MEK are not favorable. Annual savings of $800 are projected based on the following assumptions:

1. Approximately 80 percent of the waste stream is recoverable MEK (250 gal/yr) (based on use and vendor estimates).

2. Avoided new solvent purchase costs will be $670/yr (based on an estimated purchase cost of $2.70/gal).

3. Distillation residues are disposed off-site at a cost of $200/yr (based on a 12 percent waste rate and $3.20/gal off-site disposal cost).

4. Current disposal costs of $990/yr are saved (based on an estimated off-site disposal cost of $3.20/gal).

5. System O&M costs will be $0.20/gal or $50/yr.

Based on typical system purchase and installation costs of $8500, payback is projected to occur in 10 years.

Alternately, waste MEK could be reused on-site as fuel, which would save the disposal cost and recover heat value from the waste. On-site reuse of waste solvents as fuel is discussed in detail in Section 3.10.

3.5.3 Recommendations

Thiokol should evaluate the technical and economic feasibility of on-site recycling of MEK through distillation. Although the economics of on-site recycling of MEK do not appear to be favorable, the reduction in potential liabilities associated with off-site disposal resulting from on-site recycling should be considered as part of the evaluation. This reduction in potential liabilities makes on-site recycling more attractive than economics alone would indicate. Alternately, Thiokol should consider recycling this waste through on-site reuse as fuel, as discussed in Section 3.10.

3.6 WASTE EXPLOSIVE MATERIAL

3.6.1 Waste Description and Management Practices

Waste explosive materials are routinely generated during the manufacture of propellants at AFP 78. Table 3-6 presents a listing of the various explosive wastes generated at AFP 78 and the projected 1985 generation rates for those materials.

As shown, ammonium perchlorate (AP) accounts for 47 percent of the total waste generation. Over 99 percent of the waste AP is currently sold to off-site explosives manufacturers for reuse at a net revenue of $0.83/lb or $461,500/yr. Unreclaimable AP, together with the other 53 percent of AFP 78's explosive wastes, are destroyed on-site through open detonation/burning. These wastes are placed, in bulk, in an open pit located on Thiokol property and remotely ignited once per week. On-site waste management and disposal costs are not available but are presumed to be negligible.

3.6.2 Waste Minimization Opportunities

Thiokol has developed a system for the recovery of saleable AP from composite propellant. Composite propellant, which represents 23 percent of the explosive waste stream, consists of carboxyl terminated polybutadiene (CTPB), hydroxyl terminated polybutadiene (HTPB), polybutadiene acrylic acid acrylonitrite (PBAN), AP, aluminum powder, ferric oxide and miscellaneous plasticizers and antioxidants. The recovery system developed by Thiokol consists of maceration of solid composite propellant with high temperature/high pressure water jets to increase the surface area of solids followed by leaching of AP into hot water solution. The liquid slurry is cycloned and filtered to separate AP-concentrated liquid from sludge residue. The liquid is then crystalized for precipitation of AP crystals, which are centrifuged and drummed as wet AP product. Liquid from the centrifuge is recycled to the macerator to eliminate a large effluent waste stream. Sludge residue is collected from the system in drums for disposal or possible further recovery of additional components. A flow schematic of the reclamation process is provided as Figure 3-1.

TABLE 3-6
AFP 78 WASTE EXPLOSIVE MATERIAL
GENERATION RATES

WASTE	1985 GENERATION RATE (LBS.)*
Ammonium perchlorate (solid)	557,000
XLDB propellant	309,270
Composite propellant	272,830
HMX fiberpacks	30,750
Ammonium perchlorate (washwater)	6,650
HMX propellant	5,040
Explosive-contaminated solvents	3,600
Embedment powder	1,730
C0-4 ignitors	770
OPC test motors	160
TOTAL	1,187,800

*Generation rates extrapolated based on Thiokol records for period from 5/17/85 to 8/11/85.

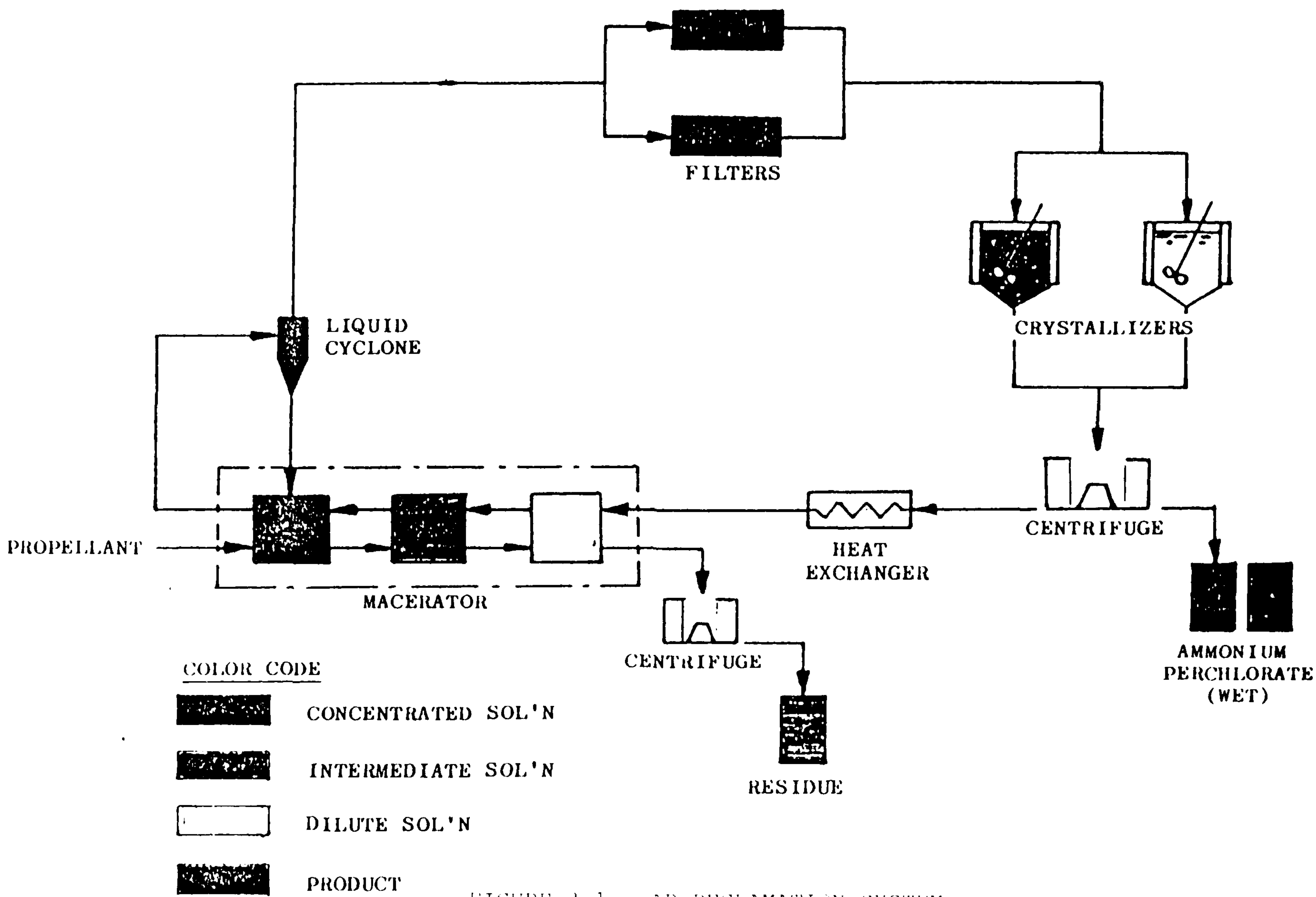

FIGURE 3-1. AP RECLAMATION SYSTEM

Thiokol's detailed study of the AP recovery system based on pilot tests indicated a minimum resale value of \$0.80/lb of recovered AP would be required for economic operation. Thiokol recently solicited bids from potential AP purchasers to determine the potential for full-scale implementation. As the highest bid received was \$0.50/lb, the system does not appear to be economically attractive when compared to existing on-site detonation and is no longer being considered. No other opportunities for reducing explosive waste generation rates have been identified.

3.6.3 Recommendations

If future economic changes result in increased AP resale values, it is recommended that Thiokol reconsider the AP recovery system. In the absence of such changes, it is recommended that Thiokol continue existing open detonation practices as these represent a currently environmentally acceptable approach for disposal of waste propellants. It should be noted that EPA plans to develop regulations that set forth controls over open detonation which may change current economics. However, EPA estimates that changes in the current status of open detonation requirements will not occur for several years. It is recommended that Thiokol monitor regulatory changes and reevaluate recovery options in light of increasing restrictions on open burning.

3.7 PHOTOGRAPHIC SOLUTION WASTE

Waste photographic solutions and rinsewaters are generated at AFP 78 from processing films used for radiographic inspection of finished motors. Waste solutions contain EP toxic levels of silver (5000 ppm) and cadmium (50 ppm). Waste photographic solutions are collected in bulk and treated on-site to both recover silver and reduce concentrations of silver and cadmium remaining in solution to below hazardous levels. Following recovery, wastewater is discharged to evaporation ponds on Thiokol property. Recovered silver is sold to off-site precious metal smelters for reuse.

The Thiokol recovery system consists of an in-house designed batch treatment unit which utilizes sodium borohydride as a reducing agent to convert silver cations to an insoluble silver metal precipitate which is separated from solution by gravity settling. A typical metal reduction reaction for this process is:

$$8\ AgX + NaBH_4 + 2\ H_2O \rightarrow 8\ Ag + NaBO_2 + 8\ HX$$

where X is an anion such as chloride, or carbonate. System operation consists of the following steps:

1. Waste photographic solutions are charged to a 360 gal process tank for batch reaction.

2. The pH is adjusted through addition of sodium hydroxide.

3. Sodium borohydride is added to the process tank in excess of stoichiometric quantities and mixed.

4. Clean water is decanted to a 100 gal tank, and silver precipitate is settled to a 30 gal collection tank.

5. Clean water is sampled: if less than 5 ppm, it is discharged to an evaporation pond; if greater than 5 ppm, it is recirculated to the process tank for additional treatment.

6. Periodically, silver is removed from the collection tank for sale to an off-site recovery facility.

Approximately 2.5 times the stoichiometric quantity of sodium borohydride is used to remove silver from the photographic solution. This system is effective in reducing silver concentrations from approximately 5,000 ppm to less than 5 ppm, resulting in a removal efficiency of about 99.9 percent and consistent reductions in effluent silver content to below the EP toxicity level (5 ppm). Additionally, it reduces cadmium concentrations to below the EP toxicity level (1.0 ppm).

Thiokol generates and treats 130,000 lb (15,600 gal) of waste photographic solutions annually. Operating costs for the treatment system are approximately $21,400/yr, based upon $20,000/yr in O&M and $1,400 in chemical costs. Costs for on-site disposal of the treated effluent are negligible. Recovered silver is worth about $71,400 (based upon an average silver concentration of 5000 ppm, recovery efficiency of 99.9 percent, and a current silver price of $6.10/troy ounce), resulting in net operating revenues for the recovery system of $50,000/yr.

Thiokol has also experimented with the use of an electrolytic silver recovery system at the recommendation of the General Services Administration (GSA). This system was used to recover silver upstream of the sodium borohydride recovery unit. The electrolytic recovery unit, manufactured by X-Rite Systems, consists of a rotating cylindrical cathode which "plates-out" silver cations from waste photographic solutions. As used at Thiokol, the solution was then discharged to the sodium borohydride unit for final silver recovery.

The use of this unit adversely affected the quality of effluent produced by the overall treatment system, resulting in production of an effluent which was EP toxic and, therefore, had to be disposed as a hazardous waste. Thiokol discontinued use of the electrolytic process and returned to using the sodium borohydride recovery system alone.

The currently used waste photographic solution recovery system effectively recovers valuable materials in this waste stream and produces a nonhazardous effluent. No further recommendations are made for minimizing this waste.

3.8 GENERAL PLANT WASTEWATERS

Wastewaters are generated at AFP 78 through the cleaning of equipment, floors, mixing bowls, and grinding machines in propellant mixing, grinding, casting and drying buildings and in other buildings. Wastewaters are collected in floor sumps in the buildings in which they are generated, vacuumed into tankers, and transported to and disposed in evaporation ponds on Thiokol property. After the collected wastewaters evaporate, the solid residues remaining in the ponds are flashed (ignited) to dispose of explosive materials contained in the residue.

A total of 5.45 million lb (653,000 gal) of wastewaters are produced annually at AFP 78. Of this amount, 3.1 million lb (370,000 gal) is from cleaning of HMX preparation equipment and production buildings. This wastewater is estimated to contain approximately 5000 ppm of entrained insoluble HMX powder. An additional 1.3 million lb (161,500 gal) is from cleaning of ammonium perchlorate (AP) preparation equipment and production building, and is estimated to contain roughly 2000 ppm soluble AP in solution. Thus, 80 percent of all wastewaters produced, or 531,500 gal/year are contaminated with propellants. The remaining 1.0 million lb (121,450 gal) of wastewaters produced at AFP 78 are contaminated with inert materials and are generated in buildings not used for propellant preparation, casting, and drying.

Due to the extremely reactive nature of the propellant materials entrained in these wastewaters, no methods for reducing their volume or recovering entrained propellants have been identified. As described in Section 3.6, future regulatory changes may require additional controls on open detonation resulting in higher on-site costs. However, the current disposal method for this waste satisfactorily destroys its hazardous characteristic under controlled conditions.

3.9 PAINT BOOTH WASTEWATER

3.9.1 Waste Description and Management Practices

Approximately 50,000 lb (6,000 gal) of wastewater is generated from two water wall painting booths located in Bldg M-508. The wastewater, which typically contains trace metal and paint pigment contamination, is collected in the building sump and periodically removed in bulk for disposal in hazardous waste evaporation ponds located on Thiokol property. The solid pond residues, which include explosive materials from evaporated wastewaters, are periodically removed and burned on-site with other explosive wastes as described in Section 3.6.

The existing ponds do not meet the EPA's revised criteria for hazardous waste storage facilities and must be removed from service by November 1988. Thiokol anticipates replacing the existing ponds with permittable surface impoundments to accomplish the desired on-site wastewater treatment. Current treatment costs are not available but are presumed to be negligible.

3.9.2 Waste Minimization Opportunities

Thiokol has recently received approval to replace one waterwall paint booth with a dry filter booth and is seeking approval for similarly modifying the second M-508 waterwall booth. Thiokol is pursuing these changes to eliminate operational problems such as splashing which have resulted in damage to surface coatings being applied in the booths. The impact of these changes would be to eliminate the generation of all paint booth wastewaters.

Dry filters contaminated with paint overspray will be generated from the renovated spray booths. As Thiokol has determined that the filters are nonhazardous, they will be disposed on Thiokol property together with other nonhazardous wastes.

3.9.3 Recommendations

Although operating and capital cost data concerning paint booth renovation are not available, it appears that the changeover to dry booths will have positive economic impacts. Provided the used paint filters are nonhazardous, it is recommended that Thiokol continue with the planned paint booth rennovations. It is recommended, therefore, that Thiokol continue with present plans for changeover of both M-508 water curtain booths to dry filter systems.

3.10 COMBUSTIBLE ORGANIC WASTE

A number of liquid organic wastes generated at AFP 78 could potentially be used as supplemental boiler fuels, thereby reducing dependance on off-site treatment/disposal facilities while reducing fuel purchase rates. This section explores the feasibility of such measures.

3.10.1 Waste Description and Management Practices

Table 3-7 lists the wastes potentially amenable to use as supplemental boiler fuels. The solvents on this list (waste numbers 1 through 5) are currently collected and transported in drums for off-site disposal. It is estimated that disposal fees are approximately $3.20/gal or $2,200/yr. In addition, 140 gal/yr of tramp oils would be generated by the coolant recovery system described in Section 3.1. The oils, which would be excellent supplemental fuels, are now disposed on-site as an integral constituent of waste coolants at negligible costs.

3.10.2 Waste Minimization Opportunities

As shown in Table 3-7, approximately 74 mmBtu/year of energy are available from AFP 78 combustible liquid organic wastes. These wastes could serve as supplemental fuels in the two Wickes A-frame boilers which provide AFP 78's steam needs. Number 5 and 6 fuel oil are currently used in these boilers at rates ranging from approximately 90,000 gal/month to 240,000 gal/month and averaging approximately 158,000 gal/month. This corresponds to approximately 265,000 mmBtu/year of energy consumption.

Two viable approaches are available for introducing waste fuels into the boilers:

1. Bending with the fuel oil during storage.

2. Direct injection using a separate burner dedicated to waste fuels.

Given the low quantities of waste fuels available and their apparent compatibility with fuel oil, direct blending appears to be the most attractive option. Annual savings of $2500 are projected based on the following assumptions:

1. Avoided disposal costs will be $2200/yr (based on $3.20/gal off-site disposal fees).

TABLE 3-7
AFP 78 WASTES AMENABLE TO USE AS
SUPPLEMENTAL BOILER FUELS

WASTE	QUANTITY[1] (LBS/YEAR)	HEAT CONTENT (BTU/LB)	AVAILABLE HEAT (MMBTU/YEAR)
1. Acetone	1,220	13,080	16.0
2. Isopropyl Alcohol	230	14,300	3.3
3. Xylene	240	18,200	4.3
4. Toluene	80	18,030	1.4
5. Methyl Ethyl Ketone[2]	1,920	14,550	27.9
6. Tramp Oils[3]	1,170	18,000	21.0
TOTALS	4,900	- - -	73.9

1 Quantities based on Thiokol estimates of annual waste generation rates.
2 MEK rates are unrecoverable portion of waste stream Item 5.
3 Estimated quantity of recovered tramp oil based on use of coolant recovery system.

2. Avoided fuel oil purchases will total 530 gal/yr (based on a heat content of 140,000 Btu/gal for no. 5 fuel oil).

3. Avoided fuel oil purchases will total $330/yr (based on typical purchase costs of $0.62/gal).

4. Operating costs will total approximately $60/yr (based on handling 10 drums/year at $6.00 each).

Implementation costs are projected to be approximately $1000 for provision of a drum handling/pumping station adjacent to the existing fuel oil storage tanks. On this basis, payback would occur in less than half a year.

3.11.3 Recommendations

It is recommended that Thiokol evaluate the on-site reuse of combustible, nonhalogenated, liquid organic wastes as supplemental boiler fuels. The U.S. Environmental Protection Agency has recently adopted regulations for waste fuel reuse (40 CFR 266) which will apparently, for facilities such as AFP 78, minimize regulatory complications previously associated with on-site waste fuel use. However, requirements for storage and handling are still included. Therefore, Thiokol should review regulations for potential impacts of on-site burning.

If requirements do not prove to be prohibitive, it is recommended that Thiokol conduct simple jar tests to verify the compatibility of the wastes to be burned and fuel oil. Drum pumps with cleanable screen filters should be used to transfer wastes directly to the existing fuel oil storage tanks. Appropriate safety measures should be incorporated in the transfer equipment, including grounding containers, pumps and tanks and transferring waste to the tanks in a manner that will avoid static charges during pumping. Empty drums may be reused for collection of wastes compatible with the materials previously held in the drums or sold for reuse or scrap value.

APPENDIX A

APPENDIX A
UNIT WASTE MANAGEMENT COSTS

1. Oil and Solvent Process Co.
   Henderson, Colorado

Methyl Chloroform	$0.85/gal recovered

2. No disposal contractor now used. Contract under negotiation.

APPENDIX B

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTI
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Machine Coolants

CHARACTERISTICS: Trimsol & Cimcool diluted 1:20 with H_2O (deionized)

(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: Machine shops

Pumped out every 2-3 months w/air pump to drums – taken to MTI evaporation ponds

GENERATION
1. RATE:
2. FREQUENCY: 5250 gal/year
3. COST:

PROPOSED CHANGES:

RAW MATERIAL DATA
1. CHARACTERISTICS: Pure coolant
2. QUANTITY: 300-400 gal/year
3. COST:

NOTES:

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTI
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Hydraulic Oils

CHARACTERISTICS: 5% contain tricresyl phosphate (TCP)
95% regular hyd oils

(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: Machine shops - drain machines every 6 or 12 months on AF schedule.
TCP oils go to off-site disposal
Other oils combined with MTI waste oils taken by oil suppliers at no cost - use 3 suppliers

GENERATION
1. RATE: 3000 gal/year (est)
2. FREQUENCY:
3. COST: None

PROPOSED CHANGES:

RAW MATERIAL DATA
1. CHARACTERISTICS:
2. QUANTITY:
3. COST:

NOTES:

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTI
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Methyl Chloroform (1,1,1-Trichloroethane)

CHARACTERISTICS: 85 % Trichloroethane or greater

(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: 3 vapor degreasers - 1000 gal Circo in Bldg M-50P, 115 gal Detrex in Bldg. M-50S, and 115 gal. Detrex in Bldg. M-605. Degreaser sumps are drained to drums when additives out of balance or solvent is oil or water contaminated. Stored on-site at E-501, then sent off-site for recycling at OSCO. Some also used in hand cleaning parts and assemblies - collected in drums where used, stored, and shipped to OSCO.

GENERATION
1. RATE: 7520 gal/yr
2. FREQUENCY:
3. COST: $0.85 revenue/gal recovered

PROPOSED CHANGES:

RAW MATERIAL DATA
1. CHARACTERISTICS:
2. QUANTITY: 67,000 gal/yr
3. COST: $3.77/gal

NOTES: Use Chlorothane VG and VWR TCA

TITLE: Costs for Methyl Chloroform Recovery	PROJECT NO.: AFP-78 PROJECT NAME:	PAGE 1 OF 1

1. Capital Cost

1 Recycling unit @ $11,900	$11,900
Piping modifications	500
Electrical modifications	500
	12,900
Engineering @ 10%	1,290
Contingencies @ 10%	1,290
Total	$15,480

2. Operating Cost

3800 gal @ $0.60/gal — $2280
($0.20/gal for utilities, $0.40/gal for labor)

3. Revenue Lost for Off-Site Recycling

3800 gal @ 80% recovery @ $0.85/gal — $2600

4. Revenue Saved on Material Purchase

3800 gal @ 80% recovery @ $3.77/gal — $11,460

5. Residue Disposal Cost

760 gal @ $1.00/gal — $760

6. Total Annual Savings

(4 − (2+3+5)) — $5820

7. Payback Period

(1 ÷ 6) — 2.7 yr

BY: E. Hillenbrand DATE:	CHECKED BY: DATE:	The Earth Technology Corporation

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTI
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Freon TA

CHARACTERISTICS: Azeotrope of trifluoromonochloromethane and acetone

(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: Used in degreasing and cleaning parts and assemblies by hand. Collected in drums where used, stored, and shipped off-site for disposal or recovery. No contract in place for disposal of this waste, so disposal method and cost are not available.

GENERATION
1. RATE: 390 gal/yr (estimated)
2. FREQUENCY:
3. COST: NA

PROPOSED CHANGES:

RAW MATERIAL DATA
1. CHARACTERISTICS:
2. QUANTITY: 3880 gal/yr
3. COST:

NOTES:

TITLE: Costs for Freon Recovery	PROJECT NO.: AFP 78 PROJECT NAME:	PAGE 1 OF 1

1. Capital Cost

1 Recycling unit @ $6100	$6100
Piping modifications	500
Electrical modifications	500
	$7100
Engineering @ 10%	710
Contingencies @ 10%	710
	$8500

2. Operating cost

390 gal @ $0.90/gal — $350

($0.20 for utilities, $0.70 for labor)

3. Revenue Saved on Material Purchase

390 gal @ 88% recovery @ $10.00/gal — 3432

4. Revenue Saved on Disposal

390 gal @ $1.00/gal (estimated) — 390

5. Cost of Residue Disposal

47 gal @ $1.00/gal (estimated) — 47

6. Total Annual Savings

(3+4 − (2+5)) — $3425

7. Payback

(1 ÷ 6) — 2.5 yr

BY: E. Hillenbrand DATE:	CHECKED BY: DATE:	The Earth Technology Corporation

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTI
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Methyl Ethyl Ketone (MEK)

CHARACTERISTICS: ______

(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: Used for painting, painting eqpt. cleaning, and part and assembly cleaning. Collected in drums where used, stored, and sent off-site for disposal or recovery. No contract for disposal is in effect right now, so disposal methods and costs are not available.

GENERATION
1. RATE: 810 gal/yr
2. FREQUENCY: ______
3. COST: NA

PROPOSED CHANGES: ______

RAW MATERIAL DATA
1. CHARACTERISTICS: ______
2. QUANTITY: ______
3. COST: ______

NOTES: ______

TITLE: Costs for MEK Recovery	PROJECT NO.: AFP - 78 PROJECT NAME:	PAGE 1 OF 1

1. Capital Cost

1- Recycling unit @ $ 6100	$ 6100
Piping modifications	500
Electrical modifications	500
	$ 7100
Engineering @ 10%	710
Contingencies @ 10%	710
	$ 8500

2. Operating Cost

310 gal @ $0.90/gal ($0.20 for utilities $0.70 for labor)	$ 280

3. Revenue Saved on Material Purchase

310 gal @ 80% recovery @ $2.70/gal	670

4 Revenue Saved on Disposal Cost

310 gal @ $ 1.00/gal (estimated)	310

5. Cost of Residue Disposal

62 gal @ $ 1.00/gal (estimated)	62

6. Total Annual Savings

(3 + 4 - (2+5))	$640

7. Payback Period

(1 ÷ 6)	13.3 yr

BY: E. Hillenbrand DATE:	CHECKED BY: DATE:	The Earth Technology Corporation

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTI
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Waste Explosive Material

CHARACTERISTICS: See list

(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: See list

Collected in bulk - detonated once/week in open pit

GENERATION
1. RATE: 1.19 x 10^6 lbs/year
2. FREQUENCY: daily
3. COST:

PROPOSED CHANGES:

RAW MATERIAL DATA
1. CHARACTERISTICS:
2. QUANTITY:
3. COST:

NOTES:

TITLE: Waste Explosives	PROJECT NO.: AFP 78 PROJECT NAME:	PAGE 1 OF 1

Based on 92-days of records May 17, 1985 – Aug. 11, 1985

WASTE	QUANTITY (LBS/YR)
1. Composite (Peacekeeper)	272,833
2. AP (Solid – on site disp)	992
3. AP (Solid – recycled)	556,000
4. AP (washwater	6,645
5. Binder Premix	139
6. Embedment Powder	1,726
7. Diesel Fuel (HMX-cont)	3,975
8. HMX	5,039
9. Solvents	3,600
10. XLDB	309,247
11. C-4 Ignitors	774
12. HMX Fiberpacks	30,747
13. OPC (1-16 test motors)	159
	1,184,600

BY: DATE:	CHECKED BY: DATE:	The Earth Technology Corporation

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTL
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Waste Photographic Solutions and Rinses

CHARACTERISTICS: Water with 5000 ppm silver and 50 ppm cadmium

(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: Generated through processing of x-rays used to inspect parts in Bldg. M-508 and M-636. Collected rinsewaters and solutions are batch processed in silver recovery system which uses sodium borohydride to precipitate silver metal. Supernatant water is discharged to evaporation pond. Metal is sold to smelter for reuse.

GENERATION
1. RATE: 23,400 gal/yr
2. FREQUENCY:
3. COST: $ 50,000 revenue/yr from Ag recovery

PROPOSED CHANGES:

RAW MATERIAL DATA
1. CHARACTERISTICS:
2. QUANTITY:
3. COST:

NOTES:

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTI
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Waste Waters

CHARACTERISTICS: Wastewater (99%) with entrained HMX, dissolved ammonium perchlorate, or inert materials.
(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: Generated through floor and equipment washing. 370,000 gal/yr generated through washing HMX mixing, grinding, casting, and drying equipment and bldgs. 161,500 gal/yr generated through AP mixing, grinding, casting, drying equipment and bldg. washdown. 121,450 gal/yr generated in inert areas. Collected, transported in bulk to evaporation ponds, evaporated, and residues are flash burned for disposal.

GENERATION
1. RATE: 652,950 gal/yr (5.45×10^6 lbs)
2. FREQUENCY:
3. COST: Negligible

PROPOSED CHANGES:

RAW MATERIAL DATA
1. CHARACTERISTICS:
2. QUANTITY:
3. COST:

NOTES:

The Earth Technology Corporation

PLANT # 78
OPERATOR: MTI
DATE: 9-16-85

WASTE MINIMIZATION PROGRAM
DATA SHEET

WASTE STREAM: Paint Booth water

CHARACTERISTICS: 99% + water - some pigments, oils, metals

(ATTACH ANALYSIS IF AVAILABLE)

SOURCE/MANAGEMENT: Bldg 508 water curtain paint booth sumps (2)

Bulk transport to hazardous waste evap ponds east of burning grounds

GENERATION
1. RATE: 500 gal/mo = 6000 gal/year
2. FREQUENCY:
3. COST:

PROPOSED CHANGES: Both booths to be replaced w/ dry booth (only one approved so far)

Dry filters to be disposed on MTI property in non-HW landfill

RAW MATERIAL DATA
1. CHARACTERISTICS:
2. QUANTITY:
3. COST:

NOTES:

END
DATE
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