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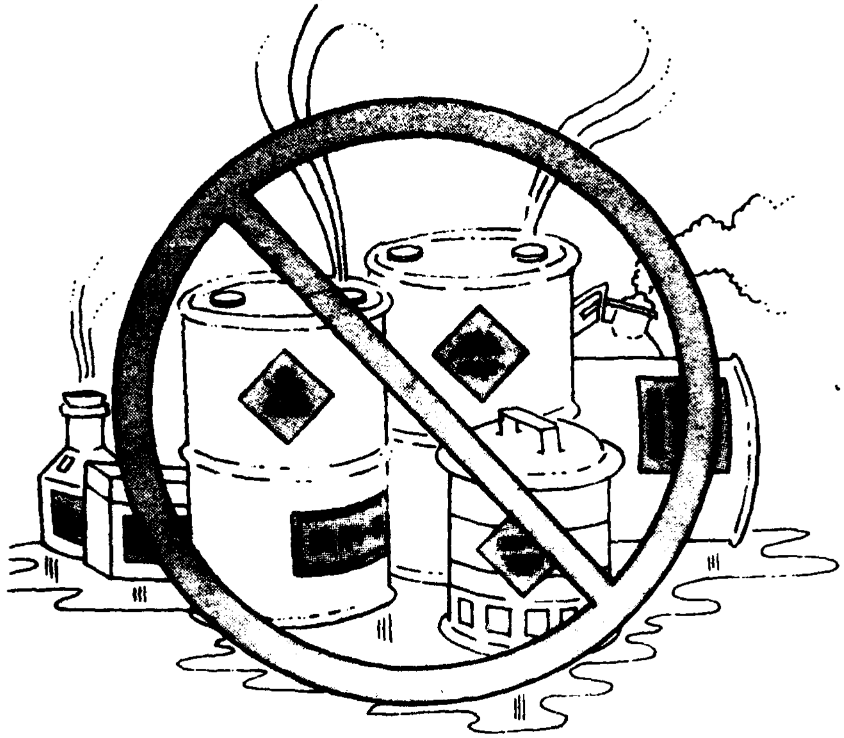
TECHNICAL NOTE

TN-1787

VOLUME II – APPENDIXES



HAZARDOUS WASTE MINIMIZATION INITIATION DECISION REPORT

by

R.M. Roberts, J.L. Koff, and L.A. Karr

June 1988

Sponsor: Naval Facilities Engineering Command
Program No.: 71-021A

NAVAL CIVIL ENGINEERING LABORATORY, PORT HUENEME, CA

88 9 6 128

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

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

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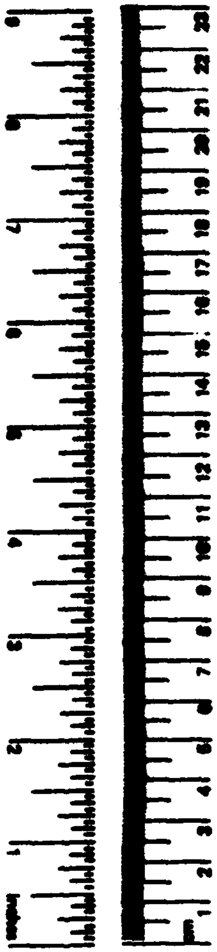
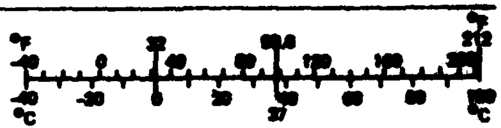
*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

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



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

The IDR study defines the magnitude of process and hazardous wastes and the costs associated with their management. A review of other military applications, civilian practices, as well as new and emerging technologies and practices, are presented for each HW-generating process. Using this information, comparisons are made to identify which areas can be upgraded to more current technologies and techniques. Administrative practices that cause HW to be formed are also considered and suggestions offered as to how such management procedures might be beneficially modified.

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PREFACE

This report was reviewed and amended in two separate phases. An initial version was transmitted by CNO letter in December 1986. That volume presented the engineering information required for the first three sections of the IDR format as specified in NAVFACINST 3900.7; that is, the Introduction, Problem Definition, and State of Navy Hazardous Waste Management Technology and Alternatives. It was felt that information in these areas should be corroborated by the overall industrial sector of the Navy before the second portion of the IDR was finalized - that is, the Projections for Evolving Technologies, Recommendations, Technology Goals, and Capability Goals. Reviewers included all of the Syscoms, NAVFAC EFDs, and the twenty four activities responsible for most of the hazardous waste generated in the Navy.

After these reviewers furnished their comments on the initial volume and these were incorporated, a draft of the complete report was returned to the same reviewers. Again comments were submitted and incorporated. The document was then finalized after a last review within NCEL itself. This IDR is thus the product of Navy-wide inputs from activities already in dramatic change with regard to hazardous waste minimization and management.

ACKNOWLEDGMENTS

This Initiation Decision Report was developed under the auspices of the Naval Facilities Engineering Command on work unit No. 71-021A. The cognizant organization of that command was the Environmental Quality Division (code 112) with Mr. T. J. Zagrobelny ably serving as task manager.

The report was prepared by the Naval Civil Engineering Laboratory with initial assistance from Systems Technology Corporation. Technical editorial management of this rather complex document was the well-acquitted responsibility of Dr. E. C. Riser of Syscon Corp.

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EXECUTIVE SUMMARY

OVERVIEW

The Navy generates over 4 million tons of process and hazardous wastes (HW) a year. A conservative estimate (most Navy labor excluded) of the cost of handling this waste is set at $18 million. It is projected that that figure will increase by a factor of three over the next seven years due to the tightening of regulatory constraints. In order to fulfill CNO objectives, the Navy must implement a hazardous waste minimization program to reduce by at least half the amount of hazardous wastes it produces.

The Resource Conservation and Recovery Act (RCRA) places strict controls on the storage, treatment, and disposal of HWs. In response to this, and subsequent amendments that establish a regulatory schedule that the Navy must meet over the next ten years, the present study was initiated at NCEL to assess Navy HW management practices. The study resulted in an initiation decision report (IDR) that defines:

- The optimum process technologies that are immediately implementable to minimize HW generation,
- The optimum treatment and disposal technologies that are immediately implementable, and
- The RDT&E required to modify processes to render them less HW productive and to improve HW treatment, and disposal technologies.

The IDR study defines the magnitude of process and hazardous wastes and the costs associated with their management. A review of other military applications, civilian practices, as well as new and emerging technologies and practices, are presented for each HW-generating process. Using this information, comparisons are made to identify which areas can be upgraded to more current technologies and techniques. Administrative practices that cause HW to be formed are also considered and suggestions offered as to how such management procedures might be beneficially modified.

Ordnance processes are considered by reference only and are restricted to "end-of-pipe" HW minimization issues. Installation Restoration topics are being addressed at NCEL in a separate IDR now under preparation and are therefore not included here. This is also true of asbestos and PCBs, which are considered special action items. Cost burdens in HW management are not limited to the Navy only but include the entire Department of Defense, particularly those of the Defense Logistics Agency (DLA).

The top industrial processes accounting for 95% of all HW generated in the Navy in 1984 were:

- Industrial Waste Treatment Plant
- Electroplating/metal finishing
- Ordnance
- Bilge water
- Abrasive blasting
- Nonrecurring
- Painting operations
- Demilitarization
- Pipe flushing/cleaning
- Boiler layup
- Ship boiler cleaning
- Fluids changeout
- Submarine steam generator cleaning
- Cleaning with solvents
- Battery repair/replacement
- Metal prep
- Bilge derusting
- Chemical paint stripping
- Torpedo cleaning

TECHNOLOGY ASSESSMENT

A technological assessment of the various alternatives for each process was performed with the assistance of a computer model, which prioritized the options considered. The Hazardous Waste Management Technology Assessment Model (HAMTAM) considers technology options in terms of RCRA-conformance, cost/benefits, availability, logistical adaptability, and risk in realizing sought-for performance improvements. The figures-of-merit generated thus enabled the objective selection of the most desirable process modifications.

APPLICATION OF IMPROVED KNOW-HOW (READILY IMPLEMENTABLE)

This technology is not in general use in the Navy, but is found to some degree there or in industrial practice. Some of the following examples have already been, or are on the verge of being implemented at selected Naval facilities.

- Plastic Media Blasting
- Used Solvent Elimination Program
- Hard Chrome Plating
- Waste Acid/Alkali as IWTP Reagents
- Dry Paint Booth Conversion
- Used Oil Reclamation and Recycle
- Delisting
- Mechanical IWTP Sludge Dewatering

- Otto II Fuel Recycling
- Reduced Overspray Paint Technology
- Dual Media Spray Technology
- Steam Purity Testing
- Conventional IWTP Process Optimization
- Minimal HW-Producing Electroplating Technology

APPLICATION OF TECHNOLOGY NOT COMMERCIALLY AVAILABLE

This technology is in the R&D sector and may be implemented within the Navy only after a 6.3/6.4 program. This technology is not available through industrial/commercial products and practices.

- Recycling of Hydroblast Wastewater
- Aircraft Paint Stripping Wastewater Treatment
- Nonpersistent Emulsifiers
- Plastic Media Blasting
- Reducing Blasting Grit Hazards and Type
- Recycle of Steam Generator Wastes
- Recycle of Bilge Tank Cleaning Wastes
- Cyanide Oxidation
- Ion Exchange/Metal Recovery
- Waste Acid/Alkali as IWTP Floccing Reagents
- Reuse Technology for Pickling/Electroplating Bath
- Thermal Combustion Technology
- Distillation of Spent Torpedo Solvents
- Torpedo Afterbody Washwater Treatment
- Encapsulation/Fixation
- Peroxidation of Pink Water

ADVANCES IN TECHNOLOGY (EXPLORATORY DEVELOPMENT)

These technologies require exploratory development to advance the state of technology with respect to specific technical parameters and their application to Naval HW minimization problems.

- Supercritical Fluid Technology
- Innovative Encapsulation/Fixation
- New Solvent Selection (to replace chlorofluorocarbons)
- Carbon Dioxide Pellets to Strip Paint
- New High-Energy Battery Types
- HW Thermal Destruction

Based on the results of the technology assessments made, specific recommendations were developed. These included twelve discrete recommendations for modifying Navy administrative practice so as to reduce HWM. Twenty two RDT&E projects were proposed for DERA funding and a number of additional projects were recommended for 6.2 and 6.3 funding. This body of information was then formally organized into technology goals that the Navy should pursue and acquire in order to attain a 50% reduction in the HW it now produces.

GLOSSARY

WORD, ACRONYM, OR ABBREVIATION	MEANING
AAP	Army ammunition plant
ABG	Ammunition burning ground
A/C	Aircraft
AFB	Air Force base
AFFF	Aqueous firefighting foam
AIMD	Air Intermediate Maintenance Department
Al	Aluminum
APC	Air pollution control
APCD	Air pollution control district
API	American Petroleum Institute
As	Arsenic
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ASW	Antisubmarine warfare
ATCC	American Type Culture Collection
atm	Atmosphere
BOD	Biological oxygen demand
$CaCl_2$	Calcium chloride
CALTRANS	California Department of Transportation
CBC	Construction Battalion Center
CBS	Carolina Biological Supply [Co.]
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESD	Chemical Engineering Science Division [NBS]
CFC	Chlorofluorocarbon
CFR	Code of Federal regulations
Cl_2	Chlorine
CN	Cyanide [ion or complex]
CNO	Chief of Naval Operations
CO_2	Carbon dioxide
COD	Chemical oxygen demand
Cr	Chromium
CR	Contractor report
CSTR	Continuously stirred reactor
Cu	Copper
CWA	Clean Water Act
CY	Calendar year
DAF	Dissolved air flotation
DEMIL	Demilitarization
DLA	Defense Logistics Agency
DNT	Dinitrotoluene
DOD	Department of Defense
DOE	Department of Energy

DRE	Destruction and removal efficiency
DRMO	Defense Reutilization and Marketing Office
DSRV	Deep submergence rescue vessel
DTR	Developmental technical report
DTRC	David Taylor Research Center (formerly Naval Ship R&D Center)
EDR	Earliest date ready
EDTA	Ethylenediaminetetraacetic acid
EGDN	Ethyleneglycol dinitrate
EP	Extraction procedure [toxicity test]
EPA	Environmental Protection Agency
EUAC	Equivalent uniform annual cost
FB	Fluidized bed
Fe	Iron
$FeCl_2$	Ferrous chloride
FFR	Final feasibility report
F/M	Food-to-microorganism [ratio]
FOR	Fuel oil relaimed
FY	Fiscal year
GAC	Granular activated charcoal
GOCO	Government-owned, contractor-operated
gpd	Gallons per day
HAMTAM	Hazardous Waste Minimization Technology Assessment Model
HAZMAT	Hazardous material
HCl	Hydrochloric acid
HCN	Hydrogen cyanide
H.E.	High energy [fuels]
HF	Hydrofluoric acid
HM/W	Hazardous materials/wastes
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
H_2O_2	Hydrogen peroxide
H_2SO_4	Sulfuric acid
HSWA	Hazardous and Solid Waste Amendments [1984]
HTH	High test hypochlorite [calcium hypochlorite]
HW	Hazardous waste
HWERL	Hazardous Waste Engineering Research Laboratory [EPA Cincinnati]
HWF	Hazardous waste fuel
HWM	Hazardous waste minimization
IDR	Initiation decision report
IFR	Initial feasibility report
IGT	Institute of Gas Technology
I/O	Input/output
IR	Infrared
IRAD	Independent research and development
IWTP	Industrial wastewater treatment plant
IX	Ion exchange
JP	Jet propulsion [fuels]

KGPD	Kilograms per day
$KMnO_4$	Potassium permanganate
K_2O	Potassium oxide
KO_2	Potassium superoxide
KOH	Potassium hydroxide
KWH	Kilowatt-hour
LAP	Load, assemble, and pack
LAS	Linear alkyl sulfonate
LD_{50}	Lethal dose for 50% of recipient animals
L.E.S.S	Leading Edge Space Shuttle
LET	Load equalization tank
Li	Lithium
LiBr	Lithium bromide
LSU	Louisiana State University
MARCORP	Marine Corps
MCAS	Marine Corps air station
MCB	Marine Corps base
MEK	Methylethyl ketone
MFD	Marine fuel diesel
mg/l	Milligrams per liter
Mgpy	Million gallons per year
MILCON	Military construction
MLSS	Mixed liquor suspended solids
N.A.	Not applicable
NAC	Naval Avionics Center
NaCN	Sodium cyanide
NADC	Naval Air Development Center
NADEP	Naval aviation depot
NAEC	Naval Aviation Evaluation Center
$NaNO_2$	Sodium nitrite
$NaNO_3$	Sodium nitrate
NaOH	Sodium hydroxide
NAPC	Naval Air Propulsion Center
NARF	Discontinued designation; see NADEP
NAS	Naval air station
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air [Systems Command]
NAVBASE	Naval Base
NAVFAC	Naval Facility [Engineering Command]
NAVFACHQ	NAVFAC Headquarters
NAVMED	Naval Medical Systems Command
NAVSEA	Naval Sea [Systems Command]
NAVSSES	Naval Ships System Engineering Station
NAVSUP	Naval Supply [Systems Command]
NBS	National Bureau of Standards
NCEL	Naval Civil Engineering Laboratory
NEESA	Naval Energy and Environmental Support Activity
NH_4ClO_4	Ammonium perchlorate
NH_4NO_3	Ammonium nitrate
NH_4OH	Ammonium hydroxide
$NiCl_2$	Nickel chloride

ng	Nitroglycerine [glycerol trinitrate]
NIROP	Naval Industrial Reserve Ordnance Plant
NOS	Naval ordnance station
N.O.S.	Not otherwise specified
NOSC	Naval Ocean Systems Center
NOx	Oxides of nitrogen (NO_2 and/or NO)
NPDES	National Polluted Discharge Elimination System
NR	Not reported
NS	Naval station
NSC	Naval supply center
NSL	Naval supply list
NSN	Naval stock number
NSWC	Naval Surface Warfare Center
NSY	Naval shipyard
NUWES	Naval Undersea Warfare Engineering Station
NWIRP	Naval Weapon Industrial Reserve Plant
NWS	Naval weapons station
NWSC	Naval Weapons Support Center
O&M	Operation and maintenance
OBA	Oxygen breathing apparatus
OB/OD	Open burning/open detonation [of explosives and munitions]
OESO	Ordnance Environmental Support Office
ONR	Office of Naval Research
OSH	Occupational safety and health
OT&E	Operational test and evaluation
OTR	Operational technical report
OWTP	Oil/water treatment plant
Pb	Lead
PCB	Polychlorinated biphenyl(s)
PCP	Pentachlorophenol
PGDN	Propylene glycol dinitrate
PHST	Packaging, handling, storage, transportation
PIC	Products of incomplete combustion
PM	Preventive maintenance
PMB	Plastic media blasting
PMI	Preventive maintenace inspections
PMS	Preventive Maintenance System
PMTC	Pacific Missile Test Center
POC	Point of contact
POHC	Principal organic hazardous constituents
POPS	Paperless Order Procurement System
POTW	Publicly owned treatment works
POTWP	Publicly owned treatment works plant
ppm	Parts per million
PVC	Polyvinyl chloride
PWC	Public works center
PWD	Public works department
PWO	Public works office
QA	Quality assurance

QC	Quality control
R&D	Research and development
RAM	Reliability, availability, maintainability
RAS	Return activated sludge
RBC	Rotating biological contactor
RCP	Request for Contractual Procurement
RCRA	Resource Conservation and Recovery Act
RDT&E	Research, development, test, and evaluation
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
RO	Reverse osmosis
SCF	Supercritical fluid
SCW	Supercritical water
SECNAV	Secretary of the Navy
SIR	Savings-to-investment ratio
STABCHAPS	Ship and Tank Chemical Cleaning Hardware and Process System
STP	Sewage treatment plant
SWOB	Ships waste off-loading barge
SYSCOM	Systems Command
T0	Technology in routine use in the Navy
T1	Technology in routine use in industry
T2	Technology proven at least at bench scale
T3	Technology and concepts requiring proving
TADS	Technical assessment data sheet
T&E	Test and evaluation
TCE	Trichloroethylene
TCLP	Toxicity characteristic leaching procedure
TEA	Triethanol amine
TIC	Total installed cost
TM	Technical memorandum
TN	Technical note
TNT	Trinitrotoluene
TOC	Total organic carbon
tpy	Tons per year
TSD	Treatment/storage/disposal [facility]
TSP	Trisodium phosphate
TTO	Total toxic organics
tpy	Tons per year
UBSC	Unspecified boiler system component [in nuclear-powered ships and submarines]
UDP	Users' data package
UG	Users' guide
UO&S	Used oils and solvents
USE	Used Solvent Elimination [Program]
UV	Ultraviolet
VOC	Volatile organic compounds
WQEC	Weapons Quality Engineering Center (NWSC Crane)
WR	Work request
WW	Wastewater

APPENDIX A

TECHNICAL ASSESSMENT DATA SHEET SUMMARIES

APPENDIX A

SUMMARY DATA FOR EACH NAVY ACTIVITY

- Camp LeJeune MCB
- COMNAVBASE Norfolk
- MCAS Cherry Point
- NADEP Cherry Point
- NADEP Norfolk
- NAS Alameda
- NAS Jacksonville NARF
- NIROP Pomona
- NSC Pt. Molate
- NSY Charleston
- NSY Long Beach
- NSY Mare Island
- NSY Norfolk
- NSY Pearl Harbor
- NSY Philadelphia
- NSY Puget Sound
- NUWES Keyport
- NWIRP Dallas
- NWS Earl
- NWS Seal Beach
- NWSC Crane
- PWC Pensacola
- PWC San Diego

Table A1. NCEL Technology Assessment Data Sheet Summary for Camp LeJeune MCB

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Battery Repair/Replacement	Battery acid and cases	24	T	9700	PWC IWTP trtmnt and dsp
Fluids Changeout	Misc fluids	800	D	0	No re-sale due to contaminants
Solvent Cleaning	Solvents - PD680	92	D	27600	Balance mixed w/ waste oil
Vehicle Wash/Repair	Oil water	280	D	0	Oil-water separator; oil to tanks
	TOTAL	1,196		$37,300	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A2. NCEL Technology Assessment Data Sheet Summary for COMNAVBASE Norfolk

			Disposal			
Process	Waste ID	Tons	ID	Cost	Comment	
Boiler Cleaning	Acids	58.03	D	16220	71% citric, 28% sulfamic	
Boiler Cleaning	MEA	15.193	D	15515	Dsp to barges, trted @ SD IWTP	
Boiler Testing	Mercuric nitrate	31.9	D	10210	Testing for chloride	
Breathing Apparatus	Potassium superoxide	90.71	D	116110	Spent oxygen breathing apparatus	
Container/Drum Disposal	Empty paint containers	24.69	D	5000		0
Fluorescent Tube Replacement	Mercury debris	11.7	D	0	8 drums (55 gal)	
Metal Prep	NaOH	16.875	D	3715	Shipboard & shore cleaning operations	
Painting Operations	Paint, waste	191.82	D	73275		0
Painting Operations	Solvents, nonchlorinated, pa	17.5	D	5425		0
Ships Offloaded Stores	laundry detergent, misc	40.56	D	15000	17.6 T detergent, other expired matls	
Solvent Cleaning	Solvents, chlorinated	66	D	9700		0
Solvent Cleaning	Solvents, nonchlorinated	64.5	D	14190		0
	TOTAL	629		$284,360		

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A3. NCEL Technology Assessment Data Sheet Summary for MCAS Cherry Point

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Battery Repair/Replacement	Acid	5	T,D	140	1000 gal neutralized, balance "neat"
Battery Repair/Replacement	Batteries; Li	9	D	45000	Rejected defective lot
Container/Drum Disposal	Drums - empty	19.5	D	2600	0
Nonrecurring	Fuel - out of spec	184	D	138000	DRMO attempting to dispose;cost assumes haz
Nonrecurring	Fuel, oil, absorbent	28.5	D	0	Haz waste spill
Vehicle Wash/Repair	Oily wastes	60	D	56250	Cost assumes hax waste dsp; water fract est
	TOTAL	306		$241,990	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A4. NCEL Technology Assessment Data Sheet Summary for NARF Cherry Point

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Abrasive Blasting	Glass bead residue	53	F	0	Aircraft - Stored; DRMO will not accept
Chemical Paint Stripping	Spent paint stripper	200	T	140	$3.5/1000 gal, batchtreat @ IWTP
Chemical Paint Stripping	Solvents, chlorinated	15	D	11250	Paint stripping parts
Electroplating/Metal Finishing	Chromic acid anodize	108.5	T	76	Batch treat; aircraft paint stripping
Electroplating/Metal Finishing	Plating bath, sludge	5	D	10000	Silver recovered, residual dsp @ $1/lb
Fluids Changeout	Hydraulic fluids	77.2	D	61760	Synthetic & pet. based
Fluids Changeout	Oil, lube	103	D	77250	Lube transmission oil w/ JP 4 & 5
Fueling Operations	Hexane	120	D	120000	Fuel for jet engine tests
IWTP	Sludge	134	0	0	Belt press is used
IWTP	Wastewaters	360000	T	252000	Aircraft stripping & electroplating waters
Metal Prep	Silica soap	10	T	7	Batch treat
Metal Prep	NaOH	10	T	7	Paint stripping of non-Al alloys
Metal Prep	K2MnO4, alkaline	13.75	T	10	Descale ops, inc 250 gals sludge, batch trt
Metal Prep	KOH chelates	25.5	T	18	Batch trtmnt, mach. shp descale ops
Nonrecurring	Oils, absorbent	50	D	0	Haz waste spill
Nonrecurring	Electroless nickel	100	D	0	Discontinued operation
Painting Operations	Solvents, nonchlorinated	38	D	30400	10% naptha, 90% acetate thinner
Solvent Cleaning	Solvents,PD680 non-chlorinat	140.7	D	112520	Balance evaporates or goes to IWTP
Solvent Cleaning	Solvents, Trichloroethane	24	D	19200	50% solvent, bal. contaminated rags,vapor d
Solvent Cleaning	Solvents, chlorinated	18.5	D	13910	Includes 500 gals dragout, carbon removal
	TOTAL	361,246		$708,548	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A5. NCEL Technology Assessment Data Sheet Summary for NARF Norfolk

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Abrasive Blasting	Grit	147.8	D	149205	70% rice hull:10%Al oxide;20% glass bead
Chemical Paint Stripping	Paint sludge	22.65	D	49850	Drummed collection paper,Cr,phenols
Chemical Paint Stripping	Solvents, paint sludge	32.45	D	10830	Cr, Cd, phenols, part stripping
Container/Drum Disposal	Contaminated w/ paint/solven	8.73	D	5008	0
Electroplating/Metal Finishing	HCl, $NiCl_2$, w/Cr, Cd	15.97	T,D	2985	Brush plating ops
Electroplating/Metal Finishing	Chromic acid w/ Cd	18.12	D,T	6260	Anodizing
Electroplating/Metal Finishing	$KMnO_4$ w/Pb & EDTA	41.7	D,T	2740	Silver recovered, residual dsp @ $1/lb
Electroplating/Metal Finishing	NH_4OH-H_2O thiourea	27.92	D,T	8465	Contains Ni
Electroplating/Metal Finishing	NaCN w/Cd	46.84	D,T	8005	0
Fluids Changeout	Misc fluids	111.87	D	82805	Cr, Cd, cutting oils, mainly coolants
IWTP	Wastewaters	175000	T	1400000	Plating & aircraft stripping wastewaters
IWTP	Sludge	216.1	F	94000	0
Metal Prep	H_2SO_4 w/Cd, Cr	30.54	T	200	Treated @ IWTP
Metal Prep	NaOH	101.2	D,T	35015	Treated @ IWTP
Metal Prep	Acids	20.51	T	390	HCl, HF, HNO_3 w/HF, H_3PO_4 etching ops
Painting Operations	Paint, thinners	37.93	D	0	0
Solvent Cleaning	Solvents, chlorinated	63.87	D	0	0
Solvent Cleaning	Solvents - chlorinated	41.12	D	8315	Cr,phenols,cresols,CH_2Cl_2,carbon remover
	TOTAL	175,985		$1,864,065	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A6. NCEL Technology Assessment Data Sheet Summary for NAS Alameda

Process	Waste ID	Tons	Disposal ID	Cost	Comment	
Abrasive Blasting	Grit	298.4	F	46860	Grit +20% sand;$.50/gal	
Bilge Water	Oil and water	163.5	F	16350	Class 1 landfill, cont heavy metals	
Boiler Layup	Sodium nitrite	23	F	2300	Boiler passivating: hydroblasting	
Chemical Paint Stripping	Solvents, chlorinated	26	F	2600	$.5/gal;phenol,dichloromethane,chromium	
Chemical Paint Stripping	Paint sludge	74.5	F	7450	Paint skins	
Container/Drum Disposal	Empty lube oil, etc.	32	F	10500		0
Electroplating/Metal Finishing	Cd, Cu, Ni. CN	114	F	11400	Rates vary to waste type	
IWTP	Wastewaters	82500	T	825000	27% aircraft stripp.waters;73% electroplati	
IWTP	Sludge, wastewater	903	F	90300	Class 1 LF, hydroxide	
Nonrecurring	Fuel - soil	74	F	0	Spill opn	
Nonrecurring	NaOH - soil	10	F	0	Spill opn	
Nonrecurring	Cr, water	50.5	F	0	Clean out palting sump	
Painting Operations	Booth waters	43.25	F	4325		0
Painting Operations	Paint, solvents, oils	145	F,D	12250		0
	TOTAL	84,457		$1,029,335		

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A7. NCEL Technology Assessment Data Sheet Summary for NAS JAX NARF

			Disposal		
Process	Waste ID	Tons	ID	Cost	Comment
Abrasive Blasting	Grit	1176	F	282250	Grit recycling planned
Chemical Paint Stripping	Paint chips	19.185	D	7675	DRMO administered
Electroplating/Metal Finishing	Degreaser wax	10	D	2540	Listed w/ NOS paint waste;vol est
Electroplating/Metal Finishing	Plating sol; spnt CN	25900	T	175000	Dilute Cr, batch chlorination, evap
Fluorescent Tube Replacement	Mercury trash	10	D	4000	Hg trash spill clnup, 95% NOS ORM
Painting Operations	Paint w/ solvent NOS	33.34	D	26675	Listed w/ NOS paint waste;vol est
Painting Operations	Paint - solidified	9.77	D	7815	DRMO administered disposal
Solvent Cleaning	Carbon removal cmpd	100	D	25400	Listed w/ NOS paint waste;vol est
	TOTAL	27,258		$531,355	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A8. NCEL Technology Assessment Data Sheet Summary for NIROP Pomona

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Electroplating/Metal Finishing	Chromic acid, spent	138.83	T	0	Circuit brds;IWTP trtmnt and disposal
Electroplating/Metal Finishing	Photoresist stripper	942.07	F	9420	Contains Cu; circuit brds
Electroplating/Metal Finishing	Acids, solder flux	34.5	T,F	1820	Circuit brds;IWTP trtmnt. LF solder flux
Electroplating/Metal Finishing	Rinsewaters	5156.6	T	0	Circuit board manufacturing
Fluids Changeout	Oil and water	24	T,F	200	100 gals oil LF @ $100/drum
IWTP	Acids, water	364923	T	45000	IWTP trtmnt, formerly LF
IWTP	Lime sludge, 4% wt Cu	540	F	297000	Cu reclaimed by mining co.
Painting Operations	Solvent spent	17.5	F	6365	Disposed in cement kiln
Painting Operations	Paint sludge (booths)	27.65	F	10055	Changing to dry, then only filters to dispo
	TOTAL	371,804		$369,860	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A9. NCEL Technology Assessment Data Sheet Summary for NSC Pt. Molate

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Fueling Operations	Oil and water	12.5	F	1250	Water rinse of JP5 & diesel tanks
IWTP	Pond bottums	1615	F	161500	OWTP sedimentation, ~every 5 yrs
	TOTAL	1,628		$162,750	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A10. NCEL Technology Assessment Data Sheet Summary for NSY Charleston

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Air Conditioner Repair	LiBr	44	D	33440	Expired shelf life, dsp @ 3.80/gal
Battery Repair/Replacement	H2SO4	15	D	11430	0
Battery Repair/Replacement	KOH (70% water)	27.6	D	20975	DRMO to treat Cd waste from electroplating
Battery Repair/Replacement	Lead dross (plates)	888.3	D	799470	Batt. drained;plates piled, DRMO dsp (????
Boiler Cleaning	HCl	45.3	T	0	Neutralized on barge, dsp to sewer
Boiler Layup	Sodium nitrite	340.5	T,D	0	Hydroblast:Also 1.8 T expiredphoto reagent
Boiler Testing	Mercuric nitrate	9.1	D	6915	Contractor recycled @ 3.8/gal
Breathing Apparatus	K-superoxide	13.2	D	11880	Unused and empty containers
Electroplating/Metal Finishing	Chromic acid	50.6	D	38455	0
Fluids Changeout	TCP (synthetic oils)	19	D	14440	Lube oils, also from shipps off...
IWTP	Chrom-hydrox sludge	38.7	D	34840	Contractor dsp @ 3.8/gal
IWTP	Wastewater	0	0	0	Plating waste Jenny should call w/ more in
Metal Prep	Corrosives, NOS	7.3	D	5550	Alkaline cleaning sols
Metal Prep	NaOH (40% water)	10	D	7600	Expired matl
Nonrecurring	Oil: 5-10% water	168.3	D	127910	Spill cleanup: contractor recycle @3.8/gal
Nonrecurring	Freon 12	20.2	D	0	diCl-difl methane
Painting Operations	Paint wastes, thinners	441.5	D	335540	Contractor dsp @ 3.8/gal
Pipe Flushing/Cleaning	TSP	37.2	T	0	Neutralized on barge, sewer discharge
Pipe Flushing/Cleaning	Freon (4% water)	18.8	D	14290	Plans to recycle on site
Ships Offloaded Stores	Monoethaolamine	12.4	0	9425	Contractor recycle @ 3.8/gal
Ships Offloaded Stores	Sulfamic acid	7	D	6300	Solid NOS - usually considered sulfamic
Ships Offloaded Stores	KOH (solid)	19	D	17100	$0.45/lb dsp: expired shelf life
Solvent Cleaning	Petroleum naptha	12.8	D	9730	Contractor dsp @ 3.8/gal - not RCRA hazardo
Steam Generator Cleaning	Various chemicals	195	T,D	10640	181 ton treaed on site:14 T expired, recycl
Steam Generator Cleaning	Various chemicals	367.9	D	279605	
Tank Cleaning- CHT System	Chlorinated water	170	T	0	Stored in barge, Cl dissipates, sewer
	TOTAL	2,979		$1,795,535	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A11. NCEL Technology Assessment Data Sheet Summary for NSY Long Beach

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Abrasive Blasting	Grit	4347	F	365150	Cu slag blast ships
Bilge Derusting	Citric acid	24.95	T	630	Hauled to Norris-San Diego IWTP
Bilge Water	Oil and water	1736	T	43745	Oil/water sep; cont. blr clng nitrites
Bilge/Tank Degreasing	Haz waste liq: ORM-E	120	T	3025	Treated at N.Isl NARF
Boiler Cleaning	Alk sol : TSP	200	T	5040	Dsp to barges, trted @ SD IWTP
Boiler Cleaning	HCl; metal cleaning	199.5	T	5025	PWC, SD IWTP:hauled @ .12/gal
Boiler Layup	Alk sol; Na nitrite	1350	T	34020	Tube cleaning w/ water jet blast
Container/Drum Disposal	Drums (empty)	26.875	D	25800	1075 drums, haz. residue; to TSD site
Electroplating/Metal Finishing	Chromic acid	40.5	T	1020	Treated @ N. Isl NARF, hauled @ .12/gal
Firefighting Practice	AFFF	100	T	2520	From feed syst tests; drains to bilge
Fueling Operations	Oil and water	25	D	5000	DRMO to American Processing Co, TSD site
Metal Prep	Alk sol: metal prep	20	D	4000	Cont. Cr, Cd, Cu; to TSD site
Painting Operations	Paint solids/sludge/booths	118	D	23600	Water fract see Alk sol;DRMO to TSD site
Painting Operations	Alk sol:spray booth water	619.5	D	123000	American Processing Co to TSD site
Painting Operations	Epoxy solids	11	D	17600	DRMO to contractor to TSD site
Painting Operations	Paint solids - enamels	84.9	D	135840	DRMO to contractor to TSD site
Pipe Flushing/Cleaning	TSP	450	T	11340	To barges/tanks then SD IWTP
	TOTAL	9,473		$806,355	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A12. NCEL Technology Assessment Data Sheet Summary for NSY Mare Island

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Abrasive Blasting	Spent abrasives	490	N	40600	Mare Island Flammable Waste Landfill
Battery Repair/Replacement	Lead cmpd (80%)	37.4	D	29920	1000 gal neutralized, balance "neat"
Fluids Changeout	Misc. fluids	36.02	D	11885	Includes cutting, tool coolant, & hydraulic
IWTP	Sludge	388	F	45000	Sludge dried in beds at IWTP
IWTP	Wastewaters	255000	T	399220	Industrial wastewaters
Metal Prep	Acids/alkalis	400	T	625	neut. in tank bled to IWTP
Nonrecurring	Contaminated soil	513	0	0	0
Painting Operations	Epoxy resins	22.4	D	7390	Solidified in containers, drummed, lndfld
Painting Operations	Flammable waste	325	N	26900	Empty containers, paint&solvent, rags, etc
Pipe Flushing/Cleaning	TSP	40	T	60	Coll. in tanks,neut,bled to IWTP
Solvent Cleaning	Non-chlorinated solvents	11.275	D	3720	Cleaning various items-electronics, tools
Steam Generator Cleaning	Various chemicals	600	T	95	added to IWTP sludge drying beds
	TOTAL	257,863		$565,415	

Disposal ID: **D: DRMO**
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A13. NCEL Technology Assessment Data Sheet Summary for NSY Norfolk VA

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Battery Repair/Replacement	H2SO4	84.325	T	29920	0
Bilge Derusting	Citric acid, TEA	349.571	T	3025	Treated at N.Isl NARF
Bilge/Tank Cleaning	NaOH, EDTA	30	T	0	cnlg ship sewage tanks
Bilge/Tank Cleaning	KOH	30	T	0	cnlg ship sewage tanks
Boiler Cleaning	HCL	1000.8	T	16220	treated at IWTP
Boiler Layup	Sodium nitrite	1314.793	T	0	Hydroblast
Electroplating/Metal Finishing	Chromic acid	46.295	T	0	anodizing operations
Fluorescent Tube Replacement	Mercury	11.72	F	1430	0
IWTP	Wastewaters	37500	T	900000	total cost, all onsite treatment
IWTP	Sludge, sulfides	570	F	105175	78% sludge, 22% liq sulfides
Nonrecurring	NH4OH (expired)	42.25	F	0	altered sop; do not generate
Nonrecurring	Styrene, butediene,latex,Pb	232	F	0	spill cleanup waste
Nonrecurring	CN, Cd, Pb, & Cu	66.7	F	0	spill cleanup waste
Nonrecurring	Trichloroflorowethane	13.125	F	0	waste was minimized
Pipe Flushing/Cleaning	TSP	62.75	T	0	see IWTP waters
Pipe Flushing/Cleaning	Acids, chelated	83	D	24235	Erythorbic,citric,TEA
Pipe Flushing/Cleaning	TSP	1800	T	38000	in add. to above TSP
Pipe Flushing/Cleaning	phosphoric acid	29.13	T	0	treated at IWTP
Pipe Flushing/Cleaning	Freon	28.6	R	0	currently recycled onsite if <25ppm dirt et
Pipe Flushing/Cleaning	Sulfamic acid	16.225	T	0	0
Steam Generator Cleaning	Various chemicals	0	T	0	
	TOTAL	43,311		$1,118,005	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A14. NCEL Technology Assessment Data Sheet Summary for NSY Pearl Harbor

Process	Waste ID	Tons	Disposal ID	Cost	Comment	
Air Conditioner Repair	LiBr rinse water	65	T	13000	PWC IWTP batch operation	
Battery Repair/Replacement	Battery acid	160	T	32000	PWC IWTP trtmnt and dsp	
Bilge/Tank Cleaning	Oily sludge	290	T	58000	Degreasing operation	
Boiler Cleaning	Sulfamic acid	17.5	T	3500		0
Boiler Cleaning	HCl	1130	T	226000	Precipitate metals, neutralize	
Chem Lab	Chem rinse waters	170	T	34000		0
Electroplating/Metal Finishing	Brush plating waste	170	T	34000	Sludge to IWTP @ NAVBASE PH	
Electroplating/Metal Finishing	Chrome plating solution	16.5	T	3300	Cr reduction, neytralize, @ IWTP	
IWTP	Plating rinses	216.1	T	330000	Pretreat unit separate from PWC batch ops	
Metal Prep	Caustics	128.5	T	25700	PWC IWTP treats and disposes waste	
Painting Operations	Expired paint	54.5	D	46280	Shipped to mainland, sold by DRMO	
Painting Operations	Solvents,thinners	20.85	D	23350		0
Pipe Flushing/Cleaning	TSP	191	T	38000	Metal removal, PWC IWTP batch operation	
	TOTAL	2,630		$867,130		

Disposal ID:	**D:**	**DRMO**
	T:	**On site treatment**
	F:	**Final off site contract**
	N:	**Final disposal on site**
	R:	**Recycle**

Table A15. NCEL Technology Assessment Data Sheet Summary for NSY Philadelphia

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Boiler Cleaning	HCl	353	0	0	Contractor operation; inc. dsp cost
Breathing Apparatus	OBA Canisters	28.325	0	69155	Potassium superoxide
Firefighting Practice	AFFF	107.49	0	15048	Contractor disposal
Fluids Changeout	Oils and water	366	0	172592	TCE contaminated oils; 23.9 T incinerated
Fluorescent Tube Replacement	Mercury contaminated	5.2	0	807	Inc other Hg items eg gauges, thermometers
Metal Prep	Acids	68.15	0	26851	Cr,nitric,muriatic,HCl
Metal Prep	NaOH	98.5	0	38805	Contractor to TSD site
Nonrecurring	Medical supplies	170	0	0	Cr and Pb
Painting Operations	Solvents	36.3	0	14456	Thinners; Contractor/DRMO
Painting Operations	Paint	231.19	0	108661	DRMO
Solvent Cleaning	Chlorinated solvents	185	0	0	0
	TOTAL	1649		$446,375	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A16. NCEL Technology Assessment Data Sheet Summary for NSY Puget Sound

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Battery Repair/Replacement	Sulfuric acid	8	F	6040	0
Bilge Derusting	Citric acid	670	F	503320	Derusting operation
Breathing Apparatus	OBA canisters	11.115	F	4150	Out of date canisters
Chemical Paint Stripping	Solvents - chlorinated	160	F	120195	Methylene chloride,acidic paint stripper
Electroplating/Metal Finishing	CN	1502	T	12220	Primarily tank dumps
Electroplating/Metal Finishing	Cr waste	15758	T	128230	Primarily tank dumps
Firefighting Practice	AFFF -expired	21.455	R	0	to fire dep. or dilute to sewer
Fluids Changeout	Houghto-safe	13.225	F	4865	Hydraulic fld for munition ele.
Fluids Changeout	Cellulube	32.125	F	11820	Carrier elevator fluid
Fluids Changeout	Oil	105.95	F	38980	IWTP.fluid changes,ship wastes,spills
IWTP	Wastewaters	40200	T	327130	Plating, cleaning rinsewaters
IWTP	Sludge	18.175	F	6690	Electro,chrome,pipe shop,metal shop,misc
Metal Prep	HCl, acid mixture	12.78	F,T	4700	$101.18/55 gal or IWTP
Metal Prep	Corrosive liquid	43.5	F	16000	Mostly NaOH from throughout shpyrd
Metal Prep	Acid sludge	7.95	F	2925	$101.18/55 gal drum
Painting Operations	Paint -Organo-tin	25.01	F	920	Use is discontinued; $101.18/55 gal
Painting Operations	Paint chips	16.16	F	5945	Mechanical paint remova; from ships; landfi
Painting Operations	Paint	330.895	F	121745	Expired, off spec, $101.18/55 gal
Pipe Flushing/Cleaning	Freon 113	31.56	F	11610	Solvent cleaning engins, air line flush
Pipe Flushing/Cleaning	Acids - various	445	F	334295	Sulfuric;suilfamic;citric&some metal prep a
Pipe Flushing/Cleaning	Alkaline liquids	198.4	F	37140	Alk baths (TSP flushes on board ships)
Ships Offloaded Stores	CO2 absorbent	6.33	F	2325	Out of date stores;clean air syst bckup
Solvent Cleaning	Trichloroethylene	116	F	42680	Vapor degreasing
Steam Generator Cleaning	Various chemicals	392.17	F	182355	Contractor treats
	TOTAL	60,126		$1,826,280	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A17. NCEL Technology Assessment Data Sheet Summary for NUWES Keyport

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Electroplating/Metal Finishing	Sludge, rinsate	27	T	30	Tank dumps
IWIP	Wastewaters	53750	T	650000	Plating rinsewaters
Nonrecurring	Var: expired shelf life	50	0	0	Discontinued palting operation
Nonrecurring	Solid Otto fuel	60.15	0	0	0
Painting Operations	Paint stripper	840	D	208320	SLudge once per year
Painting Operations	Paint thinner	23.1	D	7485	Drums to DRMO, 1.62/gal dsp
Torpedo Cleaning	Otto fuel	125	R	0	Fuel is reclaimed-see rinse water
Torpedo Cleaning	Carbon waste	22	F	62920	Contaminated w/ Otto fuel
Torpedo Cleaning	Organic wash	145	D	0	Given to school as fuel: mineral spirits
Torpedo Cleaning	Rinse water	225	T	270	Activated charcoal separation treatment
Torpedo Cleaning	Afterbody flush	150	D	69600	Incinerated, detergent & 400ppm CN
	TOTAL	55,417		$998,625	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A18. NCEL Technology Assessment Data Sheet Summary for NWIRP Dallas

Process	Waste ID	Tons	Disposal ID	Cost	Comment	
Electroplating/Metal Finishing	Cr and CN	185000	T	520000	Tank dumps batch trted @ IWTP	
Fluids Changeout	Oil and water	588	F	52410	Cutting oils, fluids to IWTP	
IWTP	Wastewaters	1480000	T	0	Plating rinsewater and oily water	
IWTP	Filter cake sludge	349.39	F	78200	Cost increase for '86 to 102,000	
L.E.S.S. Manufacturing	Furfural alcohol	51.5	F	4175		0
Painting Operations	Paint, waste, thinner	130.6	F	76930	Paint thinner,23375; sludge, 2525 gals	
	TOTAL	1,666,119		$731,715		

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A19. NCEL Technology Assessment Data Sheet Summary for NWS Earl

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Bilge Water	Oil and water	10444.45	F	626665	Part recycled, part landfilled
Fluids Changeout	Oil, lube	12.035	D	1205	0
Nonrecurring	Gasoline	25	D	0	0
Nonrecurring	FS smoke	185.84	D	0	0
Torpedo Cleaning	Otto fuel	9.95	F	1990	0
	TOTAL	10,677		$629,860	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A20. NCEL Technology Assessment Data Sheet Summary for NWS Seal Beach

			Disposal		
Process	Waste ID	Tons	ID	Cost	Comment
Bilge Water	Oil and water	129.5	F	4500	Part recycled, part landfilled
Chemical Paint Stripping	Paint strip water	288	F,D	230400	11,100 to DRMO, 46500 to Class 1 LF
Nonrecurring	Cr solution	2446.25	F	0	Cleanout waste from discontinued ops
Nonrecurring	Fuel and water	37.5	F	0	0
Torpedo Cleaning	Otto fuel, detergent	6.225	F	0	Drummed, contractor dsp, administered by Ke
Vehicle Wash/Repair	Oil and water	100	F	3600	Oil recycled, water treated, landfilled
	TOTAL	3,007		$238,500	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A21. NCEL Technology Assessment Data Sheet Summary for NWSC Crane

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Abrasive Blasting	Grit	150	F	15750	Torpedo paint stripping - sand blasting
Chemical Paint Stripping	ALodine	66	F	6960	Landfilled -Alabama
Demilitarization	Open burn explosives	1767	T	0	Army operation
Demilitarization	Ash	1375	F	0	From open burning of explosives
Demilitarization	Detonate obs. ordnance	409	T	0	Army operation - cost not available
Demilitarization	Ammonium picrate	23	T	0	OPen burning operation -Navy
Demilitarization	Ash	75	F	0	From open burning of ammonium picrate
Electroplating/Metal Finishing	Chromic acid	20	F	2630	0
IWTP	Sludge	36.24	F	0	See IWTP
IWTP	Wastewaters	0	T	89000	Plating/metal prep wastewaters; total IWTP
Metal Prep	Plating waste, 10% Cr	43	F	6300	Drummed bath solutions: acids/alkalis
Nonrecurring	Smokescreen	1173	F	0	See FS smoke
Nonrecurring	FS smoke	523	D	0	Contains chlorosulfonic acid/sulfertrioxide
Nonrecurring	Soli/solvent	143	F	0	Spill cleanup
Ordnance (PAL)	Spent carbon	16	T	0	Open burning of spent carbon from pink wate
Ordnance (PAL)	Pink water	26722	T	0	Treated on site by carbon absorption
Painting Operations	Waste paint & paint sludge	20	F	2115	Repainting shells
	TOTAL	32,561		$122,755	

Disposal ID:
D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A22. NCEL Technology Assessment Data Sheet Summary for PWC Pensacola

Process	Waste ID	Tons	Disposal ID	Cost	Comment
IWTP	Wastewaters	765000	T	755820	From NARF & NAS, plating, bilge, painting,
IWTP	Sludge	2335	F	471670	0
Painting Operations	Paint, thinners	10.795	D	0	0
	TOTAL	767,346		$1,227,490	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

Table A23. NCEL Technology Assessment Data Sheet Summary for PWC San Diego

Process	Waste ID	Tons	Disposal ID	Cost	Comment
Battery Repair/Replacement	Batteries	9.7	D	7760	0
Boiler Layup	Hydrazine	10	T	0	0
Boiler Layup	Morpholine	8.3	D	2740	0
Boiler Layup	Sodium nitrite	75	D,T	16500	25 tons treated, 50 to DRMO (expired)
Boiler Testing	Mercuric nitrate	12.8	D	4225	0
Breathing Apparatus	OBA canisters	39	D	167700	0
Container/Drum Disposal	Drums -empty	90	D	420000	Assumes 15 lb/drum dsp @ $35 ea.
Firefighting Practice	AFFF	29	T	0	0
Fluids Changeout	Lube oils	144	T,D	39600	24 T to OW/IWTP, bal to DRMO
Fluids Changeout	Misc oils	127	T,D	33330	26 T Ow/IWTP, 101 to DRMO
Fluids Changeout	Hydraulic oils	88	T,D	16170	39 ton treated @ OW/IWTP; 49T to DRMO
Fluids Changeout	Grease	33.4	D	11020	0
Fluorescent Tube Replacement	Mercury contaminated	8.3	D	2740	0
IWTP	Wastewaters	0	0	0	Plating and aircraft stripping waste water
IWTP	Booth water	2100	T	0	0
IWTP	Bilge waters	57200	T	0	0
Metal Prep	Acid clean reaidue	12.5	T	0	0
Painting Operations	Paint waste	215	D	70950	Used and expired paint
Solvent Cleaning	Paint waste	215	D	70950	Used and expired shelf life
Solvent Cleaning	Solvents, thinners	185	D	0	0
	TOTAL	60,602		$863,685	

Disposal ID: D: DRMO
T: On site treatment
F: Final off site contract
N: Final disposal on site
R: Recycle

TECHNOLOGY ASSESSMENT DATA SHEET

1.0 WASTE ID (from annual report): ______________________________

Volume Generated __________________________

2.0 GENERATING PROCESS DESCRIPTION

(Collect information on the process/operation which generates the HW. HW management is covered under item 4. If applicable, request a copy of the activity process instruction. Information including any equipment descriptions, manpower requirements, O&M costs, and waste reduction techniques employed would be hepIful)

____
____
____
____
____
____
____

(Use note book in addition, if required)

Contact/Code ___________________ Phone ______________________

3.0 WASTE CHARACTERIZATION

Chemical Identification (if not specified) _________________
____

Waste Contaminants. List any known contaminants contained in the HW:

Heavy Metals (such as chromium, cadmium, etc. see attachment A for list)_____________________________
____

Toxic Organics (such as phenols, methylene chloride, trichloroethane, etc. see attachment A for toxic organics listed by EPA) ______________________________
____
____

Oil and Grease ___________________

Solids___________________________

Acidity or Alkalinity (identify pH if possible)______

Other ____
____

If the waste is analyzed by the activity's chemical laboratory, obtain a copy of a recent analysis.

4.0 HAZARDOUS WASTE MANAGEMENT PRACTICE

Is the waste:

___ A. Recycled (onsite or offsite)
___ B. Treated (onsite or offsite)
___ C. Disposed in Class I landfill or
___ D. Disposed by DRMO

___ E. Other disposal practice _______________

Collect information on HWM practice using appropriate part A, B, C, D or E.

Part A: Recycling Technique

Contact/Code _________________________ Phone_________________

Quantity Recycled ____

Description of Technology Employed _____________________________
____
____

Equipment Description (manufacturer, age, cost)________________
____
____

Manpower Requirements - skill level , hrs ______________________
____
____

Operation and Maintenance Requirements and Costs _______________
____
____

Residual Wastes - description, volume, disposal practice ________
____
____

If recycled outhouse: by contract, identify the contractor, phone and costs ____
____

Part B: Treatment Technique

Contact/Code _________________________ Phone_________________

Volume Treated______________________

Technology Description ____
____
____
____

Equipment Description - manufacturer, age, cost ________________
____
____
____
____

Manpower Requirements - skill level , hrs ______________________

Operation and Maintenance Requirements and Costs ______________

Residual Waste - description, volume, disposal practice ______

If treated offsite : by contract, identify contractor, phone, and costs ______________

Part C : Class I Landfill Disposal

(Most of this information should be available from the survey form completed by the activity POC)

Contact/Code ______________ Phone ______________

Volume Disposed ______________

Waste Haul Contractor/Phone ______________

Landfill Site ______________

Disposal Cost ______________

Part D: DRMO Disposal

Volume Disposed ______________

Contact/Code ______________ Phone______________

DRMO Practices :

How is waste transported to DRMO facility? ______________

How is waste handled after DRMO recieves it? i.e. mixed with other wastes, kept in container recieved, ______________

What is HWM practice by DRMO? (reuse, recycle, lanfill diposal etc.) ______________

DRMO HWM practice - description and associated costs _______
____
____
____

Part E : Other disposal practices

Contact/Code __________________________ Phone __________________

Volume Disposed ___________________________

Describe practice employed and appropriate information on tranportation requirements, equipment utilized, operation and maintenance requirments, contactors utilized, and associated costs ____
____
____
____
____
____
____
____
____
____

HAZARDOUS WASTE MANAGEMENT SURVEY

DIRECTIONS: Please fill this form out as best as possible. It is organized by questions pertaining to hazardous waste generation/sources, reduction techniques, recycling operations, treatment operations, and disposal practices. The form will be collected and reviewed by NAVCIVENGRLAB during their site visit to your activity.

1.0 ACTIVITY INFORMATION

Installation ____
Address ____
____

Environmental Officer ____________________________
Telephone: Autovon___________ Commercial _________

2.0 PREVIOUS SURVEYS/STUDIES.

Has a hazardous or industrial waste survey or other study applicable to hazardous waste reduction, recycling, treatment, or disposal been performed at your activity within 5 years?

Yes ____ No ____

If yes, please provide a copy of any applicable documents for use by the survey team.

3.0 HAZARDOUS WASTE GENERATION

Activity Codes/Shops Generating Hazardous Wastes:

(Please notify appropriate personnel that a survey team will be on site to collect information on activity operations that generate hazardous waste)

Code	Contact/Supervisor	Telephone
___________	____________________________	____________
___________	____________________________	____________
___________	____________________________	____________
___________	____________________________	____________
___________	____________________________	____________
___________	____________________________	____________
___________	____________________________	____________

In the spaces provided on Encl. 1, identify the processes associated with each type of waste generated at your activity, using the following numbers:

1. Abrasive blasting
2. Aircraft paint stripping
3. Battery repair/replacement
4. Bilge/tank degreasing
5. Bilge derusting (citric acid process)
6. Boiler lay-up
7. Boiler cleaning
8. Chem. lab. analysis/operations
9. Demil operations
10. Electroplating/metal finishing
    - 10A. chrome plating
    - 10B. Cd,Cu,Ni, or Ag cyanide plating
    - 10C. brush plating
    - 10D. metal preparation/acid solutions
    - 10E. metal cleaning/alkaling solutions
    - 10F. solvent cleaning/stripping
    - 10G. vapor degreasing
11. Empty drum/container disposal
12. Flourescent tube replacement
13. Fire fighting practice
14. Fueling operations
15. Industrial waste treatment
16. Oily waste treatment
    (DONUT operation, oil/water separator, treatment plant)
17. Ordnance manufacturing
18. Painting operations
    - 18A. epoxy coatings
    - 18B. other coatings
    - 18C. paint thinning (solvents)
    - 18D. solvent paint removal
    - 18E. paint/solvent contaminated clothing/rags disposal
    - 18F. spray booth water disposal
19. Pesticide control
20. Pipe flushing/cleaning
21. Machine/engine shop operations
    - 21A. hydraulic fluids changeout
    - 21B. lube oil replacement
    - 21C. machining coolant use
    - 21D. transmission fluid changeout
    - 21E. solvent cleaning
    - 21F. misc. fluids changeout
    - 21G. grinding/polishing (metal wastes)
22. Steam generator cleaning
23. Ships offloaded stores/wastes
24. OTHERS - please specify
25. etc.

3.0 REDUCTION TECHNIQUES

What techniques, if any, are employed at your activity to reduce the generation of hazardous wastes? (Reduction techniques include for example, the use of flow restrictors, substitution to nonhazardous materials, and process modifications such as the innovative hard chrome electroplating process or plastic bead blasting medium for aircraft paint removal)

Please identify these techniques and the supervisor or point of contact at your activity who can be interviewed for more information.

Technique	Contact/Code	Phone

4.0 RECYCLING/RECOVERY OPERATIONS

Do you recycle or recover any hazardous wastes? Yes ___ No ___
If yes, please identify the wastes, recycling technology (i.e. solvent distillation, electrolytic recovery of gold in electroplating, etc.), and the supervisor or contact who can be interviewed for more information.

Waste Type	Technique	Contact/Code	Phone

What hazardous wastes generated do you think could be recycled that are not currently recycled? ______________________________

5.0 HAZARDOUS WASTE TREATMENT

Does your activity have an industrial or oily waste treatment plant (IWTP)? Yes ____ No ____

IWTP Supervisor ______________________ Phone _____________

What waste streams are treated at your activity? __________

Does the IWTP have any batch treatment capability for handling concentrated wastes? Yes _____ No _______
If yes, what types of wastes are batch treated? ________________
____
____

Are any concentrated hazardous wastes bled into the IWTP? Yes ___ No _____ If yes, what waste types? _________________
____
____
____

If the IWTP does not treat any concentrated hazardous wastes (wastes other than rinse waters), is there adequate space and capacity of the IWTP to incorporate a plant modification which would allow this capability? Yes ____ No ______
Please attach any supporting information you may have relative to this question.

Does the IWTP have sludge dewatering capability?
Yes ____ No ____

What is the annual cost for IWTP treatment? ______________
and the quantity of wastes treated annually? __________________

What other techniques or operations are employed at your activity for treating hazardous wastes? Identify the treatment practices and the supervisor or activity personnel who could be interviewed for more information.

Technique	Contact/Code	Phone
____________________	____________________	______________
____________________	____________________	______________
____________________	____________________	______________
____________________	____________________	______________
____________________	____________________	______________

6.0 HAZARDOUS WASTE DISPOSAL PRACTICES

List any contractor used by your activity for offsite disposal and the current costs for disposal. If the disposal charges are specified for specific waste types, transportation, etc. in a contract, please provide a copy of any applicable contracts.

Contractor/Company	Phone	Disposal Costs (per lb or gal)
______________________	__________	___________________
______________________	__________	___________________
______________________	__________	___________________

What landfill site(s) are currently being used for disposal of hazaradous wastes (through contract, DRMO, or by your activity)? What are the present limitations on the types of wastes they will accept or reject?

Site	Location	Comments
____________________	____________	________________________
____________________	____________	________________________
____________________	____________	________________________

Does your activity dispose of any hazardous wastes through the Defense Reutilization and Marketing Office (DRMO, formorly DPDO)? Yes ______ No ______

If yes, what types of wastes are disposed through DRMO and what criteria or limitations are used at your activity for determining which wastes are sent to DRMO? ____________________

____

____

____

____

DMRO Location ______________________________________

DMRO Contact ______________ Phone _______________

What do you percieve to be your most critical problems regarding hazardous waste disposal? ____________________________

____

____

____

____

____

For what hazardous wastes generated by your activity do see the most need for alternative reduction , recycling or treatment or disposal technologies? ______________________________________

____

____

____

____

____

What plans, if any, do you have for upgrading or expanding your current hazardous waste management program? ______________

____

____

____

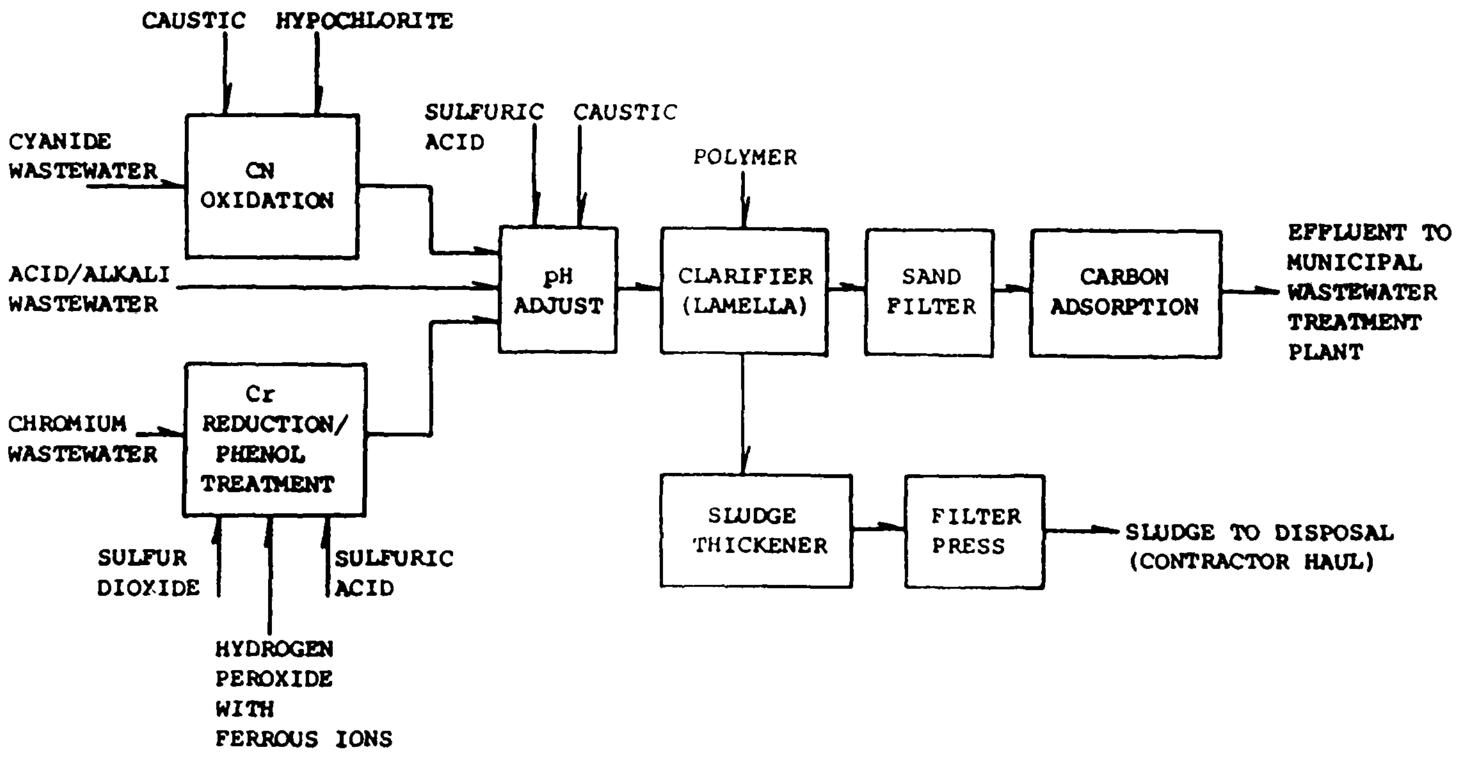
____

APPENDIX B

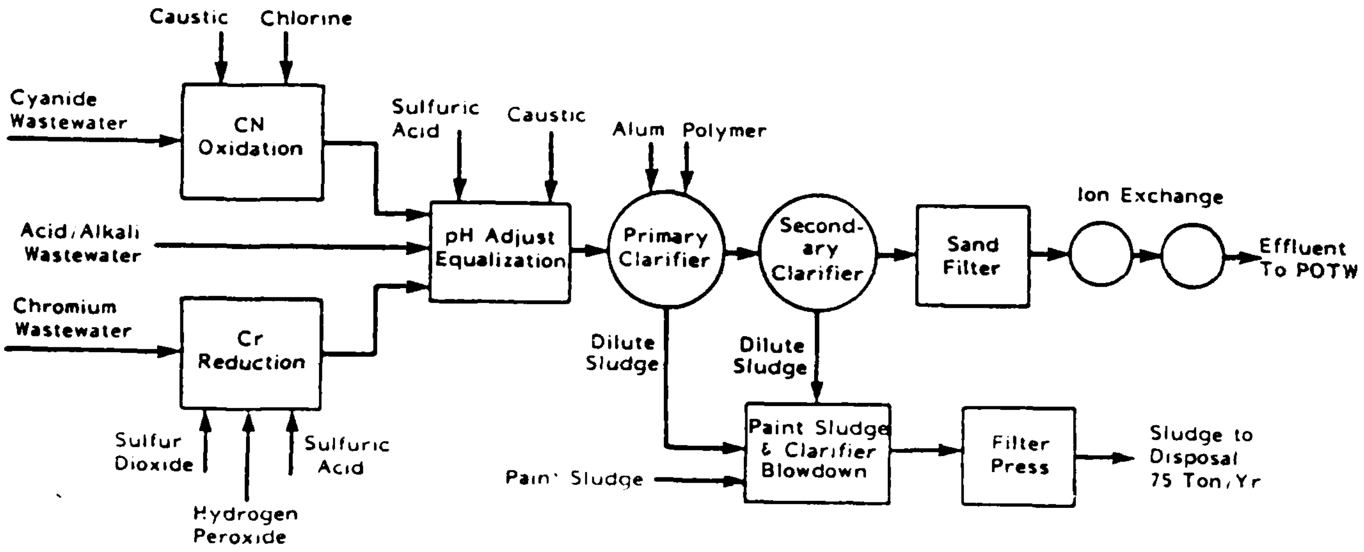
FLOW DIAGRAMS OF THE NAVY'S IWTP PROCESSES

FLOW DIAGRAMS OF THE NAVY'S IWTP PROCESSES

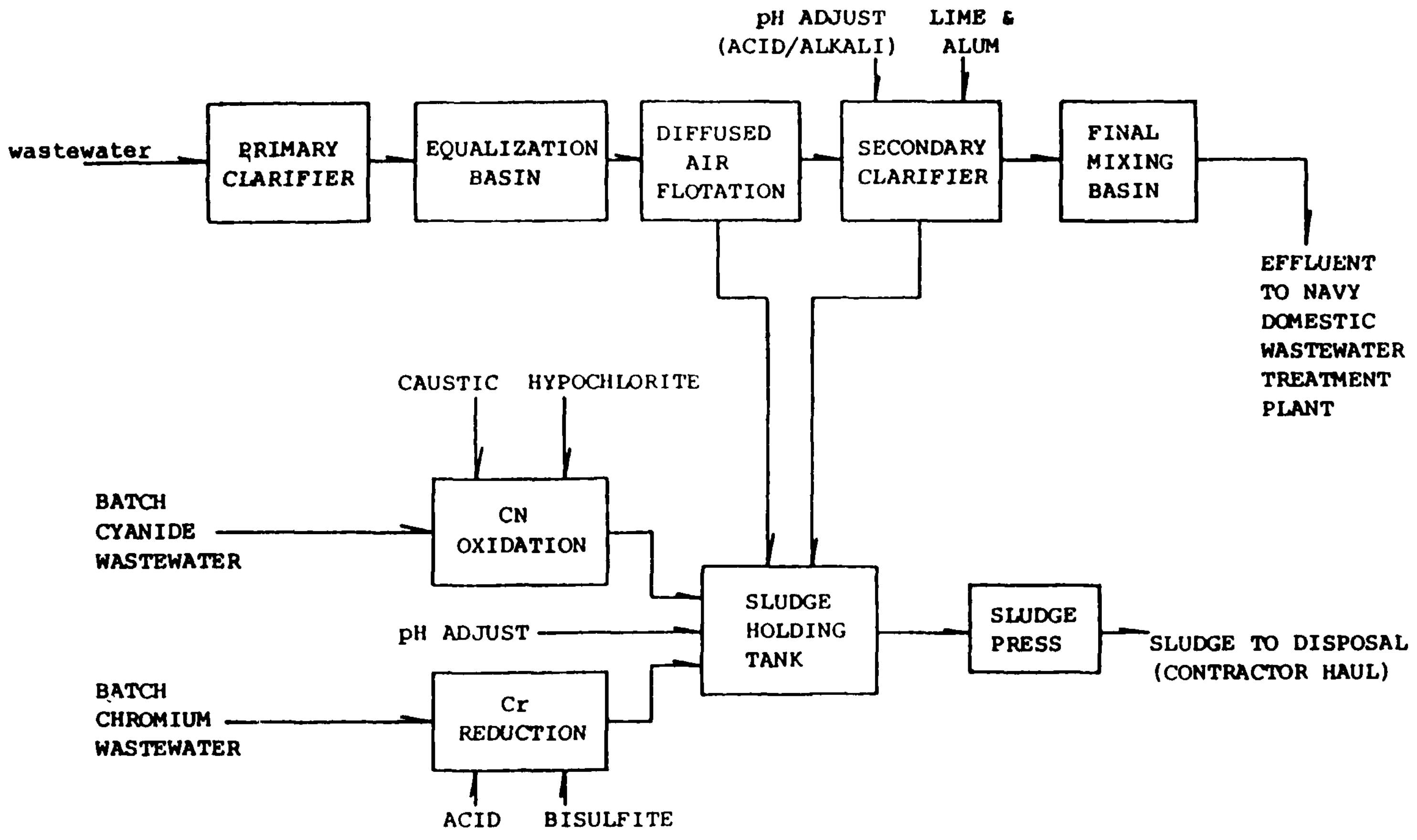
- NADEP Norfolk
- NSY Puget Sound
- NADEP Cherry Point
- NAS Alameda
- NADEP Alameda
- NADEP North Island
- NADEP Pensacola
- NADEP Jacksonville



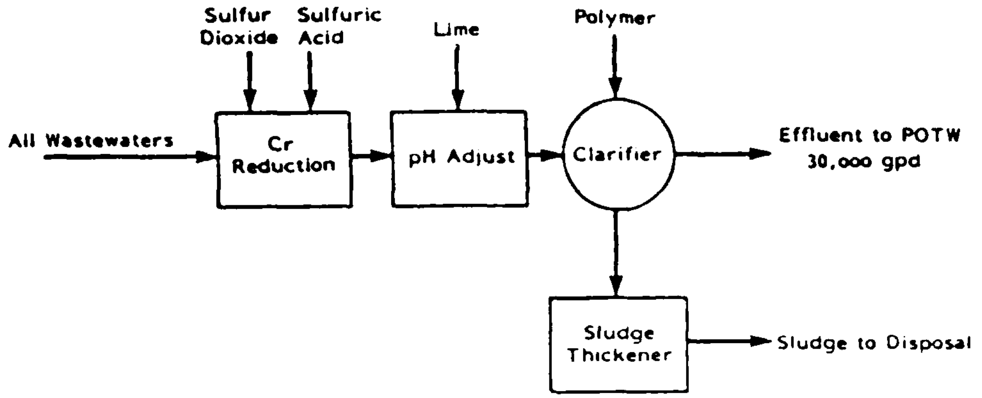
Industrial wastewater treatment facility for NARF Norfolk.



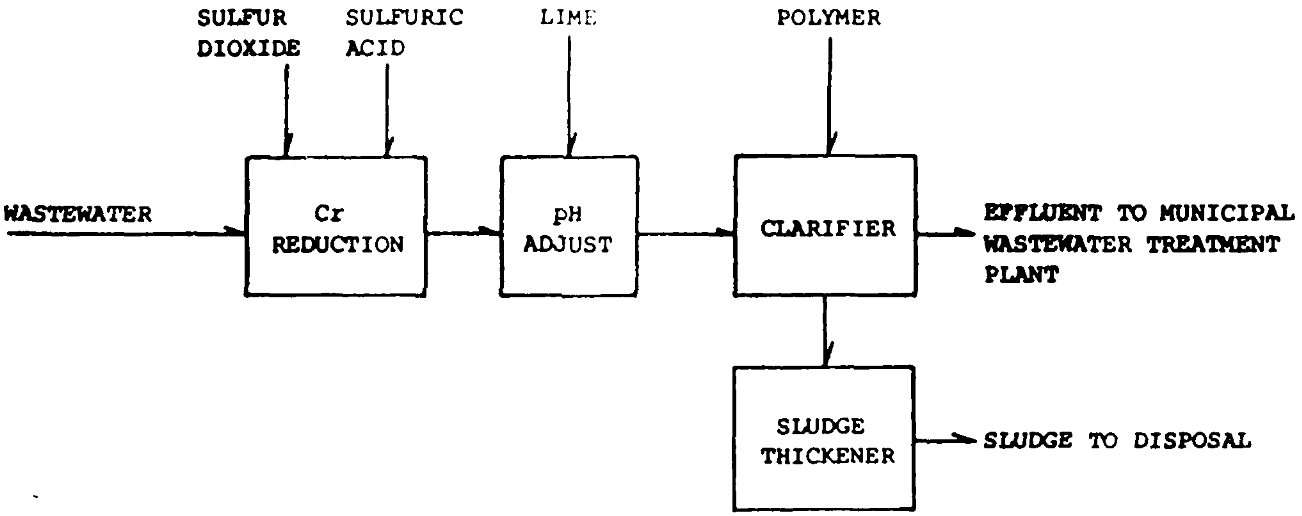
Industial wastewater treatment facility for Puget Sound NSY.



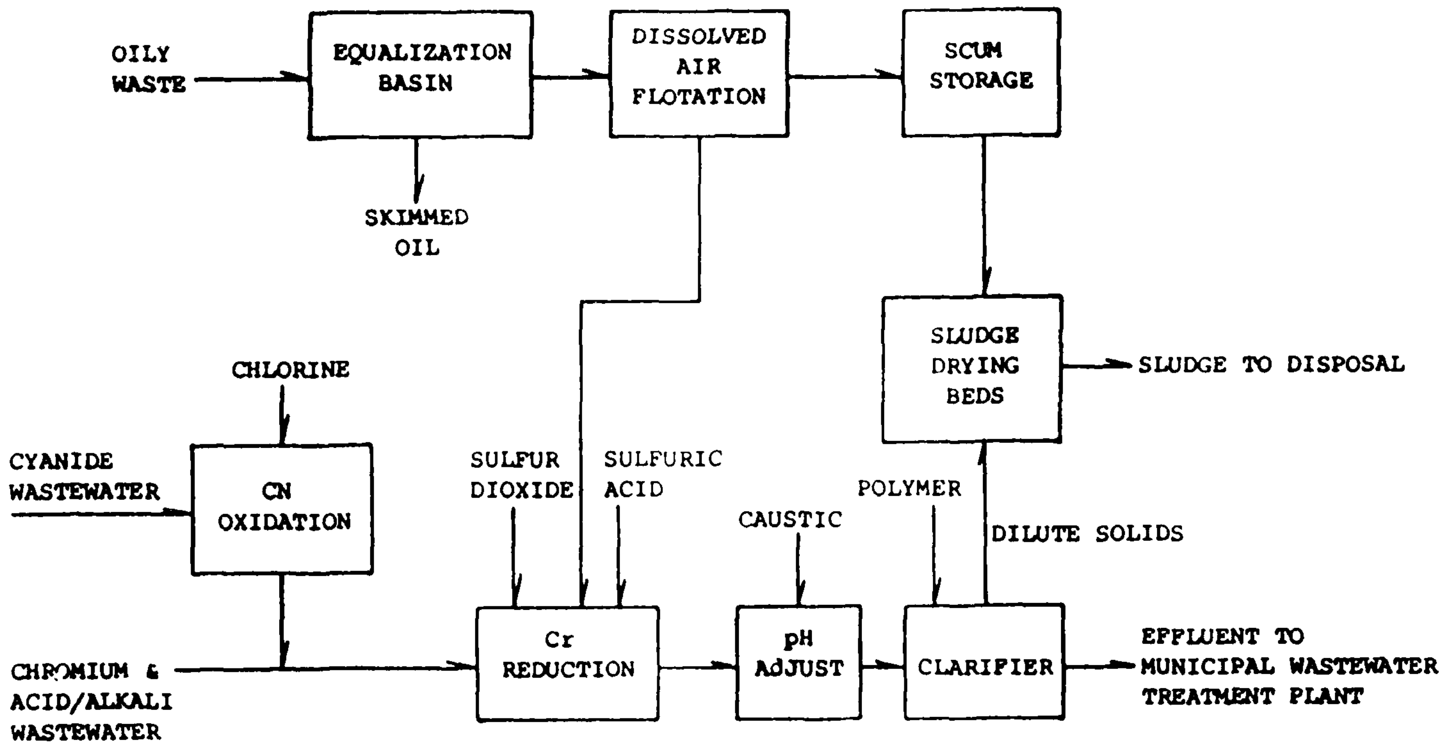
Industrial wastewater treatment facility for NARF Cherry Point.



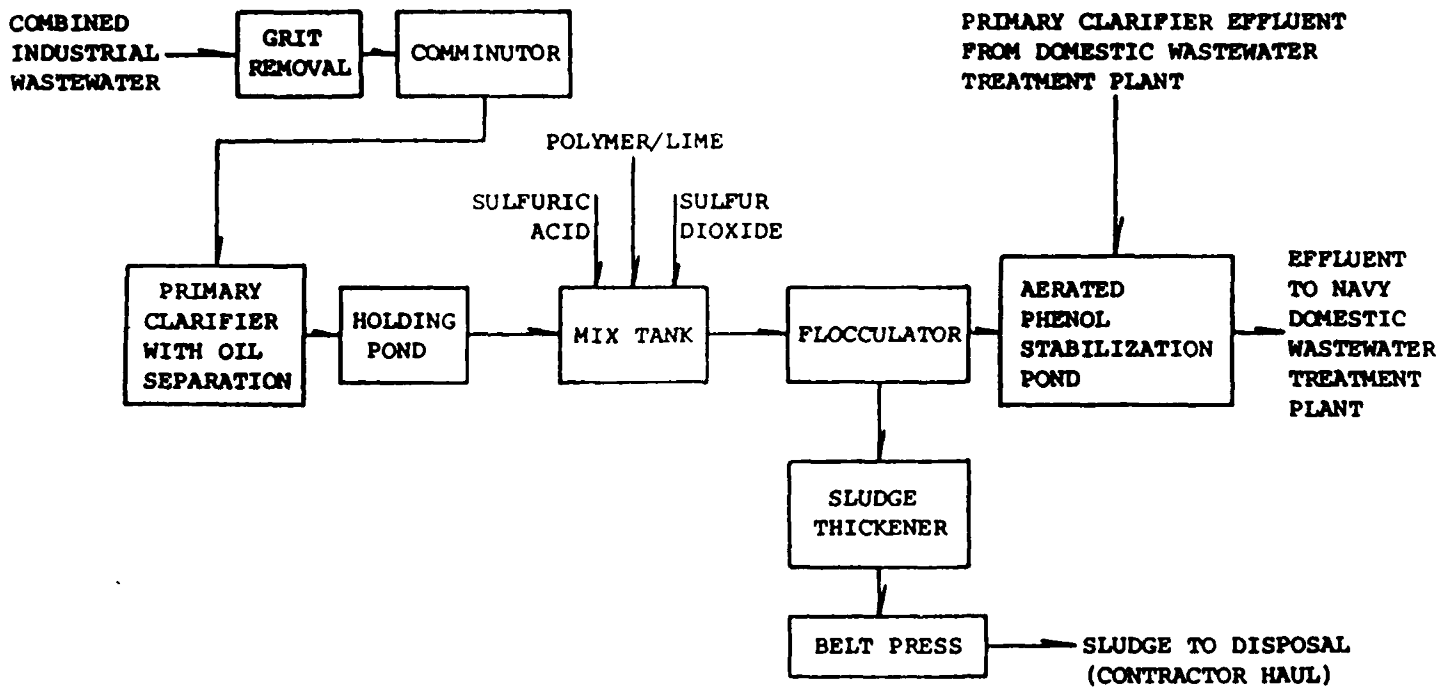
Industrial wastewater treatment facility for NAS Alameda.



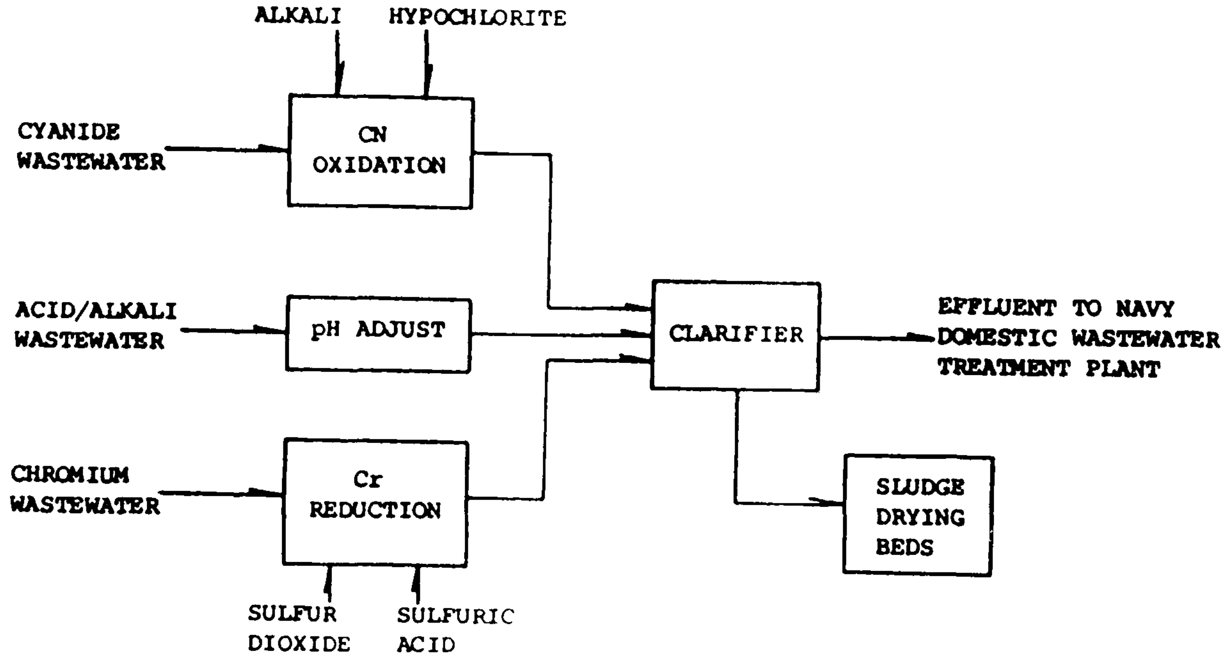
Industrial wastewater treatment facility for NARF Alameda.



Industrial wastewater treatment facility for NARF North Island.



Industrial wastewater treatment facility for NARF Pensacola.



Industrial wastewater treatment facility for NARF Jacksonville.

APPENDIX C

PHYSICAL/CHEMICAL TREATMENT PROCESSES

APPENDIX C

PHYSICAL/CHEMICAL TREATMENT PROCESSES

The technology descriptions included in this appendix are intended to provide a more detailed discussion of the unit processes, the applicability and limitations of those processes, and the availability and possible manufacturers of the necessary equipment.

- Alkaline Chlorination
- Carbon Adsorption
- Chemical Precipitation
- Distillation
- Electrodialysis
- Electrolytic Oxidation
- Evaporation
- Filtration
- Fuel Blending
- Heavy Media Separation
- Ion Exchange
- Metal Reclamation Using Coupled Transport
- Neutralization
- Ozonation
- Supercritical Extraction
- Ultraviolet Photolysis

TECHNOLOGY: ALKALINE CHLORINATION

Status: T1

Brief Description: When chlorine is added to wastewaters under alkaline conditions, the resulting reactions lead to oxidation of the contaminant products, such as hydrochloric acid, chloride salts, and various gases. This oxidation process, which is widely used in the treatment of cyanide wastes, is generally referred to as the "alkaline chlorination" process. The cyanides can be oxidized with chlorine to the less toxic cyanates. Additional chlorine will then oxidize the cyanates to nontoxic nitrogen gas, carbon dioxide, and bicarbonates.

Applicability/Limitation: The process is used to treat free and complex cyanides, although, when the cyanide is in combination with Fe or Ni, a longer time will be required. Limitations include the exothermic heat of the reaction, pH, non-selective competitions with other species, and additional chlorine demands. Fairly close pH control (7.5 to 9.0) is necessary to avoid release of toxic volatiles.

Availability: Generally available

Manufacturer: See buyer's guides in trade journals.

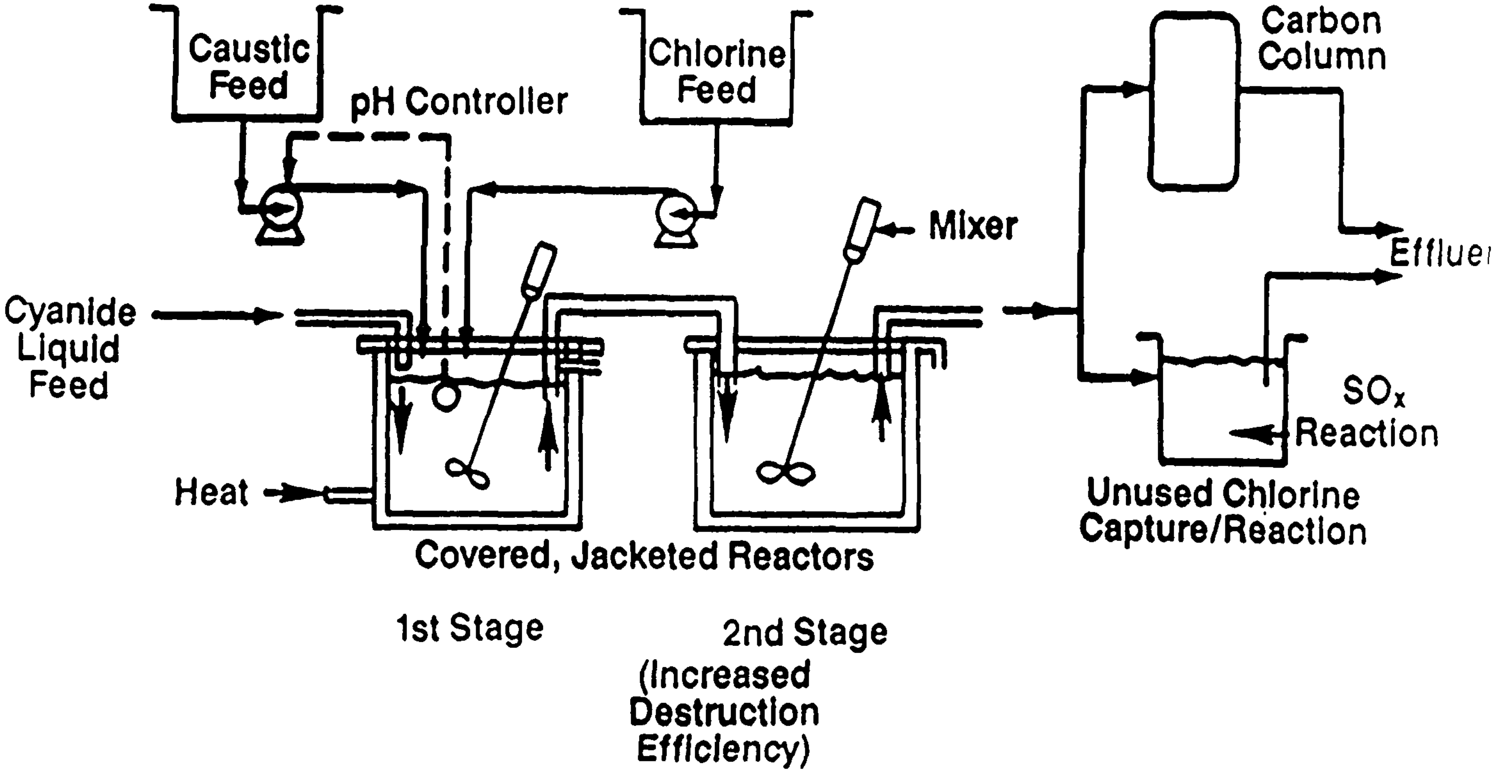
TECHNOLOGY: CARBON SORPTION

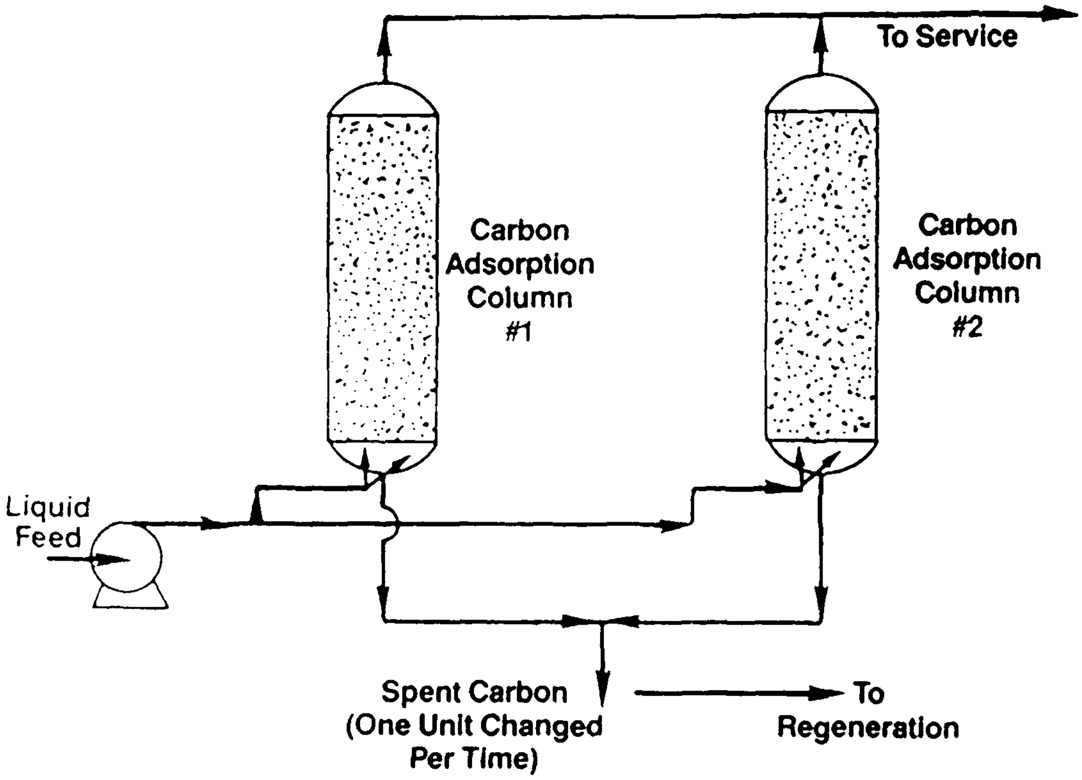
Status: T1

Brief Description: The chemistry of carbon is such that many organic compounds and many organics will readily attach to carbon atoms. The strength of that attachment (and, thus, the energy required for subsequent desorption) depends upon the bond formed. This, in turn, depends upon the specific compound being adsorbed. Carbon to be used for adsorption is usually treated to produce a product with a large surface-to-volume ratio, thereby, exposing a practical maximum number of carbon atoms to be active adsorbers. Carbon so treated is said to be "activated" for adsorption.

Applicability/Limitation: This process is used to treat single-phase, aqueous organic wastes with high molecular weight and boiling point and low solubility and polarity, as well as

SAMPLE CHEMICAL OXIDATION—
ALKALINE CHLORINATION (DESTRUCTION OF CYANIDE)





SCHEMATIC OF CARBON ADSORPTION

chlorinated hydrocarbons, such as tetrachloroethylene and aromatics, such as phenol. It is also used to capture volatile organics in gaseous mixtures. Limitations are concentrations <10,000 ppm, suspended solids <50 ppm, dissolved inorganics, and oil and grease <10 ppm).

Availability: EPA Environmental Emergency Response Unit - two transportable systems (50-gpm and 600-gpm units)

Manufacturer: Several; see buyer's guides.

TECHNOLOGY: CHEMICAL PRECIPITATION

Status: T0 and T1

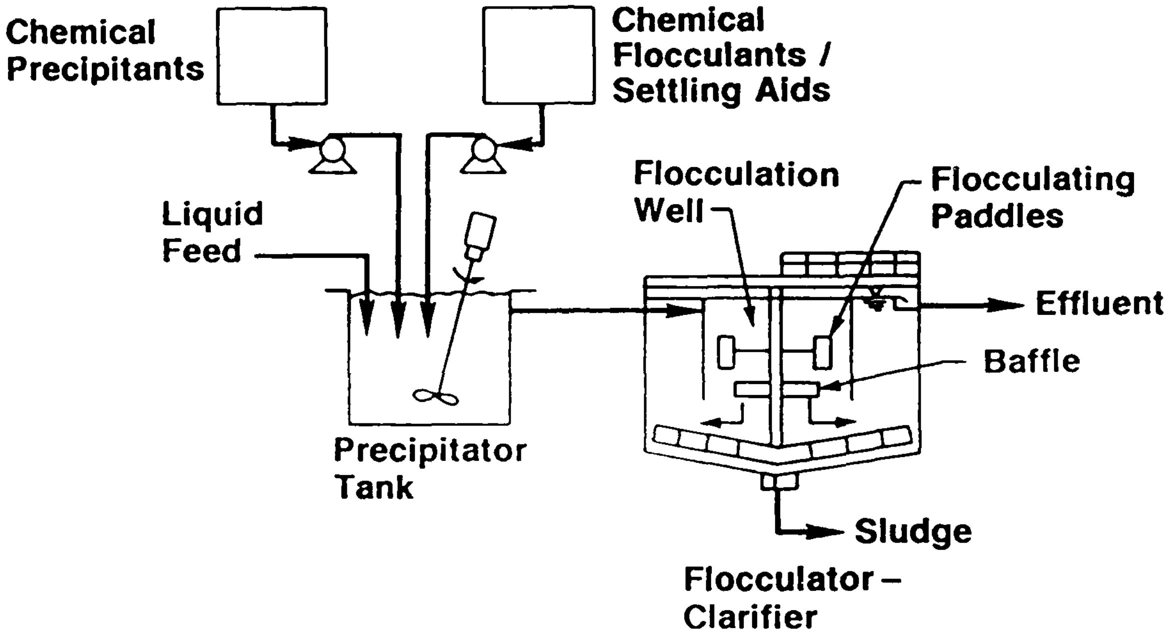
Brief Description: Chemical precipitation facilitates removal of dissolved metals from aqueous wastes by chemically converting the metals into insoluble salts. Metals may be precipitated from solution as hydroxides, sulfides, carbonates, or other salts. Hydroxide precipitation with lime is most common; however, sodium sulfide is sometimes used since it can result in lower effluent metal concentrations. Solids separation is effected by standard flocculation/coagulation techniques. The resulting residuals are a metal sludge, the treated effluent with an elevated pH, and, in the case of sulfide precipitation, excess sulfide.

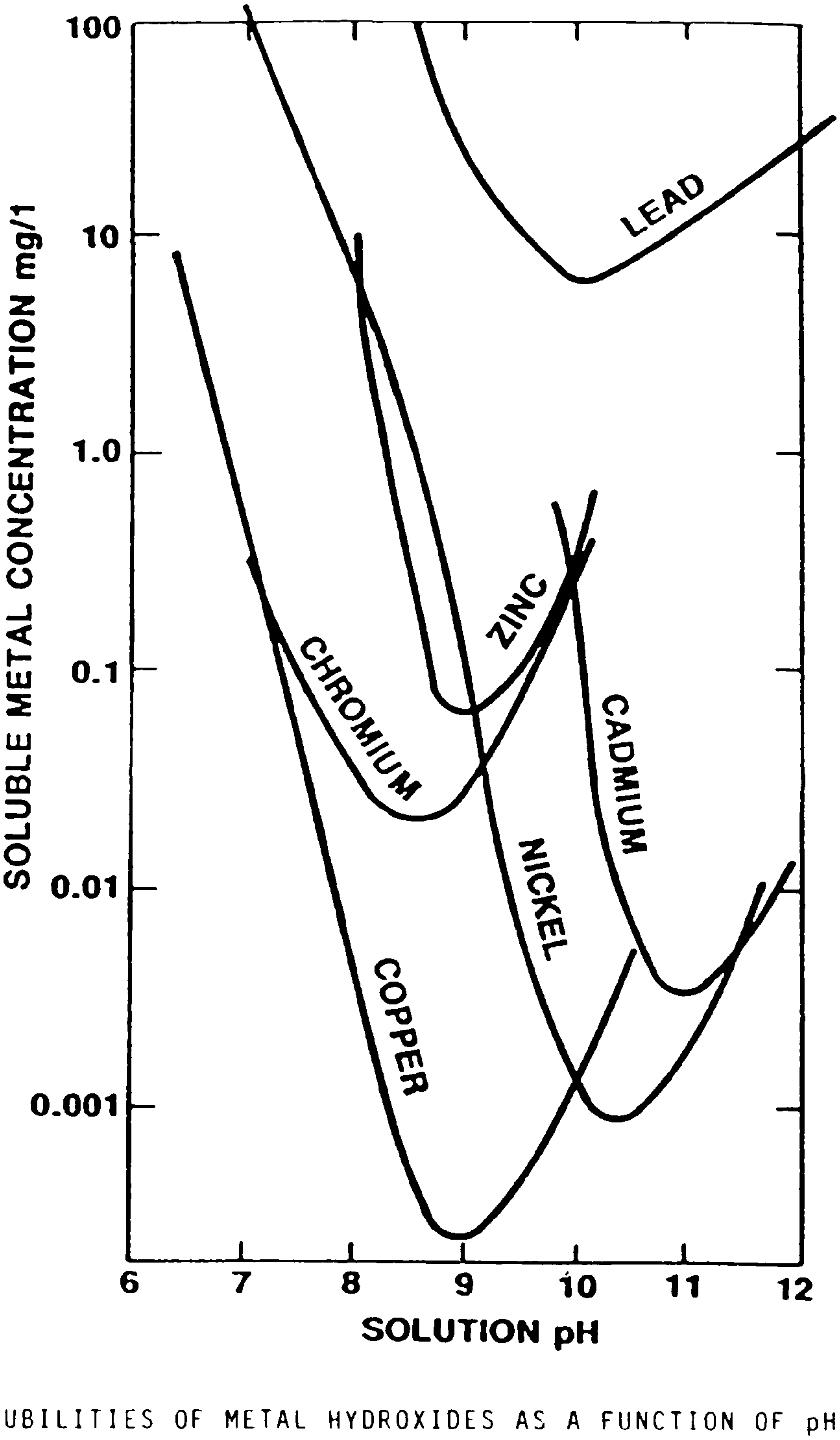
Applicability/Limitation: This technology is used to treat aqueous waste-containing metals including zinc, arsenic, copper, manganese, mercury, cadmium, trivalent chromium, lead, and nickel. Selective precipitation of barium as barium sulfate and silver as silver chloride are other applications. Limitations include achieving an optimum pH for the mix of metals and chelating or complexing agents present. Organics are not removed except through absorptive carryover.

Availability: commercially available

Manufacturer: Mobile systems - Rexnord CRIG, Richard Ostawski
(414) 643-2762 Ecolochem, Inc., Richard Smalwood (800) 446-8004
Dravo Corporation, Ogden Clemons, (412) 777-5235

CHEMICAL PRECIPITATION AND ASSOCIATED PROCESS STEPS





SOLUBILITIES OF METAL HYDROXIDES AS A FUNCTION OF pH

TECHNOLOGY: DISTILLATION

Status: T0

Brief Description: Distillation is a combination of the processes of evaporation followed by condensation, wherein separation of volatile materials can be optimized by controlling both the evaporation-stage temperature (and pressure) and the condenser temperature. Distillation separates miscible organic liquids for solvent reclamation and waste volume reduction. The resulting residuals are still bottoms and intermediate distillate cuts. Two major types of distillation processes are batch distillation and continuous fractional distillation.

Applicability/Limitation: This process is used to treat liquid organic wastes. These are primarily spent solvents, either halogenated compounds, such as 1,1,1-trichloroethane degreasing solvent, or nonhalogenated compounds, such as a methyl-ethyl ketone solvent mixture from paint line clean-out. Liquids to be separated must have different volatilities. The limitations are heat-sensitive suspended solids and azeotropes. Batch distillation in a heated sill pot with condensation of the overhead vapors is easily controlled and flexible but cannot achieve the high product purity of continuous fractional distillation. Small packaged batch stills treating one drum per day or less are becoming popular for on-site recovery of solvents. Continuous fractional distillation is accomplished in tray columns or packed towers ranging up to 40 ft in diameter and 200 ft high. Each is equipped with a reboiler, condenser, and accumulator. The capacity of a unit is a function of the waste being processed, purity requirements, reflux ratio, and heat input.

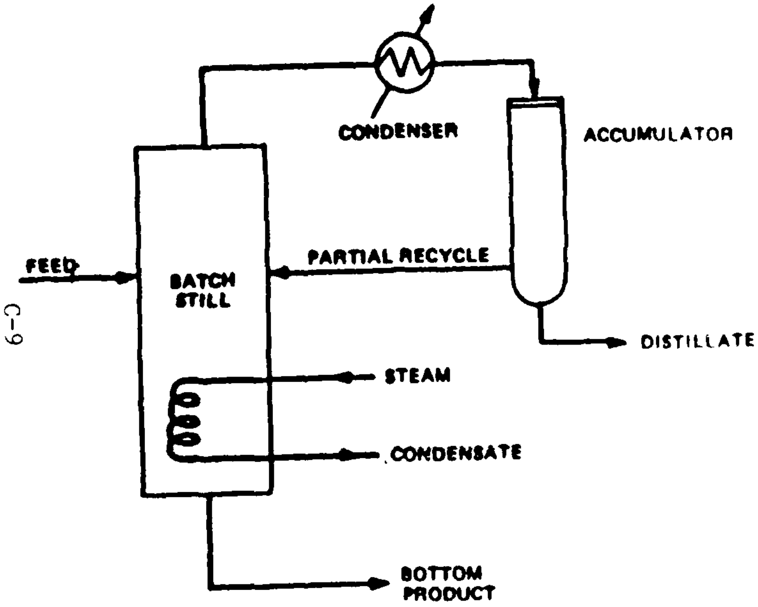
Availability: Commercially available

Manufacturer: Exceltech, Inc., John Sedwick, (415) 659-0404
Kipin Industries, Peter Kipin, (412) 495-6200
Mobile Solvent Reclaimers, Inc., Larry Lambing, (816) 271-4392

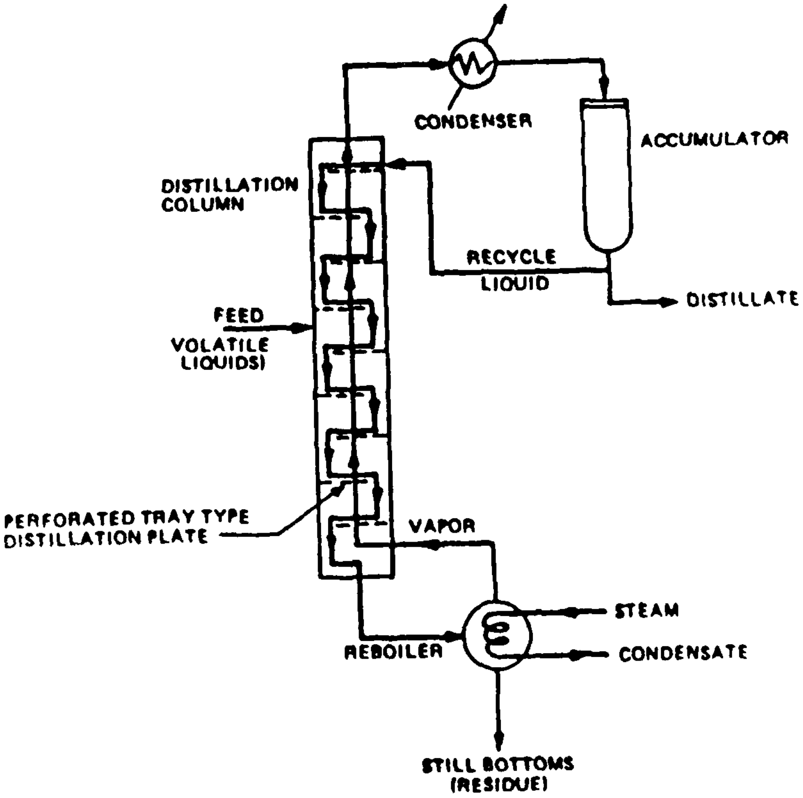
TECHNOLOGY: ELECTRODIALYSIS

Status: T1

Brief Description: Electrodialysis concentrates or separates ionic species contained in a water solution. In electrodialysis,



BATCH DISTILLATION



CONTINUOUS FRACTIONAL DISTILLATION

a water solution is passed through alternately placed cation-permeable and anion-permeable membranes. An electrical potential is applied across the membrane to provide the motive force for the ion migration. The ion selective membranes are thin sheets of ion exchange resin reinforced by a synthetic fiber backing.

Applicability/Limitation: The process is well established for purifying brackish water and recently has been demonstrated for recovery of metal salts from plating rinse. EPA tests confirm the applicability of electrodialysis for recovery of plating solutions.

Availability: Units are being marketed to reclaim metals of value from rinse streams. The units can be skid mounted and require only piping and electrical connections (Centec Corporation, 1979)

TECHNOLOGY: ELECTROLYTIC OXIDATION

Status: T1

Brief Description: In this process, electrodes are immersed in a tank containing the waste to be oxidized, and a direct current is imposed. The process is particularly applicable to cyanide-bearing waste that may also contain ammonia, urea, and carbon dioxide. During the electrochemical reaction, metals present are plated out at the cathode.

Applicability/Limitation: The process is used to treat high concentrations (up to 10 percent) of cyanide and separate metals to allow their potential recovery. Limitations include the physical form (such as sludge or solids), nonselective competition with other species, and long-process times at up to 200° F. Electrolytic recovery of single metal species can be high (90 percent and higher).

Availability: Commercially available

TECHNOLOGY: EVAPORATION

Status: T0

Brief Description: Evaporation is the physical separation of a liquid from a dissolved or suspended solid by the application of energy to volatilize the liquid. In hazardous waste treatment, evaporation may be used to isolate the hazardous material in one of the two phases, simplifying subsequent treatment. If the hazardous material is in the volatilized phase, the process is usually called "stripping."

Applicability/Limitation: Evaporation can be applied to both aqueous and organic solvent wastes where the contaminants are nonvolatile solids, provided the liquid is volatile enough to evaporate under reasonable heating or vacuum conditions. (Both the liquid and the solid should be stable under those conditions.) If the liquid is water, evaporation can be carried out in a large pond with solar radiation providing the energy. Evaporation of aqueous wastes can also be conducted in closed-process vessels with the energy provided by steam and the resulting water vapor condensed for possible reuse. Energy requirements are usually minimized by such techniques as vapor recompression or multiple-effect evaporators. Evaporation is applied to solvent wastes contaminated with nonvolatile impurities, such as oil, grease, paint solids, or polymeric resins. Mechanically agitated or wiped, thin-film evaporators are used. Solvent is evaporated and recovered for reuse. The residue is the bottoms stream, typically containing 30 to 50 percent solids.

Availability: Commercially available

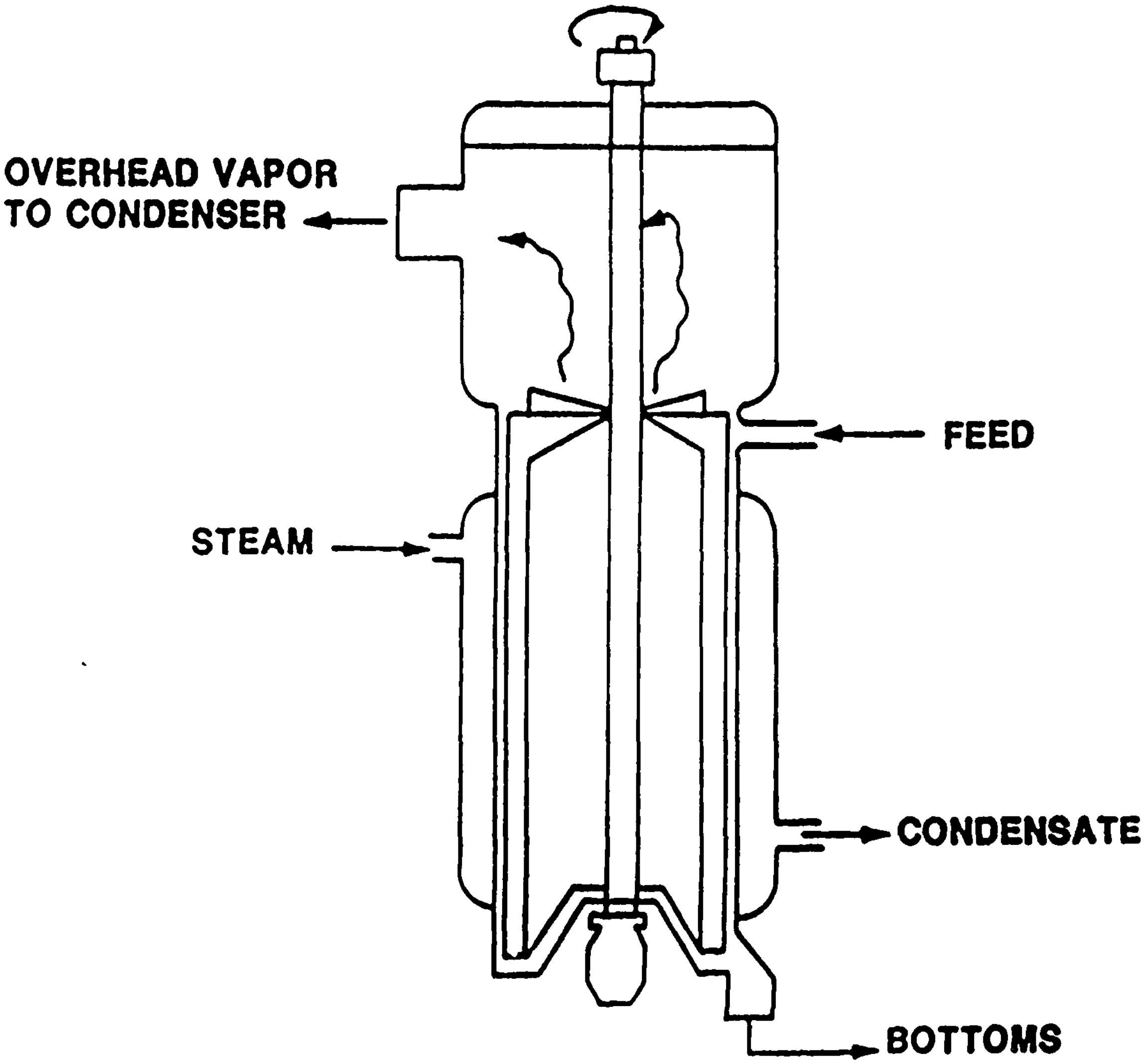
Manufacturer: Resources Conservation Company, (Mobile Brine Concentration Systems), Bellevue, Washington

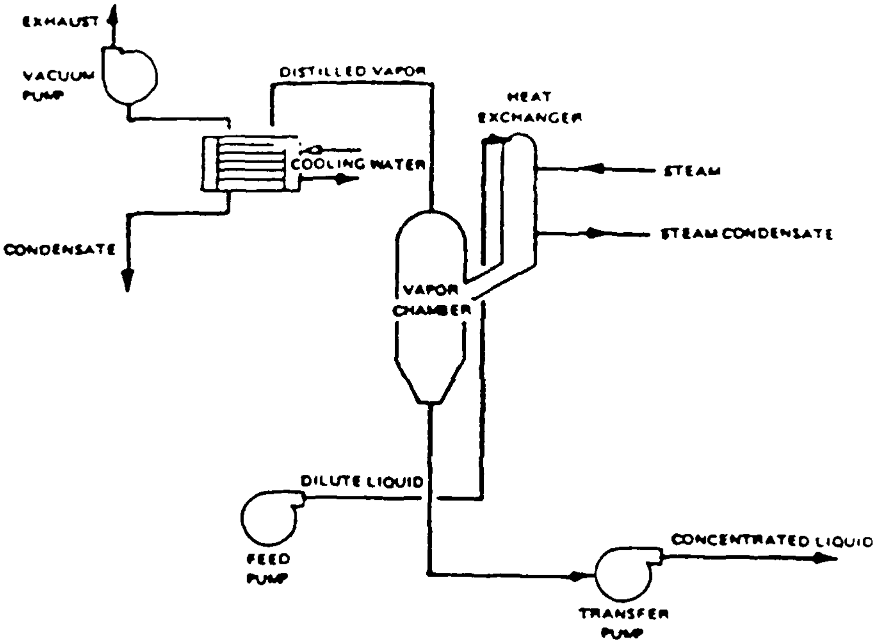
TECHNOLOGY: FILTRATION

Status: TO

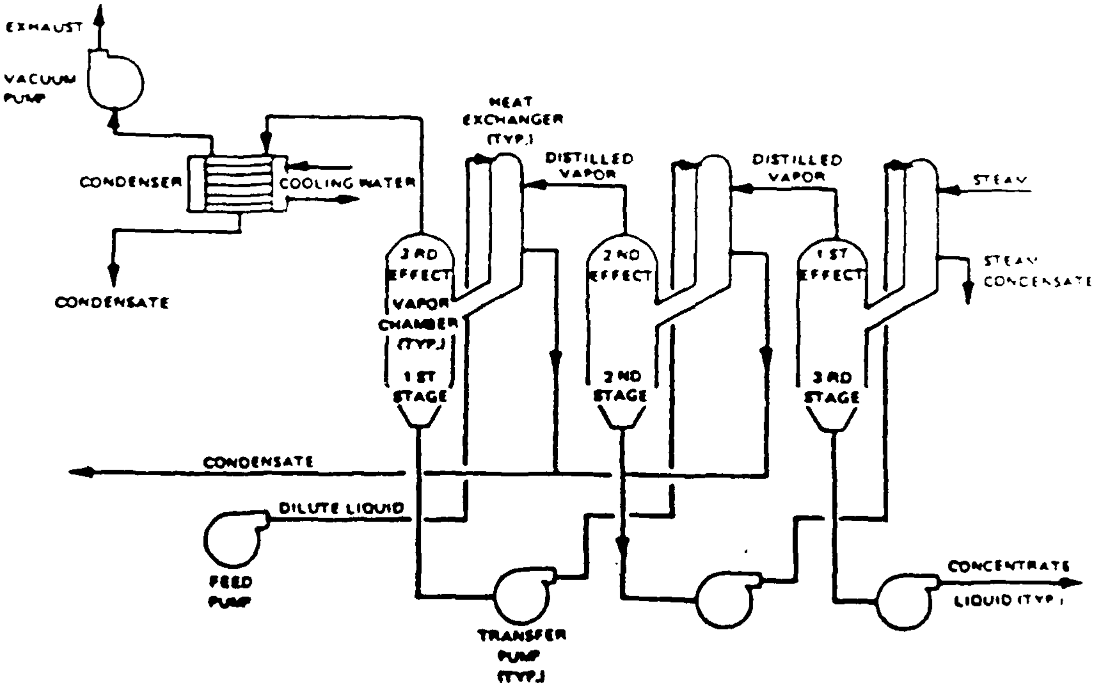
Brief Description: Filtration is a process of separating and removing suspended solids from a liquid by passing the liquid through a porous medium. The porous medium may be a fibrous fabric (paper or cloth), a screen, or a bed of granular material. Fluid flow through the filter medium may be accomplished by gravity, by inducing a partial vacuum on one side of the medium, or by exerting a mechanical pressure on a dewaterable sludge enclosed by filter media.

WIPED FILM EVAPORATOR





Typical Single Effect Evaporator - Falling Film Type



Typical Multi-Effect (Triple Effect) Evaporator - Falling Film Type

SCHEMATIC OF SINGLE AND MULTIPLE EFFECT EVAPORATORS

Applicability/Limitation: Filtration processes are the most common of all dewatering methods in use in the waste treatment industry. The pore size of the filter medium must be selected to capture the suspended solids without itself becoming clogged (blinded). Liquid/solid mixtures usually require some form of pretreatment to maximize the effectiveness of the filtration process. Such pretreatment may include chemical treatment to precipitate dissolved solids, the addition of flocculants to increase the effective size of the solid particles, and the coating of filter fabrics to aid in filter cake removal. Solids content of the resultant filter cake can range from 10 percent up to almost 45 percent when separating fibrous solids using a cone press. Suspended solids removal efficiencies should be higher than 90 percent in a properly designed and operated filter system.

Availability: All forms of filtration processes are in common use in industrial and municipal waste treatment applications.

Manufacturer: Several; see buyer's guides in trade journals.

TECHNOLOGY: FUEL BLENDING

Status: T0 and T1

Brief Description: This is a method to reuse waste organics as fuel substitutes. The objective of this process is the controlled blending of segregated wastes of known characteristics into a fuel product with chemical and physical characteristics that meet the fuel specifications of the fuel user.

Applicability/Limitation: The process is used to combine waste oils, solvents, and organic sludges to produce a material with a fuel value usually greater than 10,000 Btu/lb. Limitations include the chlorine and water content, the waste viscosity, and the need for low solids. In addition, the presence of certain hazardous constituents (such as PCBs) and the corrosiveness of the waste can be limiting criteria for certain wastes.

Availability: In use for lime and cement manufacturing, process heating, and blast furnace operation, where permitted.

TECHNOLOGY: HEAVY MEDIA SEPARATION

Status: T1

Brief Description: Heavy media separation is a process for separating two solid materials that have significantly different absolute densities. The mixed solids to be separated are placed into a fluid with a specific gravity chosen (or adjusted) to allow the lighter solid to float while the heavier sinks. Usually, the separating fluid (the heavy media) is a suspension of magnetite in water. The specific gravity of the fluid is, thus, adjustable by varying the amount of magnetite powder used. Magnetite can be easily recovered magnetically from rinsewaters and spills and then reused.

Applicability/Limitation: It is readily used for separating two insoluble solids having different densities. Limitations include the possibility of solids dissolving and ruining the heavy media, the presence of other solids of similar density, and the inability to separate magnetic materials cost-effectively (because of the need to recover magnetite). The process can probably can be used to separate and recover used blasting grit.

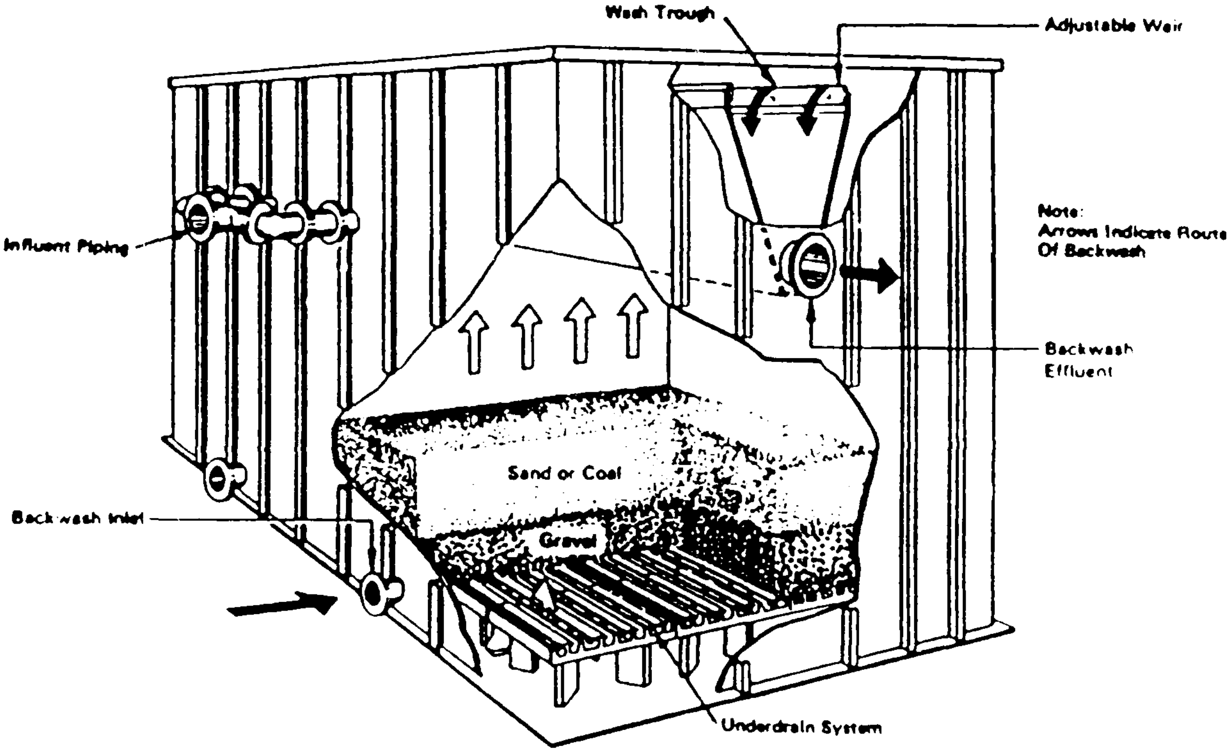
Availability: Commonly used in the mining industry to separate ores from tailings.

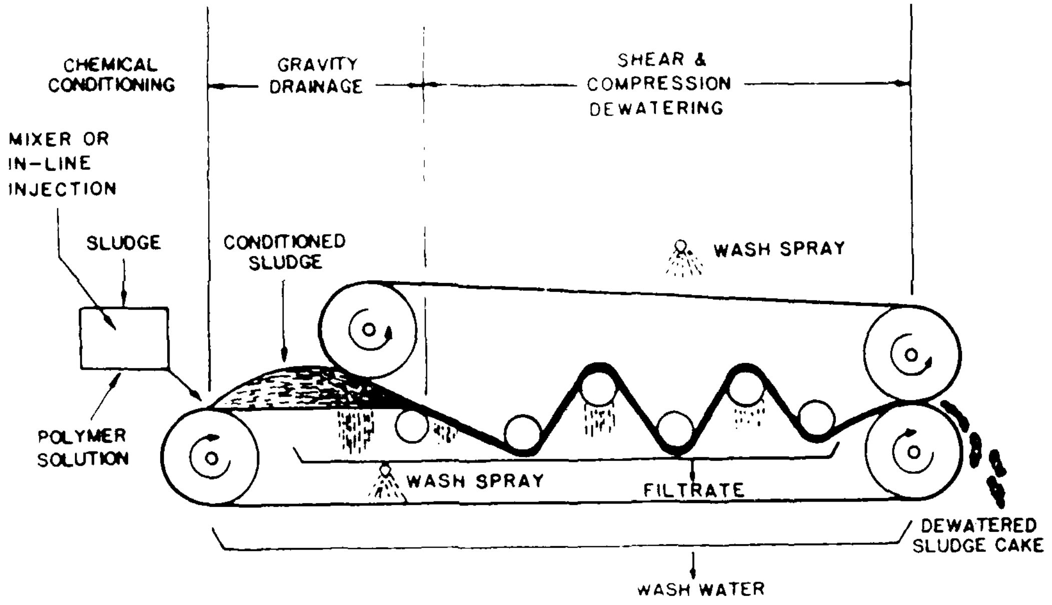
TECHNOLOGY: ION EXCHANGE

Status: T1

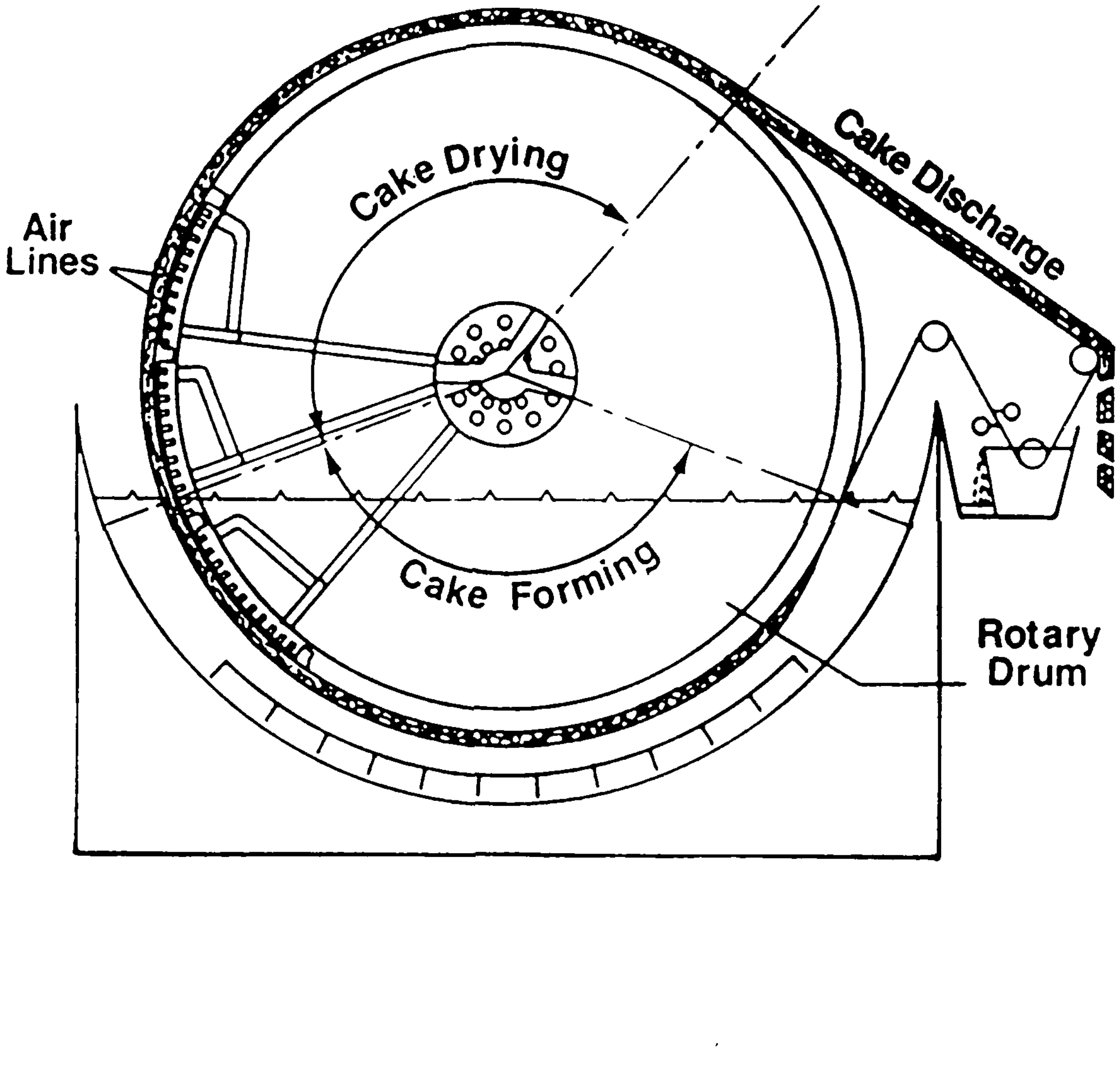
Brief Description: Although there are naturally occurring ion exchange media, the process is usually based upon the use of specifically formulated resins having an "exchangeable" ion bound to the resin with a "weak ionic" bond. Ion exchange depends upon the electrochemical potential of the ion to be recovered versus that of the exchange ion. It also depends upon the concentration of the ions in solution. After a critical relative concentration of "recoverable" ion to exchanged ion in solution is exceeded, the exchange resin is said to be "spent." Spent resin is usually recharged by exposing it to a very concentrated solution of the original exchange ion. This causes a "reverse" exchange to take place, producing regenerated resin and a concentrated solution of the removed ion, which can then be further processed for recovery and reuse. The process is commonly used to remove toxic metal

PACKAGED GRANULAR MEDIA GRAVITY FILTER

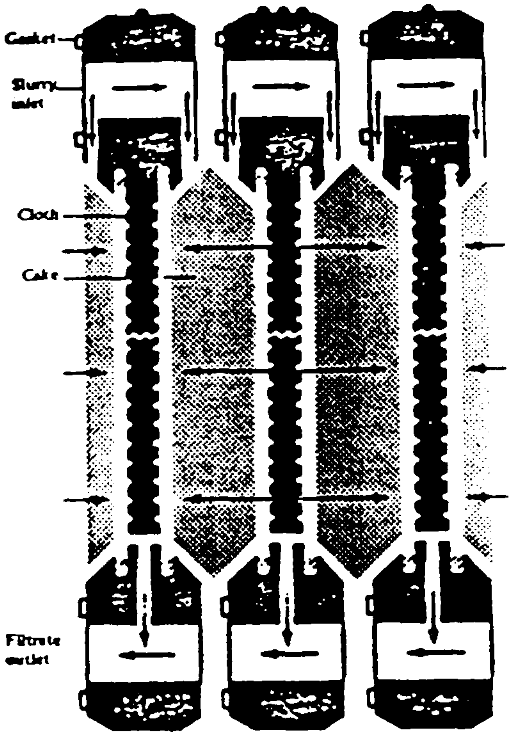



CHEMICAL CONDITIONING
GRAVITY DRAINAGE
SHEAR & COMPRESSION DEWATERING
MIXER OR IN-LINE INJECTION
SLUDGE
CONDITIONED SLUDGE
WASH SPRAY
POLYMER SOLUTION
WASH SPRAY
FILTRATE
DEWATERED SLUDGE CAKE
WASH WATER

BELT PRESS



VACUUM FILTER



FILTER PRESS UNIT

ions from solution to recover concentrated metal solutions for recycling. The resulting residuals include spent resins and spent regenerants, such as acid, caustic, or brine.

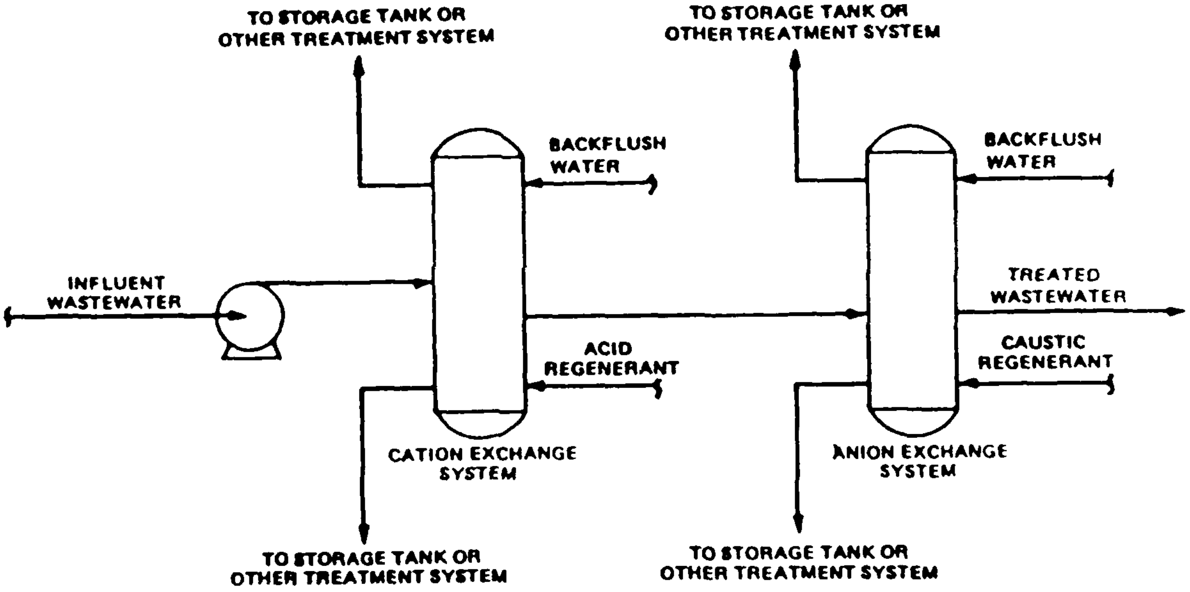
A specialized ion-exchange process developed by DeVoe-Holbein, Inc., is a method of metal extraction from relatively clean wastes. Ion exchange is used to extract specific metals from solution. To date, some 30 synthetic "metal loving" compositions of resins that attract specific metals have been developed. The method of attraction employed by the synthetic compositions is similar to that of living cells. Natural cells have a built-in survival mechanism that is highly selective for the capture and transport of certain metals necessary for cellular nutrition, specifically iron, cobalt, zinc, copper, sodium, nickel, potassium, magnesium, and manganese. The synthetic compounds are patterned after the high efficiency and natural metal extraction capability of living cells.

Each of the 30 synthetic compositions developed by DeVoe-Holbein is capable of extracting a different metal from the solution treated. A major feature of the process is that both the composition and the extracted metal can be recovered and reused. Recoverability can greatly reduce the cost of the process. Regeneration of compositions reduces the operating cost of the system, and the recovered metals help offset the cost of owning/operating the system. The technology can function as either an independent waste treatment center or in conjunction with other processes for the recovery of certain metals before treatment. The technology is applicable mainly for treating wastes in the metal finishing operations, such as those involved in electroplating. These industries produce mainly dilute wastes containing certain metals. The company has developed synthetic compositions that can effectively capture nearly 100 percent of the cadmium, chromium, copper, and zinc present in industrial wastes.

<u>Applicability/Limitation</u>: This technology is used to treat metal wastes including cations (Ni^{2+}, Cd^{2+}, Hg^{2+}) and anions (CrO_4^{2-}, SeO_4^{2+}, $HAsO_4^{2-}$). Limitations are selectivity/competition, pH, and suspended solids. The oxidizing agent concentration should be greater than 50 meq/l for practical operation. Highly concentrated waste streams (>2500 mg/l contaminants) or high solid concentrations (>50 mg/l) should be avoided.

<u>Availability</u>: Commercially available

<u>Manufacturer</u>: Calgon, Dionex DeVoe-Holbein



SCHEMATIC OF ION EXCHANGE

TECHNOLOGY: METAL RECLAMATION USING COUPLED TRANSPORT

Status: T2

Brief Description: The coupled transport system is essentially an immobilized-liquid membrane process that allows certain metals to be selectively extracted from a solution containing various other metals. This process uses an inert, microporous support that has been impregnated with a water-miscible liquid ion exchange resin; the agent is held in the pores of the support material by capillary forces. When the membrane contacts an aqueous solution containing metal ions, the membrane exchanges for ions of like charge, thereby extracting the metal contaminant from solution.

A flow of hydrogen ions across the membrane is the most important force in the coupled transport system. The aqueous solutions on either side of the membrane must therefore be maintained at different pH values. Ions of the metal selected for extraction (e.g., copper) are transported from the higher pH solution to the lower, and hydrogen ions travel in the opposite direction. Amphoteric metals exhibit rather complicated behavior in these systems and must be dealt with in a correspondingly involved manner with respect to pH control.

Coupled transport technology offers several advantages over other ion exchange processes currently available. For example, the coupled transport membrane requires very little ion exchange agent because site availability is molecular not matrical, and since liquid ion exchange agents are often very expensive, it offers lower costs from that point of view.

Feed pretreatment, especially the removal of suspended solids, is expected to be minimal, but this depends upon the content of solids in site-extracted waste streams.

The manner in which the membranes are modularized has a strong bearing on both the operation and economics of the process. Bend Research recommends a hollow-fiber membrane module configuration. The microporous fibers in these modules are made of polysulfone, a chemically resistant thermoplastic. A feed solution flows through the fiber, and product solution flows along the outside during operation. The organic complexing agent is held in the porous fiber walls, while metal ions are transported from the inner to the outer fiber walls.

The process train includes acid leaching of sludge, as a first step, followed by the exchange process and electrolytic extraction of the exchange-concentrated solutions.

Applicability/Limitation: The operating cost estimates depend to a significant degree upon the useful life of the exchange membrane, especially when applied to actual mixed wastes, as found in the field. Laboratory results have confirmed lifetimes in the order of two years. The copper and zinc membranes have lasted less than one year in the laboratory study application.

Other major costs are chemicals, disposal of residue as a potential hazardous waste, and power. Sulfuric acid is used for sludge dissolution (leaching), regeneration of the ion exchange resin, and conversion of chromium (where applicable). Even with a conservative cost estimate, the payoff period could be as low as two years.

Availability: The reclamation process has not been tested on anything beyond the lab scale, but the process is likely to be successful on properly extracted and pretreated solutions, since electrolytic aspects of the technology have been amply demonstrated in the past.

Manufacturer: Bend Research

TECHNOLOGY: NEUTRALIZATION

Status: TO

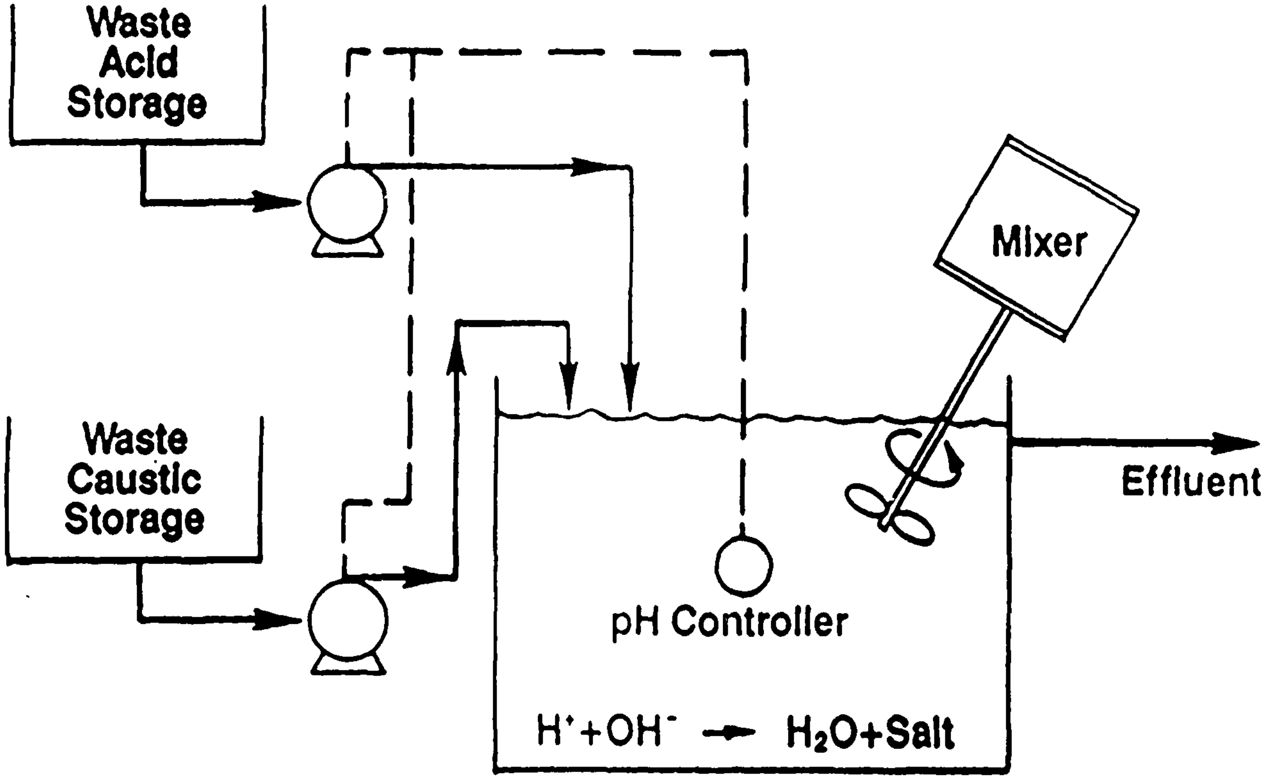
Brief Description: Renders acid or caustic wastes noncorrosive by pH adjustment. Operators usually try to use wastes to treat other wastes; e.g., using spent pickle liquor to neutralize waste caustic. The resulting residuals are neutral effluent and dissolved salts.

Applicability/Limitation: This process is used to treat corrosive wastes, acids, and bases. Limitations include the concentration (because of the heat of the exothermic reaction), the physical form (such as sludges or solids), and the need for corrosion-resistant equipment.

Availability: Commercially available

Manufacturer: Newpark Waste Treatment Systems, Inc., James Hobby, (419) 586-6683; Solid Tek Systems, Inc., (404) 361-6181; Ecolochem, Inc., Richard Smallwood, (800) 446-8004; CECOS, Ernest C. Neal, (716) 873-4200

SIMULTANEOUS NEUTRALIZATION OF ACID AND CAUSTIC WASTE



TECHNOLOGY: OZONATION

Brief Description: Ozone is an oxygen molecule containing three oxygen atoms. It is relatively unstable and, thus, is chemically ideal as an oxidizing agent. Ozonation is a chemical oxidation process appropriate for aqueous streams that contain less than 1.0 percent oxidizable compounds.

Applicability/Limitation: Ozone can be used as a pretreatment for wastes to break down refractory organics or as a polishing step after biological or other treatment processes to oxidize untreated organics. Ozone is currently employed for treatment of hazardous wastes to destroy cyanide and phenolic compounds. Ozone is usually produced by high-voltage ionization of atmospheric oxygen. The rapid oxidation of cyanides with ozone offers advantages over the slower alkaline chlorination method. Limitations include the physical form (i.e., sludges and solids) and nonselective competition with other species.

Availability: Commercially available

Manufacturer: See buyer's guides or trade journal.

TECHNOLOGY: SUPERCRITICAL EXTRACTION

Status: T2

Brief Description: At a certain combination of temperature and pressure, fluids reach their critical point, beyond which their solvent properties are greatly altered. These properties make extraction more rapid and efficient than processes using distillation and conventional solvent extraction methods. Presently, the EPA is investigating the use of supercritical carbon dioxide to extract hazardous organics from aqueous streams. The National Bureau of Standards is investigating the potential of various fluids to serve as supercritical extractive solvents.

Applicability/Limitation: This technology is potentially useful to extract hazardous waste from the aqueous streams. It is limited at this time, since it is new and it appears that the capital cost is high.

Availability: Laboratory tests only

TECHNOLOGY: ULTRAVIOLET PHOTOLYSIS

Status: T2

Brief Description: Ultraviolet photolysis is a process that destroys or detoxifies hazardous chemicals in aqueous solutions by employing UV irradiation. Absorption of energy in the UV spectrum results in a molecule's elevation to a higher energy state, thus, increasing the ease of bond cleavage and subsequent oxidation of the molecule.

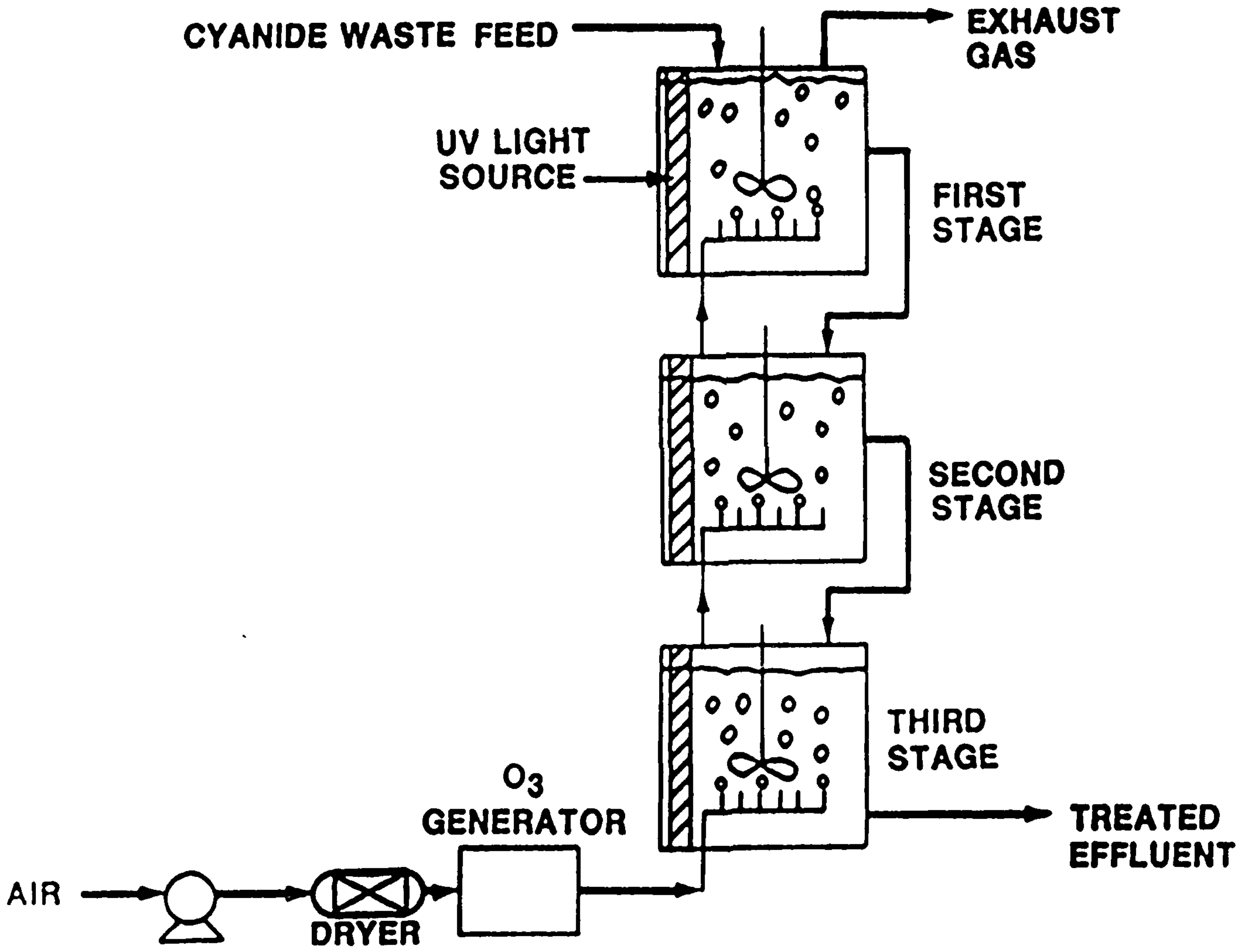
For example, ultraviolet light has been used for degradation of dioxins in waste sludge. This process requires extraction of the waste to be destroyed into a clean transparent solvent. Reaction products are dechlorinated materials and free-chlorine gas. Use of UV photolysis on nitrated wastes has been successfully demonstrated on a pilot scale.

Applicability/Limitation: The inability of UV light to penetrate and destroy pollutants in soil or in turbid or opaque solutions is a limitation of this approach. Photolysis can be enhanced by simultaneous introduction of ozone or hydrogen peroxide.

Availability: Laboratory scale

Manufacture: SYNTEX

UV – ENHANCED OZONATION FOR CYANIDE DESTRUCTION



APPENDIX D

INCINERATION AND THERMAL DESTRUCTION PROCESSES

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INCINERATION AND THERMAL DESTRUCTION PROCESSES

Thermal destruction is often a highly desirable disposal system in that wastes "disappear" from the RCRA universe and thus, from the potential for future liability and litigation. New EPA guidelines will probably direct that wastes be banned from land disposal and incinerated as the first alternative. While limits exist for specific incineration technologies, there are no a priori technical limitations on incineration for any wastes; i.e., any waste can be burned at some cost. Under the regulations, the Navy party responsible for disposal is also responsible for ensuring that each waste goes to an appropriate incinerator technology. Thermal destruction processes include several energy recovery processes, traditional incineration processes and several innovative thermal processes.

ENERGY RECOVERY PROCESSES:

- o Use as Fuel in Blast Furnaces
- o Use as Fuel in Kilns
- o Use as Fuel in Boilers

TECHNOLOGY: USE OF WASTE AS FUEL IN FERROUS BLAST FURNACES

Status: T1

Brief Description: Blast furnace temperatures may reach up to 3400° F and are generally above 3000° F. High-heat-content hazardous wastes can be used to supplement coke and other fuel requirements for blast furnaces. A blast furnace produces molten iron from iron ore and other iron-bearing feed materials. Iron ore, carbon (coke), and limestone feed to the top of the furnace and iron product and slag are removed in different layers from the bottom. Hazardous waste fuel (HWF) can be injected just above the slag layer.

Applicability/Limitation: Composition (trace elements) of hazardous waste fuel (HWF) must be controlled to avoid product quality problems. Waste oils were fired in blast furnaces in Hazardous Waste Engineering Research Laboratory (HWERL) test programs.

Availability: There are fewer than 80 blast furnaces currently operating in U.S.

Manufacturer: N/A

TECHNOLOGY: USE OF WASTE AS FUEL IN INDUSTRIAL KILNS

Status: T1

Brief Description: Rotary kilns are constructed of steel casings lined with refractory brick. Blended feed material is fed into the upper (higher) end of the kiln, and fuel (coal, gas, oil, or hazardous waste) is fired at the lower end. Kiln temperatures are about 3000° F for lime kilns and less than 2000° F for aggregate- and clay-drying kilns. Hazardous waste fuel usually fired into kiln with separate burner other than primary fuel. Waste blending may be necessary to obtain the desired fuel characteristics.

Applicability/Limitation: It is generally limited to liquid waste. The chlorine and sulfur content of the waste fuel must be controlled to prevent kiln-operating and product-quality problems. Contaminated soils are not good candidates for treatment in industrial kilns.

Availability: There are 280 cement and lime kilns, but use of hazardous waste fuel is not widespread. At least three cement kilns now burn HWF as supplemental fuel.

Manufacturer: Various manufacturers. Kilns are field constructed.

TECHNOLOGY: USE OF WASTE AS FUEL IN INDUSTRIAL BOILERS

Brief Description: Hazardous waste is used as supplementary fuel to coal, oil, or natural gas in fire-tube and water-tube industrial boilers. HWF, which is generally limited to liquid wastes, can be blended with primary fuel and fired in a boiler with primary fuel, or it can be fired alone through other burners. The heat release rate of boilers that have been tested with HWF ranges from 100 to 800 x 10^3 Btu/ft^3/hr.

Applicability/Limitation: Chlorine and sulfur must be limited in HWF to minimize corrosion of boiler construction materials and to avoid increases in HCl and sulfur oxide air emissions. Solid hazardous wastes, such as contaminated soils, are not applicable for use as HWF in boilers. The process is particularly useful for the disposal of hazardous wastes generated on-site.

Availability: Only a small fraction of the nation's 23,000 fossil-fueled boilers are in use burning HWF.

Manufacturer: Various manufacturers. May be package units or field constructed.

INCINERATION PROCESSES:

- o Fluidized Bed
- o Infrared Systems
- o Rotary Kiln
- o Wet-air Oxidation

TECHNOLOGY: FLUIDIZED BED INCINERATION

Status: T1

Brief Description: The fluidized bed system consists of an inert or chemically reactive material that is similar to sand in form and consistency. This bed material is placed in the lower portion of a vessel just above a porous floor. Pressurized air is then injected through the porous floor and disperses evenly throughout the bed material. This causes the bed material to expand and become suspended. The suspended materials behave like a pot of boiling water, moving turbulently and chaotically within the combustor. This mixing and constant interaction of bed material and waste improves heat transfer.

A typical fluidized bed system would be used to treat sludge. An incinerator with a refractory lining is sized to provide a one-second residence time for the fluidizing gas and combustion products. This is done before entering the high-temperature cyclone. A fluidizing fan with an in-line preheat burner is used to provide fluidizing and combustion air. Once the combustion temperature is reached, the burner is turned off and the waste injection can begin. Wastes are pumped into the incinerator via several injection systems. Auxiliary fuel is injected directly into the bed.

The fluidized bed system is capable of treating a wide variety of hazardous wastes. Solids, sludges, slurries, and liquids can all be treated with this system, although it is not very economical to treat liquids with a fluidized bed. All inorganic wastes larger in size than the bed material, such as rocks and metal filings, are removed from the incinerator during operation. This is accomplished by a screening and recycling system. Clean bed media is then reintroduced into the combustion chamber. Flue gases and wash ash are sent from the combustion chamber to the hot cyclone in order to remove particulate matter. The scrubber also neutralizes acidic vapors in the flue gas. Finally, the flue gas is neutralized in a packed scrubbing tower.

A number of different feed systems can be attached to the basic incinerator. The proper feed system depends upon the mixture of solids and sludges being treated.

Applicability/Limitation: A fluidized bed pilot unit was used to test the operating capability of the system. Chemical compounds, as well as actual wastes, were tested by Waste-Tech in their pilot incinerator. All of the components tested had destruction efficiencies of at least 99.99 percent, except tetrachlorophenol, which had a destruction efficiency of 99.97 percent. Waste-Tech claims to have destroyed tetrachlorophenol up to 99.99 percent in subsequent experiments by raising the system temperature. One further interesting finding from the pilot-scale testing was that destruction efficiency was found to be inversely related to feed rate.

Availability: Commercially available and presently in use.

Manufacturer: Waste-Tech Services, Inc., Dorr-Oliver, G. A. Technologies

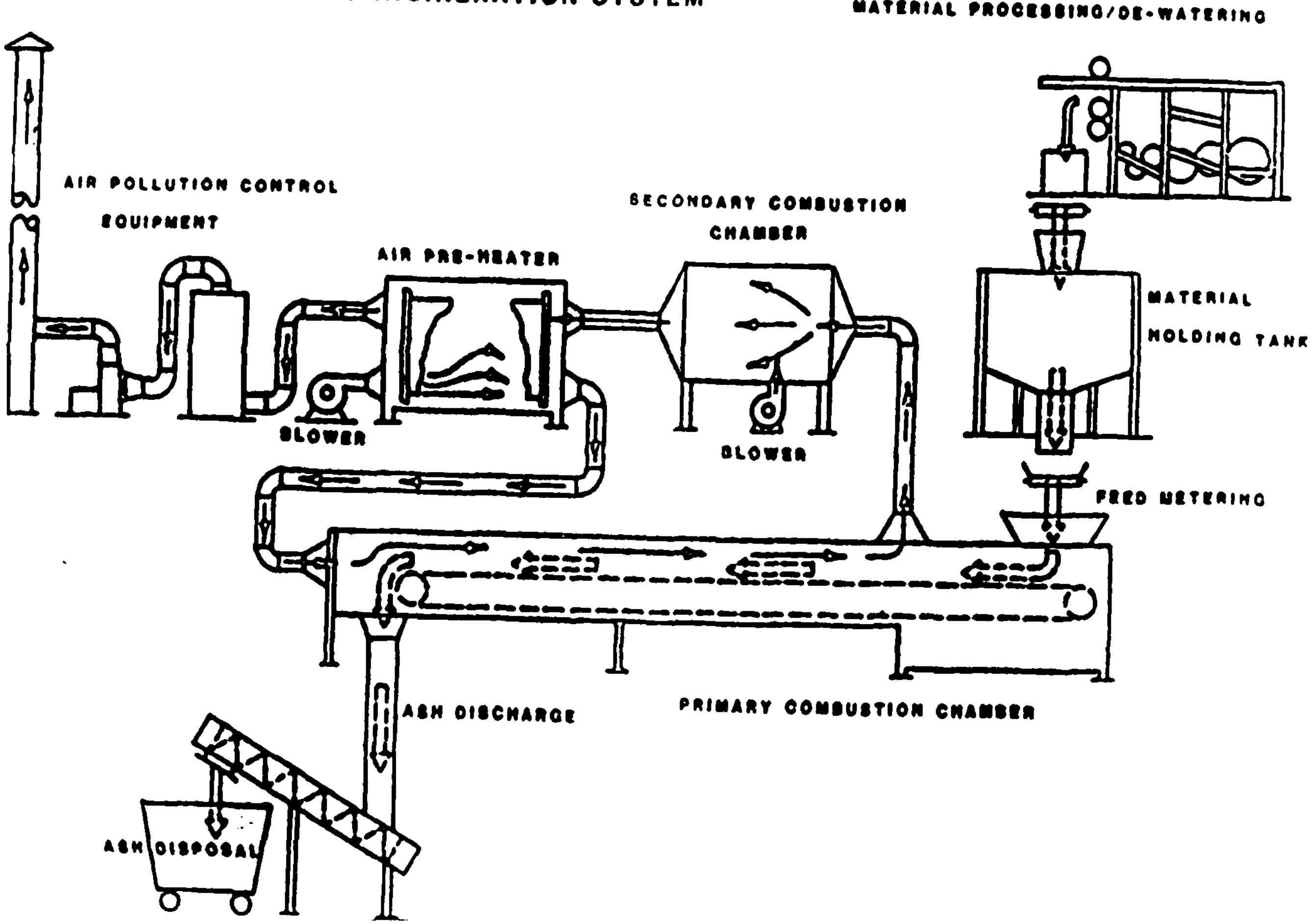
TECHNOLOGY: INFRARED INCINERATION SYSTEMS

Status: T1 - Presently in use for industrial hazardous waste disposal

Brief Description: The primary chamber consists of a rectangular cross section "box" of carbon steel lined with layers of lightweight ceramic fiber blanket. Infrared energy is provided by silicon carbide resistant heating elements. The material to be processed is conveyed through the furnace on a woven wire belt. When the material reaches the discharge end of the furnace, it drops off the belt into a hopper. The residuals are the gaseous products of waste combustion, low particulates, and solid residuals. The advantages include a quiescent combustion zone for low-particulate emissions; reduced gaseous emissions, since no fossil fuel is used; and up to 50-percent turndown. The system also allows a high degree of control, and long residence times are achievable.

Applicability/Limitation: The process is used to treat solids, sludges, and contaminated soils. It is used primarily for solids, but liquid or gaseous injection systems are available.

PROCESS FLOW DIAGRAM
INFRARED INCINERATION SYSTEM



Availability: Operational units at several locations, mobile units under construction, pilot-test unit available.

Manufacturer: Shirco Infrared Systems, Jim Welsh, (214) 630-7511

TECHNOLOGY: ROTARY KILN INCINERATION

Status: T1

Brief Description: Wastes and auxiliary fuel are introduced to the high end of the kiln which is slightly inclined to horizontal. Wastes are oxidized, tumbled and agitated as they move through the kiln due to its rotation thus, enhancing the burnout. Exhaust gases from the kiln pass to a secondary chamber, or afterburner for further oxidation. Ash residues are discharged and collected, from the low end of the kiln. Exhaust gases may require acid gas and particulate removal, and the ashes may require solidification before landfilling.

Applicability/Limitation: Most types of solid, liquid and gaseous organic wastes can be treated with this technology. Wastes with high inorganic salt content and heavy metals as well as explosive wastes require special evaluation.

Availability: Commercially available and in wide use

Manufacturer: S. D. Myers Inc., Joe Isle, (415) 794-6301, American Industrial Waste of ENSCO, Inc., (615) 383-1691; Exceltech, Inc. (415) 659-0404; International Waste Energy System, Dwight Brown, (314) 389-7275; Winston Technology, Inc., (914) 273-6533; Industronics Inc., (203) 289-1551; Volund USA (312) 655-1490; Thermal; TR Systems; C & H Combustion; CE Raymond; Von Roll

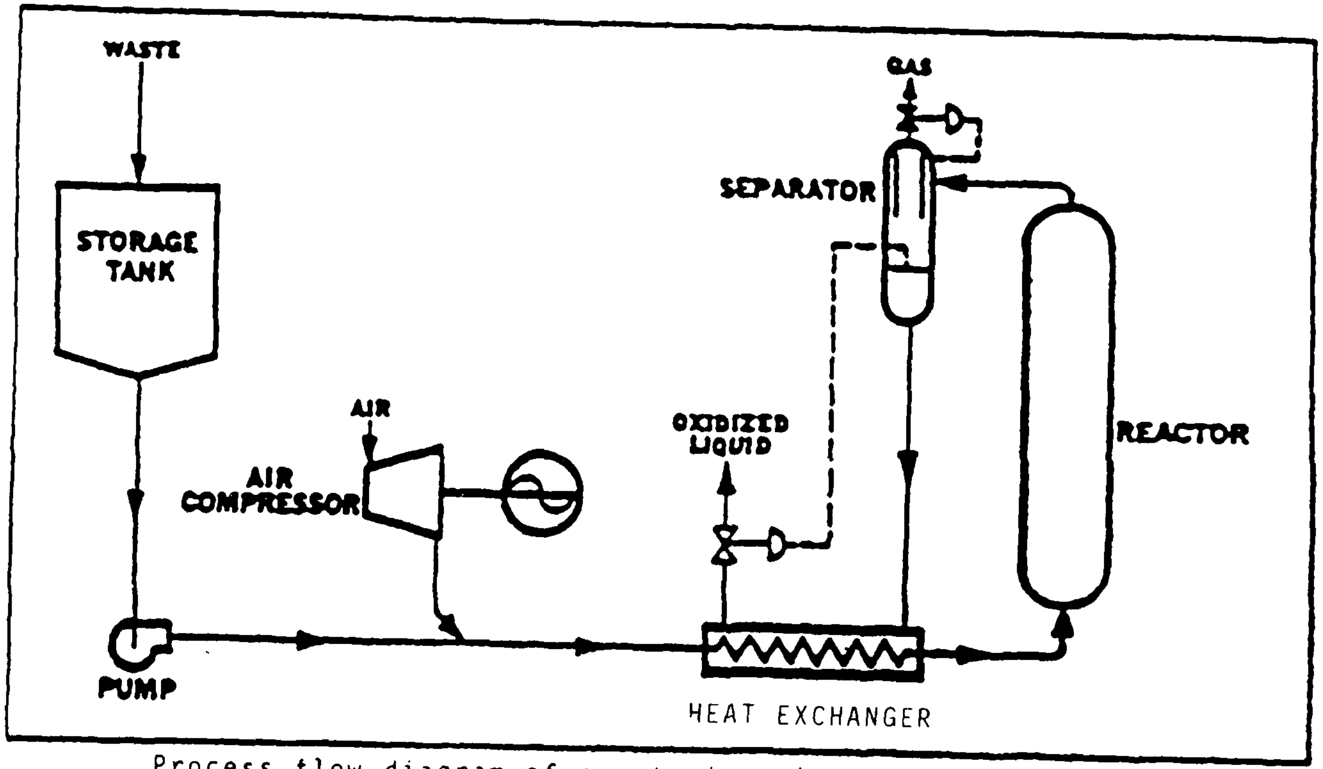
TECHNOLOGY: WET-AIR OXIDATION

Status: T1 - Presently in use for industrial hazardous waste disposal

Brief Description: The process uses elevated temperature and pressure to oxidize organics. The oxidation products and inorganics stay in the liquid. The off-gas is low in nitrogen oxides, sulfur oxides and particulates. Off-gas treatment may be used for hydrocarbon emissions. The advantages are that it is thermally self-sustaining, accepts wastes with organic concentrations between biological treatment and incineration, detoxifies priority pollutants, and maintains the products of oxidation in the liquid phase. Wet air oxidation is particularly well suited for treating organic compounds in aqueous waste streams that are too dilute (<15 percent organics) to treat economically by incineration. Oxidation of the organic compounds occurs when the aqueous solution is heated to about 300° C and 137 atm in the presence of compressed air. Typically, 80 percent of the organic substances will be completely oxidized. The system can accommodate some partially halogenated compounds, but highly chlorinated species, such as PCBs, are too stable for complete destruction without the addition of catalytic reagents. In about 1980, IT Enviroscience, Inc., developed a catalyzed wet-air oxidation process for the destruction of PCBs. Their process is patented and involves the direct oxidation of PCBs by air or oxygen in an acidic aqueous medium at high temperatures. Oils with >500 ppm PCBs can be disposed of in this process. Dioxins are reduced 99 percent in four hours reactor time at 250° F. Inorganic salts, acids, trace metals, and any substance that could cause fouling or corrosion must be eliminated by pretreatment.

Applicability/Limitation: Wet-air oxidation is used to treat aqueous waste streams containing less than 15 percent organics, as well as some pesticides, phenolics and organic sulfur, cyanide wastewaters. It is not recommended for aromatic halogenated organics because it is ineffective. This technology is not economical for concentrated wastes, and it is not appropriate for solids or viscous liquids.

Availability: Available on a commercial scale.
Manufacturer: Zimpro, Inc., William Copa, (715) 359-7211; IT Enviroscience, (615) 690-3211; MODAR, Inc., (617) 655-7741; Methods Engineering, (713) 331-7268; Vertech Treatment Systems, (303 452-8800; Oxidyne, Vern Miller, (214) 991-2452



Process flow diagram of a wet air oxidation process.

THERMAL DESTRUCTION PROCESSES

- Catalyzed Wet Oxidation
- Supercritical Wet Oxidation
- Moving Fluidized Bed Rotary Combustor
- Pyrolysis
- Molten Glass Furnace
- Molten Salt Destructor

TECHNOLOGY: CATALYZED WET OXIDATION

Status: T3

Brief Description: In conventional wet oxidation, heat and pressure are used to drive the dissolution of oxygen from air and the reaction with dissolved organics in aqueous solution. In the bromide-dinitrate-manganese catalyst system, the transfer of oxygen to the dissolved state is speeded by using very rapid gas and liquid reactions associated with the catalyst components. The importance of the enhanced oxygen transfer is the ability to oxidize organics at much lower temperatures than uncatalyzed wet oxidation; i.e., at 165 to 200° C versus 250 to 325° C. The lower operating temperature also means lower operating pressure.

The catalyst system, because of its homogeneous nature, permits application to toxic or hazardous organic residues, such as still bottoms or other organic wastes. The advantages of a homogeneous catalyst are best utilized with a reactor design that is different from the conventional wet-air oxidation process. In its simplest form, the continuously stirred reactor (CSTR), contains the catalyst solution. Air and waste are continuously pumped into the reactor and the organics are oxidized. The only materials to leave the reactor are CO_2, N_2, water vapor, and any volatile organics and inorganic solids formed, and these are oxidized. Water and condensable organics are condensed and returned to the reactor, if necessary, as are condensable organics. Any inorganic salts or acids that may have formed must be removed by treatment of a closed-loop stream of catalyst solution. Such treatment is individually designed employing conventional technologies, such as filtration or distillation. The vent gases from the reactor are low in volume and may, if necessary, be treated by conventional techniques, such as absorption, adsorption, or scrubbing. The most important features of this process concept are that the nonvolatile organics remain in the reactor until they are destroyed, and there is no aqueous bottoms product.

Applicability/Limitation: IT Corporation is currently developing a pilot plant to demonstrate the continuous feed process. The experimental evaluation of catalyzed wet oxidation was conducted in a 1-liter agitated titanium autoclave. More than 200 test runs have been made in the titanium autoclave to record process efficiency on a wide variety of organic compounds, in order to measure the effects of different catalyst combinations. The experiments were limited to batch oxidations, which were started by "shot-loading" the catalysts into the hot reactor containing water, the organic to be oxidized, and oxygen. The organic destruction rates were measured according to the solubility of that particular organic in water. The destruction rate for insoluble organics was determined by terminating the reaction, cooling the material, and solvent extracting the reactor system and catalyst mixture. Next, the solvent was analyzed for unreacted organics and by-products by gas chromatography. Secondary measurements were also made to determine the completeness of organic destruction.

Initial examination of the data revealed that wet oxidation was effective in destroying most of the compounds tested. The oxidation of atrazine, butyl phthalate, chloroaniline, diphenyl hydrazine, ethylene dibromide, malathion, pentachlorophenol, and xylene was rapid (less than 60 min) and essentially complete (greater than 60 percent destruction to CO_2) under mild oxidation conditions (165 to 200° C). Some of the compounds (acetonitrile, chloroanthracene, DDT, hexachlorobutadiene, nitrobenzene, and trichloropropane) required higher oxidation temperatures (200 to 250° C), longer reaction times (up to 120 min), and were only partially oxidized to CO_2 (less than 40 percent destruction to CO_2).

Availability: Ready for pilot-scale evaluation - Initial lab-scale evaluation complete

Manufacturer: IT Corporation

TECHNOLOGY: OXIDATION WITH SUPERCRITICAL WATER

Status: T2 - Demonstrated on pilot scale

Brief Description: The supercritical water oxidation process is basically a high-temperature, high-pressure, wet-air oxidation. The unique properties of water above 500° C or 705° F (supercritical region) cause it to act as an excellent nonpolar solvent for nearly all organic materials. Aqueous solutions or slurries (organic content >5 percent) are mixed with high-pressure oxygen (3200 to 3600 psi or >218 atms) to chemically oxidize wastes in less than one minute with >99.99 percent efficiency. The process is an emerging technology that may be less expensive than high-temperature incineration for destruction of organically contaminated aqueous wastes.

Two processing approaches have been evaluated: an aboveground pressure vessel reactor (MODAR) and the use of an 8,000- to 10,000-ft well reactor (Oxidyne). The supercritical water (SCW) process is best suited for large volume (200 to 1000 gpm) dilute (1.0 to 10,000 mg/l COD) aqueous wastes that are of a volatile nature and that contain sufficient Btus to sustain the process. In many applications, high-Btu nonhazardous wastes can be mixed with low- Btu hazardous wastes to provide the heat energy needed to make the process self-sustaining.

Emissions/residues include gaseous effluent (nitrogen and carbon dioxide), precipitates of inorganic salts, and the liquid containing only soluble inorganic acids and salts. The advantages are rapid oxidation rates, complete oxidation of organics, efficient removal of inorganics, and no requirement for off-gas processing.

Applicability/Limitation: The process is used to treat aqueous organic solution/slurry and mixed organic/inorganic waste. It can accept wastes having less than 15 percent organics; however, long-term continuous operations have not yet been demonstrated. The manufacturer claims that the SCW process is potentially capable of destroying a wide variety of Navy wastes, including red water wastes, chemical warfare wastes, organically contaminated dilute groundwaters, phenolic wastes, cyanides, pesticides, acrylonitriles, organonitrogen/phosphates, herbicides, organosulfur compounds, rocket fuels, torpedo wastewaters, as well as many other hazardous organic wastes. A high degree of removal has been demonstrated in laboratory or small pilot-scale reactors on aliphatic hydrocarbons, halogenated aliphatic compounds, aromatic hydrocarbons, halogenated aromatics, aliphatic alcohols, aromatic alcohols, aldehydes, and ketones.

Availability: Demonstration completed in 1985, commercial unit stated to be available in 1987.

Manufacturer: Oxidyne Corporation, Dallas, Texas; MODAR, Inc., Natick, Massachusetts

TECHNOLOGY: MOVING FLUIDIZED BED ROTARY COMBUSTOR

Status: T2

Brief Description: The ROTECH burner is a rotary fluidized bed incinerator, which because of the cascading motion of the fluidizing medium, operates similarly to a moving fluidized bed unit with all of its advantages.

The reactor consists of a hollow, compartmentalized cylinder, which rotates at from 10 to 20 revolutions per minutes (rpm). A conventional rotary kiln incinerator usually rotates at 1 to 3 rpms. The reactor acts as a mechanically fluidized bed with a hot, inert bed medium, such as sand. Solid or semisolid wastes are mechanically lifted on internal radial fins and cascaded through combustion gases in the combustion zone. The solids cascading action provides excellent contact between solids and gases and also between solids and solids. High rates of heat transfer are, thus, possible. This intimate contact between cascading solids and gases also provides the possibility of in situ gas purification upon addition of limestone or other alkali to the combustion zone (a reaction also possible with other moving, fluidized bed designs). Conventional rotary kilns provide a tumbling rather than a cascading action for gas-solids contact.

Applicability/Limitation: The combustor has applicability to a wide range of wastes - solids (pretreated, if necessary, for size consistency), gases, solid-laden gases, sludges, and liquids. For example, sewage sludge, with a heating value as low as 1650 Btu/lb, has been successfully incinerated at approximately 1500° F without auxiliary fuel. The system includes air preheating and solids reheating by countercurrent flow with combustion gases. Combustion takes place between 1200 and 1500° F.

At the present time, a pilot- or small commercial-size unit is operating on industrial and other wastes, and has been tested on a sludge/emulsion, and acrylic emulsion and chlorinated aromatic waste. The destruction efficiency is expected to be high and typical of other combustors.

Availability: Three 130-ton/day capacity units designed for 22200-Btu/lb feed materials are being constructed by ROTECH to fill orders, and the technology is ready for full-scale application, if DREs in excess of 99.99 percent can be shown.

Manufacturer: ROTECH

TECHNOLOGY: PYROLYSIS

Status: T1

Brief Description: Pyrolysis consists of heating material in the absence of air to thermally degrade it to a volatile gaseous portion and a residual solid composed of fixed carbon and ash. There are two main ways to heat the material. One is by direct heating, which heats the material by direct contact with hot combustion products. The result of direct heating is production of an off-gas that is a combination of volatiles from the waste and burner flue products. Another method is indirect heating. This method keeps the burner flue products from mixing with the volatiles. Indirect heating is the necessary mode of heating, if resource recovery is to be attempted, however, it is also more complex and more expensive than direct heating. Indirect heating will probably prove economical only in very large units. Because of the drawbacks of indirect heating, Midland-Ross is concentrating on smaller units that can convert the waste to a preheated gaseous fuel and burn the fuel near the pyrolyzer. In this way, direct heating imposes almost no penalty on overall fuel efficiency.

The pyrolysis equipment is designed to convert waste that is not suited for boiler fuel into a gaseous fuel. The main objective of this system is to convert waste material from a disposal problem to a gaseous fuel source.

Applicability/Limitation: This technology is used to treat viscous liquids, sludges, solids, high ash materials, salts, metals, and halogenated wastes. The limitations are that it requires a homogeneous waste input, and metals and salts in the residue can be leachable.

Availability: Commercially available in batch and continuous form.

Manufacturer: Midland-Ross Corporation, (419) 537-6444

TECHNOLOGY: MOLTEN GLASS

Status: T1

Brief Description: This process uses a pool of molten glass as the heat transfer mechanism to destroy organics and to capture ash and inorganics. The emissions include acid gas and particulates, and all residues are contained in the glass. The advantages include: the volume is significantly reduced, most wastes are treatable, and the residual is stabilized glass. The process is based upon existing glassmaking technology.

Applicability/Limitation: The molten glass process is used to treat any solid or liquid, such as plastics, asphalt, PCB, or pesticides. Sodium sulfates greater than 1 percent of the final glass may pose a problem. It is inappropriate for soils or high ash waste, and it requires additional treatment for the off-gas.

Availability: Commercially available for uses other than hazardous waste incinerators.

Manufacturer: Penberthy Electromelt International, Inc., (206) 762-4244; Battelle - Northwest, (509) 375-2927

TECHNOLOGY: DESTRUCTION IN MOLTEN SALT

Status: T2

Brief Description: Molten salt combustion is a method of burning organic material while, at the same time, scrubbing the objectionable by-products of that combustion from the effluent gas stream. This process of simultaneous combustion and scrubbing is accomplished by mixing the material to be burned with air and injecting the mixture under the surface of a pool of molten sodium carbonate. The melt is maintained at temperatures on the order of 900° C, causing the hydrocarbons of the organic matter to be oxidized to carbon dioxide and elements, as phosphorous, sulfur, arsenic and the halogens react with the sodium carbonate. These by-products are retained in the melt as inorganic salts rather than being released to the atmosphere. In time, inorganic products resulting from the reaction of organic halogens, phosphorous, sulfur, etc., accumulate and must be removed to restore the ability of the molten bed to absorb acidic gases. Ash introduced by the waste must be removed to preserve the fluidity of the melt. An ash concentration in a melt of approximately 20 percent by weight provides an ample margin of safety to maintain melt fluidity.

Applicability/Limitation: Although molten salt technology has been used by several companies to burn wastes, only one system has been applied to burning liquid or solid wastes that might be termed hazardous. This system is the molten salt combustion system developed by Rockwell. The company is currently operating three sizes of units: bench-scale combustors for feeds of up to 2 lb/hr of wastes; a pilot-scale molten salt unit for feeds of up to 250 lb/hr of wastes; and a production scale unit, which is operated completely as a coal gasifier for up to 2000 lb/hr of coal. In coal gasification, the bed is operated at similar temperatures but in an air-deficient mode so the partial combustion reactions produce a fuel gas. This process can operate at atmospheric pressure or elevated pressure. The coal gasification unit however, has not been designed for hazardous wastes.

The salt itself is fed through the carbonate feeder and into the molten salt vessel. Solid combustible materials are transferred with a variable speed auger directly from the hammer mill, where they are crushed to the proper size into a hopper. They are then introduced into the air steam for transport into the vessel. The unit can also be fitted to process liquid fuels.

The ability of the Rockwell molten salt destruction process to effectively destroy organic chemicals (at least at the bench-scale level) has been documented. Since the bed depth in layer units is proportionately larger, it is reasonable to expect that destruction efficiencies in the larger units would be at least as great as in the bench-scale units. To date there have been no hazardous waste streams burned in the larger units.

Several experiments have documented the fact that the molten bed acts as a scrubber for acidic gases. It has been determined that if only 1 percent of the bed remains sodium carbonate, the bed will effectively scrub acidic gases.

Availability: It has been demonstrated on a pilot scale. There has been a wide range of materials incinerated in molten salt units; however, very few of these materials would be classified as hazardous wastes. For the wastes that have been incinerated, there have been good results. In all instances, the destruction efficiencies exceeded 99.99 percent. No operating molten salt system has been constructed by Rockwell as of this writing.

Manufacturer: Rockwell International

APPENDIX E

BIOLOGICAL PROCESSES

APPENDIX E

BIOLOGICAL PROCESSES

Report by Mary Pat Eisman and Dr. S. Landon-Arnold on biotechnology available or potentially available to degrade, accumulate, recover, or render harmless the hazardous waste generated by Naval facilities.

Naval Civil Engineering Laboratory, February 1987

PART I - BIOTECHNOLOGY APPLICATIONS

Microorganism biodegradation, detoxification and bioaccumulation of hazardous chemicals generated from industrial wastes are the subjects of intense investigation in various scientific fields. Technological development of systems to biodegrade wastes is advancing rapidly.

1.0 REMOVAL OF METALS

The following Naval processes generate hazardous wastes that extensively or partially contain metals: electroplating and metal preparation painting, paint stripping, bilge water cleanup, abrasive blasting material, solvent cleaning, and boiler lay-up/cleaning.

Removal of metals from waste and low-grade sources has been accomplished for uranium, selenium, copper, cadmium, and gold. The work on uranium is preliminary but is of interest for clean up and for understanding how uranium and other heavy metals may bioaccumulate.

1.1 BIOLEACHING

Thiobacillus ferooxidans has been used to recover gold from low-grade ores. Processes are available that recover metals from mine tailings, incinerator ash, (GEMCOR Laboratories of South Africa) and other non gold metal recovery operations (Bio Logicals, Canada). New metal-leaching strains are being developed for potential applications, such as electroplating wastes (Biomet). Two Japanese firms (Dow Mining Co., Ltd., and Nippon Electric Co., Ltd.) are using T. ferooxidans for bioleaching and wastewater treatment. Other companies involved in such research are PM Mineral Leaching Technologies, Inc. (Canada), Advanced Mineral Technologies (New Mexico), and Gorham International, Inc. (Maine). None has advanced bioleaching beyond the pilot-plant stage, due mainly to the problem of bioconversion to microbial growth inhibitors. (1)

1.2 BIOACCUMULATION AND DESULFURIZATION

The Sixteenth Symposium on Biotechnology and Bioengineering detailed many relevant research projects on the bioleaching of metals from ores, the use of microbes in metal recovery, metal accumulation and environmental cleanup, and microbial desulfurization, as well as comments on the application of genetics and genetic engineering to biotechnology and the mining, metal refining, and fossil-fuel desulfurization. (2)

Microbial desulfurization of two bituminous coals having a total sulfur content of 2 to 8 percent has been investigated using the acidophilic microorganism, Thiobacillus ferrooxidans. Results from this study show that proposed coal slurry pipelines could be used as a biological plug flow reactor under aerobic conditions. (3)

2.0 CYANIDES

Naval facilities that have electroplating and metal finishing shops generate cyanide-containing wastewaters.

Imperial Chemical Industries markets fungal enzymes that hydrate cyanide to nontoxic formamide. The enzyme method is more cost effective than alkaline chlorination. Homestake Mining uses Pseudomonas paucimobilis ATCC 39204 for detoxification of a 5.5 million gal/day treatment plant. Cyanide concentration is reduced from 25 mg/l to 0.5 ppm. A mutant strain of P. paucimobilis, named "mudlock" has been used to oxidize free and complex cyanides. Such cyanide compounds include stable iron-complexed cyanides and thiocyanates. Chemical requirements for this process are phosphorus, and inorganic carbon in the form of sodium bicarbonate. Conversion products are environmentally acceptable nitrates and sulfates. "Mudlock" has been used on water pumped from underground mining operations and from tailing empoundments, where pollutants consist of free cyanide, ferrocyanide, ferricyanide, thiocyanates, and cyanides of copper, nickel, and zinc. Imperial Chemical Industries has a patent for the use of fungal mycelia from organisms, such as Stemphylium loti ATCC 11718, Fusarium monilforme CBS 161.82, Mycoleptidiscus terrestris CBS 231.53, Helminthosporium sorghicola CBS 249.49, and Gloecoerospora sorghi, for degrading inorganic cyanides. (1)

3.0 TNT, RDX, AND RELATED EXPLOSIVES

Wastewaters containing dissolved explosives are generated from ordnance manufacturing, testing, and demilitarization at Naval munitions plants.

The white rot fungus, Phanerochaete chrysosporium, has been shown to degrade TNT in pink and red water. Refer to Appendix F.

4.0 PAINT BLASTING RESIDUES

Preparation of surfaces to be painted requires a variety of blasting materials, depending upon the surface to be painted and the paint to be applied. In some Naval operations, rice hulls are used as a blasting material.

Rice hulls are steam-acid digested to obtain furfural, an aldehyde, which is then converted to furfuryl alcohol, a road repair material. This road repair material can be used to repair runways under a wide range of temperatures. It is water compatible and more durable than expected, having survived several hundred freeze-thaw cycles. The formulation is made up of 9 percent furfuryl alcohol, an aggregate containing up to 8 percent water, and a catalyst system composed of trichlorotoluene and a metal salt. This furfuryl alcohol composition hardens within an hour to a strength that is able to withstand more than 2000 psi. (1) Rice hulls from blasting operations are contaminated with paint residue, and usually include heavy metals. These contaminants can also be biodegraded. (1,4)

5.0 PAINTS AND SOLVENTS, PAINT STRIPPING OPERATIONS

Waste streams from painting operations and solvent cleanup are generated at Naval facilities. Several solvents are amenable to biodegradation, as are the wastewaters from paint removal.

5.1 SOLVENT CHEMICALS

Toluene can be biooxidized to muconic acid, a chemical readily hydrogenated to adipic acid, which is a nylon intermediate and, therefore, of potential commercial interest. A patent assigned to Occidental Petroleum describes methods and materials used in biologicially degrading toxic and obnoxious chlorinated organics and the process of identifying, producing, and using microorganisms for such a purpose. Chlorotoluenes, benzoates, and chlorobenzoates are among the materials degraded to carbon dioxide, water, and salt by seven strains of Pseudomonas cepacia var. Pseudomonas oleovorans is being used to convert 6- to 12-carbon alkenes to 1,2-epoxides and n-alkanes first to primary alcohols, then to aldehydes, then to carboxylic acids. The process involves a simple one-enzyme system in a two-phase, immobilized-cell reactor. A researcher at Cranfield Institute of Technology in England has also been investigating methylotrophs capable of oxidizing alkanes and alkenes. In a second patent assigned to the same researcher, such oxidations of alkanes and alkenes is carried out with methane-utilizing bacteria adapted to using methanol as a carbon source: specifically mentioned are Methylosinus trichosporum and Methylococcus capsulata. Among the oxidations named are: benzene to phenol, propylene to propylene oxide, and toluene to benzoic acid and p-hydroxytoluene. (1)

5.2 PHENOLIC WASTES

Phenolic wastes and wastewater are subject to biodegradation. For phenol concentrations up to 500 ppm, biological degradation is the generally recognized treatment method for phenolic wastewater. Biodegradation is essentially complete for feeds containing less than 150 ppm phenol and ranges from 95 to 100 percent complete for higher concentrations. At phenol concentrations of 10,000 ppm, biodegradations of 99 to 100 percent have been reported for phenol, methylphenols, nitrophenols, and chlorophenols.(4)

Further, a biological system for treatment of phenolic wastewaters is marketed by Polybac Corporation. This system has reportedly been used to treat wastewater from paint removal/aircraft maintenance operations. The Polybac system consists of a stirred-tank bioreactor that contains PVC packing. (4)

Cornell University researchers have defined mixed cultures of Azotobacter sp. and other soil bacteria that can reduce phenols from 1500 ppm to less than 1 ppm in 7 hr. This process allows phenolic resin wastewaters to be mixed with municipal sludge streams without increasing retention time. Resin manufacturers usually use toluene or isopropyl ether to recover phenols. These solvents also contaminate wastewater. Evaporation and burning of the resinous concentrate is an expensive alternative. (1)

Another biological method of dealing with phenolic wastewaters has been developed by Oak Ridge National Laboratory. This is a fluidized-bed digester using immobilized aerobic organisms. In lab-scale testing, less than 4 minutes are needed to reduce phenol levels from 30 mg/l to less than 1 mg/l. This experimental system has handled waste concentrations up to 50 percent. Another method, developed by Sybron Corp. (Patent 4,447,539), uses a mutant of Pseudomonas putida CB-173 (ATCC 31800). This organism is active at temperatures as low as 1 to 4 °C. This can result in a tremendous cost savings by not having to heat the wastewater lagoon to normal operating temperatures during the winter months. (1)

6.0 BENZENE-DEGRADING BACTERIA

Researchers at the University of Illinois have isolated benzene-degrading bacteria called PA-1 and P-2. These organisms are, however, very slow growing, and optimization studies are underway. (1)

7.0 DIOXIN ANALOG DEGRADER

Sybron Corp. has a mutant strain of Pseudomonas that degrades a structural analog of dioxin 1000 times faster than other organisms developed today. However, the organism has not been tested against the highly controlled dioxin itself. (1)

8.0 POLYETHYLENE GLYCOL

Naval facilities involved in fluids change-out generate waste polyethylene glycol. A researcher at Michigan State University has extracted enzymes from bacteria that degrade polyethylene glycol and produce methane or ethanol and acetic acid. The bacteria are strains of Desulfovibrio desulfuricans and Bacteroidaceae sp., first isolated from sewage sludge. When they are grown as a monoculture on polyethylene glycol, each strain converts glycol to acetate and phenol. Ethanol can be further oxidized to acetate and hydrogen. Coculture with methanogens allows the use of hydrogen and cleavage of acetate to generate methane and carbon dioxide. Complete conversion of 0.2 percent of 20,000 molecular weight polyethylene glycol takes five days. Breakdown of a 0.2 percent diethylene glycol with a molecular weight of 100 takes 18 hr. Aerobic degradation with Pseudomonas is two to three times slower. It is the ether bond in ethylene glycols that make them susceptible to aerobes; therefore, these organisms can probably degrade other ether-bond compounds, such as oil recovery polymers. (1)

9.0 BIODEGRADATION CATALYZED BY ACTIVATED CHARCOAL

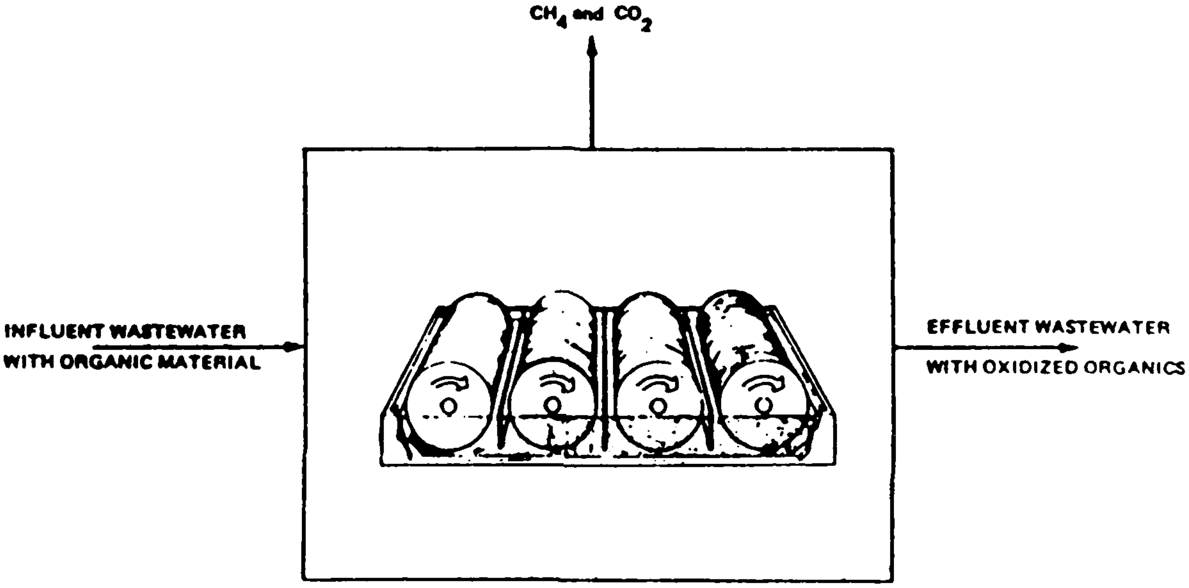
If organisms are immobilized on granular activated carbon filters, enhanced biodegradation of industrial aromatic effluents can be promoted. Refractory aromatic compounds, such as indole, quinone, and methylquinone have been successfully degraded in concentrations over 300 mg/l. (1)

PART II - BIOLOGICAL TREATMENT CONFIGURATIONS

10.0 AEROBIC BIOLOGICAL SYSTEMS

Aerobic treatment systems include conventional activated sludge processes and their modifications, such as sequencing batch reactors, and aerobic attached-growth biological processes, such as rotating biological contactors (RBC - see next figure) and trickling filters. Aerobic processes are capable of significantly reducing a wide range of organic toxic and hazardous compounds; however, only dilute aqueous wastes (usually not exceeding 1 percent) are treatable. Recent developments with genetically engineered bacteria have been reported to be effective for biological treatment of specific hazardous wastes that are relatively uniform in composition. Typically, such systems are used to treat aqueous wastes contaminated with low levels (BOD <10,000 mg/l) of nonhalogenated organic or certain halogenated organics. The treatment requires consistent, stable operating conditions.

There are numerous variations of the conventional activated sludge process. Fundamentally, however, the principles of the unit operations are about the same. The first step in the process involves aeration in open tanks, in which the biodegradable organic matter in the waste is degraded by microorganisms in the presence of oxygen. The hydraulic detention time of this unit operation is usually from 6 to 24 hr. Depending upon the process mode, shorter or longer detention times may be achieved. This is followed by a sludge-liquid separation step in a clarifier. Organic loading rates can vary from 10 to 180 lb of BOD applied per 1000 cf, depending upon the mixed liquor suspended solids (MLSS) concentration, the food to microorganism (F/M) ratio, and oxygen supply. Variations of the



ROTATING BIOLOGICAL CONTACTOR
(COURTESY OF ENVIREX)

SCHEMATIC OF ROTATING BIOLOGICAL CONTACTOR conventional activated sludge system that incorporate pure oxygen or powdered activated carbon have reported excellent pollutant removals for wastes that are difficult to treat.

11.0 ANAEROBIC BIOLOGICAL DIGESTERS

These systems promote the reduction of organic matter to methane and carbon dioxide in an oxygen-free environment. The most common anaerobic attached-growth treatment process is the anaerobic filter. This process consists of a column filled with solid media. A number of proprietary anaerobic biotechnology processes are actively being marketed, each with distinct features, but all utilizing the fundamental anaerobic bacterial conversion to methane. The digester gas can be flared or fired in boilers, gas turbines, or reciprocating engines with or without the prior removal of sulfurous gases. A schematic of a typical anaerobic filter system is given in the next figure.

Such systems are used to treat aqueous wastes with low to moderate levels of organics. Anaerobic digestion can handle certain halogenated organics better than aerobic treatment can. Stable, consistent operating conditions must be maintained. Anaerobic degradation can take place in native soils, but when used as a controlled treatment process, an air-tight reactor is required. Hazardous organic substances that have been found to be amenable to anaerobic treatment include acetaldehyde, acetic anhydride, acetone, acrylic acid, aniline, benzoic acid, butanol, creosol, ethyl acrylate, MEK, phenol, and vinyl acetate.

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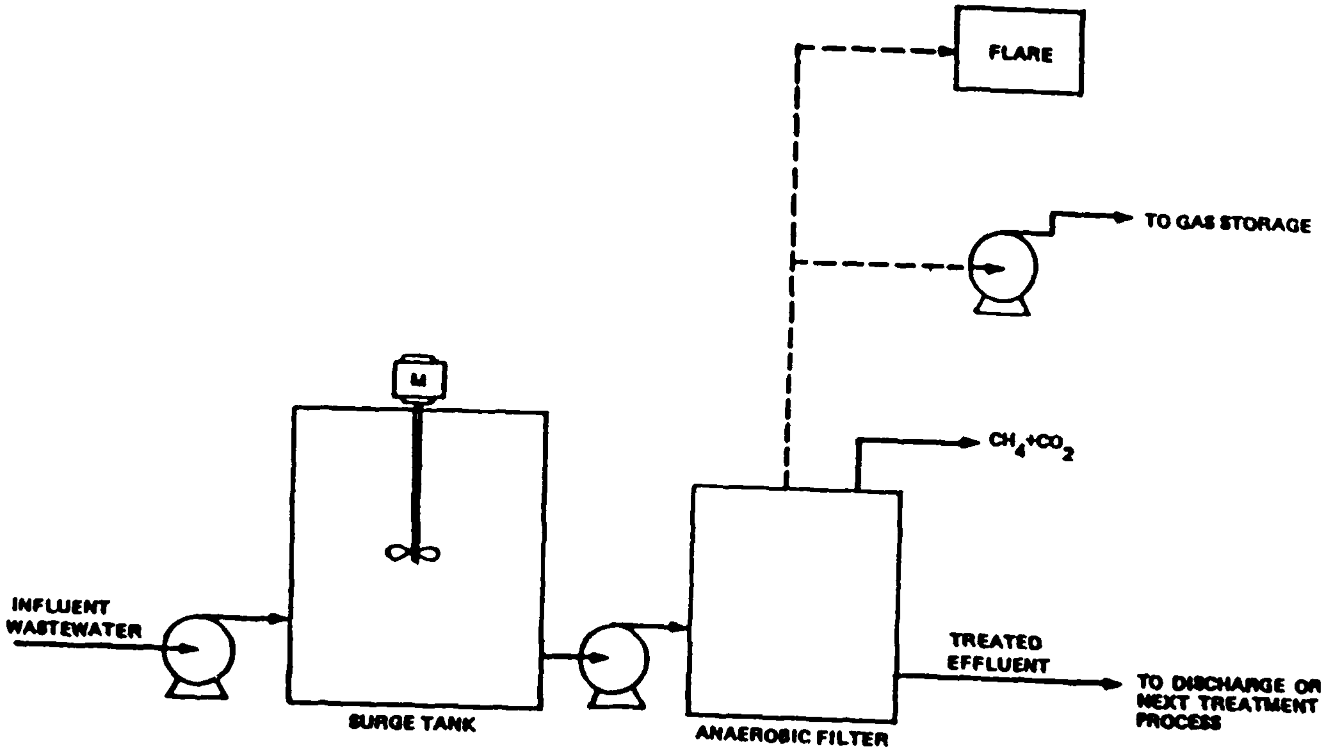

SCHEMATIC OF ANAEROBIC FILTER SYSTEM

APPENDIX F

BIOTREATMENT OF PINK WATER WITH A FUNGAL-BASED TREATMENT METHOD

BIOTREATMENT OF PINKWATER WITH A FUNGAL-BASED TREATMENT METHOD

SUMMARY REPORT

COMBUSTION ENGINEERING
ENGINEERING DEVELOPMENT CENTER

APRIL 20, 1987

SUMMARY

The Engineering Development Center of Lummus Crest Inc. (LCI) has conducted studies on the biotreatability of "pink water", a waste water stream generated in munitions plants. This work consisted of four distinct phases viz. literature survey; development of analytical procedures; batch and continuous tests with a selected bacteria; batch and continuous tests with a selected fungus. Based on these test results a preliminary plant configuration and economics have been developed by the Lummus Technology Division. This report summarizes the results of this work.

The primary constituents of "pink water" are TNT (Trinitrotoluene) and RDX (cyclotrimethylenetrinitramine). A proprietary bacteria (L-103) supplied by Solmar Corporation and a fungus species supplied by North Carolina State University were used in the biotreatability tests. It is concluded from the batch tests that the L-103 bacteria can essentially completely decompose TNT from concentration levels of 80 ppm in under 24 hours. Operating temperature of 32°C appears to be the optimum. The bacteria does not decompose RDX. Continuous flow tests with the bacteria have successfully decomposed TNT for a period of 3 to 5 days only. The inability to operate for more than 5 days is attributed to the lack of sufficient nutrient addition.

In both batch and continuous flow tests, the fungus species decomposed TNT essentially completely and as high as 90% of RDX. The continuous flow test lasted over a month and was voluntarily terminated. During the entire operating period, there was no indication of any deterioration in the fungal activity. The reactor configuration approximated two, continuous stirred tank reactor (CSTR) stages in series. The preliminary sizing criteria obtained from the continuous flow tests are estimated to be conservative. Further studies on optimization of nutrient requirements, other operating conditions and reactor staging could reduce the reactor size.

Preliminary design and cost estimates for three biotreatment process plant capacities (50,000 gpd, 100,000 gpd and 170,000 gpd) based on the test results have also been prepared. The cost data, summarized in Table 1 shows that the total installed cost of the plant including new activated carbon polishing step is 3 to 4 times the cost of the currently practiced activated carbon adsorption process. However, the operating costs for the biotreatment plant are only 20 to 25% of the activated carbon process. The resulting payback for the biotreatment process, within the range of capacities studied, over the carbon process is about 12 to 20 months.

FIGURE 3.2.1

BLOCK FLOW DIAGRAM - BIOTREATMENT OF PINK WATER

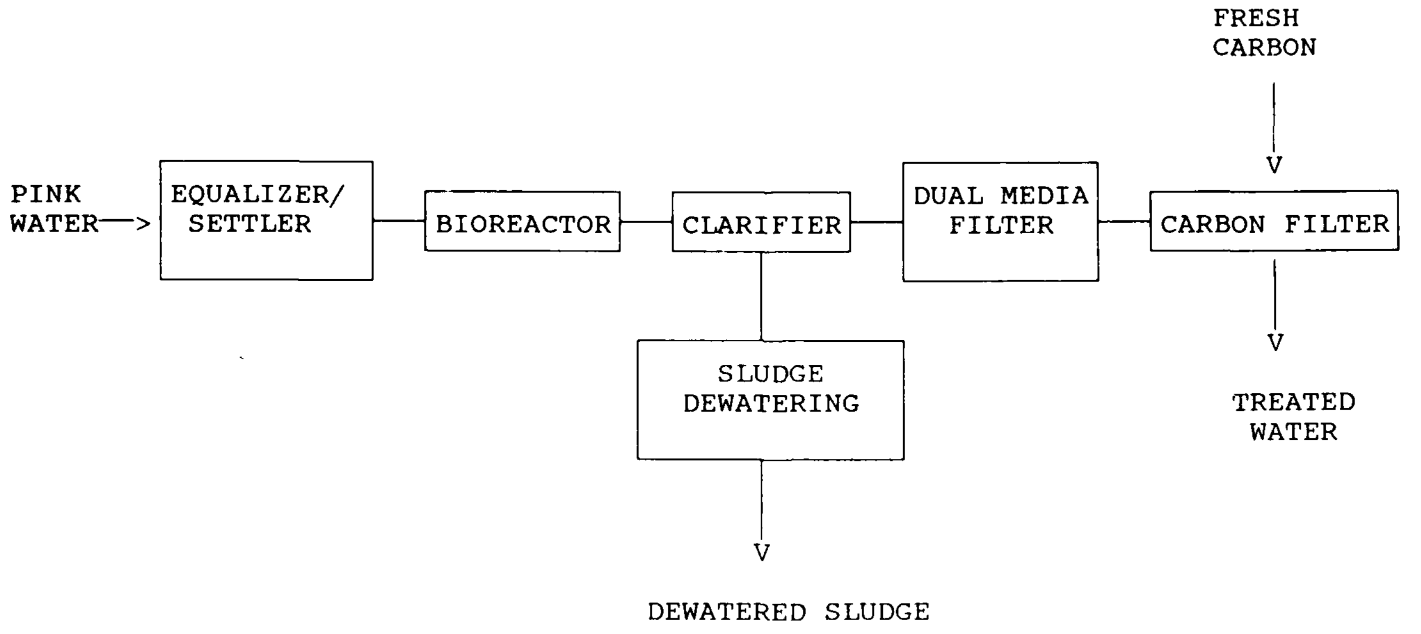

TABLE 1

CAPITAL AND OPERATING COST SUMMARY

	Total Installed Cost
Case-A 50,000 gpd	
Biotreatment Process with Existing Carbon Treatment	$1.0 Million
Biotreatment Process with New Carbon Treatment	$1.178 Million
Carbon Treatment (Current Practice)	$410,000
Case-B 100,000 gpd	
Biotreatment Process with Existing Carbon Treatment	$2.00 Million
Biotreatement Process with New Carbon Treatment	$2.15 Million
Carbon Treatment (Current Practice)	$760,000
Case-C 170,000 gpd	
Biotreatment Process with Existing Carbon Treatment	$2.91 Million
Biotreatment Process with New Carbon Treatment	$3.21 Million
Carbon Treatment (Current Practice)	$1.44 Million
Operating Costs:	
Biotreatment with Carbon Polishing Case A/Case B/Case C	$7.35/8.05/8.95/1,000 gal
Carbon Treatment (Current Practice) only	$35.88/35.68/35.58/1,000 gal.

Conclusions

In summary, both the L-103 bacteria and the fungus can efficiently decompose TNT. The fungus, in addition, also decomposes RDX to a signicicant extent. On the basis of the laboratory test results obtained, further development on biotreatment of "pink water" should be based on the fungal spiecies. The design data obtained from the tests are believed to be conservative and sufficient for the preliminary design of a demonstration biotreatment plant. There are however, a number unresolved questions which were not addressed during this series of tests. Some of these issues and their impact on the "pink water" treatment process are listed below:

1. *Optimize the nutrient composition, amount and operating temperature required with the fungus. This will have the effect of minimizing the operating costs. Most importantly, this study could eliminate the addition of certain nutrients which probably are not metabolised by the microbe and therefore remains in the treated water. Elimination of these nutrients would improve the quality of the biotreated water and could result in reduced capital cost as well.*
2. *Establish the effect of operating the biotreater as a plug flow reactor i.e.as several CSTR stages in series. This could potentially reduce the reactor size and thereby capital costs.*
3. *Determine the life of the fungus.*
4. *Determine the quality of the biosludge and the optimum means for disposing of the same.*

The above work could be carried out concurrently with the development of a demonstration plant design without adversely affecting the final design.

PRELIMINARY DESIGN AND COST ESTIMATE

A preliminary design and cost estimate of an industrial-scale "pink water" treatment facility is presented in this section. The design and cost analysis are based on the results of laboratory tests.

Design Basis

The process consists of biotreatment steps using a fungus species to degrade the bulk of the organic contaminants, followed by an activated carbon polishing step. The active carbon step is designed to produce water quality for either discharge to public waterways or re-use in the plant. The process economics rationale is to reduce the organic load on the carbon treating step to a level where the biotreatment process becomes cost-competitive with the existing practice which is based on carbon adsorption of "pink water" without prior treatment. The design basis for the "pink water" to be treated was derived from the sample received from Mason and Hanger and is summarized in Table 2. The "pink water" influx rates listed in Table 2 were selected to encampass the minimum and maximum plant capacities likely to be encountered.

Process Description

Biotreatment System

The process scheme is shown in Figure 1. It consists primarily of a pretreatment system, a bioreactor system, a clarifier and a sludge dewatering system. As a final polishing step, the effluent water from the bioreactor is treated in an existing activated carbon adsorption step. This scheme is estimated to be capable of removing TNT to under 1 ppm and other organic contaminants (RDX and HMX) to under 5 ppm.

Based on discussions with the U.S. Navy and literature review, the production and quality of pink water varies considerably within the same operating plant. When this water is produced in weekly washdown of equipment and plant in general, the water could contain gritty suspended solids and oil. The pretreatment step therefore, is essentially a holding tank of 24 hour capacity with provisions for screening out gritty suspended matter. This tank also serves as a mixing conditioning tank to add the necessary nutrients for the fungal growth and to adjust the pH. Even though the biotreatment is estimated to be not greatly susceptible to flow and contaminant variations, the pretreatment system will permit equalization of these variations and result in smoother operation of the biotreater.

"Pink water" after conditioning in the pretreatment system, is fed to a continuous biological reactor system using a fungus species for the degradation of the TNT and RDX. The system is sized fo 85% COD reduction, exclusive of nutrients added. A summary of the biotreater operating conditions is given in Table 3.

The next step of the process is to separate the biosludges from the treated water. Thus, the biotreater effluent is fed to the clarifier.

The clarifier bottoms (sludge) is pumped to the filter press for dewatering to 20% solids content. The daily wet cake production is 440 lbs (3.0 cu. ft.) for Case A, 875 lbs (6.0 cu. ft.) for Case B and 1500 lbs (10 cu. ft.) for Case C. The sludge is water-washed in the filter prior to discharge, to remove traces of TNT and RDX. The dewatered sludge is disposed by truck to a non-hazardous landfill.

The clarifier effluent is pumped through a standard sand/coal dual media filter for suspended solids removal. The filtered water is passed through two carbon beds in series. The carbon adsorption system is sized for removal of the residual organics to 1 ppm level. The spent carbon is discharged periodically and trucked to an approved solid waste incineration service. In modifying a currently operating "pink water" treatment plant, it is possible to use the existing dual media (or equivalent) filters and the carbon beds.

Currently Practiced Technology: Activated Carbon Process

The current practice is to adsorb the TNT, RDX and other organics contained in "pink water" in activated carbon. The spent carbon is disposed of by incineration.

Thus, the "pink water" is first passed through a dual media filter containing sand and coal to remove suspended solids which would otherwise reduce the life of the activated carbon. The filtered water then flows through two carbon adsorbers in series. When the carbon in the first adsorber is spent, it is taken out of service, and the carbon is replaced. During this period, the second adsorber will function as the primary unit.

Equipment List and Plant Cost

The process equipment is listed in Table 4 for the biotreatment process described above. Equipment sizing is given for the carbon treatment process (base case - without biotreatment), in Table 5. In-house equipment cost data (previously obtained from vendors) and standard multipliers were used to estimate the total installed cost (TIC). The capital costs are summarized in Table 6.

Operating costs consist of variable cost items: chemicals, nutrients, inocula, actived carbon, utilities, sludge disposal and spent carbon disposal; and fixed cost items: labor, maintenance (labor and materials) and overhead. Cost of supervision, analytical and office services is included in the overhead. The operating costs are summarized in Table 7.

Design Considerations

The process configuration, and the preliminary equipment sizes used for estimating capital costs presented in this section of the report were determined on the basis of the results obtained from laboratory tests. The biotreator size estimated from these test results and used in arriving at the capital costs are conservative and will result in considerable spare capacity. Discussions with the researchers in North

Carolina State University, who provided us the fungus, leads us to believe that many of the nutrient additives used in the laboratory tests may not be necessary.

Atomic absorption analysis of the "pink water" received from Mason and Hanger, indicated that many of the metallic elements added as nutrient minerals are already present in the water. Accordingly, in determining the operating costs, only the necessary nutrients have been considered. It is further assumed that all of the nutrient additives are completely consumed so that the final polishing step with activated carbon can be designed for removal of trace quantities of TNT and RDX. Based on literature data, the activated carbon requirement is estimated to be approximately 8 pounds per pound of TNT removed. The carbon requirements for RDX removal is assumed to be the same.

Estimated costs of the currently used activated carbon process (without prior biotreatment) are also presented in the report for comparison with the biotreatment process. In order to provide realistic comparisons, this activated carbon process is also designed for a requirement of 8 pounds of carbon per pound of TNT and RDX removed. The carbon beds are sized for 45 days operation. By increasing or decreasing the carbon bed size, the total installed cost of the activated carbon could be substantially varied, but this should have relatively little impact on the biotreatment plant with activated carbon polishing step. Thus, plant costs are presented in this report only as an indicator of the cost effectiveness of the biotreatment process.

TABLE 2

DESIGN CONDITIONS OF PINK WATER

Flow Rate, gpd	Case A - 50,000	Case B - 100,000	Case C - 170,000
TNT, mg/l	150		
RDX, mg/l	70		
Oil mg/l	200 max		
COD, mg/l	280		
Temperature	Ambient (approx.)		
pH	Neutral (approx.)		
On Stream Factor	8,000 hours/year		

TABLE 3

BIOTREATER OPERATING CONDITIONS

	Inlet mg/l	Effluent mg/l
TNT	120	less than 2
RDX and other Organics (exclusive of nutrients)	56	25
COD (calculated)	660	30
BOD	550	25
pH	6.0	4.8

TABLE 4

Equipment List - Biotreatment of Pink Water

Item	*Quantity*
Settler/Equalizer	1
Biotreater	1
Clarifier	1
Filter Press	1
Auxiliary equipment	-
Dual media filter	2
Carbon column system	2

TABLE 5

Equipment List - Base Case

Item	Quantity
Dual media filter	2
Carbon column	2
Auxiliary equipment	-

TABLE 6

CAPITAL COST SUMMARY

Direct cost includes packaged equipment, and labor for setting the equipment. Total installed cost (TIC) includes in addition to direct cost, material and labor costs for activated carbon inventory, structures, civil, all non-packaged piping, instrument, electrical and other engineering costs but excludes cost of land, access roads, etc.

CASE-A

50,000 gpd PINK WATER FACILITY

		Direct Cost $1,000	TIC $1,000
1.	Biotreatment Process with existing carbon treatment	456	1,000
2.	Biotreatment Process with new carbon treatment	537	1,178
3.	Carbon treatment (base case) only	248	410

CASE-B

100,000 GPD

		Direct Cost $1,000	TIC $1,000
1.	Biotreatment Process with existing carbon treatment	868	2,000
2.	Biotreatment Process with new carbon treatment	976	2,150
3.	Carbon treatment (base case) only	460	760

CASE-C

170,000 gpd "PINK WATER" FACILITY

		Direct Cost $1,000	TIC $1,000
1.	Biotreatment Process with existing carbon treatment	1,320	2,910
2.	Biotreeatment Process with new carbon treatment	1,460	3,210
3.	Carbon treatment (base case) only	870	1,440

TABLE 7

OPERATING COSTS SUMMARY
($ PER 1000 GALLONS)

	Biotreatment Process	Act. Carbon Process (Base Case)
I. *Variable Costs:*		
Inoculum, nutrients and chemials	1.84	---
Activated carbon, @ $.90/lb (delvd.)	1.21	13.24
Sludge disposal, @ $20.0/ton (inc. frt.)	0.09	---
Spent carbon incineration, @ $250/55 gal. drum (excl. frt.)	1.90	20.78
Spent carbon transportation, 1000 mi. round trip @ $29.0/cu.yd.	0.06	0.66
Utilities, @ .05/kwh & $4.00/MM BTU	.25	neglig.
Subtotal Variable Costs	5.35	34.68
II *Fixed Costs:*		
Operating labor		
Maintenance, L&M		
Overhead (incl. supervision & lab)		
Subtotal Fixed Costs		
Case - A	3.6	1.2
Case - B	2.7	1.0
Case - C	2.0	0.9

APPENDIX G

FEASIBILITY TESTS ON RECLAMATION OF USED BLASTING GRIT FROM NAVY SHIPYARDS

FEASIBILITY TESTS ON RECLAMATION OF USED BLAST GRIT FROM NAVY SHIPYARDS

Submitted to

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Port Hueneme, California 93043

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May 1986

SUMMARY

The U. S. Naval Shipyards produce about 100,000 tons of used blast grit annually that is presently disposed in landfills. In the near future it will become increasingly prohibitive both environmentally and economically to dispose the used blast grit containing paint residue. Therefore it is desirable for the Navy to develop a simple method to clean and recycle used blast grit.

The Institute of Gas Technology (IGT) has developed a fluidized-bed calciner which appears ideally suited for this application. The calciner has a unique patented bottom grid design that ensures combustion and effective separation of paint chips from the used blast grit. The design also allows removal of tramp material from the used grit without impairing the calciner operation.

Preliminary feasibility tests have been conducted by IGT, under its internal R&D program, on used blast grit from Long Beach Naval Shipyard. These tests show that the paint's organic binder materials are thermally decomposed and the majority of metallic components along with fine grit are selectively removed from the used grit. The data also indicates that more than 90% of the original used blast grit can be recovered in a form that meets the specifications for new blast grit.

Application of IGT's fluidized-bed calcining technology can reduce both the purchase of new blast grit and the disposal of used grit by 90%. If the costs of the Long Beach Naval Shipyard are typical -- $100 per ton for new blast grit and $150 per ton for disposal -- then at an annual usage rate of 100,000 tons, the potential savings to the Navy could be as high as $20 million.

IGT proposes a three-phase, two-year program to verify the initial test results on different types of blast grits, at larger scale, and to design a prototype unit for testing at a designated shipyard.

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INTRODUCTION

The U. S. Naval Shipyards generate about 100,000 tons per year of used blast grit from surface preparation of ships while being serviced in dry docks. The blast grit consists of primarily slag from either coal power plants, copper smelters or nickel smelters. During blasting the grit is contaminated with organic binder materials and metals such as zinc, titanium, copper and tin commonly found in marine paints. Presently the used blast grit is disposed of in landfills. As the availability of landfills diminishes, the disposal costs for used blast grit will become increasingly prohibitive. Therefore it is desirable to develop a simple method to clean and reuse the blast grit.

BACKGROUND

Naval vessels are applied with a protective coating to avoid damage from the harsh marine environment. These coatings are mainly for corrosion and fouling protection but also for appearance and camouflage. The marine coatings consist of a binder and pigments. The binder is an organic film forming liquid that converts to a continuous solid film upon drying after application. The pigments are finely dispersed solid materials that impart color, opacity, and corrosion inhibition. The pigments are inorganic oxides or compounds of metals such as zinc, titanium, copper, lead, etc. The coating may also contain biocidal chemicals to avoid growth of marine fouling organisms. The commonly used antifoulant is tri-butyl tin oxide (TBTO).

After a duration of about 2-3 years, the effectiveness of the protective coating on the Naval vessels is reduced to a level where application of a new coating is necessary. Before application of a new coating, the vessel's surface requires special preparation. The surface has to be completely cleaned of the old coating, removing all rust and imparting a white-metal surface profile. To prepare the surfaces, the vessel is brought into a dry dock at a shipyard. The method used for the preparation is high-speed abrasive blasting by air-pressured equipment. Previously, sand was usually the abrasive material used for blasting. However, due to dangers of silicosis, sand has been replaced by slag in all blasting operations. The slag is obtained from coal-fired boilers or copper and nickel smelters.

During the blasting operations, the paint coatings removed from the ship's surface gets mixed with the blast grit (slag). In addition, tramp material from the overall servicing of the vessel while it is in the dry dock also gets mixed with the used blast grit. Because of the contamination and generation of fines during the blasting operations, the blast-grit is not reused, but disposed after a single application. Since it contains metals and organics from the paint coatings, the used blast grit is considered hazardous waste in certain States and has to be disposed accordingly. Presently, the used blast grit is one of the major hazardous waste generated in a Naval shipyard.

There are eight domestic Naval shipyards where blasting operations are carried out:

Charleston, NC
Long Beach, CA
Mare Island, CA
Norfolk, VA
Pearl Harbor, HI
Philadelphia, PA
Portsmouth, NH
Puget Sound, WA

These shipyards produce a total of about 80,000-100,000 tons per year of used blast grit that is disposed of in dump sites. Depending cn the state regulations, several shipyards have to use hazardous waste dump sites. Recently the cost of using hazardous dump sites has increased significantly and future regulations are likely to restrict dumping of such wastes.

Therefore, the problem for the Naval shipyards is how to eliminate this hazardous waste or at the least how to drastically reduce its quantity.

FLUIDIZED BED SLOPING GRID CALCINER

The Institute of Gas Technology (IGT) has developed a versatile fluidized bed, sloping grid calciner (FB calciner) which is ideally suited for reclamation of used blast grit. The FB calciner has been tested successfully for reuse of contaminated foundry sand.

The FB calciner is not necessarily an entirely new concept, it is an improvement on existing fluidized bed concepts. The sloped grid design has been developed for our U-GAS coal gasification process. The U-GAS process is being considered for several large-scale projects both here and overseas. We feel that the sloping grid FB calciner system has some unique features:

- Intensive mixing of the fluidized bed such that all contaminants are completely destructed.
- The capability to discharge tramp material that would accumulate on the surface of a horizontal grid.
- Countercurrent cooling of the discharged sand with a portion of the fluidizing air.
- The ability to separate by air classification the fine burned paint particles, liberated by calcining, from the discharged grit.
- Capability to use any fuel -- natural gas, fuel oil or pulverized coal.
- Capability to incinerate waste materials from other sources in a shipyard, e.g., waste water-oil mixtures, oil or fuel contaminated soil, etc.

For the foundry sand application, the FB calciner was able to reduce the organic content of the sand and to a very low level (0.2 wt % measured as loss on ignition) and also remove clay particles from the sand. To demonstrate the feasibility of this application, IGT processed a batch of 5 tons of sand in an experimental unit of 100 lb/h capacity followed by a batch of 50 tons of sand in a pilot unit of 1 ton/h capacity. This work was done for a major automobile manufacturer's foundry and the reclaimed sand was found to be reusable in their foundry production line.

For the blast grit reclamation, the FB calciner will be used as shown in Figure 1. Used blast grit will be transported into a grit preheater where hot air will be used to dry the grit. Then it will be fed into the calciner by means of a metering screw feeder or a drag feeder. In the calciner, the grit

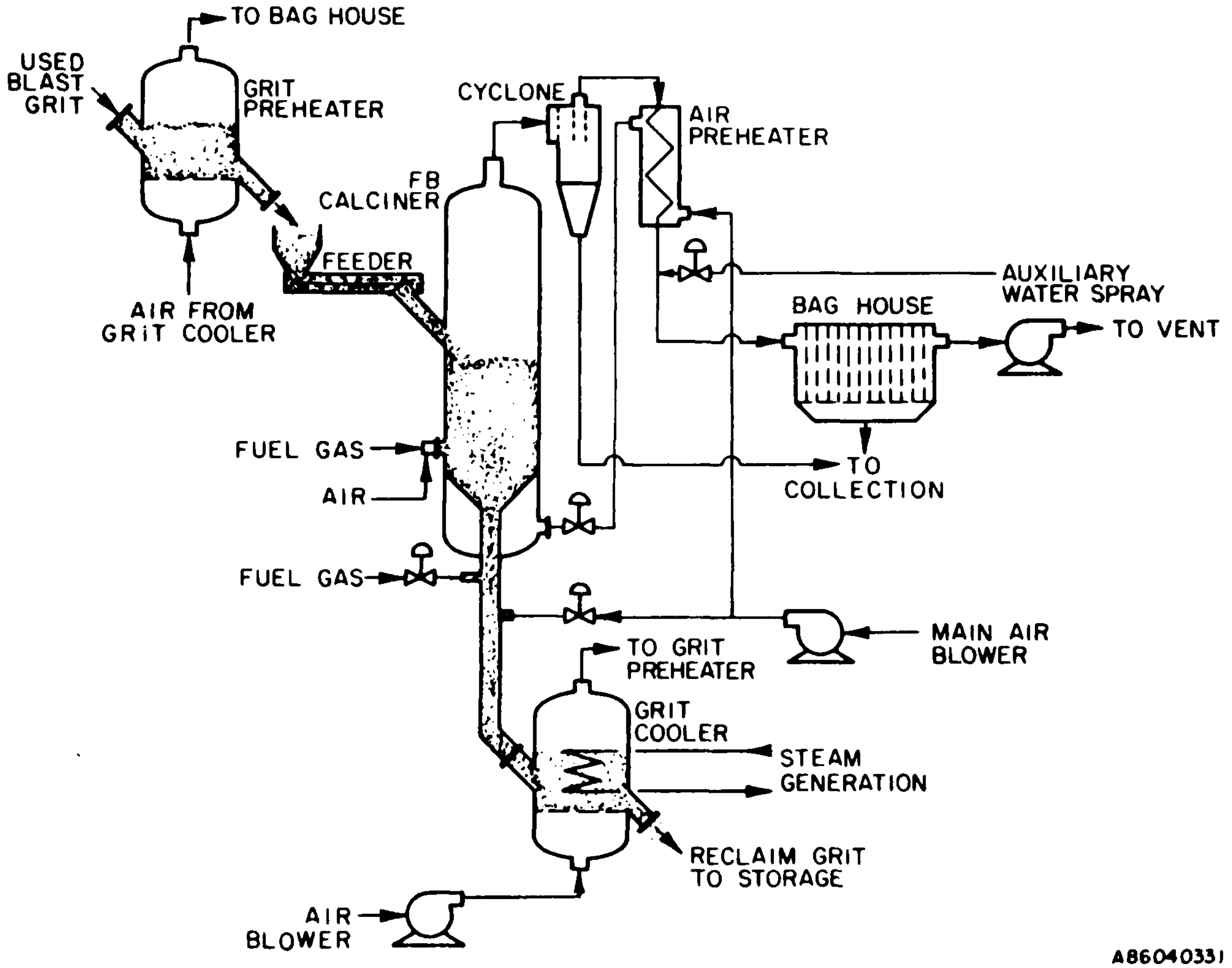

Figure I. FLUIDIZED BED CALCINER FOR BLAST GRIT RECLAIM SYSTEM will be heated to a temperature of 1200°-1500°F by burning a fuel -- natural gas or oil -- directly in the fluidized bed. The organic content of the paint chips will be combusted to water vapor and carbon dioxide, the inorganic metallic components, after being oxidized, will be elutriated along with fine grit out of the calciner with the flue gases. The reclaimed grit, free of paint and fines, will be properly sized by adjusting the gas velocity in the calciner. The grit will be withdrawn from the opening at the bottom of the calciner into a grit cooler. The heat in the discharged grit will be used to generate low-pressure steam and also heat air for drying the wet grit. The cooled, reclaimed grit can then be transported to storage for reuse. The fine grit and combusted paint will be removed from the flue gases by a cyclone and then the flue gases will be cooled against air to be used for combustion in the calciner. The flue gases will be passed through a bag house for final dust removal before venting to the atmosphere.

This design is highly efficient in recovering energy from the hot grit and flue gases so that the overall thermal efficiency of the calciner is excellent. The objective of utilizing the FB calciner will be to reclaim a maximum amount of grit for reuse and render the small quantity of fines from the calciner suitable for disposal.

FEASIBILITY TEST ON USED BLAST GRIT
FROM LONG BEACH SHIPYARD

Introduction

IGT has conducted some preliminary tests in a small laboratory calciner to investigate the feasibility of using the FB calciner for reclaiming blast grit. The study was conducted under IGT's Internal R&D program.

The blast grit was obtained from Long Beach Naval Shipyard. Two types of grits are used by this shipyard -- both are smelter slag produced during refining of copper and nickel. The copper slag is black in color and the nickel slag is of greenish color. Samples of both fresh grit delivered to the shipyard and used grit being sent to landfills were collected. The fresh grit basically consists of gangue left behind after the metal (nickel or copper) has been extracted from the ore. The major components of the grit are iron and magnesium silicate. We also received a sample of grit being used by Norfolk Shipyard which is crushed slag or ash from coal fired power plants. IGT did not conduct any tests on this material.

The complete major oxides, metal and size analysis of the fresh and used grit from the Long Beach shipyard is shown in Tables 1, 2 and 3. The fresh grit contains only about 5 wt % material smaller than USS Sieve Size 80, whereas the used grit contains 15-20 wt% material of the same size. The used grit contains about 1 wt% of paint chips and other tramp material. An indication of this is the measure of organics content of the grit. The fresh grit contains about 1000 ppm organics whereas the used grit contains 5000-6000 ppm organics. In order to recycle the used blast grit, it must be dried, the organic materials and metals reduced and the fines separated.

Description of the Tests

IGT selected a small laboratory-scale fluidized-bed reactor for conducting the feasibility tests on the blast grit. This equipment is shown in Figure 2. It consists of a 2-inch-diameter stainless steel, tubular reactor surrounded by an electric furnace. The temperature in the reactor can

Table 1. ANALYSIS OF METALS IN BLAST GRIT

Metal	Fresh Grit	Used Grit		Test No. 1		Test No. 2		Test No. 3		Test No. 4	
		1	2	Reclaimed Grit	Fines	Reclaimed Grit	Fines	Reclaimed Grit	Fines	Reclaimed Grit	Fines
	mg/kg or parts per million										
Copper (Cu)	980	1000	--	1100	5700	2000	6200	NA	NA	1400	11900
Zinc (Zn)	3400	3700	3700	3700	9000	3400	7200	2800	6800	3100	6400
Titanium (Ti)	1900	1600	1400	1000	4000	1100	5200	1000	4900	1000	4600
Barium (Ba)	590	790	670	360	4100	400	4400	290	4600	320	4300
Chromium (Cr)	2900	4000	3900	4000	3300	4000	3100	4400	3300	3800	3200
Nickel (Ni)	2000	2700	2000	1700	1800	2700	1600	1700	660	1400	5600
Lead (Pb)	840	320	320	300	480	310	550	240	440	300	510
Tin (Sn)	160	120	130	60	110	160	80	100	140	100	100
Arsenic (As)	210	220	230	92	170	130	220	160	210	220	170
Cadmium (Cd)	8	6	6	4	12	6	9	6	11	6	11
Organics *	1000	5800	4900	800	35400	900	29000	700	4100	700	42300

* Measured as carbon and hydrogen in the sample.

Table 2. MAJOR OXIDES ANALYSIS OF BLAST GRIT

Major Oxide	Fresh Grit	Used Grit 1	Used Grit 2	Test No. 1 Reclaimed Grit	Test No. 1 Fines	Test No. 2 Reclaimed Grit	Test No. 2 Fines	Test No. 3 Reclaimed Grit	Test No. 3 Fines	Test No. 4 Reclaimed Grit	Test No. 4 Fines
	weight %										
Na_2O	0.45	0.35	0.30	0.26	0.70	0.28	0.76	0.27	0.69	0.26	0.85
MgO	15.50	20.60	20.70	21.50	18.70	21.50	17.80	21.50	17.90	22.60	18.00
Al_2O_3	3.23	2.55	2.49	2.66	3.27	2.65	3.48	2.72	3.27	2.70	3.19
SiO_2	41.90	47.80	47.60	46.50	41.00	44.40	43.20	48.10	44.70	48.90	43.90
P_2O_5	0.12	0.07	0.05	0.07	0.14	0.07	0.14	--	--	--	--
SO_3	0.52	0.55	0.47	0.62	1.85	0.52	1.22	0.5	1.30	0.50	0.87
K_2O	0.54	0.40	0.39	0.34	0.54	0.35	0.52	0.36	0.51	0.34	0.51
CaO	2.32	1.30	1.32	1.27	3.19	1.40	3.78	1.26	3.37	1.26	3.44
TiO_2	0.32	0.27	0.23	0.17	0.67	0.18	0.87	0.17	0.77	0.17	0.82
Fe_2O_3	30.20	24.60	24.40	24.30	24.80	24.30	24.80	23.70	24.80	23.70	23.50
Total	95.10	98.49	97.75	97.69	94.86	95.65	96.57	98.58	97.26	100.43	95.08

Table 3. SIZE ANALYSIS OF BLAST GRIT

U.S. Sieve No. Retained On	Fresh Grit	Used Grit		Test No. 1		Test No. 2		Test No. 3		Test No. 4	
		1	2	Reclaimed Grit	Fines	Reclaimed Grit	Fines	Reclaimed Grit	Fines	Reclaimed Grit	Fines
	----------	----------	----------	----------	----------	-weight %-	----------	----------	----------	----------	----------
6	0.0	0.2	0.03	0.0	1.3	0.0	1.9	0.0	0.0	0.0	0.0
8	0.1	0.1	0.2	0.1	1.0	0.1	0.6	0.0	0.0	0.10	0.0
12	2.7	0.8	1.1	1.1	1.0	1.2	0.6	2.2	0.5	1.1	0.4
20	49.0	25.0	30.9	28.2	2.7	31.4	0.6	36.9	0.0	28.5	0.4
30	25.9	18.6	20.4	22.2	0.7	23.2	0.0	23.1	0.0	22.2	0.0
40	12.9	18.5	18.7	19.9	0.3	19.3	0.6	16.9	0.5	20.1	0.0
50	3.5	13.2	12.1	14.5	0.7	13.1	0.0	11.5	0.0	14.5	0.4
80	2.3	12.0	9.8	10.9	1.3	8.9	0.6	7.9	4.3	10.4	1.5
100	0.8	3.1	2.2	2.3	6.4	1.5	2.5	1.2	12.9	2.0	5.8
200	1.8	5.9	2.9	0.5	65.7	1.0	57.1	0.3	54.3	0.9	55.8
270	0.4	1.1	0.6	0.1	6.1	0.1	10.8	0.0	8.6	0.0	9.6
325	0.4	0.7	0.2	0.1	4.0	0.1	6.2	0.0	6.5	0.0	6.9
Pan	0.2	0.8	0.6	0.1	8.8	0.1	16.5	0.0	12.4	0.0	19.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Bulk Density, lb/ft^2	122.5	118.6	123.7	123.2	96.0	118.6	89.1	121.8	97.8	122.2	105.5
Moisture, wt %	--	14.9	14.9	--	--	--	--	--	--	--	--

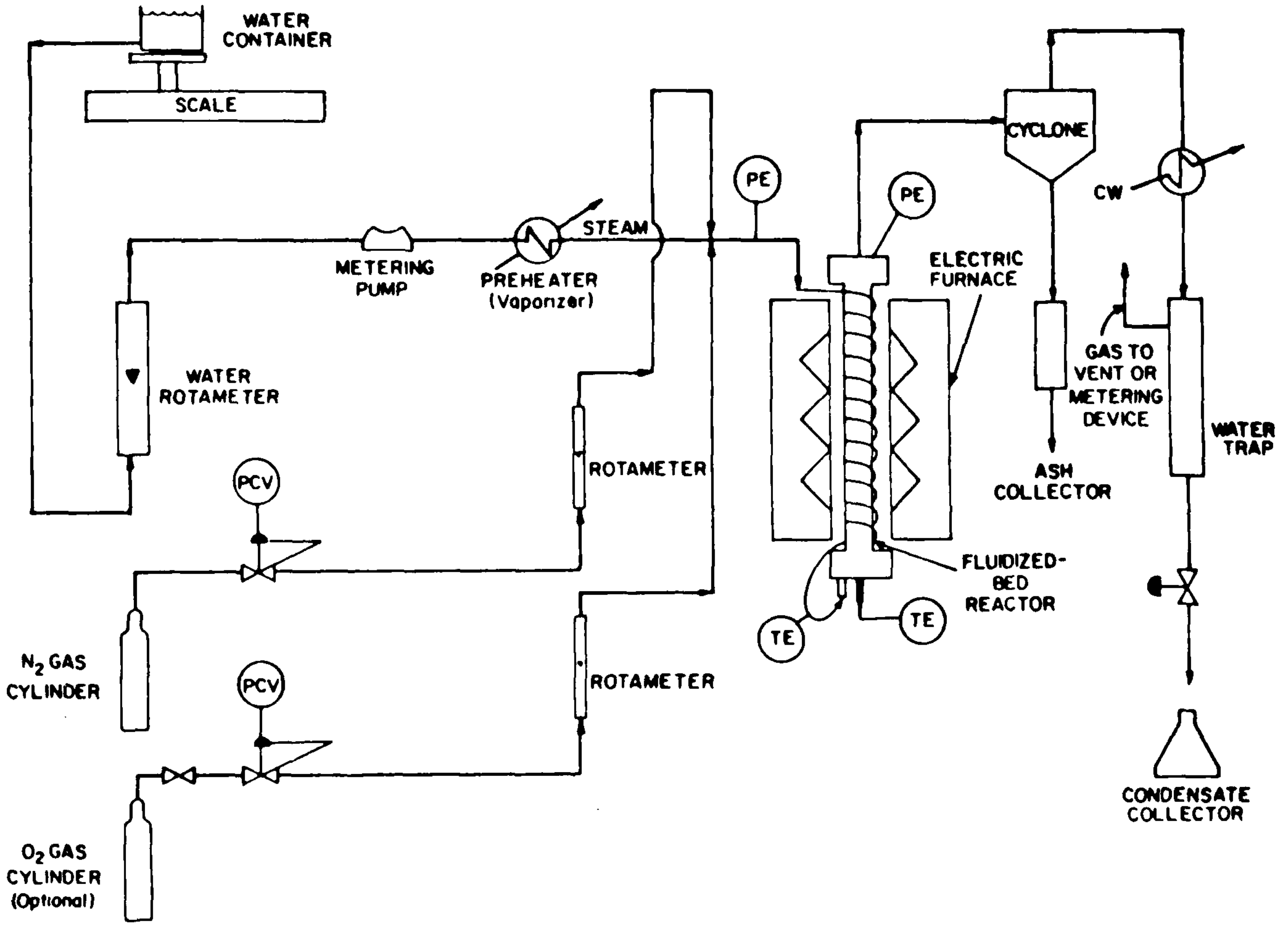

Figure 2. SCHEMATIC DIAGRAM OF 2-INCH-ID FLUIDIZED-BED REACTOR

be closely controlled in the range of 1000°-2000°F. The gas distribution grid in the reactor is a flat plate instead of a conical grid typical of the FB calciner. The feed gas to the reactor can be oxygen, or nitrogen or any mixture of them. The outlet gas from the reactor passes through a cyclone before being vented. There is no provision for combustion of natural gas and air within the reactor, instead the desired temperature is obtained by the electric furnace.

A total of four tests were conducted with the blast grit in the 2-inch fluidized bed reactor. Nitrogen was fed through the grid while air was fed through the center jet. The reactor material was heated by the external tube furnace. Gases and fines leaving the reactor passed through a cyclone where fines were separated and the gas cooled and vented.

In a typical run, about 500 grams of the blast grit was charged into the reactor which corresponds to a bed height of about 6 inches. The bed was heated from room temperature to a predetermined temperature at a rate of about 10°F/min. During the heatup period the superficial gas velocity of 0.8-1 ft/sec was used. The center jet (air) inlet temperature was 1200°F and the nitrogen inlet temperature was set at T_f (T_f is the final operating temperature of the fluidized bed) in all of the four runs. Once the bed reached T_f, the superficial gas velocity was increased to the desired value and the test started.

The operating conditions and the material distribution for the four tests are given in Tables 4 and 5.

Test Results

Visual observations indicated that the discrete gray paint chips present in the used grit were converted to a white material and most of it was reduced in size and present in the fines fraction. Some white paint chips were found in the reclaimed grit from test 1 and 2. However, when the fluidization velocity was increased in test 3, the reclaimed grit was almost free of any paint material. It was also observed that the reclaimed grit was of more uniform size and darker in color than the used grit. There was no visual difference between reclaimed grits from tests at 1500°F and 1200°F.

Table 4. TEST OPERATING CONDITIONS

Run No.	T_{max} °F	Fluidization Velocity ft/sec	Residence Time at T_{max} hr
1	1500	2	2
2	1200	2	2
3	1500	3	2
4	1200	2.3	2

Table 5. MATERIAL DISTRIBUTION

Run No.	Feed Grit	Reclaimed Grit	Fines	% Recovery
1	534.5	493.3	30.8	98.05
2	535.5	513.5	16.4	98.95
3	537.5	512.7	19.0	98.92
4	535.9	504.5	26.9	99.16

The analytical results of the four tests are shown in Table 1, 2, and 3. For comparison, information on fresh grit and used grit is also shown in these tables.

Table 1 data on metal analysis shows that the primary constituents of paint — organics, zinc, titanium and copper -- are removed from the grit and concentrated in the fines fraction. This indicates that calcining in the fluidized bed burns the paint chips, reduces them in size and separates it as fines. The fines fraction also contains the grit fines generated during blasting. The organic content of the reclaimed grit is also very low indicating that it is free of any paint residues. The organic content of the fines is high in test 1, 2 and 4, but not in test 3. This is because in tests 3, higher fluidization velocity promoted better mixing and more complete combustion.

Table 2 data shows the analysis of the major components of the blast grit. This data shows that there is no significant change in the general chemical analysis of the fresh, used and reclaimed grits. The major oxide analysis of the fines, though, indicate that concentrations of some components increased.

Table 3 data on size distribution shows that the reclaimed grit from all the tests is lower in fines than used grit but yet not as coarse as the fresh grit. This is due to limitation in operating velocities for the laboratory reactor. Use of higher fluidization velocity is necessary to remove all the fines so as to meet size specifications of fresh grit. A fluidization curve of the used grit was developed to determine the appropriate velocities necessary. This curve is shown in Figure 3. Evaluating the material distribution data of Table 5 for the four tests, indicates that operation in a FB calciner at about 4 feet/sec velocity will generate 10% fines (10 wt% of the used grit will be in the form of fines in an FB calciner and 90 wt% of the grit will be reclaimed and available for reuse). Operation at these conditions will produce reclaimed grit meeting size specification of fresh grit.

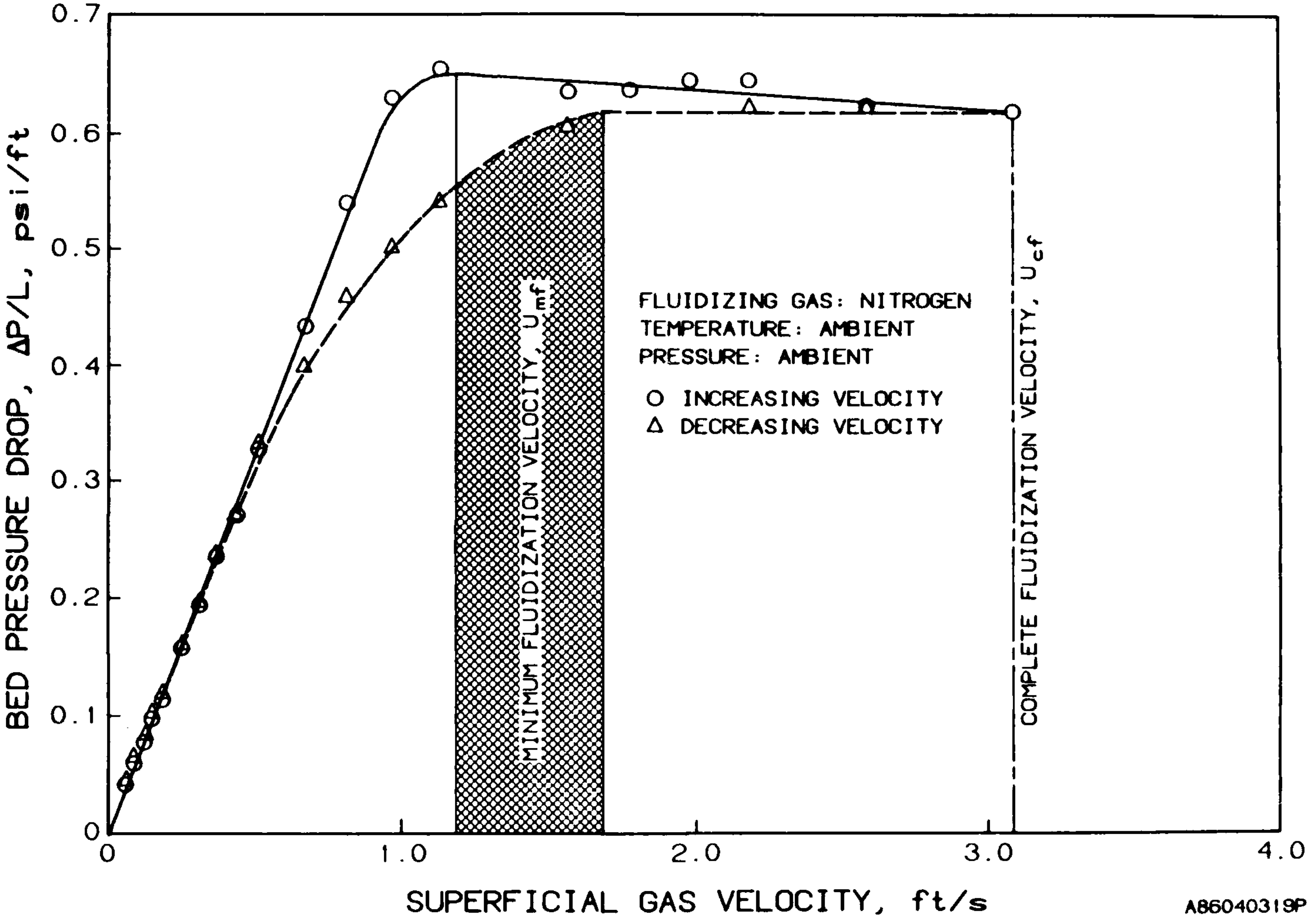

Figure 3. FLUIDIZATION CURVE OF THE USED BLAST GRIT FOR LONG BEACH NAVAL SHIPYARD

Overall, the results of the tests are promising in that used grit can be calcined to remove organics and paint chips and rendered suitable for reuse in Navy shipyards. The laboratory reactor used for the tests is not an exact replicate of the FB calciner and therefore the test results have been limited in some aspects.

ECONOMICS OF BLAST GRIT RECLAMATION

The economics of reclaiming blast grit appear very attractive based on the preliminary test results and cost information from Long Beach Naval Shipyard.

The cost of fresh grit is about $100/ton and the cost of dumping the used grit is $150/ton at Long Beach. The annual usage of grit at Long Beach is about 8000 tons. Present cost of buying and disposing of blast grit is therefore $2 million.

Based on the test results, about 90% of the used grit can be calcined and reused. The remaining 10% has to be disposed of. If a FB calciner is installed at Long Beach, the cost of buying and disposing of the fine grit will be reduced to $200,000, resulting in a savings of $1.8 million per year. Applied on a similar basis to all the shipyards which use 80,000-100,000 tons of grit per year the savings could be around $20 million per year.

Obviously, the above economics are preliminary and based on gross assumptions about costs at various shipyards and the performance of the FB calciner. However, they do indicate the potential of the savings involved while simultaneously solving a serious environmental problem.

The prototype calciner will include the entire blast grit reclaiming system -- storage of used grit, feeding, and drying and preheating of the used grit, the calciner, cooling and storage of reclaimed grit, fines collection and flue gas venting system and all electrical and other support systems. The calciner will be constructed at one of the Naval shipyards. IGT will assist in start-up and initial operation and training of operators for the prototype calciner. During its operation, all necessary data and information will be gathered for final technical and economic evaluation of the FB calciner. Based on those results, the Navy will have sufficient information to make a decision on installation of similar calciners at other Naval shipyards.

RPP/blastgrit

DEVELOPMENT OF A FLUIDIZED BED CALCINER FOR NAVAL SHIPYARDS

The preliminary feasibility test results have shown promising potential in reclaiming blast grit for reuse in Naval shipyards. To develop the FB calciner for use by the Navy, IGT proposes a 3-Phase program:

- Phase I - Evaluation of Blast Grits and Feasibility Tests
- Phase II - Parametric and Design Data Tests in a Pilot Calciner
- Phase III - Construction and Operation of Prototype FB Calciner at a Navy Shipyard

Equipment to perform Phase I and Phase II is available at IGT and therefore the costs involved will be for manpower and chemical analysis. For Phase III a new piece of equipment will have to be constructed based on results available from Phases I and II. The following is a brief description of work involved in each Phase.

Phase I. Evaluation of Blast Grits and Feasibility Tests

The first step in this phase will be to collect both fresh and used grits from all the eight Navy shipyards and characterize them. As indicated from analysis done during the preliminary feasibility, the analysis of the grit has considerable variations. This is due to the problems involved in obtaining representative solid samples and the inherent variation in concentration of paint chips in the used grit.

The laboratory reactor used in the preliminary tests will be modified to closely resemble the configuration and operating characteristics of a FB calciner. Tests will be conducted on a batch basis with different types of grits. The primary emphasis of the tests will be to prove conclusively the feasibility of the FB calciner for reclaiming used blast grit. The main operating variables -- temperature, velocity, retention time -- will be studied. Data will be obtained to determine the fate of the organics and paint chips during the calcining steps. The velocity will be varied to remove sufficient fines so as to meet the size specifications for blasting with fresh grit.

The estimated cost for Phase I is $80,000 and the time required to complete will be 6 months.

Phase II. Parametric and Design Data Tests in a Pilot Calciner

IGT has a fluidized bed reactor pilot unit that can be used to conduct tests for calcining blast grit. A schematic drawing of this unit is shown in Figure 4. This unit can process solids at a rate of 100-500 lbs/hr on a continuous basis. It has all the auxilliary equipment and utilities such as natural gas, air, water, steam, electricity to conduct tests of 1-5 days duration.

Samples containing about 5 tons of used blast grit will be obtained to conduct these tests. The pilot unit is sufficiently large to be autothermal and give representative data on fuel usage, thermal efficiency, etc. During this phase, parametric tests will be conducted to bracket the best operating conditions -- temperature, velocity, retention time -- for each of the blast grit identified as of major use in Naval shipyards in Phase I. The reclaimed grit will be used to conduct a blasting operation and returned to the calciner for reprocessing. This will simulate the reclamation -- reuse of the grit in a shipyard -- and will provide better estimate of losses during each cycle. It will also yield information on build-up of any particular hazardous metal in the blast grit. The tests will also include collecting fines in a cyclone and a simulated bag house to obtain data on cleanliness of the vent gases from the FB calciner system.

After completing the parametric tests, one additional test on each blast grit will be conducted at the optimum operating conditions to obtain data for design of a commercial type of FB calciner.

The cost estimate and time required for this phase will be available after completing Phase I work.

Phase III. Construction and Operation of a Prototype FB Calciner

Based on the results from Phase II, IGT will design a prototype FB calciner. The prototype calciner will be sized to handle 5 to 10 tons/hr of blast grit. This size is similar to what will be required at each of the Naval shipyards. Such a calciner will be able to handle sufficient blast grit so that used grit from cleaning of a previous ship is reclaimed within 10 days and ready to be used on the next ship coming into the dry dock.

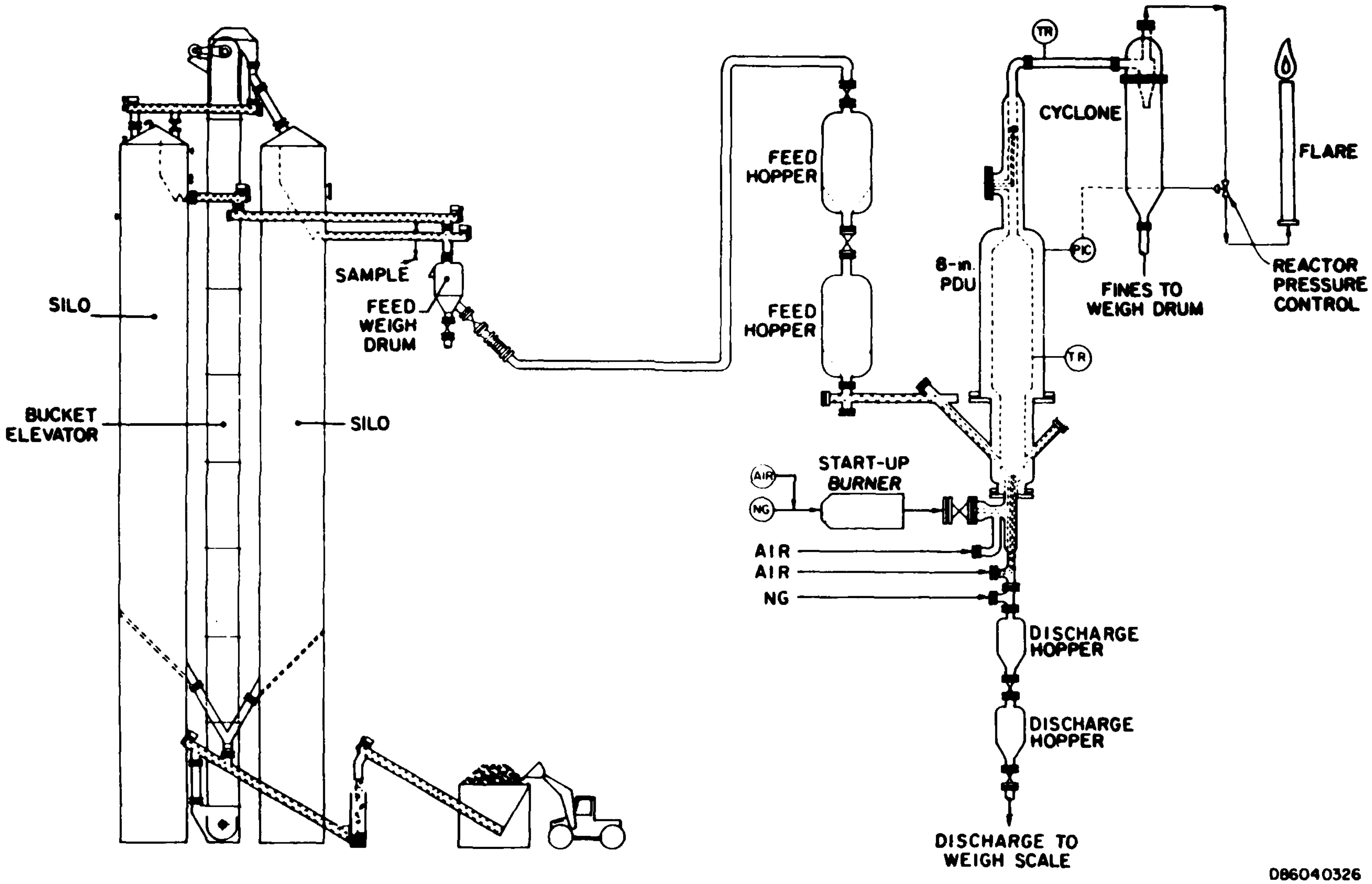

Figure 4. FLUIDIZED-BED CALCINER PILOT UNIT

APPENDIX H

INITIAL FEASIBILITY REPORT ON THE USE OF SUPERCRITICAL FLUIDS (SCF) FOR THE MINIMIZATION OF NAVY HAZARDOUS WASTES

APPENDIX H

INITIAL FEASIBILITY REPORT ON THE USE OF SUPERCRITICAL FLUIDS FOR THE MINIMIZATION OF NAVY HAZARDOUS WASTES

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1.0 INTRODUCTION

1.1 OVERVIEW

In this section, some of the industrial activities of the Navy that generate hazardous wastes are identified, an outline of the Navy program to attenuate the generation of these wastes is briefly discussed, the strategies for the management of wastes with supercritical fluid technology are listed, and the nature of supercritical fluids is outlined.

1.2 HAZARDOUS WASTE MINIMIZATION

The Resource Conservation and Recovery Act (RCRA) has resulted in the designation of certain substances as hazardous and the specification of methods for the interim handling and ultimate disposal of such materials. Some of the industrial activities of the Department of the Navy, Table H-1, result in the generation of large volumes of spent organic solvents, aqueous solutions, and solids that contain hazardous substances. Table H-2 is a partial list of such wastes with typical compositions. The Navy has initiated a program that has the objective of significantly reducing or eliminating these wastes by process modification, material substitution, and solvent recovery.

Conventional chemical processing techniques, such as extraction or distillation may be used to separate the hazardous and nonhazardous components of these wastes and reduce the net volume of the waste streams. If the waste stream were a spent solvent, the separation of the solvent from the hazardous solute could reduce the net flow of hazardous waste, since the solvent could then be reused. The solute could be destroyed in an appropriate on-site chemical reactor, such as an incinerator, or be delivered to an outside contractor for destruction. An overall strategy then might be to select from the classes of separation processes listed by King (Reference H-1), Table H-3, those that can be used to separate hazardous components from the waste solvent streams. However, some operational difficulties associated with this strategy are:

- The solutes of interest are often in low concentration.
- The separations are often thermal energy intensive.
- The solutes may be heat-sensitive (explosive).
- Additional waste solvent streams may be generated.
- The subsequent separation of the extract solvent may be difficult and the volumetric flow rates may be large.

Table H-1. Typical Industrial Processes Used by the Navy

Degreasing and Cleaning (1)

Standing piping installations requiring qualification for oxygen use, breathing air, or other cleanliness standards now typically met by Freon flushing.

Conventional vapor and spray degreaser installations.

Wastewater Treatment Plants (1)

Electroplating wastewaters containing heavy metal cyanide complexes (concentrations less than 500 ppm).

Aircraft paint stripping wastewaters containing stripper mixtures consisting of dichloromethane, phenol, and formic or hydroxyacetic acid (stripper concentrations less than 1000 ppm).

Torpedo-motor wash water containing detergent (LAS), cyanide (concentrations less than 500 ppm), and Otto fuel (concentrations less than 50 ppm).

Photo-etch bath liquids containing separated, gelatinous photoresist.

Manufacture of TNT (2)

Wastewater from TNT manufacturing processes contaminated with organic nitrobodies and alkali-metal nitrates, nitrites, sulfates, and sulfites.

Notes:
1. See Reference H-2
2. See Reference H-3

Table H-2. Hazardous Wastes Generated at Navy Activities with Some Typical Compositions

---

Abrasive blasting grit (1)

Ground smelting slags, sands, zirconia, and other hard media contaminated with ship-hull paint (to 5 wt%), possibly doped with organotin compounds (typically tributyltin oxide) at about 0.1% dry weight paint basis.

Paint sludge from water-wall spray booths (1)

Epoxy (polyamide), alkyd, varnish coatings wetted with industrial-grade water.

Paint skins screened from aircraft chemical stripping operations (1)

Epoxy, alkyd, and varnish coatings swollen with methylene chloride and phenol at a few weight %.

Waste paint with and without thinner (1)

Partially used and damaged containers of various coatings contaminated with thinner (mineral spirits) at levels ranging from a few percent to predominantly thinner.

1,1,1-trichloroethane with concentrated vapor degreaser pot bottoms (1)

Easily pourable system containing 25 to 50 vol% petroleum grease and nondescript dirt.

Spent cold carbon remover solution (1)

Various proprietary mixtures believed to include cresol solutions in methylene chloride contaminated with traces of carbonaceous matter.

Waste solvents (1)

Freon 113, xylene, 1,1,1-trichloroethane, MEK, toluene, dichloromethane, PD-680 (nonaromatic mineral spirits boiling from about 310 to 390° F). Waste solvents will contain water, dirt, paints, residues, gums, etc. and will be recovered preferentially for recycle by distillation.

2,4,6-trinitrotoluene (TNT) production (2,3,4)

"Pink water" is the washings produced in manufacturing and loading plants involving TNT, HMX and RDX explosives. The dissolved products are removed by filtration through diatomaceous earth and sorption on activated carbon.

Table H-2 (Continued)

Recovered bilge oil (1)

These oils are variously separated from the associated water phase (depending upon process). Oil recovered from an API air-flotation separator will contain as much as 75% water, as much as 10% sludge with associated heavy metal contaminants, and an oil fraction approximately equivalent to marine fuel diesel (MFD). Attempts to cofire the recovered oil in oil-fired steam generators have had mixed acceptance, largely because of heavy metal contaminants. Such emulsions, if treated with demulsifiers and subjected to thermal water knockout, will yield more water, a sludge fraction, and a clean (low metals and phosphates) oil layer that is essentially ready for use as a boiler fuel. The sludge fraction then becomes a candidate for thermal destruction. Typically, the oily sludge contains some asphaltines (1 to 3% organic solids), over 50% water, about 1% inorganic material, and 35 to 45% free oil. The predominant heavy metals are lead, chromium, iron, nickel, and zinc at levels in the few hundred ppm range (in wet sludge).

Waste oils (1)

Various oils no longer qualified for service, typically containing adventitious contaminants introduced other than from service. This category includes lube oils, hydraulic oils, mixed coolants, cellulube, greases, and other related materials.

Flammable blasting grit (1)

Various soft abrasives contaminated with paint chips containing small amounts of Cd, Cr, and As. Spent grit includes rice hulls, walnut shells and plastic media (urea-formaldehyde typically).

Other flammable solids (1)

Rags and clothing contaminated with paint, oil, and solvents.

Notes:
1. See Reference H-2
2. See Reference H-3
3. See Reference H-4
4. See Reference H-5

Table H-3. Classes of Separation Processes

Diffusional Separation Processes

Evaporation
Flash expansion
Distillation
Crystallization
Drying solids
Freeze drying
Desublimation
Dual-temperature exchange reactions
Zone melting

Ordinary Equilibration Processes

Stripping
Absorption
Extraction
Leaching or washing
Precipitation
Adsorption
Ion exchange
Ion exclusion
Paper chromatography
Ligand-specific "affinity" chromatography
Bubble fraction; foam fractionation

Imposed-gradient Equilibration Processes

Isoelectric focusing
Isopycnic ultracentrifugation

Equilibration Processes with More than One Separating Agent

Extractive and azeotropic distillation
Adductive Crystallization
Clathration

Rate-governed Processes

Gaseous diffusion
Sweep diffusion
Thermal diffusion
Mass spectrometry
Dialysis

Rate-governed Processes (continued)

Ultrafiltration
Electrophoresis
Electrolysis plus reaction
Sedimentation ultracentrifuge
Reverse osmosis
Molecular distillation
Gas permeation
Electrodialysis
Nozzle diffusion
Liquid membrane
Gel filtration

Table H-3. (Continued)

Mechanical Separation Processes, Density Based

- Sink-float
- Isopycnic centrifugation or settling
- Settling
- Cyclone
- Centrifuge (sediment type)

Mechanical Separation Processes, Size Based

- Filtration
- Mesh demister
- Centrifuge (filtration type)
- Particle chromatography

Mechanical Separation Processes, Surface Based

- Flotation

Mechanical Separation Processes, Fluidity Based

- Expression

Mechanical Separation Processes, Electrically Based

- Electrostatic precipitation

Mechanical Separation Processes, Magnetically Based

- Magnetic separation

Source: Reference H-1

1.3 NAVY PROGRAM

As a first step in the Navy program, The Naval Civil Engineering Laboratory (NCEL) located at Port Hueneme, California, was assigned the task of preparation of an "Initiation Decision Report" (IDR), which catalogs the present Navy hazardous waste production and associated management practices. The report is to evaluate available technologies that may be used to bring Naval activities into compliance with Environmental Protection Agency (EPA) regulations. The report will also identify technology related to the reduction in volume, the detoxification, and the disposal of hazardous wastes with special emphasis on process modifications that will attenuate the generation of hazardous waste materials. Specifically, the IDR will identify hazardous waste problems that are unique to the Navy and will require future research and development effort.

The Chemical Engineering Science Division (CESD) was asked by the NCEL to identify supercritical fluid technology that might be used to minimize the production of hazardous wastes from the industrial processes used by the Navy. Where specific process technology based upon supercritical fluids was identified for possible development and application to problems, the CESD was asked to:

- Describe the problem.
- Discuss the nature of the proposed solution.
- Provide an estimate of the costs.
- Delineate a plan for the development of the technology.

1.4 APPROACH

The management of hazardous waste streams consists of choosing the appropriate mix of three techniques shown in Figure H-1: storage, separation, and destruction by chemical reaction. The streams exiting the separation processes are subjected repeatedly to the same three strategies shown in the figure until compliance with regulations is achieved. If the waste stream were an inert solid, such as a sand contaminated with a hazardous liquid, the extraction of the hazardous component would attenuate the disposal problem. The hazardous component could then be destroyed in a chemical reactor, and the solute-free sand could be reclaimed, sent to a landfill, or used in some other manner.

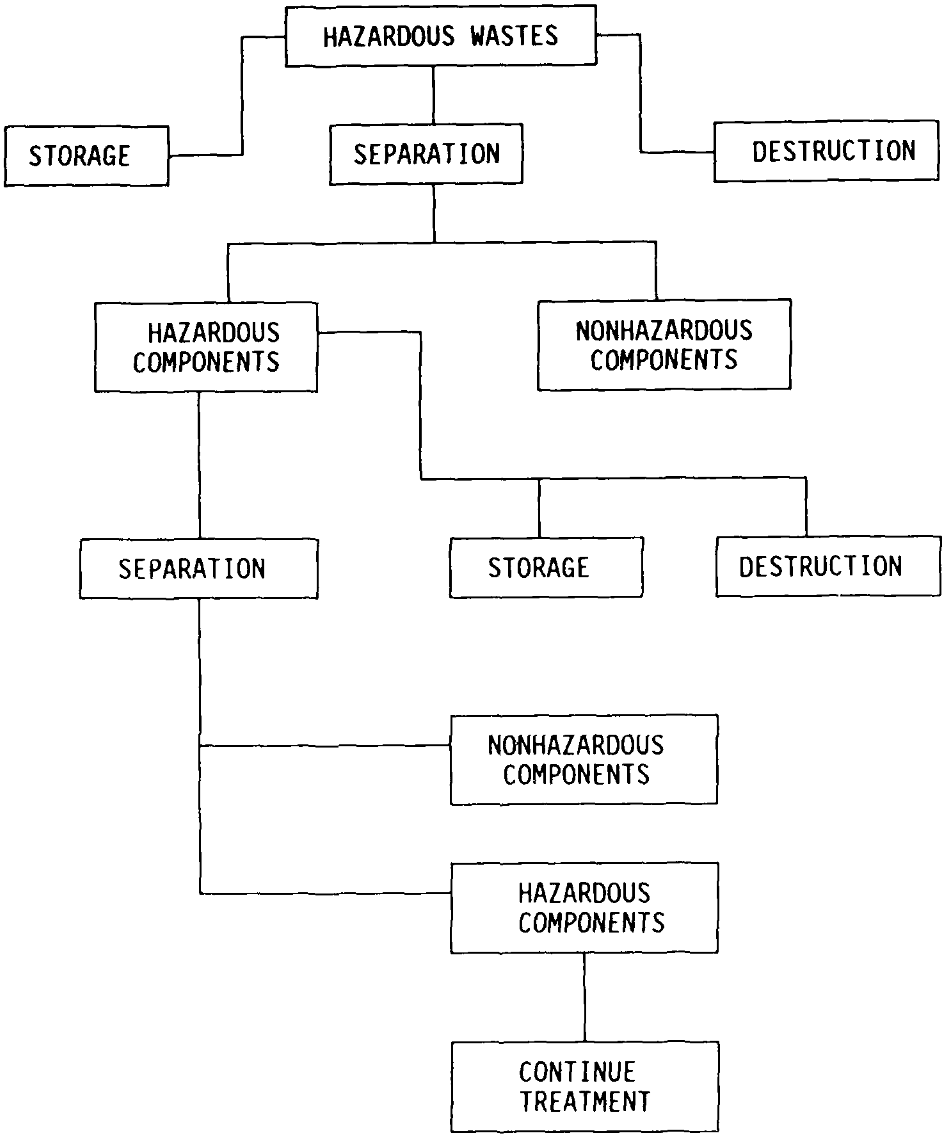

Figure H-1. Techniques for hazardous waste management

1.5 PROCESSING STRATEGIES

The review of supercritical fluid technology was divided into three major strategies listed in Table H-1:

- Replacement of conventional solvents with supercritical fluids
- Separation of hazardous and nonhazardous components by extraction
- Destruction of hazardous wastes in a supercritical fluid reactor

Destruction of organic wastes in a supercritical fluid reactor is perhaps the most attractive of all the supercritical fluid technologies relative to hazardous waste management. The hydrocarbon compounds and their derivatives may be converted to carbon dioxide and water, and the salts of the inorganic oxides may be precipitated. Further, as indicated in the table, no new developments in process equipment are required, since there exists considerable expertise relative to supercritical steam plants, steam chemistry, ammonia synthesis reactors, and steam reformers.

One of the major advantages in the use of a supercritical fluid for hazardous waste management is the relative ease of separation of the solute from the solvent. The density of the fluid may be modified by changing temperature, pressure, or both to alter the selectivity and to separate the extract solvent from the solute.

1.6 SUPERCRITICAL FLUIDS

1.6.1 Definition

A portion of the phase diagram for pure carbon dioxide is shown in Figure H-2. The line is the locus of the pressures and temperatures at which two phases, liquid (l) and gas (g), are in equilibrium. This line is terminated by the "critical point," which is in the lower left-hand corner of the figure and represents a thermodynamic region in which it is no longer possible to distinguish between the phases or liquefy the gas phase by compression. This condition is called the "supercritical" state, and the substance is termed a "fluid" to distinguish it from gas or liquid phases.

1.6.2 Characteristics

A supercritical fluid has some of the properties of a liquid and some of a gas: the transport properties are gas-like, the density is nearly that of a liquid, the surface tension is negligible, and the solvent power of the fluid is dependent upon pressure and temperature. Some selected values of density and viscosity are listed in Tables H-4 and H-5, respectively. The marked change in the solvent power of the supercritical fluid with respect to changes in temperature, pressure, or both permits extractions and separations that are not ordinarily feasible (Ely and Baker; Reference H-6). The critical properties for selected species ranked with respect to critical temperature and pressure are shown in Tables H-6 and H-7, respectively. Enhanced solubility of many compounds in supercritical carbon dioxide is described in several references; McHugh and Krukonis (Reference H-7) and Paulaitis (Reference H-8).

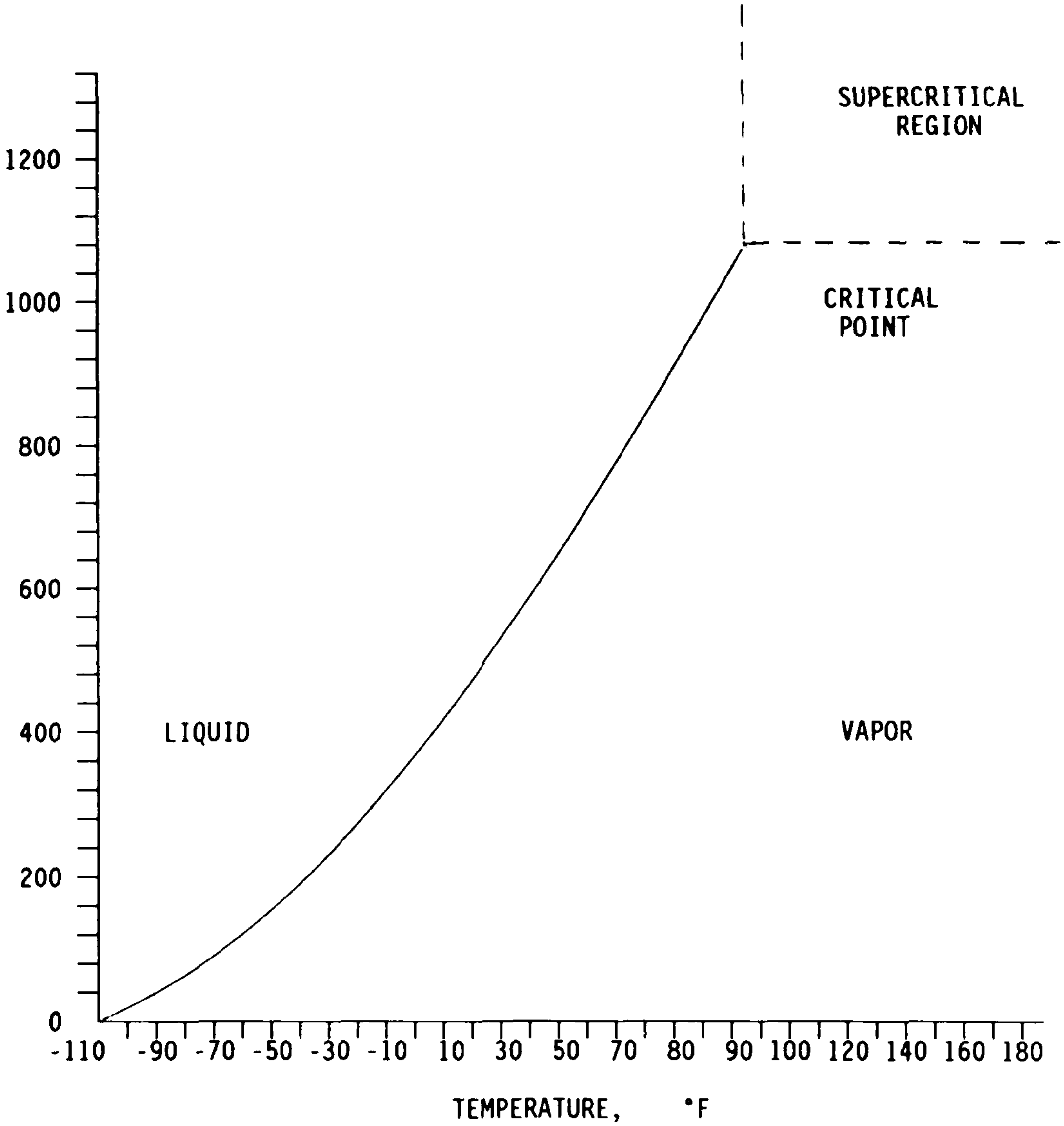

Figure H-2. Selected Portion of the Phase Diagram for Carbon Dioxide

Table H-4. Selected Values of Density of Carbon Dioxide

State	Density mol/L	T °K (°F)	p bar (psia)
Liquid	17	295 (71)	60 (870)
Gas	0.04	295 (71)	1 (14.5)
Critical	10.6	304 (87)	74 (1070)
Supercritical	2.6	500 (440)	100 (1450)

Table H-5. Selected Values of Viscosity of Carbon Dioxide and Water

Species	Carbon dioxide	Water
State	critical	subcooled liquid
Temperature		
°K	304	310
(°F)	(87)	(98)
Pressure		
bar	74	1.01
(psia)	(1110)	(14.7)
Viscosity		
N s/sq-m	34×10^{-6}	0.70×10^{-3}
(cp)	(0.03)	(0.70)

Table H-6. Critical Temperatures and Pressures

	Critical Constants			
Species	T_c, °C	P_c, atm	T_c, °F	P_c, psia
nitrogen	-147.0	33.5	-232.6	492.3
methane	-82.4	45.8	-116.3	673.1
ethylene	9.9	50.5	49.8	742.1
R-13	28.9	38.0	83.9	558.4
carbon dioxide	31.0	72.9	87.8	1071.3
ethane	32.2	48.2	90.0	708.3
nitrous oxide	36.5	71.7	97.7	1053.7
R-22	96.5	48.5	205.7	712.8
propane	96.8	42.0	206.2	617.2
R-12	111.5	39.6	232.7	582.0
ammonia	132.5	112.5	270.5	1653.3
R-114	145.8	32.3	294.4	474.7
n-butane	152.0	37.5	305.6	551.1
sulfur dioxide	157.8	77.7	316.0	1141.9
nitrogen dioxide	157.8	100.0	316.0	1469.6
acetaldehyde	187.8	54.7	370.0	803.9
n-pentane	196.6	33.3	385.9	489.4
R-11	198.0	43.2	388.4	634.9
R-113	214.2	33.7	417.6	495.3
acetone	235.9	47.0	456.6	690.7
methanol	240.0	78.5	464.0	1153.6
ethanol	243.0	63.0	469.4	925.8
R-150a	249.8	50.0	481.6	734.8
R-112	278.0	32.9	532.4	483.5
cyclohexane	280.0	40.0	536.0	587.8
carbon tetrachloride	283.0	45.0	541.4	661.3
benzene	289.0	48.6	552.2	714.2
toluene	320.8	41.6	609.4	611.4
acetic acid	321.6	57.1	610.9	839.1
n-decane	344.5	20.8	652.1	305.7
water	374.2	218.3	705.6	3208.1

Index to refrigerant designations:

R-11	trichlorofluoromethane
R-12	dichlorodifluoromethane
R-13	chlorotrifluoromethane
R-22	chlorodifluoromethane
R-112	tetrachlorodifluoroethane
R-113	trichlorotrifluoroethane
R-114	dichlorotetrafluoroethane
R-150a	1,1-dichloroethane

Table H-7. Critical Temperatures and Pressures Ranked in Order of Increasing Pressure

	Critical Constants			
Species	T_c,°C	P_c,atm	T_c,°F	P_c,psia
n-decane	344.5	20.8	652.1	305.7
R-114	145.8	32.3	294.4	474.7
R-112	278.0	32.9	532.4	483.5
n-pentane	196.6	33.3	385.9	489.4
nitrogen	-147.0	33.5	-232.6	492.3
R-113	214.2	33.7	417.6	495.3
n-butane	152.0	37.5	305.6	551.1
R-13	28.9	38.0	83.9	558.4
R-12	111.5	39.6	232.7	582.0
cyclohexane	280.0	40.0	536.0	587.8
toluene	320.8	41.6	609.4	611.4
propane	96.8	42.0	206.2	617.2
R-11	198.0	43.2	388.4	634.9
methane	-82.4	45.8	-116.3	673.1
acetone	235.9	47.0	456.6	690.7
ethane	32.9	48.2	90.0	708.3
R-22	96.5	48.5	205.7	712.8
benzene	289.0	48.6	552.2	714.2
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acetaldehyde	187.8	54.7	370.0	803.9
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carbon dioxide	31.0	72.9	87.8	1071.3
sulfur dioxide	157.8	77.7	316.0	1141.9
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ammonia	132.5	112.5	270.5	1653.3
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R-13	chlorotrifluoromethane
R-22	chlorodifluoromethane
R-112	tetrachlorodifluoroethane
R-113	trichlorotrifluoroethane
R-114	dichlorotetrafluoroethane
R-150a	1,1-dichloroethane

1.6.3 Advantages

The use of supercritical fluids in processes based upon interphase mass transfer has a number of advantages when compared with conventional solvents:

- The solute may be separated readily from the supercritical fluid solvent by decreasing the density of the fluid.
- The contact and separation processes may be conducted at relatively low temperatures, which results in increased safety in the handling of heat-sensitive materials, such as propellants and explosives.
- The solvent may serve as an inert gas cover, thereby reducing the hazard of explosion or fire.
- The solvent does not become part of the waste disposal problem.
- The proper scheduling of solvent density changes permits fractionation, if multiple solutes are present.
- The solvent power of the supercritical fluid solvent may be altered in certain cases by the addition of "entrainers," which reduce the pressure change required in the separation step.

2.0 METHODS

2.1 SUMMARY

The methods used to identify and evaluate potential applications of supercritical fluid technology to industrial processes used by the Navy are detailed in this section. The efficacy of the strategies of replacement, separation, or destruction, relative to each of the typical waste streams (Table H-2), were considered. The methods listed in Table H-8 were used to eliminate processes from consideration, and a preliminary design was prepared for processes that appeared useful.

The elements of the preliminary design were:

- Prepare a flow sheet based upon a treatment process.
- Calculate a material balance for the flow sheet.
- Estimate major equipment sizes.
- Estimate electrical power, steam, and cooling water requirements.
- Estimate fixed capital costs.
- Estimate the operating costs.
- Estimate the costs associated with development of the technology.

The preliminary design calculations and cost estimates should be repeated when the volumetric rates and the compositions of the waste streams are known.

2.2 REPLACEMENT

The strategy of replacement of a conventional solvent with a supercritical fluid solvent was identified as a potential candidate for the decontamination of hardware, such as the Mark 48 torpedo afterbody and high-pressure, life-support systems. Two separate systems were considered; one for cleaning hardware (Figure H-3) and one for cleaning standing high-pressure piping and vessels (Figure H-4).

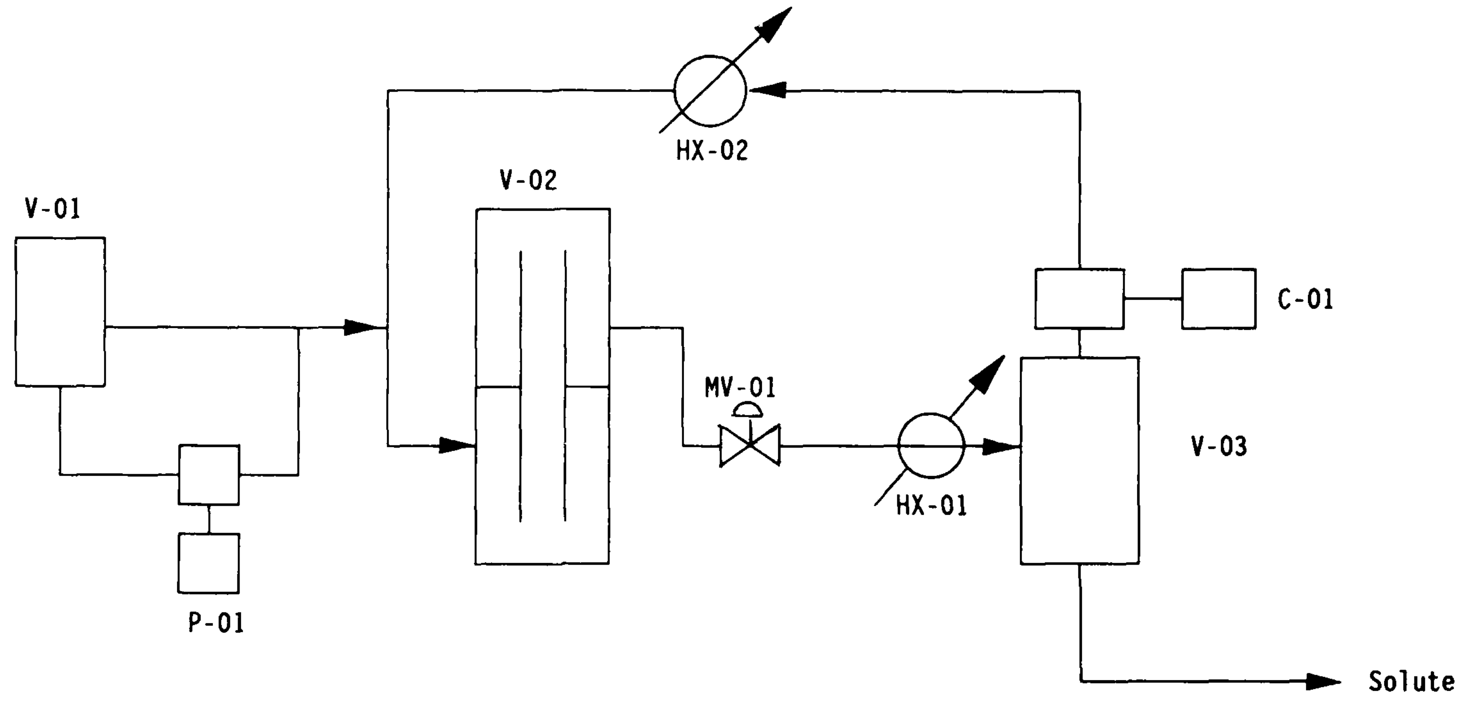
In the first system, vessel V-02 was used to contain the torpedo afterbody, and the supercritical fluid solvent was circulated through the vessel at a rate corresponding to a residence time of 12 min. The free volume in the vessel, with the afterbody and internal fixtures installed, was assumed to be 65 percent of the volume of the empty vessel. The vessels were assumed to be cylindrical in cross section with spherical ends. The length of the flushing cycle was assumed to be on the order of an hour and the hazardous solute was assigned a low solubility, 0.001 mole fraction, even though conditions could exist in which the contaminant was completely miscible. Complete separation of the solute from the solvent was assumed to occur under an isothermal pressure

Table H-8. Considerations Used in Screening a Potential Solution of a Processing Problem

---

- Define primitive problem.
  - Reduce or eliminate hazardous wastes generated by Navy industrial processes.
- Gather cognate facts.
  - Navy industrial processes are listed in Table H-1, and wastes and typical compositions are listed in Table H-2.
- Create specific problems.
  - Replace conventional solvents with supercritical fluid solvents.
  - Separate hazardous and nonhazardous components in waste streams.
  - Destroy hazardous materials in waste stream with a supercritical fluid reactor.
- Screen specific problems.
  - Is the concept illogical?
  - Can the concept be shown to be inferior to others?
  - Can the concept be shown to be equivalent or inferior to a known inferior processing concept?
  - Can the concept be shown to require too much technical or economic extrapolation from existing technology?
  - Is the concept safe?
  - Does the concept suggest a better alternative?
  - Does the concept require special technical competence that a user activity typically does not possess?
- Engineer a solution.
  - Prepare a preliminary design.
  - Perform a demonstration of feasibility, as required.
  - Prepare a detailed design.

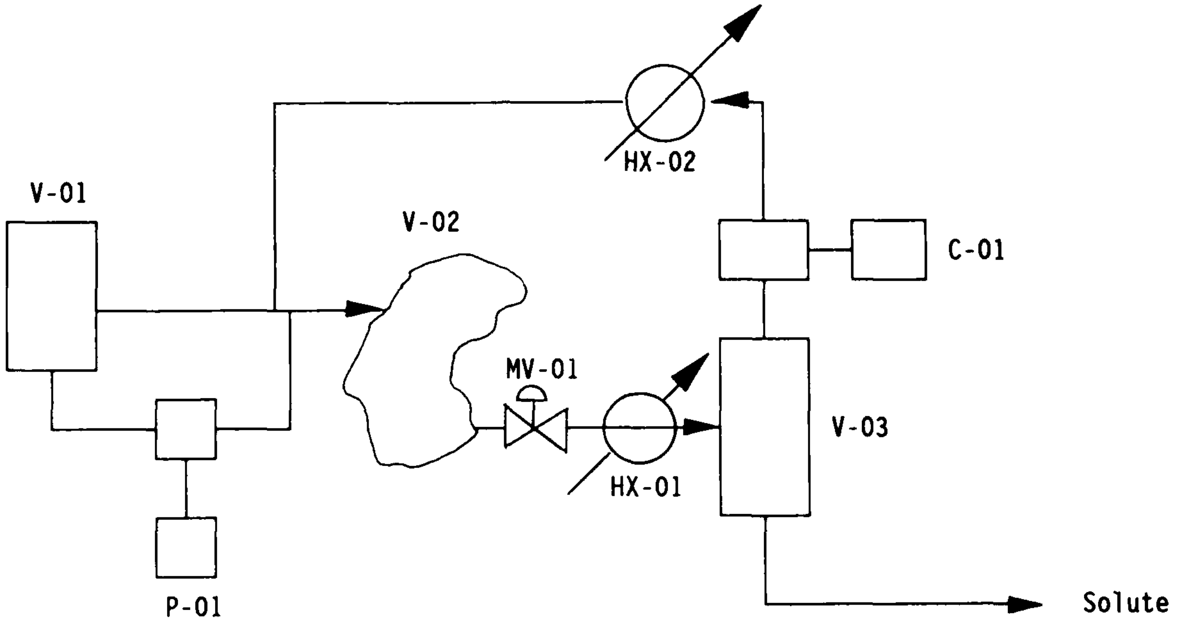
Source: Reference H-9



LEGEND:

C-01	Recycle Compressor	P-01	Charge pump
HX-01	Separator feedstream heater	V-01	Solvent storage
HX-02	Compressor discharge cooler	V-02	Extraction vessel or contactor
MV-01	Motor valve for pressure control in separator	V-03	Separator

Figure H-3. Decontamination System for Hardware



LEGEND:	C-01	Recycle compressor	P-01	Charge pump
	HX-01	Separator feedstream heater	V-01	Solvent storage
	HX-02	Compressor discharge cooler	V-02	Decontaminated system
	MV-01	Motor valve for separator pressure control	V-03	Separator

Figure H-4. SCF System for Decontaminating High Pressure Equipment change from 100 to 1 atmosphere or under an isobaric temperature change from 370 °K (206 °F) to 460 °K (368 °F). The change that required the most electrical power, cooling water, or steam was used in the cost estimates. No credit was taken for thermal exchange of inlet or outlet streams or for recovery of work in an expander.

Compressor work was calculated for a four-stage, reciprocating unit with intercooling, equal pressure ratios in each stage, and an isothermal path. The compressor efficiency was assumed to be 70 percent, and thermodynamic tables for carbon dioxide were used to obtain the required values of entropy and enthalpy. Heat exchanger surface areas were based upon an overall heat-transfer coefficient of 100 Btu/(hr sq-ft °F). Vessel V-01 in Figure H-3, the solvent storage vessel, was assumed to be identical in design to V-02 with the exception that the internal fixtures were not present. This allows one to place V-01 in service for decontamination duty. It is easier to add solvent storage in the form of flasks or conventional cylinders rather than order a new vessel.

The system illustrated in Figure H-4 is identical to that in Figure H-3, with the exception that vessel V-02 is not required, since the system to be cleaned serves as the pressure vessel. For example, the high-pressure breathing gas system on a submarine is rated for higher pressures than would be used in a cleaning process based upon supercritical fluid solvents.

2.3 SEPARATION

A stagewise contactor was considered for the decontamination of solids, such as blasting grits and a differential was considered for liquids, such as waste solvents. The stagewise contactor is operated in a countercurrent fashion; the solids contaminated by a solute are fed at the first stage and flow to the last. The extract solvent, a supercritical fluid, is fed from the last stage and flows to the first. At each stage, the inlet streams are mixed, and then the solids are separated from the liquid in a hydrocylcone. The liquid stream then flows to the next lowest stage, and the solids are conveyed to the next higher stage. A conventional liquid-liquid contactor was assumed for the differential contactor; the solute-rich solvent is expanded, heated, and then fed to a separator. The solvent flowing out of the separator is compressed, heated, and returned to the column.

The throughput for the differential contactor was taken as 100 lbm(solids)/hr, and the equilibrium concentration of the solute was assumed to be 0.001 mole fraction. This is a very conservative assumption, since conditions would be chosen such that the solute would be completely miscible. Twelve stages were specified, and the required inventory of solvent in storage was chosen as 160 liters. The circulation rate of solvent was estimated to be 1.68 g-mole/sec, and in estimation of the compressor power required, complete separation of the solute was assumed to occur for an isothermal pressure change from 100 to 1 atmosphere. No credit was taken for recovery of the thermal energy in the exit streams or for the expansion of the fluid through a turbine or engine. Each stage in the contactor was estimated at $3,000 delivered, including the mixing section. Carbon dioxide was assumed to be the solvent, although other materials might be better. A particular advantage of using a supercritical fluid solvent is that good penetration into the pores of solids is achieved because of the low viscosity and the negligible surface tension. As with the equipment associated with the replacement strategy, an overall heat transfer coefficient of 100 Btu/(hr sq-ft °F) and compression along an isothermal path in four stages with intercooling were assumed in order to estimate costs for such equipment.

The compressor, pumps, and heat exchangers for the differential contactor are identical in configuration with those for the stagewise contactor. The vessel was specified as 2 ft in diameter, with a length of 12 ft. No specification was made for the internals.

Contaminated solids could best be decontaminated in an ordinary incinerator or added to the coal feed in a spreader-stoker furnace. This would not be allowed if the particles were contaminated with heavy metals.

2.4 DESTRUCTION

A feedstream of trace organic compounds in water, or a concentrated organic waste diluted with water, is pumped to approximately 5,000 psia along an isothermal path and then mixed with an oxidant. The oxidant may be gaseous air, oxygen, or a liquid-phase species, such as hydrogen peroxide. This mixture then passes through a heat exchanger in which it is heated to approximately 1,000 °F. The heated mixture then flows through a bayonet-style tubular reactor. The oxygen present, or generated by the decomposition of the hydrogen peroxide, participates in a combustion reaction in which the hydrocarbons are converted to water and carbon dioxide. The reaction products are then cooled, passed through a let-down valve, and into a gas separator. The gas stream from the top of the separator is discharged to the atmosphere or to the suction side of a combustion-air fan for the furnace. The liquid stream may be recycled to the generation process or to the supercritical reactor, depending upon the nature of the service. The operating conditions specified here are illustrative only; the actual operating conditions are expected to be somewhat lower in temperature and pressure.

A feedstream of 500 ppm(wt) TNT in water was used as a basis for the calculations and a unit capable of processing 60 gal/hr of waste water was selected as a typical size. If additional processing capacity were required, additional tubes, pumps, and heat exchangers would be put in parallel to the original system. Thermodynamic properties of water were obtained from NBS/NRC Steam Tables. As before, heat exchanger surface areas were based upon an overall heat transfer coefficient of 100 Btu/(hr sq-ft °F). No credit was taken for recovery of the energy in the exit stream. The design of a production unit should include a provision for using the expansion of the product gases to drive the high-pressure feed pumps. The entering and exiting streams should be exchanged against each other for better thermal economy. A general expression for the stoichiometry for the oxidation reaction of the species "$C_iH_jO_kN_lCl_nI_p$" (TNT: $i = 7$, $j = 5$, $l = 5$, $k = 6$, $n = 0$, $p = 0$), Table H-9, was written and used to calculate the required amount of oxygen and the quantity of reaction products. Complete conversion, see Table H-10, was assumed for the TNT. The costs of the exchanger and the reactor tubing were based upon prices of equipment purchased for a high-pressure, supercritical

Table H-9. Stoichiometry for the Oxidation Reaction of the Species "$C_iH_jO_kN_lCl_nI_p$"

Chemical Reaction

$$0 = v_1\ C_iH_jO_kN_lCl_nI_p + v_2O_2 + v_3CO_2 + v_4H_2O + v_5N_2 + v_6SO_2 + v_7HCl + v_8I$$

Atom Balance

Atom	Species	Reactants	Products
C	carbon	i	v_3
H	hydrogen	j	$2v_4 + v_7$
O	oxygen	$k + 2v_2$	$v_3 + v_4 + 2v_6$
N	nitrogen	l	$2v_5$
S	sulfur	m	v_6
Cl	chlorine	n	v_7
I	inert	p	v_8

Stoichiometric Coefficients

$v_1 = -1$

$v_2 = (-1/2)[2i + (j - n)/2 + 2m - l]$

$v_3 = i$

$v_4 = (j-n)/2$

$v_5 = l/2$

$v_6 = m$

$v_7 = n$

$v_8 = p$

Nomenclature

v_i	Stoichiometric coefficient

Table H-10. Catalog of Reaction Coordinates

Extent of Reaction, ξ_i

$$\xi = (n_i - n_{io})/v_i$$

Fraction of Conversion, f_i

$$f_i = (n_{io} - n_i)/n_{io}$$

Volume Change for Reaction, δ_A

$$\delta_A = [V(f_A = 1) - V(f_A = 0)]/V(f_A = 0)$$

Destruction and Removal Efficiency, (DRE)

$$DRE = 100 \times (w_{in} - w_{out})/w_{in}$$

Nomenclature:

OGH	BSL	Meaning
n_i	M_i	Moles of species "i"
V	V	Volume
-	w	Mass flow rate, M/t

Notes:

1. The fraction of conversion is based upon the limiting reactant.
2. The "extent of reaction" is an extensive variable.
3. Source: See References H-10 and H-11

fluid, heat-transfer flow loop installed at NBS-Boulder. Further, one could design the hardware in such a way that the reactor could be operated as a recycle reactor, which would provide better thermal economy and greater conversion for a fixed reactor volume.

2.5 COST ESTIMATES

The methods used to estimate the fixed capital and operating costs for the equipment associated with each of the strategies, viz., replacement, separation, and destruction, are shown in Tables H-11 and H-12.
The method used to estimate the cost to develop the technology is listed in Table H-13.

Table H-11. Method for Estimation of Fixed Capital Costs

Step Description of Procedure

1. Prepare a flow sheet.
2. Specify operating conditions.
3. List major equipment.
4. Estimate equipment sizes.
5. Estimate equipment costs from
    a. Quoted costs from several manufacturers
    b. Quoted cost for similar unit of a different size scaled to size of interest
    c. Cost estimated from charts for specific types of equipment
6. Bring equipment cost to current value by use of Chemical Engineering Plant Cost Index.
7. Correct for elevated pressures and temperatures, as required.
8. Calculate installed cost by multiplication of equipment cost by the following factors:

Pressure vessels	4.0
Fired heaters	4.0
Heat exchangers	3.5
Pumps	4.0
Compressors	2.5
Miscellaneous	2.5

9. Calculate cost of ancillaries as 15% of total installed cost of equipment.
10. Calculate cost of utilities as 25% of total fixed capital.
11. Estimate cost of contingencies as 25% of total fixed capital.

Table H-12. Method for Estimation of Operating Costs

Step Description of Procedure

1. Specify the on-stream operation in hr/yr
2. Labor cost
    a. Estimate # of operators
    b. Specify direct labor rate
    c. Calculate indirect at 2 x direct
3. Materials cost
    a. Estimate circulation rate
    b. Assign loss rate at some fraction of the circulation rate
    c. Assign unit cost to circulating fluid
    d. Calculate the loss based upon the on-stream time
4. Depreciation and interest on money not included in calculations
5. Estimate annual maintenance cost as 5% of total fixed capital
6. Utilities, electrical
    a. Estimate rate from power required for pumps and compressor
    b. Calculate consumption based upon on stream operation
    c. Assign unit cost $0.10/kW-hr
    d. Calculate cost
7. Utilities, steam
    a. Estimate use from heat load on feed heater
    b. Calculate annual use
    c. Assign unit cost $2.00/1000 lbm (500 psig)
    d. Calculate cost
8. Water
    a. Estimate cooling water required for cooler
    b. Calculate annual use
    c. Assign unit cost $0.20/1000 gal (8.34 lbm/gal)

Table H-13. Method for Estimation of Development Costs

Step Description of Procedure

1. Estimate the manpower required for development of the following information relevant to the process for the following classifications: a senior engineer, a junior engineer, and a mechanical technician.

   - » Transport Properties
     - Viscosity
     - Thermal conductivity
     - Mass diffusivity
     - Heat-transfer coefficients
     - Mass-transfer coefficients

   - » Physical Properties
     - Equation of state
     - Equilibrium data
     - Density, critical point
     - Chemical nature

   - » Thermodynamic Data
     - Enthalpy
     - Heat of formation
     - Heat of solution
     - Equilibrium composition

   - » Reaction Kinetics
     - Reaction rate model
     - Rate constants

   - » Corrosion Resistance

   - » Plant Data
     - Toxicity
     - Explosion and fire hazard

2. Sum the manpower requirements by discipline.

3. Multiply the manpower requirements by the annual labor rates, including overhead, to obtain the total labor cost.

	Classification	Direct + Indirect Annual Labor Rates
a.	Senior engineer	$140,000
b.	Junior engineer	$56,000
c.	Mechanical technician	$45,000

Table H-13 (continued)

Step	Description of Procedure
4.	Calculate the balance of the components of the development costs in the manner shown in the following tabulation:

Component	Method of Calculation
Labor	Manpower x Annual Labor Rate
Materials and Supplies	0.10 x Labor
Equipment	1.00 x Labor
Supervision and Services	0.46 x Labor
Contingency	0.10 x Total

Step	Description of Procedure
5.	Sum the components to obtain the estimated development cost for the technology.

3.0 FINDINGS

In this section, the strategies defined previously, viz., replacement, separation, and destruction, are discussed in turn. A technical problem is identified, the proposed solution based upon supercritical technology is described, and the development, capital, and operating costs for the processes are estimated.

3.1 REPLACEMENT

The replacement of conventional solvents with supercritical fluid solvents has utility in that the volume of hazardous wastes is reduced and the extract solvent may be separated readily from the solute.

3.1.1 Problem Description

The removal of organic substances from solid surfaces is a common activity of the Navy; see Table H-1. A few examples of this activity are:

- Decontamination of torpedo components
- Removal of preservatives from equipment, such as small arms
- Cleaning of rags and clothing contaminated with hazardous chemicals
- Cleaning of high-pressure breathing-gas systems
- Cleaning and flushing of high-pressure hydraulic systems

It would be advantageous to reduce or eliminate the steps used in the conventional cleaning operation: preclean, clean, rinse, inspect, dry, and pressure test.

3.1.2 Proposed Process

The two processes shown in Figures H-3 and H-4 earlier are suitable for decontamination of equipment and high-pressure piping, respectively. As shown in Figure H-3, vessel V-02 has an internal fixture or rack to hold equipment, such as the afterbody of the Mark 48 torpedo. The system would be operated in the following manner:

1. Install hardware in vessel V-02 and seal.
2. Isolate separator V-03.
3. Charge the balance of system with solvent vapor from storage V-01.
4. Start charge pump P-01, and raise system pressure to operating pressure.
5. Isolate solvent storage vessel V-01.
6. Start compressor C-01 and open valves to allow flow into separator V-03.

7. Use cooler HX-02 to control system temperature.

8. Circulate the solvent until the solute concentration is less than the detection limit or some specified value is attained.

9. Pump solvent to storage

10. Vent vessel V-02

The process shown in Figure H-4, is similar to that in Figure H-3 with the exception of vessel V-02; the equipment to be decontaminated serves as vessel V-02. For example, the high-pressure breathing-gas system on board a recompression chamber, dive or salvage ship, nuclear submarine, hyperbaric chamber, or deep-submergence research vehicle serves as the vessel. High-pressure hydraulic systems could also be flushed and cleaned with such a system.

The operation of the cleaning system is the same as that described previously, with the exception that jumpers have to be used to connect the supercritical solvent circulation system with the system to be cleaned.

Certain advantages result from the use of a supercritical fluid solvent in such a system:

- A contaminant can be accumulated and retained for examination, since it is not flushed with extract solvent.
- The breathing-gas system is free of water at the end of the cleaning procedure.
- A pressure test at the operating pressure of the circulation system is obtained, while the cleaning operation is in progress.
- The high flow velocities associated with supercritical gas aid in the conveyance of foreign particles from the system.
- The procedure may be conducted at relatively low temperatures.

3.1.3 Cost Estimate: Capital and Operating Costs

The operating conditions shown in Table H-14 were chosen to be used in the calculation of equipment sizes and utility requirements. The actual operating conditions would probably be less severe. The estimates of the capital and operating costs for the decontamination systems are contained in Tables H-15 and H-16, respectively. No credit is taken in the calculations for the use of an expander, such as a turbine to recover work from the expansion of the fluid. The cost of land, taxes, and the required working capital are not considered. Worst cases were assumed in the selection of solubility data and in the costs of equipment, since the required throughput and the actual composition of the Navy waste streams is not available at this time. Both the capital and operating cost estimates are expected to be reduced, if the systems are operated at conditions under which complete miscibility exists between the solute and the solvent. The compressor power requirement was based upon

Table H-14. Equipment Operating Conditions for Replacement Strategy

	Temperature		Pressure		
Vessel	°K	°F	bar	psia	Case
V-01	295	71	60	867	-
V-02	370	206	100	1450	-
V-03	370	206	1	15	I
	460	368	100	1450	II

Notes:

1. These conditions were selected for calculating the equipment size and do not represent actual or optimum operating conditions.
2. Case I and II correspond to an isothermal expansion and isobaric temperature change respectively. The actual separation could probably be attained for smaller changes.

Table H-15. Estimated Fixed Capital Cost for Replacement Strategy

Equipment Case	Costs, \$ R1 I	 R1 II	 R2 I	 R2 II
Compressors				
Recycle	138740	0	138740	0
Pumps				
Charge	55496	55496	55496	55496
Heat Exchangers				
Feedstream	9644	9644	9644	9644
Discharge cooler	9644	9644	9644	9644
Pressure Vessels				
Solvent storage	36820	36820	36820	36820
Contactor	46820	46820	0	0
Separator	18456	18456	18456	18456
Capital Equipment	315620	176880	268800	130060
Ancillaries	47343	26532	40320	19509
Utilities	181482	101706	154560	74785
Contingency	181482	101706	154560	74785
Total Fixed Capital	\$725926	\$406824	\$618240	\$299138

Notes:
R1 = Decontamination system for hardware (see Figure H-14)
R2 = Decontamination system for high-pressure systems (see Figure H-15)
Case I = Isothermal expansion
Case II = Isobaric heating

Table H-16. Estimated Operating Costs for Replacement Strategy

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Operating Costs

Annual hours of operation	6000

Operating Labor

Number of operators	2
Hourly labor rate	$10.00
Annual cost, direct	$120000
annual cost, indirect	$240000
Annual Total	$360000

Materials

SCF Circulation rate	2.59 g-mole/s
Loss rate	1 % of circulation
	0.0259 g-mole/s
	9.29 lbm/hr
Annual loss	55759 lbm/yr
Unit value	$0.0525 /lbm
Annual Total	$2927

Maintenance

Percent of fixed capital	5 %
Fixed capital	$726000
Annual Total	$36300

Utilities

Service	Electrical	Steam	Water	All
Rate	9.9	54	3041	-
Units	kWhr	lbm-hr	lbm-hr	-
Annual hours on-stream	6000	6000	6000	-
Use	59400	324000	18246000	-
Cost per unit, x10^3	$100.00	$2.00	$0.024	-
Annual Total	$5940	$648	$439	$7027

Total Annual Operating Cost = $406254 /yr

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expansion of the solvent gas to atmospheric pressure and would be reduced as the expansion ratio decreases.

3.1.4 Development: Manpower and Costs

The estimates of the manpower and costs associated with the development of the technology are contained in Table H-17. The manpower estimates are based upon the efforts of two categories of engineers and a technician.

3.2 SEPARATION

The separation strategy is based upon the use of solid-fluid or liquid-liquid contacting and subsequent separation steps to remove hazardous contaminants from solids or liquids. Supercritical fluids are considered because their solvent properties depend strongly upon temperature and pressure. Therefore, the separation of the extract solvent (the supercritical fluid) and the solute (the hazardous or nonhazardous component) is relatively easy. For most Navy applications, hydrocarbons are not acceptable as supercritical solvents because of the cost and the handling problems associated with flammability. This is not the case in many industrial operations in which a light hydrocarbon is an intermediate stock and is handled routinely.

3.2.1 Problem Description

The decontamination of solids, such as blasting grits and sand would permit storage in an ordinary landfill or the reuse of the material. Although distillation is the preferred method of separation for most spent solvents, certain solutes that are heat-sensitive, have a low-vapor pressure, or are in low concentration are separated more easily and safely by liquid-liquid extraction. Examples of Navy wastes of this type are: 1) torpedo motor wash water, 2) waste containing cresol and phenol, and 3) recovered bilge oil.

3.2.2 Proposed Process

Stagewise and differential contactors for leaching and extraction are shown in Figures H-5 and H-6, respectively. For solid-liquid contacting, the high-pressures required by the use of supercritical fluids negate the use of conventional extraction trains composed of mixer-settler units. Instead, an individual stage in the proposed extraction train shown in Figure H-5 is composed of a section of piping, possibility with internal mixing vanes, in which the overflow from stage "k+1" and the underflow from stage "k-1" are brought into intimate contact. This mixing section is followed by a cyclone in which solids are separated from the fluid; the overflow is fed to stage "k-1", and the underflow is fed to stage "k+1". As shown in the figure, additional cyclones may be added to a single stage to achieve the desired level of separation of solids and fluid. The separation technology is well established, since this equipment is used widely in other industries, such as petroleum production.

Supercritical fluid cleaning of solids is probably not warranted, if some other more conventional means, such as incineration is available since recovered solids and the contaminant have in most cases a relatively low

Table H-17. Estimated Manpower and Costs to Develop the Replacement Strategy

	Engineers		
Information Required	Senior	Junior	Technician
Transport Properties			
Viscosity	0.0	0.0	0.2
Thermal conductivity	0.0	0.0	0.0
Mass diffusivity	0.1	0.2	0.0
Heat-transfer coefficients	0.0	0.0	0.0
Mass-transfer coefficients	0.2	0.5	0.5
Physical Properties			
Equation of state	0.0	0.2	0.0
Equilibrium data	0.2	0.2	0.5
Density, critical point	0.0	0.2	0.2
Chemical nature	0.0	0.0	0.5
Thermodynamic Data			
Enthalpy	0.0	0.5	0.0
Heat of formation	0.0	0.2	0.0
Heat of solution	0.0	0.0	0.0
Equilibrium composition	0.2	0.5	0.0
Reaction Kinetics			
Reaction rate model	0.5	0.0	1.0
Rate constants	0.0	0.5	0.5
Corrosion Resistance	0.0	0.1	0.5
Plant Data			
Toxicity	0.0	0.2	0.0
Explosion and fire hazard	0.0	0.2	0.0
Estimated Manpower Reqd	1.2	3.5	3.9
Annual Labor Rate (with ovhd)	$140000	$56000	$45000
Labor	$168000	$196000	$175500
Materials and Supplies	$16800	$19600	$17550
Equipment	$168000	$196000	$175500
Supervision and Services	$77280	$90160	$80730
Contingency	$47787	$55751	$49920
Total	$477867	$557511	$499200
Estimated Development Cost	$1534578		

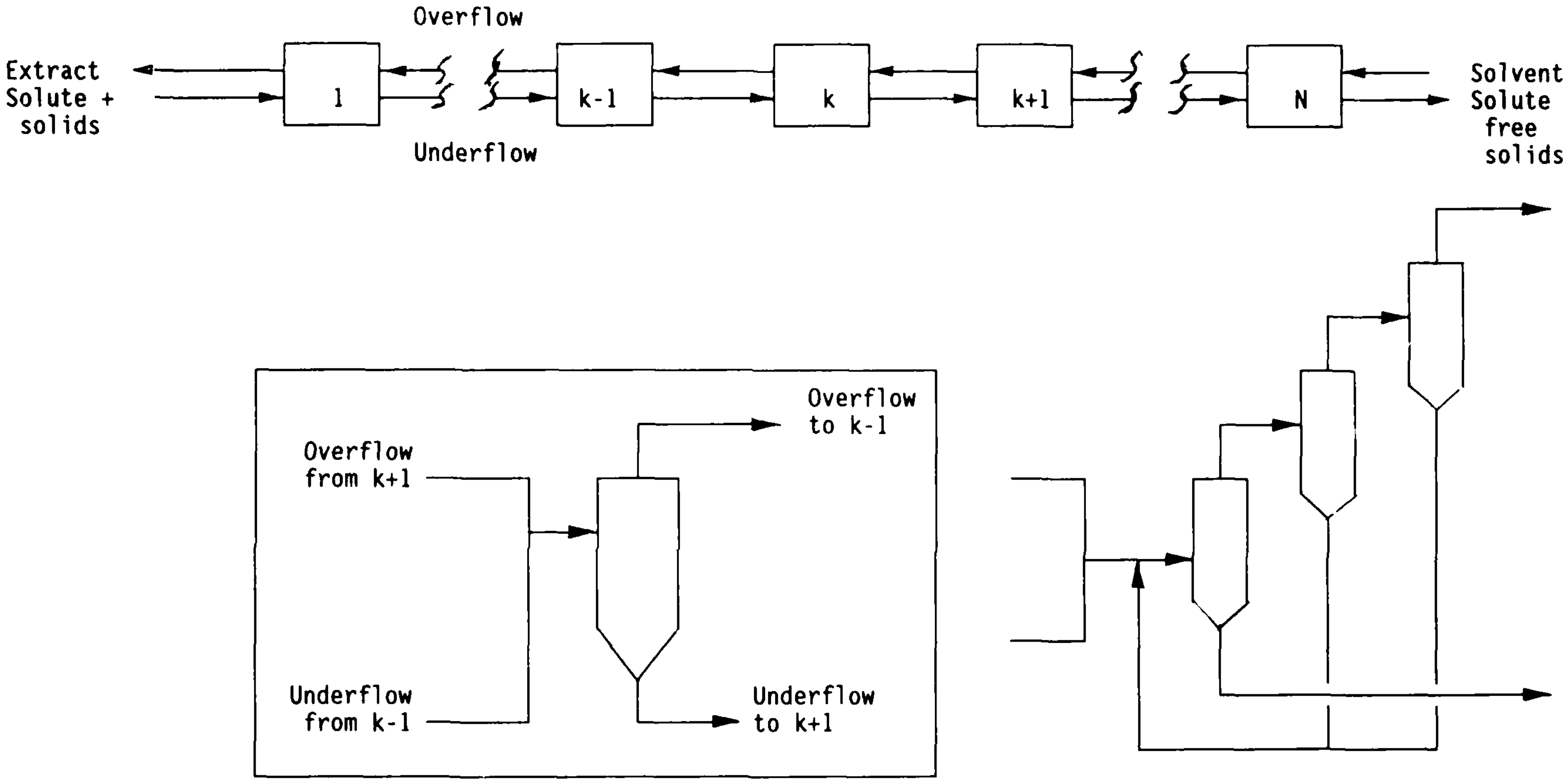

Figure H-5. Stagewise Contactor for SCF Solid/Liquid Extractions economic value. Furthermore, any money spent on the development of the supercritical technology in this application might be better spent on fixed or mobile bed reactors or supercritical water oxidation of the same materials. The use of a section of piping and a hydrocyclone as an equivalent mixer-settler stage is useful in this application, since the equipment is relatively small and suitable for high pressure.

The reclamation of spent liquid solvents may be accomplished in the more conventional system shown in Figure H-6, which consists of a differential contactor connected to a circulation and separation system for stripping the hazardous components from the extract solvent. The reclaimed solvent is then returned to service. This reduces the net volume of hazardous waste to be disposed of, which, in turn, reduces the costs associated with the purchase of new solvent. In general, differential contactors of the type shown in Figure H-6 are not useful for handling Navy waste streams since:

- They are susceptible to plugging by the solids and polymeric materials contained in the waste streams.
- The high operating pressure for supercritical fluids requires the use of vessels with relatively thick walls and small diameters, which limits throughput.
- Solubility data are lacking for other than ternary systems.
- There is a lack of data relative to the selectivity of the supercritical solvent in the presence of multiple solutes.
- There is a sensitivity of operating conditions required for a specified recovery to changes in the composition of the feedstream.

3.2.3 Estimate: Capital and Operating Costs

The estimated fixed capital and the estimated operating costs are contained in Tables H-18 and H-19, respectively. Again worst cases were chosen in the selection of solubility data and in the costs of equipment, since no information is available at this time as to the volume and composition of Navy industrial wastes.

3.2.4 Development: Manpower and Costs

An estimate of the costs to develop the technology are listed in Table H-20. The costs do not reflect the time required to install and verify the proper operation of measuring equipment. It is presumed that the equipment is in place and that no development of technique is required.

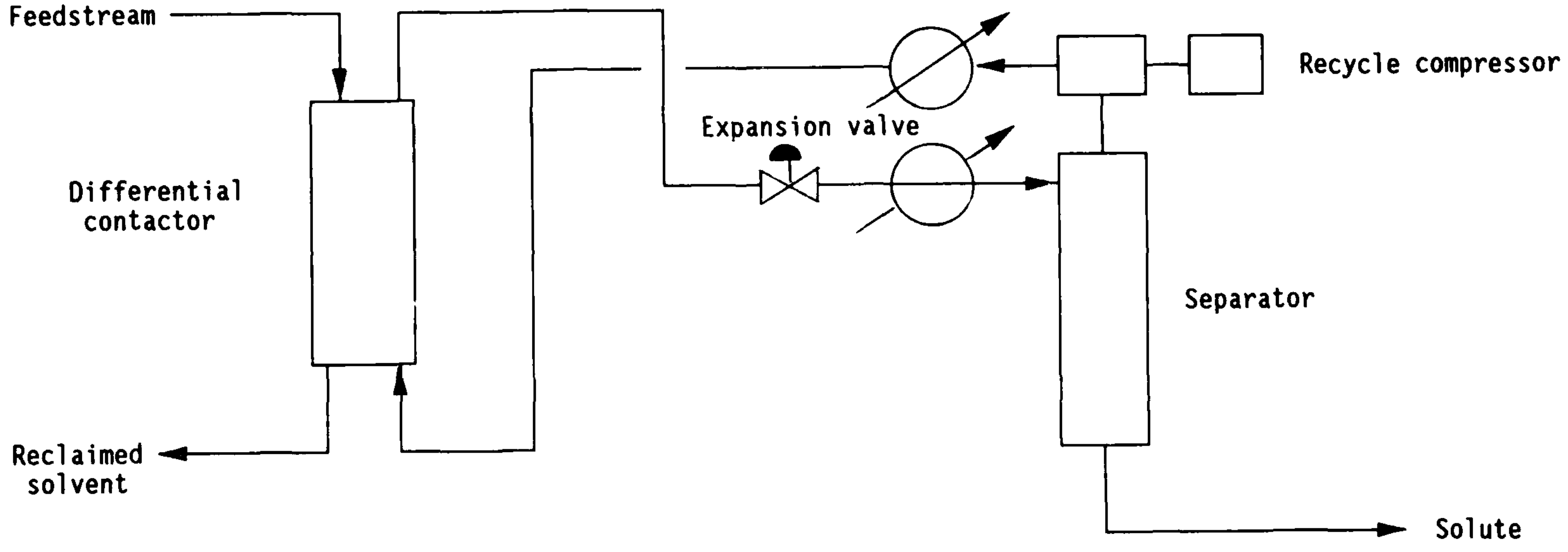

Figure H-6. Differential Contactor for SCF Liquid/Liquid Extraction

Table H-18. Estimated Fixed Capital Costs for Separation Strategy

Equipment	S1	S2
Compressors		
Recycle	$393000	$393000
Pumps		
Charge	$88800	$88800
Slurry	$25000	$25000
Heat Exchangers		
Feedstream heater	$9650	$9650
Discharge cooler	$9650	$9650
Pressure Vessels		
Solvent storage	$30600	$18204
Contactor	$24000	$36600
Separator	$18200	$18200
Capital Equipment	$598900	$599104
Ancillaries	$89835	$89866
Utilities	$344368	$344485
Contingency	$344368	$344485
Total Fixed Capital	$1377470	$1377939

ID	System Title	Figure
S1	Stagewise contactor for solid-liquid extractions	H-5
S2	Differential contactor for liquid-liquid extraction	H-6

Table H-19. Estimated Operating Costs for Separation Strategy

Operating Costs	
Annual hours of Operation	6000
Operating Labor	
Number of Operators	1
Hourly labor rate	$10.00
Annual direct	$60000
Annual indirect	120000
Total annual cost	$180000
Materials	
SCF circulation rate	1.68 g-mole/s
Loss rate	5 % of circulation
	0.084 g-mole/s
	29.3 lbm/hr
Annual loss	176000 lbm/yr
Value	$0.0525 /lbm
Total annual cost	$9240
Maintenance	
Percent of fixed capital	5 %
Fixed capital	$1377939
Total annual cost	$68897

Utilities

Service	Electric	Steam	Water	All
Rate	35.4	35	1974	-
Units	kWhr	lbm-hr	lbm-hr	-
Annual Onstream operation	6000	6000	6000	-
Cost per unit, x10^3	$100.00	$2.00	$0.024	-
Annual Total	$21240	$420	$284	$21944

Total Operating Cost = $280081 /yr

Table H-20. Estimated Manpower and Costs to Develop the Extraction Strategy

	Engineer		
Information Required	Senior	Junior	Technician
<u>Transport</u> <u>Properties</u>			
Viscosity	0.0	0.1	0.0
Thermal conductivity	0.0	1.0	0.0
Mass diffusivity	0.0	1.0	0.0
Heat-transfer coefficients	0.0	0.1	0.0
Mass-transfer coefficients	0.0	0.1	0.0
<u>Physical</u> <u>Properties</u>			
Equation of state	0.0	0.0	0.0
Equilibrium data	0.3	0.0	0.0
Density, critical point	0.1	0.1	0.0
Chemical nature	0.1	0.1	0.1
<u>Thermodynamic</u> <u>Data</u>			
Enthalpy	0.0	0.0	1.0
Heat of formation	0.0	0.0	1.0
Heat of solution	0.0	0.0	1.0
Equilibrium composition	0.1	0.3	0.5
<u>Reaction</u> <u>Kinetics</u>			
Reaction rate model	0.0	0.0	0.0
Rate constants	0.0	0.2	0.3
<u>Corrosion</u> <u>Resistance</u>	0.0	0.0	0.0
<u>Plant</u> <u>Data</u>			
Toxicity	0.1	0.0	0.0
Explosion and fire hazard	0.1	0.0	0.0
<u>Contactor</u> <u>Design</u> <u>and</u> <u>Testing</u>	0.5	1.0	0.5
<u>Estimated</u> <u>Man-Power</u> <u>Reqd</u>	1.3	4.0	4.4
<u>Annual</u> <u>Labor</u> <u>Rate</u> <u>(with</u> <u>ovhd)</u>	$140000	$56000	$45000
Labor	$182000	$224000	$198000
Materials and Supplies	$18200	$22400	$19800
Equipment	$182000	$224000	$198000
Supervision and Services	$83720	$103040	$91080
Contingency	$51769	$63716	$56320
Total	$517689	$637156	$563200
Estimated Development Cost	$1718044		

3.3 DESTRUCTION

Since hazardous wastes must be eventually destroyed or converted to a nonleachable stable form, a process that destroys aqueous wastes without pretreatment of the feed stream is of particular interest. Incineration of dilute aqueous wastes is not efficient due to the large amounts of water that have to be evaporated. In addition, the presence of heavy metal compounds in solution limits the application of incineration, since these have to be removed from the waste stream prior to introduction to the incinerator or from the flue gas prior to discharge to the atmosphere.

3.3.1 Problem Description

Many of the industrial processes used by the Navy, Table H-1, generate waste streams, Table H-2, which may be described as aqueous solutions of inorganic metals and organic compounds in concentrations on the order of a few hundred parts per million. Other processes result in the production of waste solvents, which contain a mixture of organic compounds with small amounts of water. Examples of the former are torpedo-motor wash water and rinse water from TNT manufacturing. Degreasing solvents and recovered bilge oil are examples of the latter. If these streams could be processed without treatment of the feedstream and by modification of existing equipment, considerable savings will result.

3.3.2 Proposed Process

The proposed process uses the properties of supercritical water to break down hazardous organics to carbon dioxide and water and to remove inorganics as salts. The waste stream is contacted with water in the supercritical state (above 374 °C and 218 atm) to which oxygen or air has been added. Atoms, such as chlorine, nitrogen, phosphorous, and sulfur, are converted to inorganic salts by the addition of cations. The inorganic salts have low solubility in water in the supercritical state and may be readily precipitated and subsequently separated from the fluid phase. If the concentration of organics were sufficiently high, heat released by the oxidation process might supply a significant portion of the thermal energy required in the process.

Two supercritical fluid reactor systems are shown in Figures H-7 and H-8. The first is a retrofit to an existing Navy boiler, furnace, or incinerator. A section of existing tube banks would be replaced with tubes suitable for supercritical water service. Hazardous waste and oxygen are mixed with recycled steam or condensate and flowed through the tube banks. The reaction products and the supercritical fluid are then passed through a cyclone to remove the inorganic salts and then through an expander which can be used to drive pumps or generate power. The gaseous reaction products are removed in the condenser and the condensate is recycled. A portion of the condensate is purged to balance the water entering in the aqueous waste stream.

The system shown in Figure H-8 is a conventional Rankine cycle with supercritical water as the working fluid. The system operates in the same manner as the retrofit system with the exception that is is designed to generate power as well as destroy the wastes and is a dedicated plant. As before, a purge stream is used to maintain a constant inventory of water in

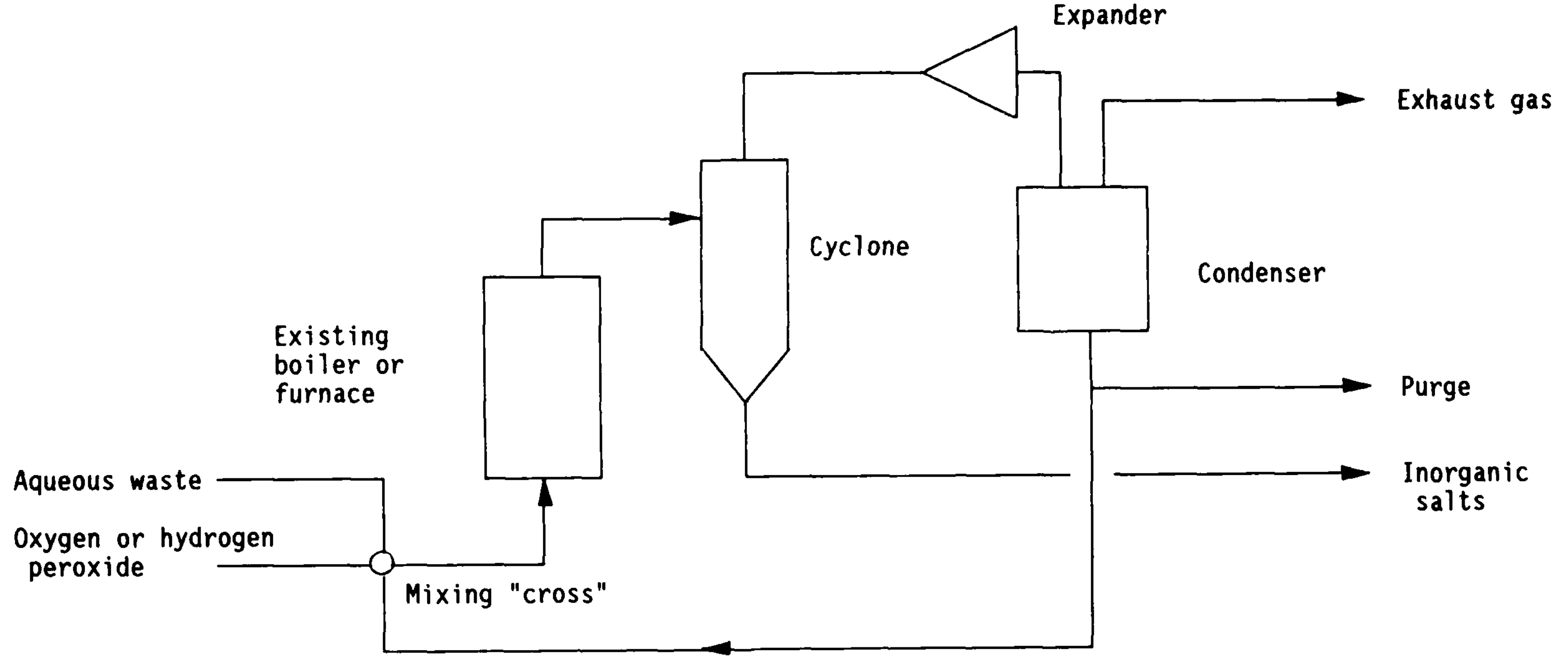

Figure H-7. SCF Reactor for Retrofit Application

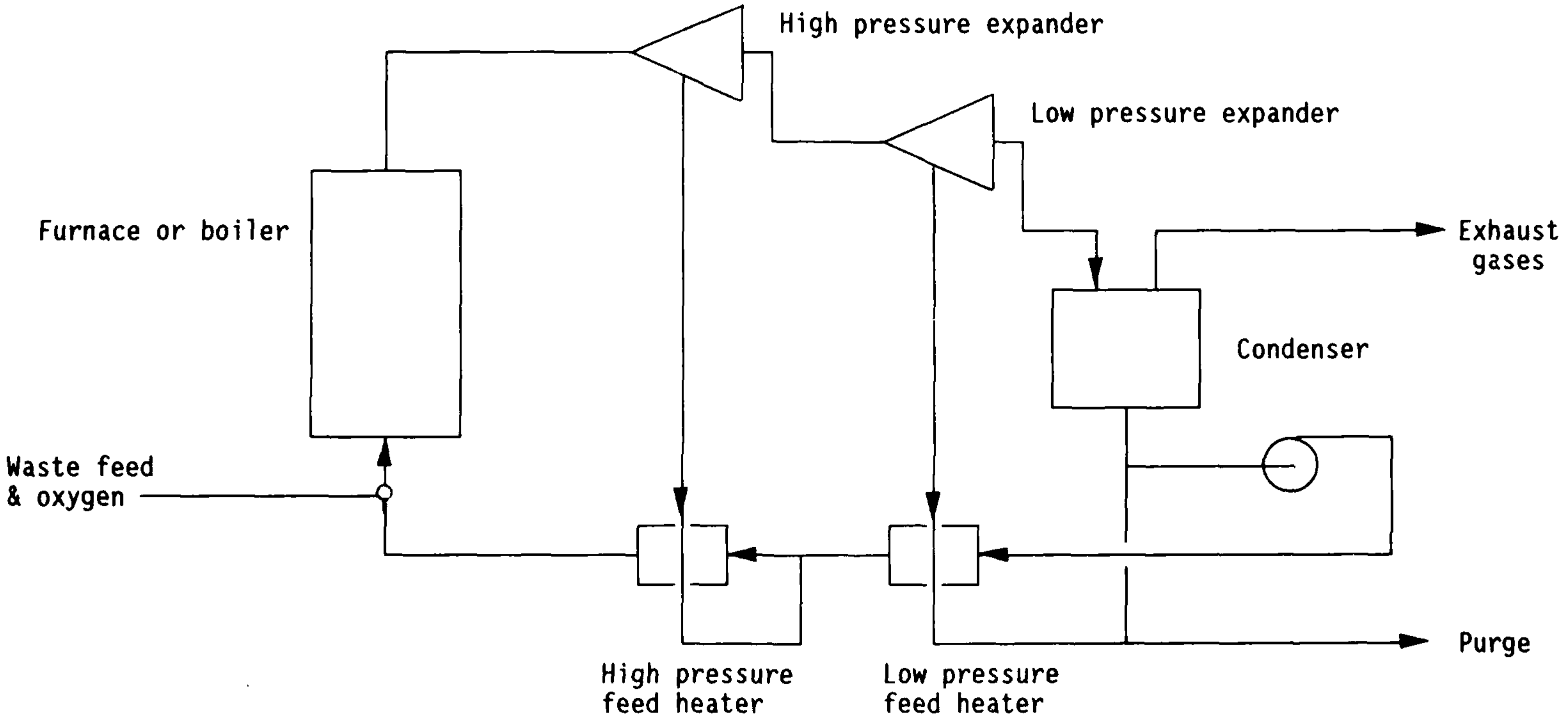

Figure H-8. SCF Reactor for Standalone Application the unit. The high- and low-pressure feedwater heaters are shown as blocks but can be multiple units in practice. Testing of the concept may be performed on a pilot scale by slipstreaming steam from an installed power plant and mixing it with a well-characterized waste stream.

The concept of using a retrofit to existing Navy equipment for supercritical fluid oxidation of waste streams is a very promising technology. The advantages are:

- No conditioning of the waste stream is required.
- Considerable expertise relative to the construction and operation of supercritical steam plants exists.
- The technology has been demonstrated on a bench-scale system.
- The volume of the exhaust gases per mole of a waste species destroyed is much less than for conventional incineration, since the exhaust gases are primarily reaction products.
- The licensing process for operation would be reduced considerably over that for new construction.
- A plant suitable for Navy purposes would be operated in a manner similar to that for existing furnaces or boilers (current operators of fired equipment could be used).

3.3.3 Cost Estimate: Capital and Operating Costs

The capital and operating costs for the retrofit of an existing furnace were estimated and are listed in Tables H-21 and H-22, respectively. No estimate was prepared for the construction of a new supercritical plant dedicated to waste destruction and steam generation. It is expected that the cost would be prohibitive relative to more conventional technologies, such as incineration.

3.3.4 Development: Manpower and Costs

The estimated cost to develop technology for supercritical oxidation is shown in Table H-23. A demonstration program based upon a retrofit of an existing Navy furnace would be considerably less but would not necessarily produce information required for design purposes, such as details of the reaction kinetics.

Table H-21. Estimated Fixed Capital Costs for Destruction Strategy

Equipment	D1
Compressor	
Air	$50000
Pumps	
Charge	$15000
Slurry	$25000
Heat Exchangers	
Feedstream heater	$10000
Discharge cooler	$10000
Pressure Vessels	
Waste storage	$1000
Tube banks	$10000
Separator	$20000
Capital Equipment	$141000
Ancillaries	$21150
Utilities	$81075
Contingency	$81075
Total Fixed Capital	$324300

ID	System Title	Figure
D1	Supercritical fluid reactor for retrofit applications	H-7
D2	Supercritical fluid reactor for standalone applications	H-8

Table H-22. Estimated Operating Costs for Destructive Strategy

Operating Costs				
Annual Operating hours	6000			
Operating Labor				
Number of operators	1			
Hourly labor rate	$10.00			
Annual direct	$60000			
Annual indirect	$120000			
Total annual cost	$180000			
Materials				
Chemical controls	$5000			
Resin	$10000			
Total annual cost	$15000			
Maintenance				
Percent of fixed capital	5 %			
Fixed capital	$324300			
Total annual cost	$16215			
Utilities				
Service	Electric	Steam	Water	All
Rate	30	0	2000	-
Units	kWhr	lbm-hr	lbm-hr	-
Annual onstream operation	6000	6000	6000	-
Cost per unit, x10^3	$100.00	$2.00	$0.024	-
Total annual cost	$18000	$0	$288	$10288

Total Operating Cost = $229503

Table H-23. Estimated Manpower and Costs to Develop Destruction Strategy

	Engineer		
Information Required	Senior	Junior	Technician
Transport Properties			
Viscosity	0.1	0.1	0.0
Thermal conductivity	0.1	0.1	0.0
Mass diffusivity	0.1	0.1	0.0
Heat-transfer coefficients	0.1	0.1	0.0
Mass-transfer coefficients	0.1	0.1	0.0
Physical Properties			
Equation of state	0.5	0.5	0.0
Equilibrium data	0.2	0.3	0.0
Density, critical point	0.1	0.1	0.0
Chemical nature	0.3	0.2	0.0
Thermodynamic Data			
Enthalpy	0.1	0.1	0.0
Heat of formation	0.1	0.1	0.0
Heat of solution	0.1	0.1	0.0
Equilibrium composition	0.5	0.5	1.0
Reaction Kinetics			
Reaction rate model	0.5	1.0	1.0
Rate constants	0.5	1.0	1.0
Corrosion Resistance	0.5	1.0	1.0
Plant Data			
Toxicity	0.1	0.2	0.0
Explosion and fire hazard	0.1	0.3	0.0
Estimated Man-Power Reqd	4.1	5.9	4.0
Annual Labor Rate (with ovhd)	$140000	$56000	$45000
Labor	$574000	$330400	$180000
Materials and Supplies	$57400	$33040	$18000
Equipment	$574000	$330400	$180000
Supervisions and Services	$264040	$151984	$82800
Contingency	$163271	$93980	$51200
Total	$1632711	$939804	$512000
Estimated Development Cost	$3084516		

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

4.1.1 Solvent Power of Supercritical Fluids

The wide variation of the solvent power of fluids in the supercritical state is the essential feature of supercritical fluid technology. A supercritical fluid may be used as:

- A replacement for an ordinary solvent
- A solvent for materials that are not usually soluble
- A medium in which chemical reactions may be conducted

Subsequent separation of the solute or the reaction products from the bulk fluid is then complete. The penalty for the use of the fluid in the supercritical state is the increase in capital cost associated with pressure vessels and the increase in operating expense due to compression work. These incremental costs may not be relevant for the situation 1) in which the unit operation cannot be accomplished by the use of an ordinary fluid or 2) when the solute is thermally labile.

Table H-24 is a summary of the potential applications of supercritical fluid technology to the management of Navy wastes defined previously. The supercritical fluid systems described are identified with respect to each Navy waste stream.

4.1.2 Conventional Methods

Currently, conventional means may be used to manage many of the waste streams, but a change in the EPA regulations, such as the banning of a particular solvent, may make the choice of a supercritical fluid solvent the only option. For example, flushing with Freon may be more economical now for cleaning standing piping, but if the release of Freon to the atmosphere were prohibited by some future regulatory action, or the cost to reclaim the Freon increased significantly, then supercritical carbon dioxide might be an appropriate substitute.

4.1.3 Supercritical Fluid Reactor

The use of a supercritical fluid reactor to destroy organic compounds in aqueous solution is a particularly promising method for management of certain Navy waste streams. Some unique features of this method are:

Single Phase Reaction. A chemical reaction is conducted in supercritical water at conditions under which only one phase exists (no mass transfer resistances associated with phase boundaries occur).

Table H-24. Potential Applications of Supercritical Fluid Technology to Management of Navy Hazardous Wastes

	Supercritical Fluid System					
Waste Stream	R01	R02	S01	S02	D01	D02
Standing piping now cleaned with CFC	A	P	-	-	-	-
Vapor and spray degreasers	P	A	-	-	-	-
Electroplating wastewater with heavy metals	-	-	-	-	P	P
Paint stripping wastewater	-	-	-	-	P	P
Torpedo motor wash water	A	-	-	-	P	P
Photo-etch bath liquids	-	-	-	-	P	P
Abrasive blasting grit	-	-	A	-	-	-
Paint sludge...	-	-	-	-	P	P
Paint skins...	-	-	-	-	P	P
Waste paint...	-	-	-	-	P	P
Spent TCE degreaser	A	A	-	-	P	P
Spent cold carbon remover	-	-	-	-	P	P
Waste solvents...	-	-	-	-	P	P
Recovered bilge oil	-	-	-	-	P	P
Waste oils...	-	-	-	A	P	P
Flammable grit...	-	-	P	-	A	A
Other flammable solids	P	-	-	-	A	A
TNT loading and packing	A	-	-	-	P	P

Note: See next page for legend

Table H-24 (Continued)

ID	System Title	Figure
R01	Decontamination system for hardware	H-3
R02	Decontamination system for high-pressure systems	H-4
S01	Stagewise contactor for solid-liquid extractions	H-5
S02	Differential contactor for liquid-liquid extraction	H-6
D01	Supercritical fluid reactor for retrofit applications	H-7
D02	Supercritical fluid reactor for standalone applications	H-8

Symbol	Meaning
-	Method not applicable
A	Method may be applicable, development required
P	Method very promising

Oxidant Control. A liquid-phase oxidant may be used, thereby, assuring intimate mixing. There would be a substantial reduction in the capital and operating costs associated with the compression of the fluid to sc operating conditions in order to use gas-phase oxidants, such as gaseous oxygen or air.

Retrofit Potential. The arrangement of the heat-transfer surfaces and the reactor configuration provides for "retrofit" of this system to existing furnaces and boilers.

Compact Geometry. The density of the fluid at the supercritical conditions is approximately that of a liquid, which assures a relatively small reactor volume per unit mass of the reactants and products.

Energy Recycle Potential. The reactor may be operated in such a manner to produce gaseous fuels by proper choice of operating conditions, or use of catalysts, thereby altering in a positive way the economics of the disposal process for hazardous materials.

Minimal Feed Preparation. No pretreatment of the feed stock is required.

Not Concentration-limited. The process may be used to treat organics at relatively low concentrations in the aqueous phase.

4.1.4 Estimation of Capital and Operating Costs

At the time flow rates and compositions for the Navy waste streams are better known, the calculations contained in this work should be repeated.

4.2 RECOMMENDATIONS

In the following paragraphs, recommendations that relate to the management of Navy waste streams are given.

4.2.1 Proof-of-concept Studies

Three efforts should be considered with respect to the application of supercritical fluid technology to the management of Navy waste streams:

1. Construction of a demonstration supercritical fluid reactor with a processing capacity of 60 gal/hr for field use on selected Navy waste streams
2. Construction of a large "bench-scale" supercritical fluid reactor for development of design engineering data, such as rate constants for particular species
3. Construction of a supercritical fluid test loop to be used to evaluate the effectiveness of supercritical fluids for the decontamination of Navy hardware

4.2.2 Establishment of Special Training Course

A course that teaches the fundamentals of chemical engineering as they relate to the management of Navy wastes should be established as a refresher course for chemical engineers in the Navy, or as an introduction for other disciplines. The course might be taught to Naval officers in transition to or from the fleet and who may have responsibilities in waste management. It could be taught at the U.S. Naval Postgraduate School at Monterey and would cover chemical engineering process principles. A graduate would have a foundation for evaluating new processes or even developing ones particularly suited for Navy needs. Individuals with a chemical engineering background and experience in the management of hazardous wastes could be appointed to teach the course on a rotating basis.

4.2.3 Computer-aided Engineering

Some of the effort associated with the evaluation or development of new processes can be alleviated by using purchased software from vendors. Note well that the following list of sources for engineering utilities is cited for reference purposes only and is not intended to be an endorsement of any particular vendor or to be considered a complete list of all such vendors.

The Chemshare Corporation
1900 Lummus Tower
Houston, TX 77056
(713) 627-8945

U.S. Department of Commerce
National Technical Information Service
Database Services Division
5285 Port royal Road
Springfield, VA 22161
(703) 487-4807

COADE
8550 Katy Fwy, Suite 122
Houston, TX 77024
(800) 231-0732

Simulation Science Inc.
2950 N. Loop West, Suite 830
Houston, TX 77092
(713) 683-1710

4.2.4 Characteristics of Waste Streams

Many hazardous waste streams consist of nonhomogeneous fluids, such as slurries, which cause operating problems in process equipment, such as atomizers and piping systems. Filtration is often not practical since:

- Filters have to be changed, which results in exposure of personnel to hazardous wastes
- Gelatinous materials penetrate the filter media, which then has to be discarded
- A "slops" stream would be generated, which would be considered hazardous and, therefore, would have to be treated in a separate step

The only satisfactory method is to grind the solids in the waste stream to a size such that the particles are conveyed or to use a device, such as a hydrocyclone to separate the solid and liquid phases for disposal in a separate process. Effort directed to the characterization of the physical nature of Navy waste streams would be well spent.

4.2.5 Disposal by Chemical Reaction

A substantial cost savings to the Navy and a reduction in the liability related to transfer of hazardous materials to contractors may be realized by the adoption of a general strategy; viz., disposal by chemical reaction on-site. Hazardous materials currently being stored would be cataloged, and those that could be reacted with to form nonhazardous substances capable of being disposed of by conventional means would be identified. This strategy can be illustrated by the following example.

The training activities of the U.S. Navy require use of a substantial number of Oxygen Breathing Apparatus (OBA) canisters, which must be disposed of in a proper manner subsequent to use. The prescribed disposal method is not followed since 1) the resultant solution is caustic (high pH) and 2) barium salts, if present, would be in a soluble form. Currently, the used canisters are packaged and transferred to DRMO at an estimated cost of $48,000 per year for just one command.

A proposed procedure for the disposal of these canisters is delineated in Table H-25. The basis of the proposed solution is the use of chemical reaction to 1) neutralize the caustic solution and 2) precipitate barium ions, if any, as an insoluble salt.

A catalog of the relevant reactions is provided in Table H-26. The next table, H-27, provides a material balance written in terms of lb-moles for the reactants and products of the slaking reaction and is based upon disposal of fifty (50) canisters per cycle. Complete reaction is assumed and the minimum amount of water required for disposal of the contents of fifty (50) canisters is estimated to be fifteen (15) gallons. Additional water should be used to absorb the heat of the reaction, and the appropriate quantity should be determined by experiment.

Table H-28 is an estimate of the amount and cost of acid required for neutralization of the contents of fifty (50) canisters. A perusal of the table will suggest that the use of sulfuric acid is approximately 2.5 times less expensive than the use of hydrochloric acid.

The following conclusions are derived from this preliminary analysis:

- The proposed process appears to be feasible from a technical viewpoint.
- The products of the slaking and neutralization reactions may be diluted and disposed of in an ordinary storm sewer.
- The process will result in considerable savings to the Navy.

The procedure proposed here is an example of a more general strategy that may be useful to the Navy; viz., catalog the hazardous materials in storage and identify those that may be reacted to form non-hazardous substances to be disposed of in an ordinary way.

Table H-25. Proposed Procedure for the Disposal of OBA Canisters

Step	Description
1	Remove the canister cap, puncture the foil in the top, and perforate the sidewalls (a mechanical punch could be constructed for this purpose).
2	Place perforated canisters in a rack in a disposal barrel until it is full.
3	Fill the barrel to the prescribed level with water and at the same time turn on a stirrer.
4	After the reaction is complete (gas bubbles no longer erupt from the surface of the liquid and the temperature no longer rises) start the acid pump.
5	Continue operation of the acid pump until the indicated pH is seven (7).
6	Drain the contents of the barrel to the sewer.
7	Rinse the barrel with fresh water.

Notes:

1. If there are any barium ions present, the use of sulfuric acid would precipitate barium as insoluble sulfate.

2. If no barium ions are present (test a small sample of the liquid by adding sulfuric acid and look for a precipitate), hydrochloric acid may be used for the neutralization step.

Table H-26. Catalog of Chemical Reactions Relevant to the Proposed Procedure

---

Slaking Reaction (Step 3)

KO_2 (s) + 1/2 H_2O (l) = KOH (aq) + 3/4 O_2 (g) (1)

Neutralization Reaction with Sulfuric Acid (Step 5)

KOH (aq) + 1/2 H_2SO_4 (aq) = 1/2 K_2SO_4 (aq) + H_2O (l) (2a)

If barium ions were present in the solution, they would be precipitated by reaction with the sulfate ions.

$Ba(OH)_2$ (aq) + H_2SO4 (aq) = $BaSO_4$ (s) + 2 H_2O (2b)

Neutralization Reaction with Hydrochloric Acid (Step 5)

KOH (aq) + HCl (aq) = KCl (aq) + H_2O (l) (3)

Notes:

1. Reactions 2a, 2b, and 3 are neutralization reactions; viz., base + acid = salt + water

Nomenclature:

Symbol	Meaning
(s)	solid
(l)	liquid
(g)	gas
(aq)	aqueous solution

Table H-27. Material Balance for the Slaking Reaction

Reaction

KO_2 (s) + 1/2 H_2O (l) = KOH (aq) + 3/4 O_2 (g) (1)

Mole Table

Species	Reactants	Products
KO_2	1.41	0.00
KOH	0.00	1.41
H_2O	6.95	6.24
HCl	0.00	0.00
K_2O	0.00	0.00
KCl	0.00	0.00
H_2SO_4	0.00	0.00
K_2SO_4	0.00	0.00
O_2	0.00	1.06

Note: Entries are in lb-moles.

Data

Fraction of conversion = 1.00
Extent of reaction = 1.41
\# cans = 50
Mass KO_2 = 2 lbm/can
Total KO_2 = 100 lbm
Vol H_2O = 15 gal(H_2O)
Mass H_2O = 125.1 lbm(H_2O)

Molecular Weights and Stoichiometric Coefficients

Species	Mi	Vi
KO_2	71.09	-1.00
KOH	56.10	1.00
H_2O	18.01	-0.50
HCl	36.46	0.00
K_2O	94.19	0.00
KCl	74.55	0.00
H_2SO_4	98.05	0.00
K_2SO_4	174.23	0.00
O_2	32.00	0.75

Table H-28. Cost Estimate for Acid Required for the Neutralization Reaction

Parameter	H_2SO_4	HCl	Units
Mi	98.05	36.46	lbm/lb-mole
KOH	1.41	1.41	lb-mole
Stoichiometry	0.5	1	mole(acid)/mole(KOH)
Required Acid	0.70	1.41	lb-mole(acid)
	69.0	51.3	lbm(acid)
Concentration	100	30	wt%
Specific gravity	1.8305	1.1493	lbm(soln)/lbm(H_2O)
Required soln	69.0	171.0	lbm(soln)
	4.5	17.8	gal(soln)
Price	$85	$90	/ton
Cost	$2.93	$7.69	/50 canisters

Data		
# cans	50	
mass(KO_2)/can	2	lbm(KO_2)
M_{KO_2}	71.09	lbm(KO2)/lb-mole(KO_2)

4.2.6 Electrochemistry at Supercritical Fluid Conditions

Electrochemical processes may provide a useful technique for dealing with the metal ions, such as cadmium, in aqueous solution at supercritical conditions. Work in this area is still at an early stage but is promising and should be tracked.

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APPENDIX I

STABILIZATION/SOLIDIFICATION PROCESSES

APPENDIX I

STABILIZATION/SOLIDIFICATION PROCESSES

The ultimate purpose of this treatment approach is to make the waste amenable to land disposal by making it "nondegradable" and "nonleaching". Long-term liability still exists, as in any land disposal, and HSWA 1984 restrictions still apply.

CONTENTS

TECHNOLOGY: LIME AND CEMENT POZZOLAN STABILIZATION/SOLIDIFICATION

Brief Description: This technology involves the addition of large amounts of a siliceous material combined with a setting agent, such as lime, cement, or gypsum, resulting in a dewatered, stabilized, solidified product. Thermoplastic (asphalt, polyethylene) can also be used.

Applicability/Limitation: The process is used for sludges and contaminated soils, including metals, waste oils, and solvents. Materials, such as borates, sulfates, and carbohydrates interfere with the process. Long-term stability and resistance to leaching are unknown in some cases.

Availability: Commercially available

Manufacturer: Different silicate processes available

TECHNOLOGY: MACROENCAPSULATION/OVERPACKING

Brief Description: The process encapsulates large particles in an environmentally secure barrier using lime or cement pozzolan or organic polymer. A matrix is formed from reactive components, but the waste is not uniformly dispersed. The product containing the waste is in nodule form. The product placement technique is very important.

Applicability/Limitation: Some processes are applicable to both organics and inorganics. Advantages are: isolated waste nodules, improved handling, low permeability, minimum treatment, and good beaming strength. Disadvantages are: presence of free liquid and a resultant leachable product.

TECHNOLOGY: POLYMERIZATION

Brief Description: Polymerization uses catalysts to convert a monomer or a low-order polymer of a particular compound to a larger chemical multiple of itself possessing greater chemical, physical, and biological stability.

Applicability/Limitation: This technology treats organics, including aromatics, aliphatics, and oxygenated monomers (such as styrene, vinyl chloride, isoprene, acrylonitrile).

TECHNOLOGY: SORPTION

Brief Description: Contaminants are bound up in pozzolan-type matrices by physical sorption or chemisorption yielding a stabilized material that is easier to handle. Liquid immobilization depends upon added ingredients. This process results in high concentrations of contaminants at the surface of the material, and contaminants may leach. The treated material is permeable.

Applicability/Limitation: For organics and inorganics. Advantages to this technology include plentiful raw materials, known mixing technology, improved handling, inexpensive additives, minimum pretreatment, and adequate bearing strength for landfill. The disadvantages include a large volume of additives, poor leachate control, placement sensitivity, limited bearing strength, temperature sensitivity, and free water may be released under high pressure.

TECHNOLOGY: THERMOPLASTIC MICROENCAPSULATION
(Asphalt-based Stabilization/Solidification)

Brief Description: This process involves the mixing of heated, dried wastes within either an asphalt bitumen, paraffin or polyethylene matrix, resulting in a solid waste mass for landfill disposal. The advantages are waste volume reduction, low impermeability, elimination of free liquid, improved handling, and good strength.

Applicability/Limitation: This method is applicable to hazardous wastes that are complex and difficult to treat. Wastes that should not be treated using this technology are: wastes with high water content, salts, tetraborates, iron and aluminum salts, and organics with low molecular weights and high vapor pressures (volatile). The disadvantages include expensive equipment, high processing cost, and air pollution potential.

Availability: Commercially available

Manufacturer: Werner A. Pfleidier - Waldwick, New Jersey; Aerojet Energy Conversion Company - Sacramento, California; Newport News Industrial Corporation - Newport News, Virginia

TECHNOLOGY: VITRIFICATION

Brief Description: Large electrodes can be inserted into a waste containing significant levels of silicates. Graphite on the surface connects the electrodes. A high current of electricity passes through the electrodes and graphite. The heat causes a melt that gradually works downward through the waste. Some contaminant organics are volatilized and escape from the soil surface and may be collected by a vacuum system. Inorganics and some organics are trapped in the melt, which becomes a form of obsidian or very strong glass as it cools.

Applicability/Limitation: It was originally tested as a means of solidification/immobilization of low-level radioactive metals. It holds promise for stabilizing contaminated soils.

Manufacturer: Battelle Northwest has developed methods for soil vitrification.

APPENDIX J

MANVILLE IMMOBILIZED BED BIOCATALYTIC REACTOR

APPENDIX J

ENZYME & MICROBE IMMOBILIZATION

TOXIC AND HAZARDOUS WASTE HANDLING

MANVILLE SALES CORPORATION

A system for detoxification of organic wastewater streams using immobilized microorganisms to metabolize toxic or hazardous materials in dilute aqueous solutions.

1.0 INTRODUCTION

In 1984, the Manville Sales Corporation set up a group of scientists dedicated to exploring the feasibility of applying their 30-odd years of expertise in the development and manufacturing of silicious, diatomite catalysts for applications in the field of biotechnology. The goals of this group were twofold: 1) to demonstrate the feasibility of bonding enzymes and microorganisms to the surface of such supports and 2) to develop new applications and markets for these unique biocatalysts. The first objective was readily achieved and supported by many other researchers in the field who had previously attained samples of the Manville biocatalyst carriers.

The second objective resulted in the union of technologies developed by the Louisiana State University (LSU) Department of Environmental Science and Toxicology and the Manville Enzyme and Microbe Immobilization (EMI) group, in early 1986. LSU had been exploring the effect of hazardous waste spills on the environment, the adaptation of microbes to this toxic environment, and the subsequent detoxification of such hazardous spills by the natural organisms in that environment. As a consequence, they isolated a number of unique microorganisms that readily metabolized a number of hazardous organic compounds into harmless by-products -- namely, carbon dioxide, water, and cell matter.

The developed technologies resulted in the immobilization or fixing of the uniquely adapted LSU microorganisms to the surface of Manville's engineered biocatalyst supports. As a result, it is now possible to concentrate large numbers of these unique microbes on the surface of Manville carriers and use them in continuous processes for the treatment and abatement of point sources of dilute aqueous solutions of priority pollutants.

2.0 MANVILLE AND LSU TECHNOLOGY

A variety of microorganisms have naturally adapted to or can be laboratory adapted to metabolize hazardous organic materials at concentrations of hundreds to several thousands of parts per million in water. Manville and Louisiana State University have undertaken a joint effort to develop this technology. Chlorinated aliphatic and aromatic hydrocarbon compounds, such as methylene chloride, pentachlorophenol (PCP), phenol, nitrophenols, PCBs, toluene, cresol, and DCE, have been microbially degraded to levels of less than one ppm under appropriate sets of operating conditions. For example, Dr. R. Portier of LSU has demonstrated that PCP at initial levels of greater than 100 ppm in water can be biodegraded to less than 1 ppm in a matter of hours under appropriate conditions with a microorganism immobilized on Manville's biocatalyst carrier, designated R-630. At Manville's Bio Applications Laboratory it has been demonstrated that phenol in water at concentrations as high as 1500 ppm can be biodegraded to less than 1 ppm at a rate of 1.0 mg/g of carrier per hour using the same R-630 carrier and a mixed population of microorganisms. We have also used microorganisms to consume p-nitrophenol and have adapted the system to treat at levels of up to 800 ppm in water. The biodegradation rates achieved were as high as 0.5 mg/g of carrier per hour with effluent concentrations less than 1 ppm.

Pilot-scale studies have been performed to explore the feasibility of detoxifying an industrial waste stream containing a high concentration of salt (4 percent), chloroacetic acid (up to 8000 ppm), and smaller concentrations of other organic compounds. The pilot study demonstrated effluents with less than 10 ppm chloroacetic acid.

A schematic flow diagram of the skid-mounted pilot unit used in this and other studies is shown in Figure 1. The pilot plant consists of mixing and feed tanks in which pH adjustment can be made and to which necessary nutrients can be added. The prepared waste is then pumped to the two 2-foot diameter columns containing the selected microorganisms retained in the Celite^{R} diatomaceous earth biocatalyst carrier. The biocatalyst carrier used in the above pilot study was that designated R-630, which is spherical in shape, has a mesh size of 3/8, and has a mean pore diameter of about 6.6 microns. The two columns of the pilot plant can be operated in series, as in the referenced study, or in parallel. The microbial toxic waste degradation occurs in the columns. Air sparging in the columns enhances the degradation reactions. The microbial colony in the columns regenerate themselves so the process can be operated continuously.

Recent laboratory work has been directed toward the development of additional cultures of microorganisms to treat a wider range of aqueous streams, including methanol/acetone/toluene in 5 to 6 percent salt water,

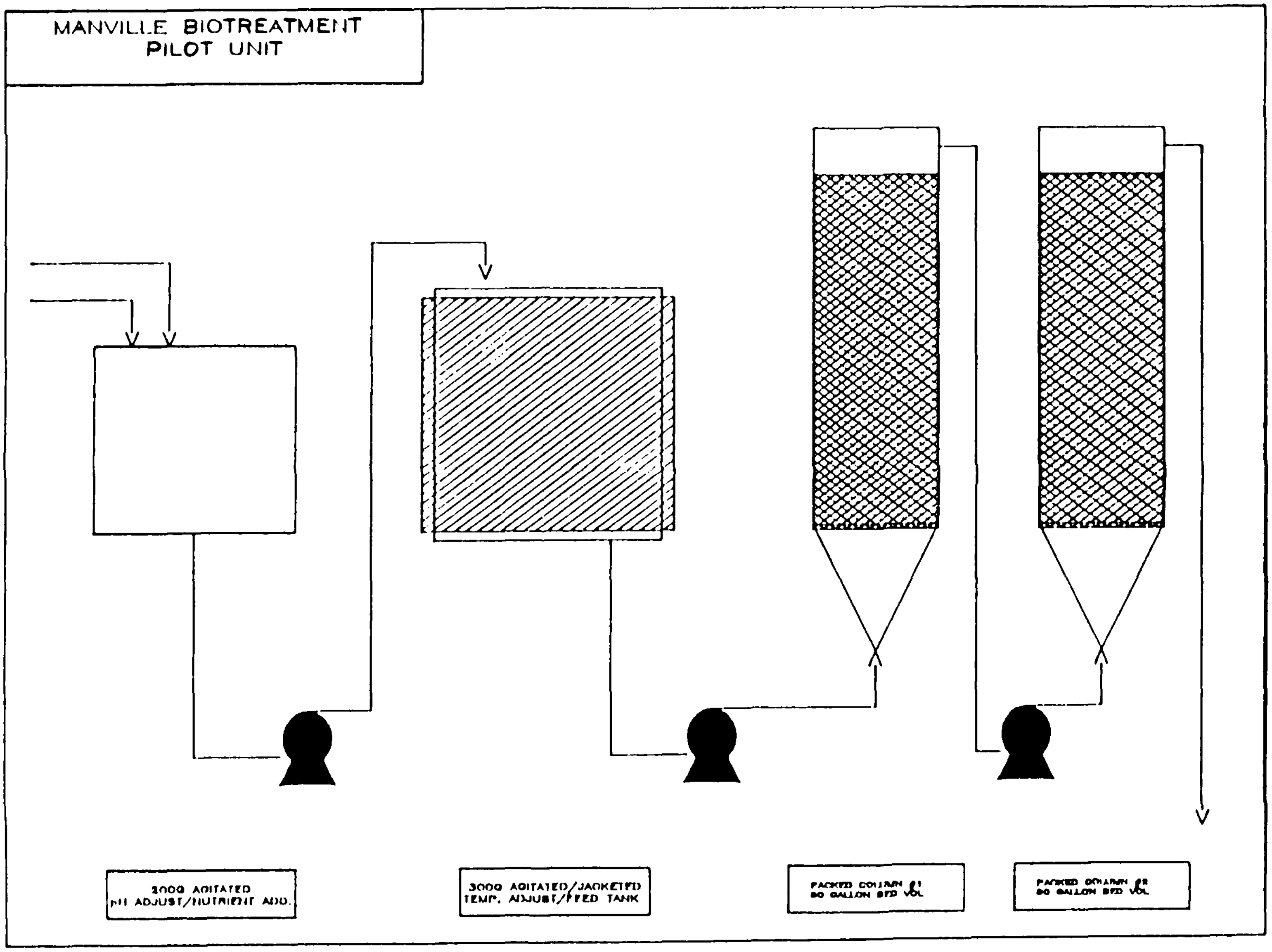
MANVILLE BIOTREATMENT PILOT UNIT
2000 AGITATED pH ADJUST/NUTRIENT ADD.
3000 AGITATED/JACKETED TEMP. ADJUST/FEED TANK
PACKED COLUMN #1 80 GALLON BED VOL
PACKED COLUMN #2 80 GALLON BED VOL

Figure 1.

benzene/toluene/xylene mixtures, and additional work on chlorinated hydrocarbons, such as PCP. Manville is developing data on the treatment of volatile organic compounds (VOC) and is learning the extent to which microbes can be used to effectively treat these and a wide spectrum of other wastes.

A recent pilot study has shown the potential for cost-effective treatment of a contaminated groundwater beneath a pesticide plant, where the ground water was withdrawn from the ground, treated by the microbes, and, subsequently, discharged to the sewer system. Another modification of the EMI technology envisioned is production of a carrier system that floats and permits microbes to treat materials spilled on water.

Manville believes that its technology represents a new way of safely handling the disposal of many hazardous organic wastes in an economical fashion, without creating future liability concerns or problems.

2.1 Application of the Technology

The above technology is believed to be adaptable to the solution of the Navy's dilute toxic waste water problems, such as the degradation of methylene chloride and phenol-containing waste water generated by aircraft paint stripping operations. With the use of the appropriate microorganisms immobilized on the Celite biocatalyst carrier, the phenol and methylene chloride content can be reduced to low levels. For example, the process would be applicable to the treatment of waste streams containing 1500 ppm of phenol and 150 ppm of methylene chloride. Laboratory studies followed by pilot-scale tests at one of the Navy's locations would verify the feasibility of such a treatment.

Based upon laboratory work on the degradation of paranitrophenol, there is the possibility of applying the process to the treatment of Navy "pink water" effluent. The identification and culturing of microorganisms would have to be specific to the organic nitro compounds found in the wastewater. Since TNT resists microbial degradation, specific microorganisms would have to be found. A considerable amount of laboratory work would be required to establish the feasibility of the process for the treatment of pink water.

2.2 Process Scheme

The process scheme would be essentially as that shown for the pilot plant in Figure 1 but scaled to the size of the waste stream. The process would be fully automated with continuous nutrient and pH adjustment of the feed stock and temperature control of the biocatalyst columns. Labor requirements would be minimal--one operator per shift to ensure good operation and to perform the necessary chemical quality control tests. In the operation of the process, there are three conditions that could kill the microorganism: 1) insufficient nutrients in the feed stock fed to the biocatalyst columns, 2) toxic shock caused by a significant overdose of toxic chemical in the waste, and 3) a pH shift outside a designated operating range. Controls to avoid these situations will have to be incorporated in the process design.

3.0 PROCESS COSTS

At the present stage of Manville's process development, process costs can only be estimated. A first projection can be made of the cost of treating a paint-stripping waste containing 1500 ppm phenol and 150 ppm methylene chloride in a pilot plant of the size described above. The effluent would contain less than 1 ppm phenol and 1 ppm methylene chloride. The following assumptions and estimates apply:

- Pilot plant throughput: 175 gph (4200 gpd)
- Capital cost for a fully automated, skid-mounted pilot plant: $100,000
- Biocatalyst charge: 1500 pounds
- Attrition rate of biocatalyst: <1%/month
- One operator per shift at $15/hr, including fringe
- Operation for 24 hr/day, 340 days/yr
- Utility requirements:
    - 2000 std cu ft compressed air/hr at 100 psi
    - 2 kw electric power
    - 500 gph cooling water
    - 250 lb/hr steam at 100 psi

For this pilot-scale operation at 175 gph, the total cost is estimated at between 10 and 15 cents per gallon. If the process is scaled up to 100,000 gallons per day, the costs will be considerably less. Without the benefit of a specific pilot plant study, such a projection can be made recognizing that the estimate is made with only educated assumptions. The cost estimates that follow are calculated based upon the supposition that the capital cost will be between $200,000 and $1,000,000. The plant is assumed to be sufficiently automated such that operator labor will be one man per shift. The following assumptions and estimates apply:

- Plant capacity: 100,000 gpd
- Biocatalyst charge: 36,000 pounds
- Attrition rate of biocatalyst: <1%/month
- One operator per shift at $15/hr with fringe
- One supervisor at 40 hr/week
- Operation for 24 hr/day, 340 days/yr
- Utility requirements:
    - Sparging air (20-50 psi) - 250 std cu ft/hr
    - Electric power - 135 kw/hr
    - Cooling water - 8000 gal/hr
    - Steam (100 psi) - 3500 lb/hr

The estimated operating costs range between 1.5 and 2 cents per gallon for the range of capital requirement.

4.0 NEXT STEPS

Manville's commercial goals of the developmental work in this biotechnology area are to establish a business of supplying biocatalyst carriers and to provide process design services. Therefore, Manville wishes to determine the technical basis for the process, be knowledgeable in the types of microorganisms that will work in the process, and provide technical service to demonstrate the feasibility of the process.

In order to evaluate and establish the utility of the Manville process to detoxify organic wastewater streams using immobilized microorganisms, the following scenario might be followed:

Phase I: Site Survey - Lab Study

1. Review chemical data of pollutants from wastestream(s).
2. Select sites for sample selection and study and collect samples for microorganisms.
3. Culture (on customer's waste stream) selected microorganisms from customer's site and other Manville-

selected microorganisms to optimize the nutrient requirements for the metabolism of the selected waste and to enrich the microorganisms for maximum tolerance to the pollutant chemicals.

4. Develop the analytical procedures to follow the metabolism of the pollutant.

5. Develop a methodology for the immobilization of selected microorganisms on a given carrier system.

6. Perform an immobilized microbe study of the waste detoxification of the waste stream, including the following:

   a. Adapt the organisms in the immobilized state to the maximum tolerable concentration of pollutants.

   b. Maximize the throughput of the feed stream for maximum kinetic rates of detoxification.

   c. Optimize the nutrient requirements for minimum usage and maximum biomass generation.

   d. Determine the stability of the system for a minimum of seven days operation at best operating conditions.

7. Summarize the scope of the Phase I work, the results of the study, and the recommendations for Phase II studies.

Phase II: Pilot Plant Study

Manville will plan the technical program and provide the technical supervision of a pilot plant program to demonstrate the feasibility of the process for detoxifying specific wastes. This would entail bringing Manville's portable pilot system to the selected site, providing technical assistance and training during a start-up phase of two to four weeks duration, providing appropriate microbial populations immobilized to a support carrier for use within the system, and assisting in the collection and evaluation of technical and economic performance data. Phase II is expected to provide sufficient engineering and economic data to determine the feasibility of a full-scale facility.

Phase III: Full-scale Process

If the customer decides to proceed to full-scale implementation of the process, Manville would provide consulting advice to the design/construction firm that would design and install the plant facility.

APPENDIX K

HAZARDOUS WASTE MINIMIZATION TECHNOLOGY ASSESSMENT MODEL (HAMTAM)

1.0 HAMTAM SOFTWARE

The listings that make up the HAMTAM program, being rather lengthy, have been deleted in the interest of saving space. They are available, however, from NCEL for those interested. The information that follows furnishes a narrative description of how the program is designed to work. The programming and the report from which the present appendix was condensed were produced by Mr. Dave Harris, when an employ of DART Associates, Inc., Oxnard, CA.

2.0 HAMTAM DECISION CRITERIA

2.1 The Parameters

The Navy would like to cost-effectively reduce the volume of hazardous waste generated at its activities so as to comply with present and future Federal, state, and local HW discharge and disposal regulations. A set of parameters has been chosen to characterize the significant attributes of the minimization options in terms of Navy objectives. The decision parameters are as follows:

- **Compliance** - Conformity to RCRA and other regulations
- **Logistics** - Maintenance, documentation, training, facilities, support, transportation, support, and related requirements
- **EUAC** - Equivalent Uniform Annual Cost
- **HW Reduction** - Percent of HW reduction availed by option relative to present practice
- **Earliest Date Ready** - The date of first full-scale operation of option
- **Risk Level** - The probability of successful technical performance of option at design specifications

2.2 Parameter Explanations, Inputs, and Calculations

2.2.1 Compliance (COMP)

The LOG (compliance-with-regulations) parameter does not enter into the calculations. It was included as a "flag" and has either a yes or no value. This approach was taken to avoid elimination of potentially valuable options that may be assumed to be noncompliant but that could be rendered acceptable through future policy changes or related interpretations of HWM regulations. [All recommendations presented in this report are considered compliant; relatively few noncompliant options were considered, and these did not earn top scores - ED.]

2.2.2 Logistics (LOG)

The logistics parameter, LOG, was included to quantify the techno-economic rigor of implementing the option within the pre-existing industrial facilities and operations environment. There are eight components considered in LOG:

- PP = Process Performance
- MP = Maintenance Planning
- TD = Technical Documentation
- TP = Training and Personnel Skills
- PHST = Packaging, Handling, Storage, Transportation
- SE = Support Equipment
- FAC = Facilities, Easements, Utilities, Roadbeds
- SS = Supply Support

The process performance component describes the effect implementation of the option will have on the Navy process. Major considerations are the effect on process time and output quality, given that military mission and specification requirements are not otherwise unacceptably compromised. The range of inputs for this and all other LOG components is set on a scale from one to 10, the latter being the poorest scoring. A score of five, the average, represents no change from the status quo in terms of logistic support requirements. The logistic value for a given option is equal to the summation of the eight logistic components:

$$LOG_i = PP_i + MP_i + TD_i + TP_i + PHST_i + SE_i + FAC_i + SS_i$$

where "i" is an option from the set (n) of options.

2.2.3 Equivalent Uniform Annual Cost (EUAC)

EUAC characterizes the cost-effectiveness of the HWM option. The EUAC represents uniform annual cost based upon the life cycle cost outlays and differential savings or losses resulting from the implementation of the option. EUAC was chosen, since it does not require a fixed economic life among a set of alternatives for the analysis period nor does it require a status quo for calculating a relative economic attractiveness. The following are inputs to the EUAC:

<u>Discount Rate</u> (DRATE) - The discounted value of money used in calculating the present value of expected annual costs and benefits. DRATE represents the price or opportunity cost of money, as expressed in NAVFAC P442. The unit of input is a percentage.

<u>Beginning Year of Recurring Costs</u> (BYEAR) - The year that the option becomes operational. This input is an integer value equal to the difference in years between the current year and the first operational year.

<u>Research and Development</u> (R&D) - The RDT&E costs necessary to bring the option to implementation. To be consistent with the time pressures of RCRA, the model accommodates an RDT&E effort lasting no more than six years. The input is in $k.

<u>Installation Cost</u> (INST) - INST includes all nonrecurring costs associated with the following: procurement of equipment and/or real property, start-up, new construction, one-time labor costs (including recruiting, training, etc.). INST costs input within the model must be for a time frame of three years. The input is $k.

<u>Replacement or MTBF</u> (RRATE) - The MTBF (mean time between failures) of a system or major subsystem is designated the RRATE. The input is in years.

<u>Replacement Cost</u> (RCOST) - The estimated cost for repair per major failure is expressed in $k.

<u>Operations and Maintenance Cost</u> (O&M) - All recurring O&M costs are input, including the following:

- Labor - all costs of civilian and military personnel and employee benefits

- Materials, Supplies, Utilities, and Other Services - the cost to the Navy for these items used in the operation of the option

- Maintenance - the cost of maintaining buildings, structures, grounds, and the option equipment itself

- Support - the increase or reduction in costs over status quo for accounting, legal, local procurement, material receipt and storage, and related services

- Energy - The differential cost or savings in energy as a result of implementing the option

<u>Salvage Value</u> (SALV) - The terminal value of the option system, if disposable. The input is in $k.

Navywide Applications (NWIDE) - The number of application points throughout the Navy where the option may be beneficially implemented.

Disposal Costs - The annual cost to dispose of the HW prior to implementation of the option. Each disposal mechanism (DRMO, IWTP, POWTP, Contract Haul) has an escalation input that describes the differential increase over general inflation. The disposal costs are expressed in $k, and escalation in percent.

A two-step methodology is used to calculate the EUAC. The first step is to obtain the total present value cost by discounting all cash flows to the base year. The second step is to uniformly spread the discounted cost across the economic life of the HWM option. The uniform annual amount must account for the time value of money.

Step 1. Present Value Calculations

Separate formulae are used for calculating the present value of a future sum (e.g., salvage value) and an annual cash flow (e.g., O&M and disposal costs). The general form of the equation for calculating the present value for a future sum is:

$$(1) \quad PV = F(1 + DRATE)^{-n}$$

where

PV = Present Value
F = Future Cash Flow
DRATE = Discount Rate
n = Number of Years from Base Year

The present value of RDT&E, installation, replacement, and salvage value are calculated using equation (1). For RDT&E and installation costs, present value calculations must be performed separately for each year. The present value cost of RDT&E is divided by the number of Navywide applications to spread the costs across the potential user points. For replacement, the total present value is determined by calculating and summing the present value for the year(s) in which replacement is required, as estimated from the MTBF input.

The present value of O&M and the disposal costs (with no differential escalation) are calculated using equation (2) below. This is the general form of the equation for calculating the present value of an annually repeating cash flow.

$$(2) \quad PV = A \frac{(1 + DRATE)^{ELIFE} - 1}{DRATE(1 + DRATE)^{ELIFE}}$$

where

A = Uniform Annual Repeating Cash Flow
ELIFE = Economic Life

In all likelihood, the disposal cost will escalate. In this case, equation (3) should be used for calculating the present value.

$$(3) \qquad PV = A \frac{e^{ELIFE(r - d)} - 1}{(r - d)(e^{ELIFE(r - d)})}$$

where

$r = \ln(1 + DRATE)$
$d = \ln(1 + \text{differential escalation rate})$

<u>Step 2. Uniform Series Calculation</u>

The EUAC is calculated by summing all present value costs (except salvage value which is subtracted) and uniformly spreading this value across the economic life of the HWM option.

$$(4) \qquad EUAC = PV \frac{DRATE(1 + DRATE)^{ELIFE}}{(1 + DRATE)^{ELIFE} - 1}$$

where

EUAC = Equivalent Uniform Annual Cost

2.2.4 HW Volume Reduction (HWVR)

The HW Volume (or mass) Reduction parameter expresses the percentage reduction in the amount of HW generated in the status quo operation by the implementation of the HWM option.

$$HWVR = \frac{\text{Status Quo HW Amt/Yr} - \text{Projected Amt/Yr}}{\text{Status Quo Amt/Yr}}$$

2.2.5 Earliest Date Ready (EDR)

The EDR factors in the importance of HWM timeliness. It is more desirable to have a particular option available immediately (off-the-shelf) than at sometime in the future because of cost escalation and the uncertainty of future regulatory pressures. The EDR input is the same as the BYEAR input used in the EUAC calculations.

2.2.6 Risk Level (RISK)

RISK quantifies the level of doubt as to whether an option can be implemented or what degree of success a developed option will have in attaining projected technical performance, availability, and costs. Risks can include programmatic features (funding, scheduling, contracting difficulties, and political matters), production-oriented questions (e.g., materials availability, lead times), or engineering factors (reliability, maintainability, complexity). The probability of failure of a system or subsystem is a function of the hardware maturity, the complexity of the option, and degree of dependency upon interfacing factors.

3.0 PROJECT PRIORITIZATION

Figure K-1 is a six-step flow chart of the prioritization procedure. Figure K-2 shows the canonical form of the HAMTAM program. Parametric data inputs for candidate HWM options are developed first. Next, weights are assigned to the decision parameters to designate the relative importance of each. The sum of the weights are set at unity, that is

$$W_{LOG} + W_{EUAC} + W_{EDR} + W_{HWVR} + W_{RISK} = 1$$

The third step is to calculate the parametric values for each option using the parametric equations presented in the previous section. The fourth step is to normalize the results within a scale of zero to unity. The parametric values are normalized by dividing the parametric value for each option by the total of all options for all parameters:

$$NCRIT = \frac{CRIT}{CRIT_{tot}}$$

where

NCRIT = Normalized criterion value for an option
CRIT = Calculated value of a criterion (LOG, EUAC, or etc) for an option
$CRIT_{tot}$ = The sum total of that criterion for all options

Step five is the scoring of the options by multiplying the parametric weight with its normalized value for the six parameters and summing (except HWVR, which is subtracted) :

$$SCORE_i = NLOG_i \cdot W_{LOG} + NEUAC_i \cdot W_{EUAC} + NEDR_i \cdot W_{EDR} + NRISK_i \cdot W_{RSK} - NHWR_i \cdot W_{HWR}$$

The final step is to sort the options in order of merit.

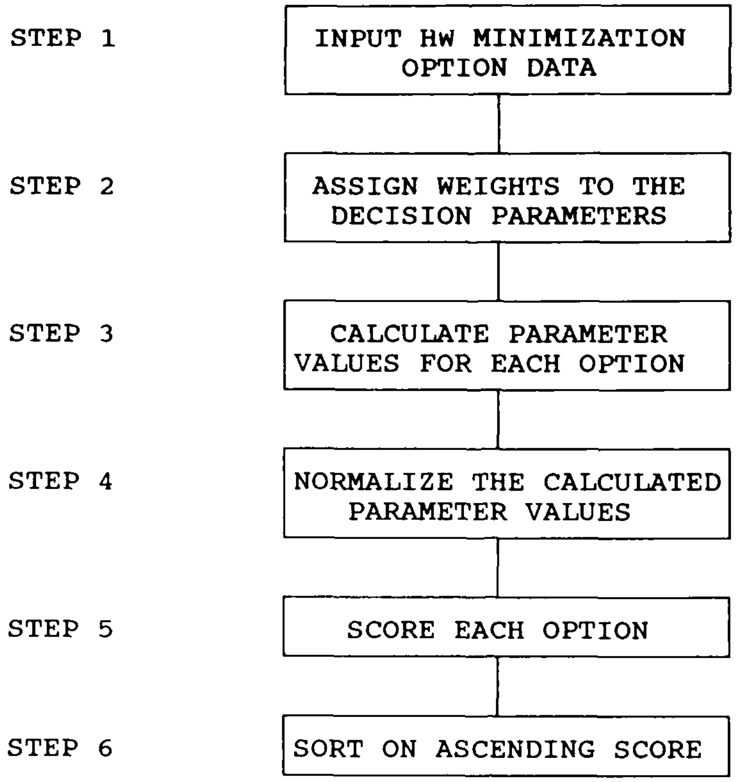

Figure K-1. Prioritization procedure

MODEL

	W_1	W_2	W_3	W_4	W_5	WEIGHTS
OPTION	A_1	W_2	A_3	A_4	W_5	CRITERIA
OPTION 1	f_{11}	f_{21}	f_{31}	f_{41}	f_{51}	Normalized
OPTION 2	f_{12}	f_{22}	f_{32}	f_{42}	f_{52}	Criteria
⋮	⋮					Values
OPTION N	f_{1N}	f_{2N}	f_{3N}	f_{4N}	f_{5N}	

$$SCORE_i = W_1 \cdot f_{1i} + W_2 \cdot f_{2i} + W_3 \cdot f_{3i} + W_4 \cdot f_{4i} + W_5 \cdot f_{5i}$$

where

$$W_1 + W_2 + W_3 + W_4 + W_5 = 1$$

$$\sum_{i=1}^{N} f_{ji} = 1$$

for $j = 1, 2, \ldots 5$

Figure K-2 Model canonical form

APPENDIX L

TECHNOLOGY ALTERNATIVES PREFERENCE-MODELLING RESULTS

HW PROBLEM 6.2.2 (I) DESCRIPTION: IWTP SLUDGE REDUCTION
TITLE: ALTERNATIVE TREATMENT TECHNIQUES TO MINIMIZE SLUDGE

The process alternatives considered include conventional treatment (alkaline chlorination of cyanides, sulfur dioxide reduction of chromium, hydroxide precipitation of heavy metals, flocculation with polyelectrolyte/clarification, and sludge dewatering), electrochemical treatment/chromium reduction, sodium sulfide/ferrous sulfate treatment, and polynucleolyte flocculation. Alternatives not included were use of wastes as treatment chemicals (see Section 6.2.16) and other process modifications that minimize influents that are covered under specific wastewater generating processes, such as electroplating and aircraft paint stripping. A 200-kgpd plant was used as a basis. Estimated influent characteristics (Reference 6-1) are:

75kgpd Chrome WW	75kgpd Cyanide WW	50kgpd Acid/Alkali WW
12ppm Cr+6	15ppm CN	3ppm Zn
6ppm Cr+3	12ppm Cd	3ppm Pb
3ppm Cu	6ppm Cu	3ppm Cu
3ppm Ni		3ppm Ni
36ppm Fe		36ppm Fe

Wastestreams are segregated. Chrome wastewaters are assumed minimized to 75kgpd through implementation of Innovative Hard Chrome Plating. Sludge generated is dewatered to 30 percent solids. See Section 3.2.

\\\\\\\\\\\\\\\\
[Mgmt Options

OPTION NO.	TITLE
1	CONVENTIONAL IWTP TECHNOLOGY
2	SODIUM SULFIDE/FERROUS SULFATE TREATMENT (USAF)
3	ELECTROCHEMICAL HEAVY METAL REMOVAL
4	POLYNUCLEOLYTE TREATMENT

HAMTAM REPORTS
PROBLEM TITLE: IWTP SLUDGE; MINIMIZATION ALTERNATIVES

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
1	1	0.36	8.00	411.17	0.00	0.00	1
4	2	0.47	10.00	512.48	14.33	1.00	2
3	3	0.53	15.00	493.21	-11.20	1.00	1
2	4	0.55	18.00	432.53	41.02	3.00	2

Mgmt Option 1:
TITLE: CONVENTIONAL IWTP TECHNOLOGY

Conventional treatment includes alkaline chlorination of cyanide ww, chrome reduction by sulfur dioxide/sulfuric acid addition, neutralization/heavy metal precipitation using lime addition, flocculation aided by polyelectrolyte addition with clarification and sludge dewatering. Chemical dosages and sludge generation were based upon assumed ww characteristics using EPA methods (Reference 6-2). Chemical costs from current manufacturer info (\$0.30/#Cl2, \$0.185/#NaOH, \$0.23/# SO2, \$0.0475/#H2SO4, \$0.612/lb Ca(OH)2, \$1.00/#polyelectrolyte). One plant supervisor and one plant operator were estimated at \$40/hr (burdened) for operation costs. Administration costs were estimated at 25 percent of labor. Utility costs were assumed to be \$0.60/kgal ww treated (pumping costs, etc.) Sewage costs were assumed at \$0.70/kgal ww. Sludge disposal costs were assumed to be \$300/ton. Twenty Navy applications were estimated including all NSY's, NADEP's, and large NWS's and GOCO's. Low risk and logistic parameters were given to this technology, which is currently in use at most Navy IWTPs.

LOGISTICS INPUT HW PROBLEM NO. 6.2.2 (I) HW MGMT OPTION NO. 1

Compliance	Y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	1	
Supply Support	1	

EUAC Input HW PROBLEM NO. 6.2.2 (I) HW MGMT OPTION NO. 1

BEGIN YEAR OF RECURRING COSTS 0
(no. of yrs from base year)

R & D ($k) 0

REPLACEMENT: MTBF (yrs) .75
COST ($k) 25

ECONOMIC LIFE (yrs) 25

ANNUAL O&M COST ($k) 258

NAVYWIDE APPLICATIONS 20

SALVAGE VALUE ($k) 0

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)	35	5
Contract Haul cost ($k)	18.2	10

HW VOLUME CHANGE HW PROBLEM NO. 6.2.2 (I) HW MGMT OPTION NO. 1

Status Quo HW Output (gal/yr) 60.7

Projected HW Output (gal/yr) 60.7

Mgmt Option 2:
TITLE: SODIUM SULFIDE/FERROUS SULFATE TREATMENT (AIR FORCE)

Sodium sulfide, ferrous sulfate, and polymer are used for chrome reduction and metals precipitation. Cyanide oxidation, neutralization of acid/alkali ww, and sludge dewatering are the same as for the conventional system. Chemical dosage rates based upon laboratory and field data provided by project engineer at Tyndall AFB. Chemical costs include \$0.10/#FeSO4 (35 percent), \$0.15/#Na2S (35 percent), and \$1.00/#polymer. Due to the hazardous potential of generating toxic H2S gas if contacted with acid ww and the lack of proven automated controls, two plant operators are envisioned (as opposed to one with a conventional system) along with the plant supervisor. Administration costs and utility costs are the same as for the conventional system. Sludge generation was estimated using a 41 percent reduction of the conventional system. This estimated reduction is based upon results obtained in laboratory testing conducted in an Air Force R&D program.

LOGISTICS INPUT HW PROBLEM NO. 6.2.2 (I) HW MGMT OPTION NO. 2

Compliance	Y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	3	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input        HW PROBLEM NO. 6.2.2 (I)     HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  3____
    (no. of yrs from base year)

  R & D ($k)     200___   700___   200___   _____   _____   _____

  INSTALLATION COST ($k)   100___   _____   _____

  REPLACEMENT: MTBF (yrs)  .5___
               COST ($k)   40___      ECONOMIC LIFE  (yrs) 25___

  ANNUAL O&M COST ($k)     334.2_     NAVYWIDE
                                      APPLICATIONS   20___
  SALVAGE VALUE ($k)       5____
```

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=============================================================

   ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
   _________________________________          __________________
   DRMO cost ($k)                 ______       ______
   STP  cost ($k)                 ______       ______
   IWTP cost ($k)                 ______       ______
   POTW cost ($k)                 35____       5_____
   Contract Haul cost ($k)        10.7__       10____

=============================================================
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 HW VOLUME CHANGE  HW PROBLEM NO. 6.2.2 (I)     HW MGMT OPTION NO.  2
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     Status Quo HW Output (gal/yr)  60.7____

     Projected  HW Output (gal/yr)  35.8____
```

Mgmt Option 3:
TITLE: ELECTROCHEMICAL HEAVY METAL REMOVAL

An electrochemical heavy metal removal system with sacrificial iron anodes is used for chrome reduction and metals precipitation as opposed to sulfur dioxide/sulfuric acid chrome reduction and lime precipitation in a conventional system. Cyanide oxidation, flocculation aided by polyelectrolyte and sludge dewatering same as conventional. Labor, administration, and basic utility costs are same as conventional. Anodes consumed at 3.5 # Fe/#Cr+6 (manufacturer data) with a cost estimated at $0.25/#Fe. Additional electrical costs include 5kWh/#heavy metal at $0.09/kWh. Lower sludge generation factors based on NaOH ppt are used (Reference 6-2) since additional sludge from excess lime is not a factor; however, additional sludge is generated from iron oxide produced during chrome reduction. One year demonstration R&D project is projected prior to implementation. Low risk assigned since this process is being operated successfully at a GOCO. Logistics projected assuming only minimal or easily effected changes.

LOGISTICS INPUT HW PROBLEM NO. 6.2.2 (I) HW MGMT OPTION NO. 3

Compliance	Y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

EUAC Input HW PROBLEM NO. 6.2.2 (I) HW MGMT OPTION NO. 3

BEGIN YEAR OF RECURRING COSTS 1
(no. of yrs from base year)

R & D ($k) 200

INSTALLATION COST ($k) 270

REPLACEMENT: MTBF (yrs) .75
COST ($k) 25

ECONOMIC LIFE (yrs) 25

ANNUAL O&M COST ($k) 256.8

NAVY-WIDE APPLICATIONS 20

SALVAGE VALUE ($k) 27

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)	35	5
Contract Haul cost ($k)	20.3	10

HW VOLUME CHANGE HW PROBLEM NO. 6.2.2 (I) HW MGMT OPTION NO. 3

Status Quo HW Output (gal/yr) 60.7

Projected HW Output (gal/yr) 67.5

Mgmt Option 4:
TITLE: POLYNUCLEOLYTE TREATMENT

Addition of polynucleolyte is used for aiding flocculation and clarification as opposed to polyelectrolyte in a conventional system. All other unit operations and costs are the same as the conventional method. Data could not be obtained on the dosage or cost of polynucleolytes and was assumed to be equivalent to a polyelectrolyte. However, it may be more expensive. Sludge is dewatered to 35% solids, which results in a reduction of sludge generated. Low installation cost of $25k is estimated for feed equipment. Logistics are the same or minimally effected by the chemical substitution. A moderate risk was assumed because data is based on manufacturer's claims that are not verified. A one year, $150k demonstration project is envisioned prior to implementation.

For further information see Section 3.2.

LOGISTICS INPUT HW PROBLEM NO. 6.2.2 (I) HW MGMT OPTION NO. 4

Compliance	Y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	2	
Supply Support	2	

```
 EUAC Input       HW PROBLEM NO. 6.2.2 (I)   HW MGMT OPTICN NO.  4
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    150__  _____  _____  _____  _____  _____

  INSTALLATION COST ($k)   25____  _____  _____

  REPLACEMENT: MTBF (yrs)  .75___
               COST ($k)   25____    ECONOMIC LIFE  (yrs) 25____

  ANNUAL O&M COST ($k)     258.5_    NAVY-WIDE
                                     APPLICATIONS   20____
  SALVAGE VALUE ($k)       0_____
```

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======================================================================


ANNUAL TREATMENT & DISPOSAL COSTS            ESCALATION RATE (%)
_________________________________            __________________
DRMO cost ($k)                 _______         ______
STP  cost ($k)                 _______         ______
IWTP cost ($k)                 _______         ______
POTW cost ($k)                 35_____         5_____
Contract Haul cost ($k)        15.6___         10____

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 HW VOLUME CHANGE  HW PROBLEM NO. 6.2.2 (I)   HW MGMT OPTION NO.  4
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  60.7_____

     Projected  HW Output (gal/yr)  52______
```

HW PROBLEM 6.2.2 (II): DESCRIPTION: IWTP SLUDGE DEWATERING
TITLE: HAZARDOUS WASTES FROM IWTP OPERATIONS

The alternatives considered for IWTP sludge dewatering include vacuum filtration, twin belt press, and plate and frame pressure filter devices. A 30-gal/hr IWTP slurry of 5% solids is used for the basis of comparison. The IWTP slurry is assumed to be a hydroxide sludge generated from lime precipitation. Dewatered sludges are disposed of by contract haul at $300/ton ($1.50/gal). Five Navy applications are estimated for IWTPs that do not have dewatering devices.

\\\\\\\\\\\\\\\\
[Mgmt Options

OPTION NO.	TITLE
45	SLURRY DISPOSAL
46	VACUUM FILTRATION
47	BELT PRESS
48	PLATE & FRAME FILTER PRESS

HAMTAM REPORTS
PROBLEM TITLE: IWTP SLUDGE DEWATERING

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
47	1	0.25	15.00	23.88	85.00	1.00	2
46	2	0.26	15.00	27.43	79.00	1.00	2
48	3	0.31	17.00	44.29	87.50	1.00	2
45	4	0.40	8.00	96.93	0.00	0.00	1

Mgmt Option 1:
TITLE: NO DEWATERING/SLURRY DISPOSAL

Contract disposal of IWTP slurry is the status quo at some Navy IWTPs. The slurry is assumed about 5% solids. No investment, replacement, or R&D costs are associated. O&M costs include chemicals for sludge thickening. Contract disposal costs are estimated at $300/ton ($1.50/gal).

LOGISTICS INPUT HW PROBLEM NO. 6.2.2 (II) HW MGMT OPTION NO. 1

Compliance	Y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	1	
Supply Support	1	

```
 EUAC Input         HW PROBLEM NO. 6.2.2 (II)   HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  0____
    (no. of yrs from base year)

  R & D ($k)     0____   _____   _____   _____   _____   _____

  INSTALLATION COST ($k)    0____   _____   _____

  REPLACEMENT: MTBF (yrs)   0____
               COST ($k)    0____     ECONOMIC LIFE  (yrs) 20___

  ANNUAL O&M COST ($k)      2.5__     NAVY-WIDE
                                      APPLICATIONS   5____
  SALVAGE VALUE ($k)        0____
```

```
ANNUAL TREATMENT & DISPOSAL COSTS            ESCALATION RATE (%)
_________________________________            ___________________
DRMO cost ($k)                 _______         ______
STP  cost ($k)                 _______         ______
IWTP cost ($k)                 _______         ______
POTW cost ($k)                 _______         ______
Contract Haul cost ($k)        90_____         10______
=================================================================
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 HW VOLUME CHANGE HW PROBLEM NO. 6.2.2 (II)    HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  60_____

     Projected  HW Output (gal/yr)  60_____
```

Mgmt Option 2:
TITLE: VACUUM FILTRATION

Investment costs for this system are estimated at $50k and include $20k for equipment and $30k for building and installation. O&M costs of $7.5k/yr include $1000/yr for filter replacement and $1500/yr for parts replacement, in addition to chemicals, utilities, and operating personnel. No additional personnel are required for this operation. The slurry is dewatered to at least 20% solids with this device, resulting in a 79% reduction in waste generation. Logistic parameters are based on only minimal or easily effected changes for implementation. Risk is based on the technology being a readily implementable process for which some elements of risk exist that are associated with sludge characterization and conditioning requirements. A one-year demonstration project and sludge characterization is proposed to evaluate the system.

LOGISTICS INPUT HW PROBLEM NO. 6.2.2 (II) HW MGMT OPTION NO. 2

Compliance	Y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	1	
Support Equipment	2	
Facilities	2	
Supply Support	2	

EUAC Input HW PROBLEM NO. 6.2.2 (II) HW MGMT OPTION NO. 2
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BEGIN YEAR OF RECURRING COSTS 1
(no. of yrs from base year)

R & D ($k) 50

INSTALLATION COST ($k) 50

REPLACEMENT: MTBF (yrs) 1
COST ($k) 2.5

ECONOMIC LIFE (yrs) 20

ANNUAL O&M COST ($k) 7.5

NAVY-WIDE APPLICATIONS 5

SALVAGE VALUE ($k) 5

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)		
Contract Haul cost ($k)	18.9	10

HW VOLUME CHANGE HW PROBLEM NO. 6.2.2 (II) HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\

Status Quo HW Output (gal/yr) 60

Projected HW Output (gal/yr) 12.6

Mgmt Option 3:
TITLE: BELT PRESS

Investment costs for the twin belt press are estimated at $55k and include equipment, building, and installation. O&M costs of $6.5k/yr include $1500/yr for belt replacement and $1000/yr for replacement of small moving parts, as well as chemical costs for polymer, electrical, and operating personnel costs. No additional personnel would be required. The slurry is dewatered to 30% solids with this device, resulting in an 85% reduction in waste generation. Logistic parameters are based on only minimal or easily effected changes for implementation. Risk is based on the technology being a readily implementable process for which some elements of risk exist. These are associated with sludge characterization and conditioning requirements. A one-year demonstration and sludge characterization project is proposed to evaluate the system.

LOGISTICS INPUT HW PROBLEM NO. 6.2.2 (II) HW MGMT OPTION NO. 3

Compliance	Y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	1	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input       HW PROBLEM NO. 6.2.2 (II)   HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)     50____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)   55____  ______  ______

  REPLACEMENT: MTBF (yrs)  1____
               COST ($k)   2.5__      ECONOMIC LIFE  (yrs) 20____

  ANNUAL O&M COST ($k)     6.5__      NAVY-WIDE
                                      APPLICATIONS   5_____
  SALVAGE VALUE ($k)       5.5__
```

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ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          __________________
DRMO cost ($k)                 _______       ______
STP  cost ($k)                 _______       ______
IWTP cost ($k)                 _______       ______
POTW cost ($k)                 _______       ______
Contract Haul cost ($k)        13.5___       10____

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 HW VOLUME CHANGE HW PROBLEM NO. 6.2.2 (II)   HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  60______

     Projected  HW Output (gal/yr)  9_______
```

Mgmt Option 4:
TITLE: PLATE AND FRAME FILTER PRESS

Investment costs for the plate and frame filter press are estimated at $60k, which includes $30k for equipment with automatic cycling and $30k for building and installation. $18k O&M costs include $1500/yr for replacement of filter cloths, $1500/yr for other parts replacement, $5k for chemicals and utilities, and $20k for press operation (500hr/yr labor, $40/hr burdened). The slurry is dewatered to 40% solids resulting in an 87.5% reduction in waste generation. Logistic parameters are based on only minimal or easily effected changes for implementation, with the exception of maintenance planning, which requires significant changes. Risk is based on the process being a readily implementable process for which minor elements of risk exist. These are associated with sludge characterization and conditioning requirements. A one-year demonstration and sludge characterization project is proposed to evaluate the system.

LOGISTICS INPUT HW PROBLEM NO. 6.2.2 (II) HW MGMT OPTION NO. 4

Compliance	Y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input      HW PROBLEM NO. 6.2.2 (II)   HW MGMT OPTION NO.  4
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    50____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)   60____  ______  ______

  REPLACEMENT: MTBF (yrs)  1_____
               COST ($k)   3_____      ECONOMIC LIFE  (yrs) 20____

  ANNUAL O&M COST ($k)     28____      NAVY-WIDE
                                       APPLICATIONS   5_____
  SALVAGE VALUE ($k)       6_____
```

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)		
Contract Haul cost ($k)	11.25	10

```
 HW VOLUME CHANGE HW PROBLEM NO. 6.2.2 (II)   HW MGMT OPTION NO.  4
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     Status Quo HW Output (gal/yr)  60______

     Projected  HW Output (gal/yr)  7.5_____
```

HW PROBLEM 6.2.3: DESCRIPTION: ELECTROPLATING WASTEWATERS
TITLE: FREEZE CRYSTALLIZATION TO CONCENTRATE TREATMENT

The concept is assessed by comparing treatment of the same wastes considered in Problem 6.2.2 (CN and Cr at 200 kgpd inflow) with and without water extraction to furnish a 5% balance. A stoichiometric advantage of 1.5/1.2 for redox was assumed in the concentrated waste; acid/base needs were identical; flocculant requirements and sludge production were set at 25% of the dilute wastewater. Freeze-dry data used are from Heist Eng. Corp. report to NAPC on contract Freeze-dry data used are from Heist Eng. Corp. report to N00140-86-C-9812 dtd MAR 87 and EPRI final report EM-5232 dtd NAPC on contract N00140-86-C-9812 dtd MAR 87 and EPRI JUN 87 (also prepared by Heist Corp.). Chrome wastewater is set at 75 kgpd so as to reflect the reduction implementation of the NCEL innovative chrome plating process will have on that flow.

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[ Mgmt Options [
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OPTION NO.	TITLE
1	CONVENTIONAL IWTP CN/CR TREATMENT
2	FREEZE CRYSTALLIZATION CONCENTRATION OF IWTP INPUT

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HAMTAM REPORTS
PROBLEM TITLE: FREEZE CRYSTALLIZATION TO CONCENTRATE TREATMENT

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
1	1	0.27	8.00	411.17	0.00	0.00	1
2	2	0.33	15.00	1192.26	95.01	1.00	1

Mgmt Option 1:
TITLE: CONVENTIONAL IWTP CN/CR TREATMENT

This option is identical with Option 1 of Problem 6.2.1 (I).

LOGISTICS INPUT HW PROBLEM NO. 6.2.3 HW MGMT OPTION NO. 1

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Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	1	
Supply Support	1	

```
 EUAC Input          HW PROBLEM NO. 6.2.3      HW MGMT OPTION NO.  1
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  BEGIN YEAR OF RECURRING COSTS  0____
    (no. of yrs from base year)

  R & D ($k)    0_____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)        ______  ______  ______

  REPLACEMENT: MTBF (yrs)  .75___
               COST ($k)   25____     ECONOMIC LIFE  (yrs) 25____

  ANNUAL O&M COST ($k)     258___     NAVY-WIDE
                                      APPLICATIONS   20____
  SALVAGE VALUE ($k)       0_____
```

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ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)	35	5
Contract Haul cost ($k)	18.2	10

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 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.3      HW MGMT OPTION NO.  1
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     Status Quo HW Output (gal/yr)  60.7____

     Projected  HW Output (gal/yr)  60.7____

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Mgmt Option 2:
TITLE: FREEZE CRYSTALLIZATION CONCENTRATION OF IWTP INPUT

The system consists of a precooler, freezer, washer, and melter, with a refrigeration loop (heat Xchange) operating between freezer and melter. Process costs are assumed to be the lowest ($0.025/gal) achievable, including credit for the water returned to IWTP process uses. The risk level has been assumed to be the same as for the conventional process, even though the approach has never been demonstrated.

LOGISTICS INPUT HW PROBLEM NO. 6.2.3 HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input          HW PROBLEM NO. 6.2.3       HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    750__   ______   ______   ______   ______   ______

  INSTALLATION COST ($k)   1500__   ______   ______

  REPLACEMENT: MTBF (yrs)  .75___
               COST ($k)   50___      ECONOMIC LIFE  (yrs) 25___

  ANNUAL O&M COST ($k)     1173__     NAVY-WIDE
                                      APPLICATIONS   20____
  SALVAGE VALUE ($k)       1000__
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ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          ______________________
DRMO cost ($k)                 _______       _______
STP  cost ($k)                 _______       _______
IWTP cost ($k)                 _______       _______
POTW cost ($k)                 1.75___       5______
Contract Haul cost ($k)        4.6____       10_____

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 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.3       HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  60.7_____

     Projected  HW Output (gal/yr)  3.03_____
```

HW PROBLEM 6.2.4: DESCRIPTION: ORDNANCE OPERATIONS
TITLE: PINK WATER TREATMENT

A 50-kgpd plant is envisioned. The processes evaluated included the existing carbon process, wet air oxidation, photolytically enhanced oxidation, and the Lummus Crest fungal process. Ion exchange was not evaluated because of the high risk assigned (nitro-bodies are weak Lewis acids and would be questionable candidates for the process). Other biological processes were not considered because of the lack of cost data.

Further information on these processes is contained in Section 3.4 of the IDR.

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[Mgmt Options

OPTION NO.	TITLE
1	PHOTOLYTICALLY ENHANCED PEROXIDATION H_2O_2
2	EXISTING CARBON PROCESS
3	WET AIR OXIDATION
4	LUMMUS CREST FUNGAL PROCESS

HAMTAM REPORTS
PROBLEM TITLE: PINK WATER TREATMENT

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
1	1	0.40	22.00	126.04	100.00	1.00	4
2	2	0.43	22.00	528.45	100.00	0.00	2
4	3	0.49	19.00	185.12	100.00	3.00	5
3	4	0.53	23.00	201.38	100.00	4.00	4

Mgmt Option 1:
TITLE: PHOTOLYTICALLY ENHANCED PEROXIDATION H_2O_2

Data on this process are uncertain. In EPA-600/2-84-136 (Glaze et al, U. of Texas at Dallas), show that this process is highly sensitive to scale and that the O&M costs rise almost asymptotically, as plant throughput is reduced below 0.1 mgd. Capital costs were derived using that EPA publication. O&M costs were averages of those estimated by NWSC Crane and escalated from 1980 dollars at 5% per year. The normal risk factor (4) assigned is largely based on the cost question. Further information on this treatment process can be found in Section 3.4.

LOGISTICS INPUT HW PROBLEM NO. 6.2.4 HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	3	
P.H.S.T.	3	
Support Equipment	3	
Facilities	3	
Supply Support	3	

```
 EUAC Input          HW PROBLEM NO. 6.2.4       HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    250___   000___   000___   000___   ______   ______

  INSTALLATION COST ($k)   300___   50___   25___

  REPLACEMENT: MTBF (yrs)  0.25__
               COST ($k)   5____      ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     100___     NAVY-WIDE
                                      APPLICATIONS   4_____
  SALVAGE VALUE ($k)       25____
```

```
==================================================================

ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          ____________________
DRMO cost ($k)              0_______            _______
STP  cost ($k)              0_______            _______
IWTP cost ($k)              00______            _______
POTW cost ($k)              12______            5______
Contract Haul cost ($k)     0_______            _______
==================================================================
```

```
 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.4       HW MGMT OPTION NO. 1
\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


    Status Quo HW Output (gal/yr)  1825000__

    Projected  HW Output (gal/yr)  0________

==================================================================
```

Mgmt Option 2:
TITLE: EXISTING CARBON PROCESS

Cost data are from Appendix H. A risk factor was assigned (2) even though the process is in routine use. This was done to reflect the probability that modifications to the process will be necessary in order to accommodate future air pollution control constraints requiring furnace disposal of spent charcoal. The assignment of logistics scores was also done on the basis of an assumed change-over in charcoal disposal to some form of combustor. See Section 3.4 for additional information.

==

```
 LOGISTICS INPUT   HW PROBLEM NO. 6.2.4       HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\
      -----------------------             -----------------------
      Compliance                _Y___     (Y or N)
      -----------------------             -----------------------
      Risk Level                _2___     1=no risk; 10=high risk
      -----------------------             -----------------------
      Process Performance       _1___     (1-10) a '1' is 'best'
      -----------------------             -----------------------

      -----------------------             -----------------------
      Maintenance Planning      _3___     Select a value on a
      Technical Documentation   _3___     sliding scale between
      Training & Personnel      _3___     one & ten.  A value
      P.H.S.T.                  _3___     of one is a relative
      Support Equipment         _3___     BEST score
      Facilities                _3___
      Supply Support            _3___
      -----------------------             -----------------------
```

```
 EUAC Input         HW PROBLEM NO. 6.2.4       HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  0_____
    (no. of yrs from base year)

  R & D ($k)    0_____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)    0_____  ______  ______

  REPLACEMENT: MTBF (yrs)   0.6___
               COST ($k)    5_____      ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)      500___      NAVY-WIDE
                                        APPLICATIONS   4_____
  SALVAGE VALUE ($k)        50____
```

```
=====================================================================

ANNUAL TREATMENT & DISPOSAL COSTS         ESCALATION RATE (%)
_________________________________         __________________
DRMO cost ($k)                  0______      ______
STP  cost ($k)                  0______      ______
IWTP cost ($k)                  0______      ______
POTW cost ($k)                  0______      ______
Contract Haul cost ($k)         0______      ______
==============================================================
```

```
 HW VOLUME CHANGE   HW PROBLEM NO. 6.2.4       HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  1825000___

     Projected  HW Output (gal/yr)  0_________

==============================================================
```

Mgmt Option 3:
TITLE: WET AIR OXIDATION (SUPERCRITICAL)

This analysis is based on data recently obtained by Oxidyne Corp. (formerly Vertox Inc.), treating various sludges evaluated by the Gulf Coast Waste Disposal Authority (An Evaluation of Supercritical Deepwell Wet Oxidation of Sludge), 15 November 1986. Materials treated included sewage sludge, paper pulp waste, and oily wastewater. DRE's of six nines have been demonstrated for materials of labilities at least comparable to pink water nitro-bodies. Operating conditions ranged from 400 to 600° F and pressures to 2000 psia. Additional information on this treatment process may be found in Section 3.4.

LOGISTICS INPUT HW PROBLEM NO. 6.2.4 HW MGMT OPTION NO. 3

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input          HW PROBLEM NO. 6.2.4     HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  4____
    (no. of yrs from base year)

  R & D ($k)     500__    500__    250__    0____    0____    0____

  INSTALLATION COST ($k)    2000_    50___    25___

  REPLACEMENT: MTBF (yrs)   0.6__
               COST ($k)    25___       ECONOMIC LIFE  (yrs) 20____

  ANNUAL O&M COST ($k)      200__       NAVY-WIDE
                                        APPLICATIONS   4_____
  SALVAGE VALUE ($k)        25___
```

```
ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)

DRMO cost ($k)                 0_______      _______
STP  cost ($k)                 0_______      _______
IWTP cost ($k)                 0_______      _______
POTW cost ($k)                 0_______      _______
Contract Haul cost ($k)        0_______      _______
```

```
 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.4     HW MGMT OPTION NO. 3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  1825000__

     Projected  HW Output (gal/yr)  0________
```

Mgmt Option 4: DESCRIPTION: ORDNANCE OPERATIONS
TITLE: LUMMUS CREST FUNGAL PROCESS

Cost analysis of this biological system was based on Appendix H. Although the technology is clearly T3, the cost reliability is, nonetheless, reasonably good. Biological processes are typically packaged in fairly standard generic arrangements and O&M costs do not range widely because of the particular culture being worked. The reliability of the Lummus Crest culture is highly uncertain, however, thus necessitating the assignment of a high risk factor (5). The proposed system design includes an activated charcoal polishing stage thus ignoring the pre-existing equipment that could certainly be used for the same purpose. The unneeded component was accordingly subtracted out of the capital cost. Further details on this process are contained in Section 3.4.

LOGISTICS INPUT HW PROBLEM NO. 6.2.4 HW MGMT OPTION NO. 4

Compliance	y	(Y or N)
Risk Level	5	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	3	
Facilities	3	
Supply Support	3	

```
 EUAC Input          HW PROBLEM NO. 6.2.4          HW MGMT OPTION NO. 4
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\

   BEGIN YEAR OF RECURRING COSTS  3____
     (no. of yrs from base year)

   R & D ($k)    300___   200___   000___   0_____   0_____   0_____

   INSTALLATION COST ($k)  1000___   15____   15____

   REPLACEMENT: MTBF (yrs)  0.5___
                COST ($k)   10____      ECONOMIC LIFE  (yrs) 15____

   ANNUAL O&M COST ($k)     92.5__      NAVY-WIDE
                                        APPLICATIONS   5_____
   SALVAGE VALUE ($k)       25____
```

```
==========================================================================

ANNUAL TREATMENT & DISPOSAL COSTS           ESCALATION RATE (%)
_________________________________           ___________________
DRMO cost ($k)                0______          ______
STP  cost ($k)                0______          ______
IWTP cost ($k)                20_____          5_____
POTW cost ($k)                0______          ______
Contract Haul cost ($k)       0______          ______

==========================================================================
```

```
 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.4          HW MGMT OPTION NO. 4
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  1825000__

     Projected  HW Output (gal/yr)  0_______
==========================================================================
```

HW PROBLEM 6.2.5: DESCRIPTION: BILGE EMPTYING AND CLEANING
TITLE: OILY SLUDGES

Oily sludges are generated at all stages of treatment and handling of oily wastewaters. Over 240,000 gallons were generated, which required treatment and disposal in FY 85. This amount was produced by 12 treatment facilities and NSYs. All calculations are based upon similar sludge composition, which includes solids, oil, and heavy metal content. These quantities can vary markedly from activity to activity. Not all technologies are applicable to each activity because of the range in quantity produced from each activity.

See HWM IDR Section 3.5 Part 3 for further information.

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[Mgmt Options

OPTION NO.	TITLE
1	CURRENT PRACTICE/CONTRACT HAUL
2	PYROLYSIS
3	BIOLOGICAL: LANDFARMING
4	OPTION DELETED
5	ACTIVATED SLUDGE TREATMENT
6	SUPER/SUB-CRITICAL WET AIR OXIDATION
7	DETOXIFICATION BY OXIDATION

HAMTAM REPORTS
PROBLEM TITLE: OILY SLUDGES

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
1	1	0.26	8.00	82.47	0.00	0.00	1
3	2	0.33	10.00	95.90	100.00	3.00	4
5	3	0.43	16.00	92.09	100.00	4.00	4
7	4	0.44	12.00	281.24	100.00	3.00	3
2	5	0.47	16.00	120.86	95.00	6.00	3
6	6	0.53	21.00	148.27	100.00	4.00	4

Mgmt Option 1:
TITLE: CURRENT PRACTICE/CONTRACT HAUL

The most common practice is to dispose of oily sludges by contract haul. Treatment of sludges varies widely; many facilities that operate an oily wastewater treatment plant have the capability to dewater their sludge before disposal, thus, reducing the volume. This option has a low risk value, but costs could escalate at any time. Activities that generate small quantities of sludge are more likely to drum the sludge and contract haul. Those with larger volumes may find other options more desirable. Haul costs were based on 20,000 gal of sludge a year, at a cost of $0.15 a gal.

See HWM IDR, Section 3.5, for further information.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.5   HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	1	
Supply Support	1	

```
 EUAC Input          HW PROBLEM NO. 6.2.5       HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  0___
    (no. of yrs from base year)

  R & D ($k)    0-----   0---    0____   0-----   0-----   0-----

  INSTALLATION COST ($k)   0-     0____   0-----

  REPLACEMENT: MTBF (yrs)  0_____
               COST ($k)   0_____     ECONOMIC LIFE  (yrs) 99____

  ANNUAL O&M COST ($k)     0_____     NAVY-WIDE
                                      APPLICATIONS   12____
  SALVAGE VALUE ($k)       0_____
```

```
=====================================================================

ANNUAL TREATMENT & DISPOSAL COSTS            ESCALATION RATE (%)
_________________________________            ___________________
DRMO cost ($k)                 0_______         _______
STP  cost ($k)                 0_______         _______
IWTP cost ($k)                 0_______         _______
POTW cost ($k)                 0_______         _______
Contract Haul cost ($k)        3_______         10_____
=====================================================================
```

```
 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.5       HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  20000____

     Projected  HW Output (gal/yr)  20000____
```

Mgmt Option 2:
TITLE: PYROLYSIS

Pyrolysis is a process in which organic material is decomposed at high temperature in an oxygen-deficient environment. This process gives a greater reduction in volume than incineration, and air pollution requirements are not as stringent. The residue requires disposal. A 95% reduction is expected. Sludge probably need not be dewatered beforehand. Overall, the process performance is quite promising, but does require several years of R&D before installation of a unit to optimally handle Navy oily sludge. This can be implemented at installations that produce significant amounts of oily sludge, and at other facilities if the unit can be used for other hazardous wastes, as well. Costs are based upon information contained in the IDR on Sludge Treatment.

See HWM IDR, Section 3.5, Part 3, for further information.

LOGISTICS INPUT HW PROBLEM NO. 6.2.5 HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	3	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

EUAC Input HW PROBLEM NO. 6.2.5 HW MGMT OPTION NO. 2

BEGIN YEAR OF RECURRING COSTS 6
(no. of yrs from base year)

R & D ($k) 250 350 400 800 250 0

INSTALLATION COST ($k) 350 50 25

REPLACEMENT: MTBF (yrs) 0.5
COST ($k) 50

ECONOMIC LIFE (yrs) 10

ANNUAL O&M COST ($k) 35

NAVY-WIDE APPLICATIONS 12

SALVAGE VALUE ($k) 100

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)	0	
STP cost ($k)	0	
IWTP cost ($k)	0	
POTW cost ($k)	0	
Contract Haul cost ($k)	0.15	10

HW VOLUME CHANGE HW PROBLEM NO. 6.2.5 HW MGMT OPTION NO. 2

Status Quo HW Output (gal/yr) 20000

Projected HW Output (gal/yr) 1000

Mgmt Option 3:
TITLE: BIOLOGICAL: LANDFARMING

Landfarming is currently being used at Craney Island Fuel Depot. They have successfully used this technology to degrade their wastes. This is currently a very attractive alternative, but a high risk factor is involved due to the likelihood of more stringent requirements being placed on it by EPA and future environmental regulations.

This alternative requires additional land to set up a plot, which may not be feasible for many installations.

See HWM IDR, Section 3.5, Part 3, for further information.

LOGISTICS INPUT HW PROBLEM NO. 6.2.5 HW MGMT OPTION NO. 3

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	2	
Facilities	2	
Supply Support	1	

```
 _______________  _______________________  _______________________
| EUAC Input        HW PROBLEM NO. 6.2.5     HW MGMT OPTION NO.  3 |
|\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\|
|                                                                  |
|  BEGIN YEAR OF RECURRING COSTS  3____                            |
|    (no. of yrs from base year)                                   |
|                                                                  |
|  R & D ($k)     100___   100___   0_____   0_____   0_____   0_____|
|                                                                  |
|  INSTALLATION COST ($k)   130___   20____   20____               |
|                                                                  |
|  REPLACEMENT: MTBF (yrs)  25____                                 |
|               COST ($k)  130___      ECONOMIC LIFE  (yrs) 25____ |
|                                                                  |
|  ANNUAL O&M COST ($k)     25____      NAVY-WIDE                  |
|                                       APPLICATIONS   12____      |
|  SALVAGE VALUE ($k)       0_____                                 |
|                                                                  |
|__________________________________________________________________|

==================================================================

ANNUAL TREATMENT & DISPOSAL COSTS           ESCALATION RATE (%)
_________________________________           ___________________
DRMO cost ($k)               0_______         _______
STP  cost ($k)               0_______         _______
IWTP cost ($k)               0_______         _______
POTW cost ($k)               0_______         _______
Contract Haul cost ($k)      0_______         _______

==================================================================

 _______________  _______________________  _______________________
| HW VOLUME CHANGE  HW PROBLEM NO. 6.2.5     HW MGMT OPTION NO.  3 |
|\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\|
|                                                                  |
|                                                                  |
|    Status Quo HW Output (gal/yr)  20000____                      |
|                                                                  |
|    Projected  HW Output (gal/yr)  0________                      |
|                                                                  |
|__________________________________________________________________|
```

Mgmt Option 5:
TITLE: ACTIVATED SLUDGE TREATMENT

This biological method of treatment aerobically degrades organic matter in the waste stream. The microbial population is suspended in the basin and continually produces new cells. Since this has not been used for oily sludge treatment, R&D is required to determine detention time, sizing requirements, and overall feasibility. Costs are derived for a 100,000 gal/day unit. Though this seems larger than may be required, it assumes an oil concentration of less than 0.1% instead of 1 to 10% found in Navy sludges.

See HWM IDR, Section 3.5, Part 3, for further information.

LOGISTICS INPUT	HW PROBLEM NO. 6.2.5	HW MGMT OPTION NO. 5
Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

EUAC Input   HW PROBLEM NO. 6.2.5   HW MGMT OPTION NO. 5

BEGIN YEAR OF RECURRING COSTS 4
(no. of yrs from base year)

R & D ($k) 350 350 350 0 0 0

INSTALLATION COST ($k) 79 5 5

REPLACEMENT: MTBF (yrs) 0.5
COST ($k) 5

ECONOMIC LIFE (yrs) 25

ANNUAL O&M COST ($k) 4.3

NAVY-WIDE APPLICATIONS 12

SALVAGE VALUE ($k) 10

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)	0	
STP cost ($k)	0	
IWTP cost ($k)	0	
POTW cost ($k)	2	5
Contract Haul cost ($k)	0	

HW VOLUME CHANGE   HW PROBLEM NO. 6.2.5   HW MGMT OPTION NO. 5

Status Quo HW Output (gal/yr) 20000

Projected HW Output (gal/yr) 0

Mgmt Option 6:
TITLE: SUPER/SUB-CRITICAL WET AIR OXIDATION

A fairly recent advance in technology, this shows great promise in treating oily sludges. High initial capital costs are required, as well as some initial R&D on specific wastes generated by the Navy. This process uses high pressure and moderate temperature to degrade oxidizable material. This system is very practicable, if other hazardous wastes may be oxidized in addition to oily sludge.

See HWM IDR, Section 3.5, Part 3, for further information.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.5   HW MGMT OPTION NO. 6

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	3	
P.H.S.T.	2	
Support Equipment	3	
Facilities	3	
Supply Support	2	

```
EUAC Input          HW PROBLEM NO. 6.2.5        HW MGMT OPTION NO.  6
\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  4____
    (no. of yrs from base year)

  R & D ($k)    350__    350__    200__    _____    _____    _____

  INSTALLATION COST ($k)    1000__    15___    15___

  REPLACEMENT: MTBF (yrs)   0.5__
               COST ($k)    10___      ECONOMIC LIFE  (yrs) 25___

  ANNUAL O&M COST ($k)      60___      NAVY-WIDE
                                       APPLICATIONS   12___
  SALVAGE VALUE ($k)        100__
```

```
================================================================

ANNUAL TREATMENT & DISPOSAL COSTS            ESCALATION RATE (%)
_________________________________            ___________________
DRMO cost ($k)              0_______           _______
STP  cost ($k)              0_______           _______
IWTP cost ($k)              0_______           _______
POTW cost ($k)              0_______           _______
Contract Haul cost ($k)     0_______           _______

================================================================
```

```
HW VOLUME CHANGE    HW PROBLEM NO. 6.2.5        HW MGMT OPTION NO.  6
\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  20000___

     Projected  HW Output (gal/yr)  0_______
```

Mgmt Option 7:
TITLE: DETOXIFICATION BY OXIDATION

This technology was identified as the best option in previous studies conducted by NCEL. It can be installed in-line with an OWTP. Hydrogen peroxide may be used, although more R&D is necessary before implementation of this technology can begin. Ozone is another potential oxidizer, but there is no commercially available system at this time.

See HWM IDR, Section 3.5, Part 3, for further information.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.5   HW MGMT OPTION NO. 7

Compliance	Y	(Y or N)
Risk Level	3	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	2	
P.H.S.T.	1	
Support Equipment	2	
Facilities	2	
Supply Support	1	

EUAC Input HW PROBLEM NO. 6.2.5 HW MGMT OPTION NO. 7

BEGIN YEAR OF RECURRING COSTS 3
(no. of yrs from base year)

R & D ($k) 350 350 0 0 0 0

INSTALLATION COST ($k) 500 25 25

REPLACEMENT: MTBF (yrs) 0.5
COST ($k) 10

ECONOMIC LIFE (yrs) 15

ANNUAL O&M COST ($k) 175

NAVY-WIDE APPLICATIONS 12

SALVAGE VALUE ($k) 50

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)	0	
STP cost ($k)	0	
IWTP cost ($k)	0	
POTW cost ($k)	2	5
Contract Haul cost ($k)	0	

HW VOLUME CHANGE HW PROBLEM NO. 6.2.5 HW MGMT OPTION NO. 7

Status Quo HW Output (gal/yr) 20000

Projected HW Output (gal/yr) 0

HW PROBLEM 6.2.6: DESCRIPTION: ABRASIVE BLASTING
TITLE: Recycling of Abrasive Blasting Grit

Two processes capable of generating recyclable grit from used abrasive blasting grit (See Sec. 6.2.17 for soft media) were considered. These were thermal processing and the rotary dryer/mechanical siever system. A NSY operation generating 5 tph of grit was envisioned. Costs for the two processes were respectively obtained from Appendix D and Ref 3-9. Also see Section 3.6. Copper slag grit (at $50/ton) was the assumed starting material. A recovery rate of 80% is used for both. The "existing" process is assumed to be a once-through operation with all of the waste grit being sent out for land burial at $150/ton, an average for five reporting activities. It should be recognized that this cost will doubtless increase with the scheduled enforcement of more stringent requirements involving landfill use. Annual rate of generation is assumed to be 2000 tpy.

```
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[ Mgmt Options

________________
 OPTION NO.       TITLE
 -----------     ---------------------------------------------
      1           EXISTING PRACTICE
      2           THERMAL PROCESSING AND GRIT RECYCLE
      3           ROTARY DRYER/MECHANICAL SIEVER

=================================================================
HAMTAM REPORTS
PROBLEM TITLE: Abrasive Blasting

OPTION    RANK    SCORE    LOGISTICS    EUAC      VOLUME     EDR      RISK
______    ____    _____    _________   ______    _______    _____    ______
  3         1      0.29      14.00       75.71     79.60     1.00      4
  2         2      0.32      14.00      198.09     79.96     2.00      4
  1         3      0.60      20.00    54440.30      0.00     0.00      2
```

Mgmt Option 1:
TITLE: EXISTING PRACTICE: ONCE-THROUGH USE AND LF DISPOSE

The wet, used grit is out-hauled by DRMO contractor to the nearest Class II landfill. Opportunities for reuse in commercial products may exist; e.g., the substitution of grit for iron oxide in cement mix (Puget Sound NSY) or in asphaltic paving (Long Beach NSY). Such opportunities are considered prime alternatives, if the grit is accepted at no cost FOB the NSY. Aside from such a recycle approach, the analysis has been confined to recycle as grit vs the "existing" practice.

LOGISTICS INPUT HW PROBLEM NO. 6.2.6 HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	4	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	3	
Support Equipment	2	
Facilities	2	
Supply Support	3	

```
EUAC Input          HW PROBLEM NO. 6.2.6        HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\

 BEGIN YEAR OF RECURRING COSTS  0____
   (no. of yrs from base year)

 R & D ($k)    0_____  ______  ______  ______  ______  ______

 INSTALLATION COST ($k)   0_____  ______  ______

 REPLACEMENT: MTBF (yrs)  99___
              COST ($k)   0_____     ECONOMIC LIFE  (yrs) 99___

 ANNUAL O&M COST ($k)     101___     NAVY-WIDE
                                     APPLICATIONS   10____
 SALVAGE VALUE ($k)       0_____
```

```
=================================================================

ANNUAL TREATMENT & DISPOSAL COSTS           ESCALATION RATE (%)
_________________________________           ___________________
DRMO cost ($k)                _______         _______
STP  cost ($k)                _______         _______
IWTP cost ($k)                _______         _______
POTW cost ($k)                _______         _______
Contract Haul cost ($k)    300____            15____
```

```
HW VOLUME CHANGE    HW PROBLEM NO. 6.2.6        HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\


    Status Quo HW Output (gal/yr)  2000to___

    Projected  HW Output (gal/yr)  2000to___
```

Mgmt Option 2:
TITLE: THERMAL PROCESSING AND GRIT RECYCLE

Data on this recycling process are uncertain at this time. Because of this, a risk factor of 4 was assigned. Capital costs used were provided by the Institute of Gas Technology, which actually conducted laboratory tests in support of the present IDR. O&M labor was assumed to be 1000 man-hr/yr in support of a system duty time of 500 hr/yr. Expert maintenance cost was estimated at 10% of capital cost. Fuel use was set estimated on the basis of a grit Cp of .21 and 35% thermal efficiency with 2000^{O} F furnace conditions. No heat recovery was included. A grit recycle of 80% was assumed with 2% paint (10% ash content) in the input. Fuel cost was set at \$20/bbl with a calorific value of 17,000 Btu/lb. Cost for waste disposal was put at \$150/ton with an escalation rate of 15%/yr.

LOGISTICS INPUT HW PROBLEM NO. 6.2.6 HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a
Technical Documentation	2	sliding scale between
Training & Personnel	2	one & ten. A value
P.H.S.T.	1	of one is a relative
Support Equipment	2	BEST score
Facilities	2	
Supply Support	2	

```
 EUAC Input        HW PROBLEM NO. 6.2.6      HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  2____
    (no. of yrs from base year)

  R & D ($k)     160___   160___  ______  ______  ______  ______

  INSTALLATION COST ($k)   750___  ______  ______

  REPLACEMENT: MTBF (yrs)  0.25__
               COST ($k)   2_____     ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     58.20_     NAVY-WIDE
                                      APPLICATIONS   10____
  SALVAGE VALUE ($k)       100___
```

```
=================================================================

ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          ___________________
DRMO cost ($k)                  _______        ______
STP  cost ($k)                  _______        ______
IWTP cost ($k)                  _______        ______
POTW cost ($k)                  _______        ______
Contract Haul cost ($k)         60.12__        15____

=================================================================
```

```
 HW VOLUME CHANGE  HW PROBLEM NO. 6.2.6      HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  2000to___

     Projected  HW Output (gal/yr)  400.8t___
```

Mgmt Option 3:
TITLE: ROTARY DRYER/MECHANICAL SIEVER FOR GRIT RECYCLE

The system envisioned (5 tph) is based on the Apache unit described in Section 3.6, except that a dryer is included to dewater and render input grit flowable. A 12% moisture content is assumed and a drying temperature of 500^{o} F. Thermal terms are the same as those observed in Option 2. No combustion of the paint fraction is credited. O&M and expert (outside specialists) maintenance are also based on the same terms as used in Option 2. No heat recovery is credited. Although a working system has been fielded, some problems have been encountered with it that are being worked on. For this reason, a risk factor of 4 is assigned.

LOGISTICS INPUT HW PROBLEM NO. 6.2.6 HW MGMT OPTION NO. 3

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	1	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
EUAC Input          HW PROBLEM NO. 6.2.6         HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\

 BEGIN YEAR OF RECURRING COSTS  1____
   (no. of yrs from base year)

 R & D ($k)    500___  ______  ______  ______  ______  ______

 INSTALLATION COST ($k)  240___  ______  ______

 REPLACEMENT: MTBF (yrs)  .25___
              COST ($k)   5_____     ECONOMIC LIFE  (yrs) 15____

 ANNUAL O&M COST ($k)     -10.8_     NAVY-WIDE
                                     APPLICATIONS   10____
 SALVAGE VALUE ($k)       24____
```

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)		
Contract Haul cost ($k)	61.2	

```
HW VOLUME CHANGE    HW PROBLEM NO. 6.2.6         HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\


    Status Quo HW Output (gal/yr)  2000to___

    Projected  HW Output (gal/yr)  408ton___
```

HW PROBLEM 6.2.7: DESCRIPTION: PAINTING OPERATIONS
TITLE: NONE

A technology assessment of this topical area was not considered practical. The recommendations contained in Section 6.2.7 are based upon engineering judgments derived from the information available.

HW PROBLEM 6.2.8: MUNITIONS DEMILITARIZATION
TITLE: NONE

This topical area was also not subjected to technology assessment. The present practices in place are considered satisfactory. No alternative technology was identified.

HW PROBLEM 6.2.9: DESCRIPTION: PIPING FLUSHING AND CLEANING
TITLE: HIGH PRESSURE PIPING CLEANING

The alternatives considered were limited to the existing practice, CFC flushing, and the use of supercritical fluid (carbon dioxide was selected for the purpose) as the cleaning agent. Because of the pressures required for supercritical piping cleaning, the analysis was limited to high pressure piping, such as are used for hyperbaric breathing gas piping where deep submergence rescue vessel (DSRV) operations are conducted. Pipe flushing was assumed to be done once per week. No alternatives were identified for alkaline (TSP) or acidic pipe flushing. The possibility of finding replacement solvents for the ionospherically hazardous CFC, of course, exists but was outside the purview of the present task.

For further information on this problem, see Section 3.9.

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\\\\\\\\\\\\\\\\
[Mgmt Options

OPTION NO.	TITLE
1	FREON FLUSHING
2	SUPERCRITICAL FLUID FLUSHING

===

HAMTAM REPORTS
PROBLEM TITLE: PIPE FLUSHING AND CLEANING

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
1	1	0.40	8.00	72.28	0.00	0.00	1
2	2	0.52	18.00	46.46	100.00	4.00	4

Mgmt Option 1:
TITLE: FREON FLUSHING

Pipe flushing is performed once per week using a system sized to handle a charge of 250 gal of circulating CFC. The flushing operation is assumed to be an 8-hr job, requiring two operators. Evaporative losses, while sometimes total when proper equipment is not available, are, nonetheless, assumed to be 15%. Cost of CFC is set at $13/gal. Waste CFC is recycled by distillation and is assumed to require one man-day for operation of the still, transfer, and storage of the distillate and pot bottoms. Freon recovery is estimated at 98%. Still bottom disposal is by DRMO and is estimated at $2/gal, but escalating at 10%/yr because of the expected RCRA prohibition of landfilling of such residues in the near future.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.9   HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	1	
Supply Support	1	

```
 EUAC Input          HW PROBLEM NO. 6.2.9      HW MGMT OPTION NO. 1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  0____
    (no. of yrs from base year)

  R & D ($k)     0_____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)   0_____  ______  ______

  REPLACEMENT: MTBF (yrs)  1_____
               COST ($k)   5_____     ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     66____     NAVY-WIDE
                                      APPLICATIONS   6_____
  SALVAGE VALUE ($k)       10____
```

```
=============================================================

ANNUAL TREATMENT & DISPOSAL COSTS           ESCALATION RATE (%)
________________________________________    ______________________
DRMO cost ($k)                 0.425__        10____
STP  cost ($k)                 ________       _______
IWTP cost ($k)                 ________       _______
POTW cost ($k)                 ________       _______
Contract Haul cost ($k)        ________       _______
=============================================================
```

```
 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.9      HW MGMT OPTION NO. 1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  200_____

     Projected  HW Output (gal/yr)  200_____
```

Mgmt Option 2 :
TITLE: SUPERCRITICAL FLUID FLUSHING

Pipe cleaning is accomplished by flushing with supercritical carbon dioxide. This operation is also assumed to be active once per week using the system described in Appendix E. Cleaning time required is assumed to be equivalent to CFC flushing (one 8-hr shift), although it is expected that complete cleaning will actually be accomplished in as little as 15 min. The system requires the use of two operators. Estimated capital, O&M, and RDT&E costs are based on those derived from a work order to the NBS Boulder, CO, and are shown in Appendix E. Operating costs for this tech evaluation were adjusted from 6000 to 400 hr/yr of pipe flushing operations at a typical activity. This alternative process is assumed applicable at four NSY's involved in the cleaning of submarine piping systems during overhaul and at two Navy activities where DSRV operations are conducted. It was assumed, on advice from NBS, that installation of piping insulation would not be necessary, since it would be easy to compensate for heat losses.

LOGISTICS INPUT HW PROBLEM NO. 6.2.9 HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	3	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input        HW PROBLEM NO. 6.2.9     HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  4____
    (no. of yrs from base year)

  R & D ($k)    475___   560___   500___   ______   ______   ______

  INSTALLATION COST ($k)   300___   ______   ______

  REPLACEMENT: MTBF (yrs)  0.25__
               COST ($k)   3.5__      ECONOMIC LIFE  (yrs) 015__

  ANNUAL O&M COST ($k)     40___      NAVY-WIDE
                                      APPLICATIONS   6____
  SALVAGE VALUE ($k)       30___
```

```
===================================================================

ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          ___________________
DRMO cost ($k)                   _______      ______
STP  cost ($k)                   _______      ______
IWTP cost ($k)                   _______      ______
POTW cost ($k)                   _______      ______
Contract Haul cost ($k)          _______      ______
===================================================================
```

```
 HW VOLUME CHANGE   HW PROBLEM NO. 6.2.9     HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  200_____

     Projected  HW Output (gal/yr)  0_______
```

HW PROBLEM 6.2.10: DESCRIPTION: BOILER LAY-UP
TITLE: BOILER LAY-UP PROCEDURES

The processes evaluated included lay-up using steam, chemical solutions (nitrite or sulfite) with or without solution recycle, and inert gas (nitrogen over boiler water load or dry gas throughout steam circuitry). The base case evaluated assumed an average-sized NSY servicing 20 ships a year in lay-up for an average period of 90 days of boiler protection. In the analysis, rust inhibition was assumed to be the same for each type of lay-up but the performance scoring, nonetheless, varied. This was because the effect on ship availability for the lay-up process was considered a key parameter. The use of hydrazine/morpholine in lay-up solutions was not considered, in deference to the arguments previously offered in opposition to their use in the Navy. These reagents are, however, still widely used by utility companies. Further information on lay-up technology is given in Sec. 3.10.

\\\\\\\\\\\\\\\\
[Mgmt Options

OPTION NO.	TITLE
1	STEAM LAY-UP
2	DRY (INERT GAS) LAY-UP
3	WET LAY-UP/ SODIUM NITRATE OR SULFITE
4	WET LAY-UP WITH SOLUTION RECYCLE

HAMTAM REPORTS
PROBLEM TITLE: BOILER LAY-UP

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
1	1	0.21	9.00	100.10	100.00	0.00	1
3	2	0.32	16.00	47.01	0.00	0.00	1
4	3	0.39	20.00	48.06	100.00	1.00	2
2	4	0.42	21.00	89.95	100.00	1.00	2

Mgmt Option 1 :
TITLE: STEAM LAY-UP

Long-term lay-up using steam is assumed using dockside steam meeting the standards contained in NAVSEA Naval Ship Technical Manual 0901 LP, Sec. 220/22.13. Although no R&D costs are considered necessary, some O&M costs are specified for initial steam purity verification at lay-up points. Annual O&M costs include an estimated steam cost of $36/day per avg ship for a lay-up period of 90 days. Because hardware is already available to connect dockside steam to berthed ships, minimal additional capital costs are foreseen. The analysis is projected for only eight Navy activities, since it likely some steam plants ashore may be very slow in upgrading their steam purity. Minimal labor costs are involved, since these would be accrued almost entirely during connect/disconnect. Steam flow monitoring would be handled by ship personnel during lay-up.

LOGISTICS INPUT	HW PROBLEM NO. 6.2.10	HW MGMT OPTION NO. 1
Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	1	
Supply Support	1	

```
EUAC Input          HW PROBLEM NO. 6.2.10        HW MGMT OPTION NO. 1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  0____
    (no. of yrs from base year)

  R & D ($k)     0_____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)   60____  ______  ______

  REPLACEMENT: MTBF (yrs)  1_____
               COST ($k)   10____     ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     90.1__     NAVY-WIDE
                                      APPLICATIONS   8_____
  SALVAGE VALUE ($k)       0_____
```

```
=====================================================================

ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          ___________________
DRMO cost ($k)                 0_______      _______
STP  cost ($k)                 0_______      _______
IWTP cost ($k)                 0_______      _______
POTW cost ($k)                 0_______      _______
Contract Haul cost ($k)        0_______      _______

=====================================================================
```

```
HW VOLUME CHANGE    HW PROBLEM NO. 6.2.10        HW MGMT OPTION NO. 1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\


    Status Quo HW Output (gal/yr)  6664_____

    Projected  HW Output (gal/yr)  0_______
```

Mgmt Option 2 :
TITLE: DRY (INERT GAS) LAY-UP

Logistic factors for this option are not favorable because of the requirement for pressurized gas storage. A central distribution plant is envisioned with piping to berths delivering nitrogen that has been dropped to about 20 psia. Lay-up includes purging, fill, and sealing of boiler for a nitrogen cost of $627 per lay-up. Forty hours of labor are estimated for each lay-up. Capital cost of the central gas storage and distribution piping system is estimated at $175k, including portable peripheral fittings, hoses, and tools. Unlike steam lay-up, which provides optimum ship readiness, dry lay-up is given an inferior performance factor. However, this factor is still better than that assigned to wet lay-up, which provides the poorest ship readiness.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.10   HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	3	
P.H.S.T.	3	
Support Equipment	3	
Facilities	3	
Supply Support	3	

```
 EUAC Input        HW PROBLEM NO. 6.2.10      HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    50___  _____  _____  _____  _____  _____

  INSTALLATION COST ($k)   175___  _____  _____

  REPLACEMENT: MTBF (yrs)  .5___
               COST ($k)   5____      ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     76.5__     NAVY-WIDE
                                      APPLICATIONS   8_____
  SALVAGE VALUE ($k)       25____

=================================================================

ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          ___________________
DRMO cost ($k)                0______         ______
STP  cost ($k)                0______         ______
IWTP cost ($k)                0______         ______
POTW cost ($k)                0______         ______
Contract Haul cost ($k)       0______         ______

=================================================================

 HW VOLUME CHANGE  HW PROBLEM NO. 6.2.10      HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  6664____

     Projected  HW Output (gal/yr)  0_______
```

Mgmt Option 3:
TITLE: WET LAY-UP WITH EITHER SODIUM NITRITE OR SULFITE

Both chemicals are considered in the same option since the cost differential is not significant. Sulfite costs are used since they are the higher ($438 per avg lay-up). Labor is estimated at 20 hr per lay-up. It is assumed that the lay-up water is wasted and air-oxidized at $20 per thousand gal at the IWTP and an additional $4.00 per thousand at a municipal sanitary treatment plant. It is recognized that the latter charge could be eliminated by obtaining an NPDES permit and discharging IWTP effluent to the ocean. This would require segregated discharge, which is assumed to be impractical in most cases. The technique is designated as existing practice for which no HWM benefits are available. Performance is scored more poorly than the other options, since ship readiness is impaired by the presence of liquid in the steam circuitry, which must be replaced with feedwater.

LOGISTICS INPUT HW PROBLEM NO. 6.2.10 HW MGMT OPTION NO. 3

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	3	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	3	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input          HW PROBLEM NO. 6.2.10     HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  0_____
    (no. of yrs from base year)

  R & D ($k)    0_____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)   0_____  ______  ______

  REPLACEMENT: MTBF (yrs)  15___
               COST ($k)   0_____     ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     24.7_____      NAVY-WIDE
                                      APPLICATIONS   8_____
  SALVAGE VALUE ($k)       0_____
```

===

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)	0	
STP cost ($k)	.3	5
IWTP cost ($k)	1.6	5
POTW cost ($k)		
Contract Haul cost ($k)		

===

```
 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.10     HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  6664_____

     Projected  HW Output (gal/yr)  6664_____
```

Mgmt Option 4:
TITLE: WET LAY-UP WITH SOLUTION RECYCLE

This option is essentially the same as Option No. 3, except that the solution is removed after lay-up and stored for reuse. It is assumed that that the nitrite (or sulfite) solution is transferred from a low-point drain in the steam circuitry to a tank trunk using minimal chase water. The subsequent washings are segregated and trucked to the IWTP for discharge in the outflow where residual oxidants should easily convert the traces of nitrate to harmless nitrates. Tankage would consist of a 25,000-gal holding tank equipped with a stirring effect so that periodic concentration makeup could be accomplished. It is assumed that tank trucks and peripheral hardware for solution transfer are already in use and, therefore, would not be capital items.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.10   HW MGMT OPTION NO. 4

Compliance	y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	3	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	3	
Support Equipment	2	
Facilities	3	
Supply Support	2	

```
 EUAC Input           HW PROBLEM NO. 6.2.10     HW MGMT OPTION NO.  4
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    50____   0_____   _____   _____   _____   _____

  INSTALLATION COST ($k)   75____   _____   _____

  REPLACEMENT: MTBF (yrs)  1_____
               COST ($k)   5_____      ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     24.7__      NAVY-WIDE
                                       APPLICATIONS   8_____
  SALVAGE VALUE ($k)       15____
```

```
=====================================================================

ANNUAL TREATMENT & DISPOSAL COSTS             ESCALATION RATE (%)
_________________________________________     ____________________
DRMO cost ($k)                 0_______         _______
STP  cost ($k)                 .16_____         5______
IWTP cost ($k)                 .24_____         5______
POTW cost ($k)                 0_______         _______
Contract Haul cost ($k)        0_______         _______

=====================================================================
```

```
 HW VOLUME CHANGE     HW PROBLEM NO. 6.2.10     HW MGMT OPTION NO.  4
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  6664_____

     Projected  HW Output (gal/yr)  0_______
```

HW PROBLEM 6.2.11 (I): DESCRIPTION: WASTE FROM NUCLEAR-POWERED SHIPS AND SUBMARINES (NOS)

TITLE: NUCLEAR-POWERED SHIP AND SUBMARINE STEAM GENERATOR CLEANING

The current treatment of waste generated in the cleaning of nuclear-powered ship and submarine steam generators is handled on-site at half the activities generating the waste and by contractors off-site in the other half of the activities. NCEL is currently engaged in an R&D program to treat this waste type. A HAMTAM analysis was conducted to establish the relative merit of the NCEL approach against the approach in use at the Navy activities treating the waste on-site. The result was nearly a tie. However, because NCEL-selected technology incorporated a high risk penalty in the assessment and would, thus, be more cost-effective if successfully proven, it was recommended that the work be continued. As pointed out earlier, the characteristics of the waste and the treatment technology cannot be discussed here because of the classified nature of the waste source.

See HWM IDR Section 3.11 for further information.

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[Mgmt Options [

OPTION NO.	TITLE
1	CURRENT PRACTICE/ON-SITE
2	NCEL RDT&E APPROACH

HAMTAM REPORTS
PROBLEM TITLE: MARINE NUCLEAR UBSC WASTE

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
1	1	0.40	8.00	183.88	0.00	0.00	1
2	2	0.41	13.00	78.94	90.00	5.00	3

Mgmt Option 1:
TITLE: CURRENT PRACTICE/ON-SITE

For 1984, the treatment costs associated with these wastes were $326,000 for 326,000 gal. Chemical costs for treatment on-site ran to $150,000.

See HWM IDR Section 3.11 for further information.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.11 (I)   HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'

Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	1	
Supply Support	1	

EUAC Input HW PROBLEM NO. 6.2.11 (I) HW MGMT OPTION NO. 1

BEGIN YEAR OF RECURRING COSTS 0
(no. of yrs from base year)

R & D ($k) 0

INSTALLATION COST ($k) 0

REPLACEMENT: MTBF (yrs) 0

COST ($k) 0

ECONOMIC LIFE (yrs) 25

ANNUAL O&M COST ($k) 37.5

NAVY-WIDE APPLICATIONS 4

SALVAGE VALUE ($k) 0

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)		
Contract Haul cost ($k)		
NOS Cost ($k)	81.50	6

HW VOLUME CHANGE HW PROBLEM NO. 6.2.11 (I) HW MGMT OPTION NO. 1

Status Quo HW Output (gal/yr) 122425

Projected HW Output (gal/yr) 122425

Mgmt Option 2:
TITLE: NCEL RDT&E APPROACH

For further information see HWM IDR Section 3.11.

```
LOGISTICS INPUT   HW PROBLEM NO. 6.2.11 (I)   HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\
    -----------------------         ------------------------
     Compliance               _y____   (Y or N)
    -----------------------         ------------------------
     Risk Level               _3____   1=no risk; 10=high risk
    -----------------------         ------------------------
     Process Performance      _1____   (1-10) a '1' is 'best'
    -----------------------         ------------------------

    -----------------------         ------------------------
     Maintenance Planning     _2____   Select a value on a
     Technical Documentation  _2____   sliding scale between
     Training & Personnel     _2____   one & ten.  A value
     P.H.S.T.                 _1____   of one is a relative
     Support Equipment        _2____   BEST score
     Facilities               _2____
     Supply Support           _1____
    -----------------------         ------------------------
```

EUAC Input HW PROBLEM NO. 6.2.11 (I) HW MGMT OPTION NO. 2

BEGIN YEAR OF RECURRING COSTS 5
(no. of yrs from base year)

R & D ($k) 130 200 120 110

INSTALLATION COST ($k) 30

REPLACEMENT: MTBF (yrs) 5
COST ($k) 3

ECONOMIC LIFE (yrs) 15

ANNUAL O&M COST ($k) 95

NAVY-WIDE APPLICATIONS 4

SALVAGE VALUE ($k) 3

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)		
Contract Haul cost ($k)		
NOS cost ($k)	20.375	6

HW VOLUME CHANGE HW PROBLEM NO. 6.2.11 (I) HW MGMT OPTION NO. 2

Status Quo HW Output (gal/yr) 122425

Projected HW Output (gal/yr) 12242

HW PROBLEM 6.2.11 (II): DESCRIPTION: BOILER TUBE HYDROBLASTING
TITLE: SODIUM NITRITE WASTES

During normal hydroblasting, sodium nitrite waste overflows into the bilge where it combines with other wastes, thus, complicating required treatment. To reduce the volume of sodium nitrite waste, a simple recirculation and filtration system is evaluated. The system effects boiler cleaning with an avg of only 400 gal of $NaNO_2$ solution versus the 8000 gal normally used. It is assumed that eight activities can utilize this system, with only small risk involved. According to Ref. 3-10, the used and filtered nitrite solution can be discharged directly to the sanitary sewer. It may be necessary or desirable, however, to air blow the waste, thereby, quickly converting nitrite to nitrate.

Further information on this process may be found in the HWM IDR Section 3.11.

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\\\\\\\\\\\\\\\\
[Mgmt Options

OPTION NO.	TITLE
1	CURRENT PRACTICE/ONCE THROUGH
2	RECIRCULATION & FILTRATION

==

HAMTAM REPORTS
PROBLEM TITLE: SODIUM NITRITE WASTES

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
2	1	0.28	10.00	2.27	90.00	4.00	3
1	2	0.32	9.00	16.51	0.00	0.00	1

Mgmt Option 1:
TITLE: CURRENT PRACTICE/ONCE-THROUGH

The current practice of boiler tube hydroblasting utilizes sodium nitrite. The solution, after used once, is allowed to overflow into the ship's bilge, which contains other waste waters, as well. It is then transferred to shore where it is treated. In 1984, 1916 tons of this wastewater was generated. Chemical costs were based upon data from Reference 3-29, no additional O&M costs were assumed.

See HWM IDR Section 3.11 for further information.

LOGISTICS INPUT HW PROBLEM NO. 6.2.11 (II) HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	1	
Facilities	1	
Supply Support	1	

EUAC Input HW PROBLEM NO. 6.2.11 (II) HW MGMT OPTION NO. 1

BEGIN YEAR OF RECURRING COSTS 0
(no. of yrs from base year)

R & D ($k) 0

INSTALLATION COST ($k) 0

REPLACEMENT: MTBF (yrs)
COST ($k)

ECONOMIC LIFE (yrs) 15

ANNUAL O&M COST ($k) 1.375

NAVY-WIDE APPLICATIONS 8

SALVAGE VALUE ($k) 0

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)	10	6
POTW cost ($k)		
Contract Haul cost ($k)		

HW VOLUME CHANGE HW PROBLEM NO. 6.2.11 (II) HW MGMT OPTION NO.1

Status Quo HW Output (gal/yr) 57500

Projected HW Output (gal/yr) 57500

Mgmt Option 2:
TITLE: RECIRCULATION AND FILTRATION OF NITRITE SOLUTION

The sodium nitrite solution used in boiler tube hydroblasting is only used once. By installing a simple recycling and filtration unit, the solution may be reused, resulting in a 90% volume reduction, and 80% cost reduction. The system envisioned (Ref. 3-10) consists of a 400-gal recirc. tank, return pump, and filter unit. The spent filter is thrown away as a nonhazardous solid; the wastewater is directly sewered. Aeration of this waste may be found necessary but was not included in the costs. The only additional O&M costs, which are also quite minor, are those associated with replacing and changing the filter.

See HWM IDR Section 3.11 for further information.

LOGISTICS INPUT HW PROBLEM NO. 6.2.11 (II) HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	3	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'

Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	1	
Support Equipment	2	
Facilities	1	
Supply Support	1	

EUAC Input HW PROBLEM NO. 6.2.11 (II) HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\

BEGIN YEAR OF RECURRING COSTS 4____
(no. of yrs from base year)

R & D ($k) 140___ 250___ 80___ _____ _____ _____

INSTALLATION COST ($k) 3.5___ _____ _____

REPLACEMENT: MTBF (yrs) 3____
COST ($k) 0.5___

ECONOMIC LIFE (yrs) 15____

ANNUAL O&M COST ($k) 3____

NAVY-WIDE APPLICATIONS 8____

SALVAGE VALUE ($k) 0____

===

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)	.035	6
IWTP cost ($k)		
POTW cost ($k)		
Contract Haul cost ($k)		

===

HW VOLUME CHANGE HW PROBLEM NO. 6.2.11 (II) HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\

Status Quo HW Output (gal/yr) 57500____

Projected HW Output (gal/yr) 5750____

HW PROBLEM 6.2.12: DESCRIPTION: FLUIDS CHANGE-OUT
TITLE: NONE

A technology assessment was not attempted on this topical area. Recommendations contained in Section 6.2.12 of the IDR proper are based upon engineering judgments, as derived from the available information.

===

HW PROBLEM 6.2.13: DESCRIPTION: BATTERY REPAIR AND REPLACEMENT
TITLE: SPENT ELECTROLYTE

The scope of this tech assessment was limited to management of sulfuric acid discarded from lead/acid batteries. The processes evaluated included: 1) neutralization of the acid at the battery shop, 2) use of the acidic flushings as IWTP chemical, and 3) processing the material through DRMO for contractor disposal (the "existing" process, in some activities). Recovery of the lead in the electrolyte was not considered because it was found that the solubility of lead in sulfuric acid is so low (<3 ppm) that reclaim could not possibly pay off. Also not considered is the option of disposing of batteries intact and acid-filled. Some salvagers operate this way, and if their payment rates are reasonable, this could be the most attractive approach to use. For comparison purposes, it was assumed that an output of 160 tpy of spent electrolyte is involved.

\\\\\\\\\\\\\\\
[Mgmt Options

OPTION NO.	TITLE
1	CONTRACT HAUL AND DISPOSAL
2	NEUTRALIZATION AT BATTERY SHOP
3	USE WASTE ACID AS IWTP REAGENT CHEMICAL

HAMTAM REPORTS
PROBLEM TITLE: BATTERY REPAIR AND REPLACEMENT/SPENT ELECTROLYTE

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
2	1	0.12	17.00	23.40	95.00	0.00	1
3	2	0.27	19.00	9.24	100.00	1.00	3
1	3	0.56	17.00	3430.56	0.00	0.00	2

Mgmt Option 1:
TITLE: CONTRACT HAUL AND DISPOSAL

The cost for outhaul and contractor treatment of battery acid and flushings was averaged at $780/ton based on three shipyards and one PWC that use(d) this service. The avg dev. was only $21/ton. Because of the Navy's derivative responsibility for contractor's process residues (lead-contaminated sludges), a risk factor of 2 was assigned.

LOGISTICS INPUT HW PROBLEM NO. 6.2.13 HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	2	
P.H.S.T.	3	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input          HW PROBLEM NO. 6.2.13       HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  0____
    (no. of yrs from base year)

  R & D ($k)    0_____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)   0_____  ______  ______

  REPLACEMENT: MTBF (yrs)  0_____
               COST ($k)   0_____      ECONOMIC LIFE  (yrs) 99____

  ANNUAL O&M COST ($k)     0_____      NAVY-WIDE
                                       APPLICATIONS   15____
  SALVAGE VALUE ($k)       0_____
```

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================================================================

ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          __________________
DRMO cost ($k)                ______         ______
STP  cost ($k)                ______         ______
IWTP cost ($k)                ______         ______
POTW cost ($k)                ______         ______
Contract Haul cost ($k)   124.8__            10____

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 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.13       HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  38415____

     Projected  HW Output (gal/yr)  38415____
```

Mgmt Option 2:
TITLE: NEUTRALIZATION AT BATTERY SHOP

A typical lime-based neutralization facility is assumed to be used. Capital costs were obtained from activities that operate such facilities; O&M costs were estimated using data also from the field and current lime costs ($122/ton plus an avg freight cost of $30/ton). Because the NCEL survey found no case of an activity being out of specification for lead in water discharged from the IWTP's, it was assumed that additional IWTP treatment of the neutralized battery shop wastewater would be unnecessary. Also, the history of performance of these facilities within the Navy has been very good, warranting a risk assignment of one. Wet gypsum sludge (contaminated with lead) is assumed to be produced at a rate of 5% that of the influent and requires disposal at a cost of $ 350/ton, based upon an average for five activities.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.13   HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'

Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	3	
Support Equipment	2	
Facilities	2	
Supply Support	3	

```
 EUAC Input          HW PROBLEM NO. 6.2.13       HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\

   BEGIN YEAR OF RECURRING COSTS  0____
     (no. of yrs from base year)

   R & D ($k)    0_____  ______  ______  ______  ______  ______

   INSTALLATION COST ($k)   25____  ______  ______

   REPLACEMENT: MTBF (yrs)  1_____
                COST ($k)   1_____    ECONOMIC LIFE  (yrs) 15____

   ANNUAL O&M COST ($k)     16____    NAVY-WIDE
                                      APPLICATIONS   15____
   SALVAGE VALUE ($k)       2_____
```

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===========================================================================

ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          __________________
DRMO cost ($k)                  _______      _______
STP  cost ($k)                  _______      _______
IWTP cost ($k)                  _______      _______
POTW cost ($k)                  _______      _______
Contract Haul cost ($k)         2.8____      10_____

===========================================================================
```

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 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.13       HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\


      Status Quo HW Output (gal/yr)  38415____

      Projected  HW Output (gal/yr)  1920_____
```

Mgmt Option 3:
TITLE: USE WASTE ACID AS IWTP REAGENT CHEMICAL

The scenario in this option is that a facility has already been installed at the IWTP to accept waste acids, as described in Section 3.16, and assessed as Option 2 in HW Problem 6.2.16. Because the battery shop diluted acidic effluent would tend to overflow the acid storage tank at busy times, a surge tank would be installed at either the IWTP or battery shop. Other capital costs would consist of pumps, interconnecting piping and control instrumentation. While a credit is assigned for reagent sulfuric acid savings at the IWTP, credits for lime displacement there from ferric hydroxide generation are not. The scoring of the process is identical with that of Option 2 for Problem 6.2.16.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.13   HW MGMT OPTION NO. 3

Compliance	y	(Y or N)
Risk Level	3	1=no risk; 10=high risk
Process Performance	3	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	3	
Facilities	2	
Supply Support	2	

```
EUAC Input          HW PROBLEM NO. 6.2.13     HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    0_____  ______  ______  ______  ______  ______

  INSTALLATION COST ($k)   10____  ______  ______

  REPLACEMENT: MTBF (yrs)  0.5___
               COST ($k)   2_____     ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     4.8___     NAVY-WIDE
                                      APPLICATIONS   15____
  SALVAGE VALUE ($k)       1_____
```

==

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)		
Contract Haul cost ($k)		

==

```
HW VOLUME CHANGE    HW PROBLEM NO. 6.2.13     HW MGMT OPTION NO.  3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  38415____

     Projected  HW Output (gal/yr)  0_______
```

HW PROBLEM 6.2.14: DESCRIPTION: CLEANING WITH SOLVENTS
TITLE: NONE

A technology assessment was not considered necessary for this topic, since the USE program largely has the problem area under satisfactory technical management.

==

HW PROBLEM 6.2.15: DESCRIPTION: BILGE DERUSTING
TITLE: CITRIC ACID WASTE TREATMENT

The present practice (except at Norfolk NSY) is to have the spent solution outhauled by contractor. The process used at Norfolk on that fraction of the derust waste liquid that is treatable is based upon the use of potassium permanganate, followed by conventional metal pptn. This process was not considered here because of the excessive costs involved. Alternatives are currently being studied at NCEL with mixed results. The only viable alternative identified at NCEL (Ref. 3-29) is to process the waste solution through an ion exchanger to retain the metals, which are subsequently eluted at 5% of original volume. Citric acid is recovered in 90% yield. Analysis is based on potential use at four activities with an average plant installed cost of $100k. Changing the derusting process itself does not appear to be necessary.

\\\\\\\\\\\\\\\\
[Mgmt Options [

OPTION NO.	TITLE
1	Citric Acid Outhaul for Treatment
2	Ion Exchange Recycle of Citric Acid

HAMTAM REPORTS
PROBLEM TITLE: CITRIC ACID WASTE TREATMENT

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
2	1	0.44	23.00	30.14	100.00	3.00	4
1	2	0.46	13.00	510.40	0.00	0.00	1

Mgmt Option 1
TITLE: CITRIC ACID OUTHAUL FOR TREATMENT

O&M costs in 1985 for contractor outhaul of 1045 tons of spent citric acid were about $194k for four NSY's. This includes Norfolk NSY which sends out only a portion of its citric acid wastes at a cost that considerably exceeds the average. Most of the Norfolk NSY spent citric acid solution is treated on-site by permanganate oxidation.

LOGISTICS INPUT HW PROBLEM NO. 6.2.15 HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	1	
Training & Personnel	1	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	1	

EUAC Input | HW PROBLEM NO. 6.2.15 | HW MGMT OPTION NO. 1

BEGIN YEAR OF RECURRING COSTS 0
(no. of yrs from base year)

R & D ($k) 0

INSTALLATION COST ($k) 0

REPLACEMENT: MTBF (yrs) 25
COST ($k) 0

ECONOMIC LIFE (yrs) 99

ANNUAL O&M COST ($k) 0

NAVY-WIDE APPLICATIONS 4

SALVAGE VALUE ($k) 0

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)		
POTW cost ($k)		
Contract Haul cost ($k)	194	6

HW VOLUME CHANGE | HW PROBLEM NO. 6.2.15 | HW MGMT OPTION NO. 1

Status Quo HW Output (gal/yr) 251000

Projected HW Output (gal/yr) 251000

Mgmt Option 2:
TITLE: ION EXCHANGE RECYCLE OF CITRIC ACID

Following the elimination of other processes, including the Norfolk NSY technology, reverse osmosis, and others, NCEL is now evaluating ion exchange as the most viable approach. The expected performance of a mixed-bed system optimum for the chemistry will be concentration of heavy metals to 5% of the original volume and 90% recovery of the citric acid. It is also possible that recovery for reuse of the triethanol amine present in the waste solution can also be achieved, but this has not been included in the technology assessment. Because the metals are isolated in free form rather than as citric chelates, they can be precipitated at the IWTP (as chelates they would tend to pass through the flocculation effect). Cost for this treatment is set at $20/1000 gal.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.15   HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	3	
P.H.S.T.	3	
Support Equipment	3	
Facilities	3	
Supply Support	3	

```
EUAC Input          HW PROBLEM NO. 6.2.15       HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\  \\\\\\\\\\\\\\\\\\\\\\\\\\\  \\\\\\\\\\\\\\\\\\\\\\\\\\\

 BEGIN YEAR OF RECURRING COSTS  3____
   (no. of yrs from base year)

 R & D ($k)    250__   300__   300__   _____   _____   _____

 INSTALLATION COST ($k)  400___  _____  _____

 REPLACEMENT: MTBF (yrs)  .33___
              COST ($k)   10____     ECONOMIC LIFE  (yrs) 15____

 ANNUAL O&M COST ($k)     0_____     NAVY-WIDE
                                     APPLICATIONS   4_____
 SALVAGE VALUE ($k)       40____
```

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)		
STP cost ($k)		
IWTP cost ($k)	.25	5
POTW cost ($k)		
Contract Haul cost ($k)		

```
HW VOLUME CHANGE    HW PROBLEM NO. 6.2.15       HW MGMT OPTION NO.  2
\\\\\\\\\\\\\\\\  \\\\\\\\\\\\\\\\\\\\\\\\\\\  \\\\\\\\\\\\\\\\\\\\\\\\\\\


   Status Quo HW Output (gal/yr)  251000___

   Projected  HW Output (gal/yr)  0_______
```

HW PROBLEM 6.2.16: DESCRIPTION: METAL PREPARATION
TITLE: HAZARDOUS WASTES FROM METAL PREPARATION

The alternatives considered included acid/base neutralization, use of acid waste for chemical treatment (alkali waste consumed in the process), and the sometimes-used practice of manifesting these wastes and sending them out for contractor disposal. Regeneration was not considered because of the still scaling issue described in Section 3.16. Four thousand gal-cap'y tanks were considered for separate waste acid and alkali storage with a 1 gpm max bleed rate. The principal difference between the neutralization and the treatment systems is that the latter has iron addition included. In both configurations, neutralization occurs upstream of the IWTP prior to flocculation/clarification, in the case of the neutralization process, and as part of the coagulation step, in the treatment version. Off-site contractor cost for treatment is projected at $1.50/gal including container.

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[Mgmt Options

OPTION NO.	TITLE
1	WASTE ACID/BASE NEUTRALIZATION AT IWTP
2	ACID/BASE WASTES AS IWTP TREATMENT CHEMICALS
3	ACID/BASE OUTHAUL FOR CONTRACTOR DISPOSAL

HAMTAM REPORTS
PROBLEM TITLE: Hazardous Wastes from Metal Preparation

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
2	1	0.22	19.00	-13.11	100.00	1.00	3
1	2	0.24	17.00	12.60	100.00	1.00	2
3	3	0.56	17.00	54.04	0.00	0.00	2

Mgmt Option 1:
TITLE: WASTE ACID/BASE NEUTRALIZATION AT IWTP

Because of the relatively standard nature of the systems, costs used for this and Option #2 are based on comm'l tank shop estimates. Stoichiometric proportions are assumed for the waste streams. This is based on the probability that an excess of alkali will actually exist, which then can be reasonably well tolerated by the system. Metals in the spent liquors are expected to be precipitated from the neutralized mixture by the flocculation treatment, although this will require laboratory verification. Some increase (~10%) in filter cake mass has been anticipated. Optimistic scores have been assigned for risk, performance, and other logistic factors, since the process is essentially off-the-shelf. Credit was assigned on the basis of reagent value of $0.05/lb with six tank dumps (acid and base), 3 kgal each, per year and reagent strength at 50 wt%. See Section 3.16.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.16   HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	3	
Facilities	2	
Supply Support	2	

```
EUAC Input          HW PROBLEM NO. 6.2.16     HW MGMT OPTION NO. 1
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  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    150__  _____  _____  _____  _____  _____

  INSTALLATION COST ($k)   175___   10___   5_____

  REPLACEMENT: MTBF (yrs)  0.5___
               COST ($k)   5_____     ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     1.6___     NAVY-WIDE
                                      APPLICATIONS   8_____
  SALVAGE VALUE ($k)       7.5___
```

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ANNUAL TREATMENT & DISPOSAL COSTS            ESCALATION RATE (%)
_________________________________            ___________________
DRMO cost ($k)                   ________       ___ ___
STP  cost ($k)                   ________       _______
IWTP cost ($k)                   ________       _______
POTW cost ($k)                   1_______       5______
Contract Haul cost ($k)          ________       _______

=============================================================
```

```
HW VOLUME CHANGE    HW PROBLEM NO. 6.2.16     HW MGMT OPTION NO. 1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\


    Status Quo HW Output (gal/yr)  18000____

    Projected  HW Output (gal/yr)  0_______
```

Mgmt Option 2:
TITLE: ACID/BASE WASTES AS IWTP TREATMENT CHEMICALS

The physical system is essentially the same as Option #1, except that a loading, storage, solution add/mixing arrangement is included for blending $FeCl_3$ into the waste acid at an equiv. of 4 lb/gal acid. An additional $25k capital has been allowed for this equipment. Ferric chloride costs are added to O&M costs, but a credit for 10% IWTP sludge reduction is allowed. Risk and performance scores are less optimistic than those of Option #1, since the experience with this otherwise proven T1 process is somewhat limited. See Sec. 3.16 for further information.

LOGISTICS INPUT HW PROBLEM NO. 6.2.16 HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	3	1=no risk; 10=high risk
Process Performance	3	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	3	
Facilities	2	
Supply Support	2	

```
 EUAC Input          HW PROBLEM NO. 6.2.16      HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)    250__  _____  ____  _____  _____  _____

  INSTALLATION COST ($k)   250___   20___   5____

  REPLACEMENT: MTBF (yrs)  0.6__
               COST ($k)   10___      ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     -44.6_     NAVY-WIDE
                                      APPLICATIONS   8____
  SALVAGE VALUE ($k)       15___
```

```
=============================================================

ANNUAL TREATMENT & DISPOSAL COSTS            ESCALATION RATE (%)
_________________________________            ___________________
DRMO cost ($k)                    _____        _____
STP  cost ($k)                    _____        _____
IWTP cost ($k)                    _____        _____
POTW cost ($k)                    1____        5____
Contract Haul cost ($k)           _____        _____
=============================================================
```

```
 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.16      HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


    Status Quo HW Output (gal/yr)  18000___

    Projected  HW Output (gal/yr)  0______
```

Mgmt Option 3:
TITLE: ACID/BASE OUTHAUL FOR CONTRACTOR DISPOSAL

This is taken as the "existing" process even though many Navy activities manage metal preparation acid/base wastes on-site. Contractor disposal is costed out at $1.50/gal, although the cost varies upward considerably at various activities. The cost is assumed to include container disposal, which, in some cases, does not pertain since outhaul occurs by vacuum truck. As "existing" technology, the practice is, nonetheless, penalized for risk, since the future of chemical shops that work HW materials such as these is, regulatorily, in considerable doubt. Present practices will, doubtless, be changed to conform with RCRA and CERCLA at considerable cost disadvantage to those who now patronize HW disposal firms.

LOGISTICS INPUT   HW PROBLEM NO. 6.2.16   HW MGMT OPTION NO. 3

Compliance	y	(Y or N)
Risk Level	2	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	2	
P.H.S.T.	3	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
| EUAC Input       HW PROBLEM NO. 6.2.16      HW MGMT OPTION NO. 3        |
|\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\|
|                                                                          |
|  BEGIN YEAR OF RECURRING COSTS  0____                                    |
|    (no. of yrs from base year)                                           |
|                                                                          |
|  R & D ($k)     0_____  ______  ______  ______  ______  ______           |
|                                                                          |
|  INSTALLATION COST ($k)   0_____  ______  ______                         |
|                                                                          |
|  REPLACEMENT: MTBF (yrs)  0____                                          |
|               COST ($k)   0____     ECONOMIC LIFE  (yrs) 25____          |
|                                                                          |
|  ANNUAL O&M COST ($k)     4.2__     NAVY-WIDE                            |
|                                     APPLICATIONS   8_____                |
|  SALVAGE VALUE ($k)       0____                                          |
|                                                                          |
|__________________________________________________________________________|

==============================================================================

ANNUAL TREATMENT & DISPOSAL COSTS            ESCALATION RATE (%)
_________________________________            ___________________
DRMO cost ($k)                ________         _______
STP  cost ($k)                ________         _______
IWTP cost ($k)                ________         _______
POTW cost ($k)                ________         _______
Contract Haul cost ($k)       27______         5______

==============================================================================

| HW VOLUME CHANGE  HW PROBLEM NO. 6.2.16      HW MGMT OPTION NO. 3        |
|\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\|
|                                                                          |
|                                                                          |
|     Status Quo HW Output (gal/yr)  18000____                             |
|                                                                          |
|     Projected  HW Output (gal/yr)  18000____                             |
|                                                                          |
|__________________________________________________________________________|
```

HW PROBLEM 6.2.17: DESCRIPTION: CHEMICAL PAINT STRIPPING
TITLE: PAINT STRIPPING WASHWATERS TREATMENT

With the implementation of plastic media blasting, chemical paint removal for aircraft, torpedoes, etc. will probably be reduced to about 10% of present usage. Washwaters will then likely be more segregatable, allowing more efficient treatment. Chemical or biological treatment can be used since both methods have been successfully demonstrated for the major problem constituent, phenol. Chemical treatment alternatives considered here included hydrogen peroxide and chlorine dioxide, as recommended in earlier NCEL work (Refs. 3-14 and 3-15). Following those same leads, biological processes evaluated included contact-aeration/sludge, rotating biological contactor (RBC), and an immobilized biocatalytic bed process. Contact aeration was dropped as being inappropriate to the small flows involved. A 5-kgpd plant was used as the comparison basis. See Sec. 3.17 (Part II).

\\\\\\\\\\\\\\\\
[Mgmt Options

OPTION NO.	TITLE
1	CHEMICAL TREATMENT USING HYDROGEN PEROXIDE
2	ROTATING BIOLOGICAL CONTACTOR (RBC)
3	IMMOBILIZED BIOCATALYTIC PROCESS

Note: There is no existing process to be compared

HAMTAM REPORTS
PROBLEM TITLE: Paint Stripping Washwaters

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
1	1	0.53	16.00	52.56	100.00	3.00	4
2	2	0.53	17.00	39.64	100.00	4.00	4
3	3	0.66	24.00	53.21	100.00	4.00	4

Mgmt Option 1:
TITLE: CHEMICAL TREATMENT USING HYDROGEN PEROXIDE (H_2O_2)

Capital investment costs were based on Ref. 3-15 and assumed that existing wastewater conduits and the incorporated settling features would continue to be used. O&M costs were augmented to include labor and utilities. Chemical costs were applied on a waste strength of 1400 mg/l phenol and a waste flow of 5 kgpd. Because the present cost for hydrogen peroxide is $22.10/lb-mol vs $168.75/lb-mol for chlorine dioxide (the other reagent considered in Reference 3-15), the T/A was limited to hydrogen peroxide. The stoichiometry was based on complete conversion of phenol to carbon dioxide and water. A low risk factor (3) was assigned to this T2 process because of its demonstrated applicability with wastewaters containing phenols. For further information see Section 3.17.

LOGISTICS INPUT HW PROBLEM NO. 6.2.17 HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	3	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	2	

```
 EUAC Input          HW PROBLEM NO. 6.2.17     HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

  BEGIN YEAR OF RECURRING COSTS  3____
    (no. of yrs from base year)

  R & D ($k)    115___   165___   115___   ______   ______   ______

  INSTALLATION COST ($k)   56.3__   5.6___   ______

  REPLACEMENT: MTBF (yrs)  0.6___
               COST ($k)   5_____      ECONOMIC LIFE  (yrs) 20____

  ANNUAL O&M COST ($k)     50.9__      NAVY-WIDE
                                       APPLICATIONS   6_____
  SALVAGE VALUE ($k)       6_____
```

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========================================================================
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```
ANNUAL TREATMENT & DISPOSAL COSTS              ESCALATION RATE (%)
_________________________________              ___________________
DRMO cost ($k)                  ________            _______
STP  cost ($k)                  ________            _______
IWTP cost ($k)                  ________            _______
POTW cost ($k)                  7.8_____            0______
Contract Haul cost ($k)         ________            _______
```

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========================================================================
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 HW VOLUME CHANGE    HW PROBLEM NO. 6.2.17     HW MGMT OPTION NO.  1
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  130000___

     Projected  HW Output (gal/yr)  0_______
```

Mgmt Option 2:
TITLE: ROTATING BIOLOGICAL CONTACTOR (RBC)

A moderate risk level (4) was set since the use of an RBC for phenolic waste treatment is not well documented. RBC costs were quoted by Envirex Corp. (Waukesha, WI) at about $50k for a 5-kgpd unit. This includes site preparation, equipment costs, including all needed ancillary equipment, erection, and start-up. Two units are envisioned, alternatively operating in tandem with the duty unit passing its effluent to the standby unit, which is maintained on nutrient additions. The system will incidentally function very effectively as a wastewater stripping device, removing most, if not all, dichloromethane contained in the influent. This VOC release can be controlled, if necessary, by passing the vented aeration stream through a gas incinerator, if APC becomes a retrofit requirement. Effluent, including biomass carry-off, is sent to an IWTP clarifier. See Section 3.17.

LOGISTICS INPUT HW PROBLEM NO. 6.2.17 HW MGMT OPTION NO. 2

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	2	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	2	
Training & Personnel	2	
P.H.S.T.	2	
Support Equipment	2	
Facilities	2	
Supply Support	3	

EUAC Input HW PROBLEM NO. 6.2.17 HW MGMT OPTION NO. 2

\\

BEGIN YEAR OF RECURRING COSTS 4____
(no. of yrs from base year)

R & D ($k) 120__ 140__ 450__ 200__ 0____ _____

INSTALLATION COST ($k) 100__ 5____ 5____

REPLACEMENT: MTBF (yrs) .5____
COST ($k) 5_____ ECONOMIC LIFE (yrs) 15____

ANNUAL O&M COST ($k) 22.1__ NAVY-WIDE
APPLICATIONS 6_____

SALVAGE VALUE ($k) 10____

===

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)	0	
STP cost ($k)	0	
IWTP cost ($k)	0	
POTW cost ($k)	7.8	5
Contract Haul cost ($k)		

===

HW VOLUME CHANGE HW PROBLEM NO. 6.2.17 HW MGMT OPTION NO. 2

\\

Status Quo HW Output (gal/yr) 130000___

Projected HW Output (gal/yr) 0_______

Mgmt Option 3:
TITLE: IMMOBILIZED BIOCATALYTIC PROCESS

A high risk factor (3) has been assigned, as this treatment alternative is still in the laboratory/early pilot plant phase of T&E, and the most dependable results have been obtained on chemically different wastewaters (halocarbon contaminants). Cost data on the process are also preliminary in nature. Capital and O&M costs were submitted to the project by the R&D Director of the Manville Corp., which has a contractual agreement with LSU to develop this technology. Fairly high capital costs were estimated ($200k to $1000k) for a 100-kgpd plant. The average was extrapolated to a 5-gpd plant using a scaling exponent of 0.6.

==

LOGISTICS INPUT HW PROBLEM NO. 6.2.17 HW MGMT OPTION NO. 3

Compliance	y	(Y or N)
Risk Level	3	1=no risk; 10=high risk
Process Performance	3	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	3	
P.H.S.T.	3	
Support Equipment	3	
Facilities	3	
Supply Support	3	

```
EUAC Input          HW PROBLEM NO. 6.2.17     HW MGMT OPTION NO. 3
\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

 BEGIN YEAR OF RECURRING COSTS  4____
   (no. of yrs from base year)

 R & D ($k)     200___    500___    750___    200___    ______    ______

 INSTALLATION COST ($k)   100___    10___    10___

 REPLACEMENT: MTBF (yrs)  0.5___
              COST ($k)   5_____       ECONOMIC LIFE  (yrs) 15____

 ANNUAL O&M COST ($k)     25____       NAVY-WIDE
                                       APPLICATIONS   6_____
 SALVAGE VALUE ($k)       10____
```

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=================================================================

ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          ____________________
DRMO cost ($k)                  _______       _______
STP  cost ($k)                  _______       _______
IWTP cost ($k)                  _______       _______
POTW cost ($k)                  7.8____       5______
Contract Haul cost ($k)         _______       _______

=====================================================================
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HW VOLUME CHANGE    HW PROBLEM NO. 6.2.17     HW MGMT OPTION NO. 3
\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


    Status Quo HW Output (gal/yr)  130000___

    Projected  HW Output (gal/yr)  0_______
```

HW PROBLEM 6.2.18 (II): DESCRIPTION: TORPEDO CLEANING
TITLE: TORPEDO AFTERBODY WASHWATER

An 800-gal batch process is envisioned, which is operated at appropriate intervals. The treatment processes considered are the existing combustion process, the NUWES pilot process, wet air oxidation, biological treatment, and photolytically enhanced oxidation. The latter two were dropped from consideration because the small volume treated rendered them impractical. This would also be true for wet air oxidation, except that other wastewaters can also be run into this process. The flow was set at 30 kgpy with wet oxidation capable of handling 4x that volume with painting and other wastewater streams. The particulate phase was assumed to require physical preseparation in all cases. The clarifier recently purchased by NUWES for this application was considered suitable for any on-site treatment.

Further Information on these processes is contained in Section 3.18.

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[Mgmt Options

OPTION NO.	TITLE
1	EXISTING TREATMENT PROCESS (COMBUSTION)
2	NUWES PILOT PROCESS (FLOC/Cl_2/CHARCOAL)
3	WET AIR OXIDATION (SUPERCRITICAL [S.C.])

==

HAMTAM REPORTS
PROBLEM TITLE: Torpedo Afterbody Washwater

OPTION	RANK	SCORE	LOGISTICS	EUAC	VOLUME	EDR	RISK
2	1	0.27	23.00	20.79	100.00	1.00	2
1	2	0.29	15.00	579.53	100.00	0.00	1
3	3	0.52	23.00	68.05	100.00	2.00	4

Mgmt Option 1: DESCRIPTION: TORPEDO CLEANING
TITLE: EXISTING TREATMENT PROCESS (COMBUSTION)

The washwater produced from detergent cleaning of torpedo afterbodies is shipped to Lenore, NC, where it is destroyed by combustion. The overall cost is $2.32/gal for disposal, including freight. A total of 30,000 gal/yr of this particular wastewater is, thus, disposed of, although other plant wastes are mixed in with the aqueous washwater; this includes some contaminated Otto fuel. Because the cost is portal to portal, in-house O&M must be added in for preparing the material for shipment. This was estimated at 0.5 man-days per week plus minor incidental costs.

LOGISTICS INPUT HW PROBLEM NO. 6.2.18(II) HW MGMT OPTION NO. 1

Compliance	y	(Y or N)
Risk Level	1	1=no risk; 10=high risk
Process Performance	1	(1-10) a '1' is 'best'
Maintenance Planning	1	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	1	
P.H.S.T.	3	
Support Equipment	2	
Facilities	2	
Supply Support	2	

EUAC Input HW PROBLEM NO. 6.2.18(II) HW MGMT OPTION NO. 2

BEGIN YEAR OF RECURRING COSTS 0
(no. of yrs from base year)

R & D ($k) 0 0 0 0 0 0

INSTALLATION COST ($k) 0 0 0

REPLACEMENT: MTBF (yrs) 0
COST ($k) 0

ECONOMIC LIFE (yrs) 50

ANNUAL O&M COST ($k) 10

NAVY-WIDE APPLICATIONS 5

SALVAGE VALUE ($k) 0

ANNUAL TREATMENT & DISPOSAL COSTS		ESCALATION RATE (%)
DRMO cost ($k)	69.6	10
STP cost ($k)	0	
IWTP cost ($k)	0	
POTW cost ($k)	0	
Contract Haul cost ($k)	0	

HW VOLUME CHANGE HW PROBLEM NO. 6.2.18(II) HW MGMT OPTION NO. 1

Status Quo HW Output (gal/yr) 30000

Projected HW Output (gal/yr) 0

Mgmt Option 2: DESCRIPTION: TORPEDO CLEANING
TITLE: NUWES PILOT PROCESS (FLOC/Cl2/CHARCOAL)

Information on this process was furnished by the Depot Support Branch, NUWES, and includes cost estimates provided by the system designer, Colloid-Piepho Co. Cost of the package unit delivered ($45k) was increased to $75k to allow for erection, start-up, stocking, and training costs. Costs for chemicals were estimated at $0.03/gal for flocculant and $1.54/lb CN oxidized. Costs for charcoal treatment using the existing charcoal system (See Sec. 3.18) were set at a 50% shared cost of $0.16/gal per base cost given in that Sec. Maintenance labor was estimated to be 1.5 man-days per week. Effluent from this process was assumed to be pure enough for discharge to a POTW. Because each of the elements of this process have been well demonstrated, low risk and good performance values for an otherwise unproven process were assigned.

LOGISTICS INPUT HW PROBLEM NO. 6.2.18(II) HW MGMT OPTION NO. 2

Compliance	Y	(Y or N)
Risk Level	3	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a sliding scale between one & ten. A value of one is a relative BEST score
Technical Documentation	3	
Training & Personnel	3	
P.H.S.T.	3	
Support Equipment	3	
Facilities	3	
Supply Support	3	

```
 EUAC Input     HW PROBLEM NO. 6.2.18(II)     HW MGMT OPTION NO. 2
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  BEGIN YEAR OF RECURRING COSTS  1____
    (no. of yrs from base year)

  R & D ($k)   100___  0_____  0_____  0_____  0_____  0_____

  INSTALLATION COST ($k)   75____  10____  5____

  REPLACEMENT: MTBF (yrs)  0.9___
               COST ($k)   5_____    ECONOMIC LIFE  (yrs) 15____

  ANNUAL O&M COST ($k)     10.8_     NAVY-WIDE
                                     APPLICATIONS   5____
  SALVAGE VALUE ($k)       4.5___
```

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=================================================================

ANNUAL TREATMENT & DISPOSAL COSTS           ESCALATION RATE (%)
_________________________________           ___________________
DRMO cost ($k)                 2.5____       10____
STP  cost ($k)                 _______       ______
IWTP cost ($k)                 _______       ______
POTW cost ($k)                 0.2____       5_____
Contract Haul cost ($k)        _______       ______

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```
 HW VOLUME CHANGE  HW PROBLEM NO. 6.2.18(II)   HW MGMT OPTION NO. 2
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\


     Status Quo HW Output (gal/yr)  30000___

     Projected  HW Output (gal/yr)  0______
```

Mgmt Option 3: DESCRIPTION: TORPEDO CLEANING
TITLE: WET AIR OXIDATION (SUPERCRITICAL [SC])

Because wet air oxidation cannot be expected to handle the solids present in this wastewater (the solids are carbonaceous), a preliminary clarification would be required. This would be done using the same type batch clarifier and the same flocculating agent (Colloid-Piepho Co.) recommended for the NUWES-designed process (Option 2). A moderate risk (4) has been assigned to this otherwise well-studied process--the behavior of cyanides in the treatment environment has not been adequately demonstrated. The present scenario is based on Navy pretreatment of wastewater to remove solids, the effluent being treated with wet oxidation at $0.20/gal including clarification (Oxidyne Corp., Dallas, TX, Technical Bulletin #M851, Rev. Oct 1986). The cost of the SC installation is set at $300k, including the clarifier. That cost reflects a reduction of 75%, to share costs with the other wastes the system should be capable of handling.

LOGISTICS INPUT HW PROBLEM NO. 6.2.18(II) HW MGMT OPTION NO. 3

\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\

Compliance	y	(Y or N)
Risk Level	4	1=no risk; 10=high risk
Process Performance	2	(1-10) a '1' is 'best'
Maintenance Planning	3	Select a value on a
Technical Documentation	3	sliding scale between
Training & Personnel	3	one & ten. A value
P.H.S.T.	3	of one is a relative
Support Equipment	3	BEST score
Facilities	3	
Supply Support	3	

```
 EUAC Input    HW PROBLEM NO. 6.2.18(II)     HW MGMT OPTION NO. 3
\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\

 BEGIN YEAR OF RECURRING COSTS  2____
   (no. of yrs from base year)

 R & D ($k)     500___   250___   ______   ______   ______   ______

 INSTALLATION COST ($k)   300___   50____   50____

 REPLACEMENT: MTBF (yrs)  1_____
              COST ($k)   25____      ECONOMIC LIFE  (yrs) 15____

 ANNUAL O&M COST ($k)     39.3__      NAVY-WIDE
                                      APPLICATIONS   20____
 SALVAGE VALUE ($k)       0_____

===================================================================
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ANNUAL TREATMENT & DISPOSAL COSTS          ESCALATION RATE (%)
_________________________________          ___________________
DRMO cost ($k)               2.5____        10____
STP  cost ($k)               0.2____        5_____
IWTP cost ($k)               0.2____        5_____
POTW cost ($k)               0______        ______
Contract Haul cost ($k)      0______        ______

=========================================================================
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 HW VOLUME CHANGE  HW PROBLEM NO. 6.2.18(II)   HW MGMT OPTION NO. 3
\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\ \\\\\\\\\\\\\\\\\\\\\\\\\\


    Status Quo HW Output (gal/yr)  30000____

    Projected  HW Output (gal/yr)  0_______
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APPENDIX M

PROJECTED IDR-RELATED WORK AND BUDGET/SCHEDULING REQUIREMENTS

Number 1
Environmental Protection Technical Proposal
No. 87-038/DBC

1. TITLE: Development of Beneficial Use of Acid and Alkali Waste Techniques at IWTP

2. NCEL POC: Dr. D.B. Chan
Code L71
Port Hueneme, CA 93043-5003
A/V 360-4191/4173, COM (805) 982-4191/4173

3. FAC POC: Ms. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENTS: NAVSEA, NAVAIR, and MARCORPS

5. OBJECTIVE: This effort will explore and develop technology to maximize beneficial use of acid and alkali waste generated from Navy industrial operations.

6. DESCRIPTION: Neutralization is a proven and commonly practiced method for treatment and disposal of acid and alkali waste. Electrolysis, electrodialysis, reverse-rack electroplating, and electrostripping processes will be developed so that the neutralization will be complete and valuable substances will be recovered for beneficial uses within the industrial operation complex.

7. TECHNICAL APPROACH: This effort will be completed in three phases:

   a. The first phase will collect and analyze in detail the acid and alkali waste currently generated from Navy industrial operations, waste volume, disposal costs, regulation requirements, and beneficial use options. An initial feasibility report will address the findings and identify recommended RDT&E efforts.

   b. The second phase will involve lab experiments for development of neutralization and associated unit processes using synthetic and field waste samples. A set of pilot plant design criteria will be developed for third-phase field testing equipment design and fabrication. A final feasibility report will be prepared and issued to the sponsor.

   c. The third phase will test the pilot plant constructed based on the result of the second phase effort in the field. Economics, manpower and skill, as well as logistic support requirements will clearly be defined during this test period. A User Data Package will be prepared, and the implementation task will then be transferred to NEESA.

8. BACKGROUND: Acid and alkali waste are generated from boiler cleaning, battery repair/replacement, bilge and ship tank derusting, metal preparation, and plating shops. It is estimated that more than 32,000 tons of such waste are generated yearly and cost the Navy millions of dollars to dispose. The conventional neutralization method is not providing a complete treatment to the Navy waste to satisfy the regulatory disposal requirements. This is primarily due to a high dilution rate to the waste and a highly toxic chemical concentration such as heavy metals contained in the waste that makes it indisposable after neutralization. The contractor hauling disposal method has cost the Navy millions of dollars. Development of the proposed technology will benefit the Navy significantly in minimizing the waste volume and cost.

9. PRODUCT: The products will be a series of three reports, an IFR, an FFR, and an UDP.

10. METHOD OF PERFORMANCE: The first phase effort will be performed solely in-house, while the second and third phases will be performed by in-house and contractor personnel.

11. NAVY NEED: The Navy needs this effort for the following reasons: to reduce hazardous waste volume and disposal cost, to protect Navy personnel and enhance fleet readiness, to recover resources for beneficial use, and to comply with all regulatory agencies' requirements. The technology proposed for development can be applied to Navy/Marcorps bases.

12. FUNDING:

	Cost ($K)					
	FY87		FY88		FY89	
	WR	RCP	WR	RCP	WR	RCP
IFR	75					
FFR			100	100		
Field Test/UDP					125	400
TOTAL	75		100	100	125	400

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Development of Beneficial Use of Alkali Waste Techniques at IWTP

```
------------------------|     FY87      |     FY88      |     FY89      |     FY90      |     FY91      |     FY92      |     FY93      |     FY94      |
      MAJOR TASKS       |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |
                        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
1.  Initial Feasibility |   |   |  ====D|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
     Report             |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Data Collection  |   |   |  ===C |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
         and Analysis   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Submit IFR       |   |   |   ===D|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
                        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
2.  Final Feasibility   |   |   |   |   |   |   |  ====D|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
     Report             |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Developmental    |   |   |   |   |   =======C|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
         Testing        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Design Criteria  |   |   |   |   |   |======C|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
                        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
3.  User Data Package   |   |   |   |   |   |   |   |   |   |   =======D|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Field Pilot      |   |   |   |   |   |   |   |   |   |  ====C|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       Plant Testing    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Data Analysis    |   |   |   |   |   |   |   |   |   |   |===C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    c. Technology       |   |   |   |   |   |   |   |   |   |   |   ===C|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       Transfer Package |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
------------------------|Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |
TOTAL FUNDING           |      75       |      200      |      525      |               |               |               |               |               |
FUNDING/QUARTER         |-- |-- |25 |50 |25 |25 |25 |25 |
FUNDING RCP             |-- |-- |-- |-- |-- |50 |50 |-- |
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DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Development of Beneficial Use of Acid and Alkali Waste Techniques at IWTP

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit IFR (MS1)										X																											
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR	Submit FFR (MS2)																					X																
DI-U	Submit DIR (MS3a)																									X												
DI-I																																						
DI-II																																						
OI-O	Submit OIR (MS3b)																														X							
OI-II																																						
OI-II-A																																						
UDP	Submit UDP (MS3)																																		X			
UG																																						
AFP																																						
ANU																																						
IN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 2
Environmental Protection Technical Proposal
No. 87-011/BYKP

1. TITLE: Recycling of Hydroblasting Wastewater

2. NCEL POC: Bingham Y.K. Pan
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Port Hueneme, CA 93043
A/V 360-4193, COM (805) 982-4193

3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NAVFAC, NAVSEA

5. OBJECTIVE: The objective of this project is to reduce the sodium nitrite waste formation from hydroblasting by 90 percent, thereby saving on chemical cost, water cost, and volume of wastewater to be treated.

6. DESCRIPTION: Hydroblasting is used to remove scales from the inside of boiler tubes. In the hydroblasting operation, a 5,000 to 10,000 psig water stream is injected into the boiler tubes using a lance nozzle. Sodium nitrite is added to the water stream to reduce corrosion. The average boiler is hydroblasted twice, consuming a total of 8,000 gallons of water per boiler. Currently, the spent hydroblasting solution is allowed to overflow from boiler to ship bilge after one pass. The sodium nitrite waste is further combined with heavy metals, oil and grease, and dirt in the bilge. The combined waste is then transferred to a waste storage tank for treatment.

It is feasible to filter out the solid scales and recycle the filtered spent hydroblasting solution for further tube cleaning. Success is expected to be achieved through careful evaluation of solids distribution, nozzle openings, filter selection, and liquid characteristics.

7. TECHNICAL APPROACH: This project is to be carried out in the following four stages:

a. Visit and evaluate the hydroblasting operations in Naval shipyards to observe equipment layout, operating procedures, flow rate and composition of hydroblasting solution, and size and shape of solids. A theoretical study shall be conducted to select a filter and the filtration conditions. A few preliminary filtration tests will be made. An initial feasibility report (IFR) will be prepared.

b. Set up laboratory unit and conduct tests. The key factor for solids removal is to filter out all particles larger than 1/10 of the lance nozzle opening, so that the nozzle will not be damaged. Operating conditions and limitations should be established. A detailed report will be prepared to include the laboratory test data and results.

c. Design and install a commercial recycling system. The major equipment will be surge tank, filters, pumps, and controls. Procedures to clean and reuse filters must be established. Solids must be analyzed for proper disposal. The filtered solution for hydroblasting should be recycled and its performance examined. A life-cycle cost analysis should be made. A final feasibility report (FFR) will be prepared.

d. A User Data Package (UDP) will be published to show how to reduce the formation of hydroblasting waste. Specifications and costs of equipment will be given. Any variations required for different shipyards will be pointed out. Safety precautions will be emphasized.

8. BACKGROUND: According to a contract study by Moore Gardner & Associates in 1982, sodium nitrite has been added at the rate of 1 pound per 100 gallons of water for hydroblasting. The wastewater contains about 120 ppm sodium nitrite and sodium nitrate. Data show that six Naval shipyards at Norfolk, Philadelphia, Charleston, Puget Sound, Long Beach, and Pearl Harbor have produced 500,000 gallons per year of sodium nitrite wastewater. A reduction of 90 percent of the wastewater could result in a savings of $500,000 and require less effort to meet the discharge permit.

9. PRODUCT: There will be one report each for the four stages of work. They are an IFR, a test report, an FFR, and an UDP. The overall product will be the technology developed to achieve a better solution to the sodium nitrite waste.

10. METHOD OF PERFORMANCE: NCEL will conduct the first-stage work. One or more contractors will carry out the second, third, and fourth stages of work under the guidance and supervision of NCEL. Cooperation with NAVSEA will be required. Access to the existing cleaning operations of boiler tubes (which is classified information) will be obtained.

11. NAVY NEED: NCEL has been tasked by NAVFAC to work on treatment of Naval shipyard wastes from cleaning and derusting. Sodium nitrite waste is one of three types of hazardous waste (the other two types are citric acid and ammonia hydroxide) under investigation. The current plan is to send the nitrite waste to IWTP after some pretreatment. Recycling and reuse will drastically reduce the volume of sodium nitrite waste before pretreatment. It is a technology of added benefit to the Navy.

12. FUNDING:

	Cost ($K)							
	FY88		FY89		FY90		FY91	
	RCP	WR	RCP	WR	RCP	WR	RCP	WR
Initial Feasibility	30	30						
Laboratory Tests	40	40	60	40				
Final Feasibility			60	40	80	40		
User Data Package							50	50
TOTAL	70	70	120	80	80	40	50	50

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Recycling of Hydroblasting Wastewater

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                        |    FY87   |    FY88   |    FY89   |    FY90   |    FY91   |    FY92   |    FY93   |    FY94   |
     MAJOR TASKS        |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|

1.  Initial Feasibility |  |  |  |  |=========D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    a. Site Visit       |  |  |  |  |======C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    b. Submit IFR (TM)  |  |  |  |  |  |  |===D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                        |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
2.  Lab Testing         |  |  |  |  |  |  |  |=============D|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    a. Select and Set   |  |  |  |  |  |  |  |======C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
         Up Lab Unit    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    b. Conduct Tests    |  |  |  |  |  |  |  |  |  |======C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    c. Submit TR (CR)   |  |  |  |  |  |  |  |  |  |  |====D|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                        |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
3.  Final Feasibility   |  |  |  |  |  |  |  |  |  |  |  | ===========D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    a. Design and       |  |  |  |  |  |  |  |  |  |  |  | =====C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
         Establish Com- |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
       mercial System   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    b. Conduct Field    |  |  |  |  |  |  |  |  |  |  |  |  |  | =====C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
         Tests          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    c. Submit FFR       |  |  |  |  |  |  |  |  |  |  |  |  |  |===D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                        |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
4.  UDP                 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |=============C|  |  |  |  |  |  |  |  |  |  |  |  |  |
    a. Make System      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |====C|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
       Modifications    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    b. Show Equipment   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | =====C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
         Costs          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    c. Submit UDP       |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | =========C|  |  |  |  |  |  |  |  |  |  |  |  |  |

------------------------|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|
TOTAL FUNDING           |           |    140    |    200    |    120    |    100    |           |           |           |
FUNDING/QUARTER         |  |  |  |  |15|15|20|20|
FUNDING RCP             |  |  |  |  |70|  |  |  |
```

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Recycling of Hydroblasting Wastewater

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit IFR (MS1)								X																													
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR	Submit FFR (MS3)																																X					
DI-U	Submit Lab Test Report																			X																		
DI-I																																						
DI-II																																						
OI-O																																						
OI-II																																						
OI-II-A																																						
UDP	Submit UDP (MS4)																																					6/91
UG																																						
AFP																																						
ANU																																						
IN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 3
Environmental Protection Technical Proposal
No. 87-035/RH

1. TITLE: Encapsulation of Hazardous Wastes at Landfills Using Innovative Methods and Materials

2. NCEL POC: Mr. Ron Hoeppel
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3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NAVAIR, NAVSEA, NAVSUB, DLA

5. OBJECTIVE: This project will develop cost effective and environmentally safe techniques and materials for encapsulation of hazardous wastes prior to landfilling that cannot be recycled or disposed of by other technologies. Innovative and modified existing methods for stabilizing and solidifying materials prior to disposal will be evaluated through approved testing protocols.

6. DESCRIPTION: Different Navy hazardous wastes will be laboratory tested using approved leaching tests and homogeneous waste preparation methods to establish baseline mobility of the contaminants. Different stabilization and solidification encapsulation techniques, materials, and forms will then be tested in a manner similar to nonencapsulated original materials. Comparable forms and techniques for different materials will be used as well as similar cross comparisons to evaluate other parameters.

7. TECHNICAL APPROACH: Six phases are proposed as follows:

   a. Review pertinent literature concerning available encapsulation techniques, materials, and recommendations.

   b. Obtain hazardous waste materials from different Navy sources and characterize according to acceptable analytical methods.

   c. Perform baseline leaching tests of nonencapsulated materials; chemically analyze leachates and perform leachate and soil/leachate bioassays to assess toxicity.

   d. Encapsulate hazardous waste and perform leaching tests, analyses, and bioassays as for (c).

   e. Evaluate different techniques and forms of encapsulation using the materials and methods evaluated for (d).

   f. Pilot testing of encapsulation techniques, materials, and forms.

8. BACKGROUND: Considerable impetus has been given by regulatory agencies to stabilization/solidification technology due to RCRA, 1984 amendments to RCRA, and CERCLA. Encapsulation has been employed as a means to delist hazardous wastes and to satisfy the prohibition on the landfilling of liquids. Under CERCLA, encapsulation is cited in the National Contingency Plan (40 CFR 300) as a feasible method for preventing mobilization from contaminated soils and sediments. Some hazardous wastes cannot be recycled or reduced effectively (e.g., some metals) so treatment to decrease their toxicity or mobility may be a valid remedy. Encapsulation serves this function for some wastes.

9. PRODUCT: Although each phase will generate written material, three separate reports will be produced. These include (a) literature review, (b through e), laboratory scale bulk analyses and leachate testing of nonencap--sulated and encapsulated hazardous wastes, and (f) pilot scale testing of techniques and materials showing superior results in smaller scale laboratory testing.

10. METHOD OF PERFORMANCE: Phase (a) will be performed in-house or by contract. The remaining phases will be contracted out to one or two contractors. NCEL will manage all contracts.

11. NAVY NEED: Hazardous wastes from many Navy sources, including from other wastes minimization technologies (e.g., incineration) may require landfill disposal as the final repository. Liquids are banned from disposal in landfills without first being converted to solid form. Since most inorganic elements cannot be removed from landfills via gaseous and products and some organics are degraded with difficulty, their persistence at a landfill are dependent on mobility (dilution) and their toxicity is usually dependent on concentration and chemical form. Stabilization/solidification treatment methods can decrease the mobility and toxicity of both inorganic and organic hazardous wastes. The effect of such materials on health and the environment depends on their chemical form and degree of binding or sorption to other compounds or solids. Although long-term liability at the landfill still exists under current law, the potential for litigation is greatly lessened for the Navy if proper and compatible encapsulation methods are developed for different hazardous wastes.

12. FUNDING

	Cost ($K)					
	FY87		FY88		FY89	
	RCP	WR	RCP	WR	RCP	WR
a. Perform Literature Review		30*				
b. Obtain Hazardous Wastes and Chemically Define		140				
c. Perform Leaching Tests With Nonencapsulated Wastes				140		60
d. Perform Leaching Tests With Encapsulated Wastes				150		75
e. Evaluate Different Techniques and Forms of Encapsulation				135		180
f. Conduct Pilot Scale Studies						150
TOTAL	0	170	0	425	0	465

*Cost is based on contracted literature review

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: ENCAPSULATION OF HAZARDOUS WASTES AT LANDFILLS USING INNOVATIVE METHODS AND MATERIALS

	FY87				FY88				FY89				FY90				FY91				FY92				FY93				FY94			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Literature Review				===	C																											
2. Obtain/Characterize Hazardous Wastes				===	===	C																										
3. Perform Leaching Tests on Unencapsulated Wastes						===	===	===	===	===	D																					
4. Perform Leaching Tests on Encapsulated Wastes						===	===	===	===	===	D																					
5. Evaluate Techniques/Forms of Encapsulation								===	===	===	===	===	D																			
6. Conduct Pilot Studies												===	===	===	===	C																
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING	170K				425K				465K				100K																			
FUNDING/QUARTER	0	0	0																													
FUNDING RCP	0	0	0	0																												

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: ENCAPSULATION OF HAZARDOUS WASTES AT LANDFILLS USING INNOVATIVE METHODS AND MATERIALS

	DELIVERABLE	CY87												CY88												CY89												CY-__
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA	MS1 (CONTRACTOR REPORT)										X																											
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	MS2,MS3,MS4,MS5(CONTRACTOR REPORT)																												X						X			
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR																																						
DT-0																																						
DT-1																																						
DT-II																																						
OT-0																																						
OT-II																																						
OT-II-A																																						
UDP																																						
UG																																						
AFP																																						
ANU																																						
TN	MS1-6																																					JAN90
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 4
Environmental Protection Technical Proposal
No. 87-019/RMR

1. TITLE: Wet to Dry Conversion of Paint Spray Booth Air Filtering Systems

2. NCEL POC: Mr. Richard M. Roberts
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3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENTS: NAVSEA, NAVAIR, NAVFAC, and all activities engaged in spray booth painting

5. DESCRIPTION: Overspray from paint application operations must be removed from the ventilation air delivered to spray booths. Because of their large sizes, Navy spray booths are typically equipped with water-wall scrubbers that circulate deluge water across the horizontal vent structure. This practice results in the production of considerable wastewater and aggregated deposits of paint sludge that must be periodically dug out and disposed of as hazardous waste.

The Navy Industrial Reserve Ordnance Plant (NIROP) at Pomona, CA, has converted its wet-wall paint booths to a dry system that utilizes packed filters. The latter devices operate at essentially the same pressure differential as wet systems, provide superior aerosol control, and result in a waste (the changed-out filters) that can be disposed of in Class II landfills as nonhazardous items. Retrofit of wet-wall spray booths with dry filters should not be a difficult proposition.

7. TECHNICAL APPROACH: This effort will be completed in three phases:

a. The first phase will involve the collection of data defining the range of design characteristics incorporated in wet-wall spray booths. This data base will be compared with the performance specifications of commercially available dry system packages that are compatible with the extremes of retrofit requirements. A detailed cost/benefit analysis will then be conducted for selected best example sets that will be reasonably well extrapolated to the entire Navy spray booth population. A feasibility report will then be submitted with recommendations as to whether to proceed with the wet/dry change-out scheme and how the subsequent phases would be organized.

b. The second phase will consist of an engineering design effort leading to the retrofit and performance evaluation of an operating Navy spray booth that combines a good mix of design features that challenge the wet/dry change-over concept and reasonable availability and convenience of access to NCEL workers and their contractors. The unmodified air filtering system of the spray booth will be monitored and recorded for standard air pollution control (APC) characteristics under controlled operating conditions. The booth will then be retrofitted with a state-of-the-art dry system selected as the probable best choice and the measurements repeated over a suitable period of time. A developmental technical report (DTR) will be prepared showing all performance/cost data, including estimated hazardous waste (HW) disposal costs.

c. The third phase will consist of a demonstration program wherein a representative mix of selected paint spray booths (up to four) will be retrofitted with different manufacturer's hardware and then normally operated by shop painters while being intermittently checked by the NCEL contractor. When sufficient operating time has been logged, an operational technical report (OTR) will be prepared describing the results of the program. A User's Data Package (UDP) will also be released to assist NEESA in the implementation of further conversions, assuming they are indicated.

8. BACKGROUND: Painting operations result in 5,770 tons per year of hazardous wastes in the 23 activities surveyed by NCEL in 1986. This does not include, however, much larger tonnages of wastewater that must be treated at IWTPs nor the wastes produced at the other activities of the Navy. A significant fraction of this hazardous waste is paint sludge. Removal of this material from sumps and wastewater channels is a tedious, expensive process that can result in operational downtime of several days per quarter. Based on expected disposal costs of such material, an annual cost of almost $3 million is projected.

The dry booth mode of operation, in contrast, involves filter change-outs that take a matter of minutes. The paint is dried onto the packing elements and thus is not leachable. The used filter, which costs only from $10 to $25, can therefore be left for the trash collector and disposal in a Class II landfill with ordinary municipal solid waste. The APC performance of the dry filter is superior to that of the water-wall effect and does not usually require a size-up in blower capacity. A successful wet/dry change-over has been demonstrated at NIROP, Pomona, where all water-wall booths were converted. However, because the booths are considerably smaller than those used at other Navy activities, exploitation of their considerable success will have to await further RDT&E studies wherein scaling and many other operational variables can be evaluated.

9. PRODUCTS: The products of this project will be four main reports: a final feasibility report (FFR) (initial feasibility has been demonstrated by NIROP, Pomona), a DTR, an OTR, and a UDP. These reports will be supplemented by contract reports on specific aspects of the engineering work.

10. METHOD OF PERFORMANCE: Phase I will be performed jointly in-house (survey and feasibility analysis) and by contractor (accumulation of performance data and cost profiling). Phase II will be essentially a contracted effort but with frequent NCEL field oversight. Phase III will also be a joint effort with most of the routine field work being done by a contractor with the help of activity personnel. In-house responsibilities will also include detailed project design, field liaison, and contractor progress review and approval.

11. NAVY NEED: The Navy needs this effort to reduce the generation of hazardous wastes, to reduce the costs of hazardous waste disposal, and to reduce the costs of paint application operations. It is estimated that $3 million can be saved annually by shifting from wet to dry booth systems. Operation and maintenance (including waste disposal) costs of dry systems are about 10 to 15 percent less than those of wet booths, and the change-over for the entire Navy would probably pay back in less than 5 years. This assessment does not include, however, the wastewater issue. Under the recently revised Clean Water Act, great emphasis will be placed on Total Toxic Organics (TTOs). Wet booth operations deliver considerable amounts of such compounds, a problem completely eliminated by dry booth conversion.

12. FUNDING:

	Cost ($K)					
	FY87		FY88		FY89	
	RCP	WR	RCP	WR	RCP	WR
Concept Feasibility	55	15		20		
Full Scale Process Evaluation			80	150		
Operational Evaluation					150	225
TOTAL	55	15	80	170	150	225

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Wet to Dry Conversion of Paint Spray Booth Air Filtering Systems

	FY87				FY88				FY89				FY90				FY91				FY92				FY93				FY94			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Concept Feasibility			===	===	===	==D																										
a. Site/Tech Survey			==	==C																												
b. Engineering Data Base				==C																												
c. Cost/Benefit Analysis				==C																												
d. Submit IFR						==C																										
tion																																
tion																																
2. Full Scale Process Evaluation						==	===	==D																								
a. Site Selection						==C																										
b. Process Study							==C																									
c. Submit DTR							==	==C																								
3. Operational Evaluation										===	===	==C																				
a. Site Selecection						=C																										
b. Retrofit Facilities									===C																							
c. Monitor Operations										===	==C																					
d. Submit OTR											===	==C																				
e. Submit UDP												==C																				
TOTAL FUNDING	70				250				375																							
FUNDING/QUARTER	--	--	5	10	_	100	35	35																								
FUNDING RCP	--	--	55	--	80	--	--	--																								

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Wet to Dry Conversion of Paint Spray Booth Air Filtering Systems

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit per MS 1d														x																							
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR																																						
DT-0																																						
DT-1																																						
DT-II	Submit per MS 2c																					x																
OT-O																																						
OT-II	Submit per MS 3d																																x					
OT-II-A																																						
UDP	Submit per MS 3e																																x					
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 5
Environmental Protection Technical Proposal
No. 87-037/DBC

1. TITLE: Development of Purification and Reuse Technology for Pickling Bath/Electroplating Bath

2. NCEL POC: Dr. D.B. Chan
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3. FAC POC: Ms. Elizabeth A. Ford
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4. PROPONENTS: NAVSEA, NAVAIR, and MARCORPS

5. OBJECTIVE: The objective of this project is to develop an innovative technology that combines ion exchange and membrane separating processes for purification and use of pickling bath/electroplating bath.

6. DESCRIPTION: A basic anion exchange resin coupled with a gas permeable membrane can concentrate, separate, and recover certain electroplating bath solutions. This technique has been experimented in the laboratory and proven applicable in the pickling bath as well as electroplating bath.

7. TECHNICAL APPROACH: This effort will be completed in three phases:

   a. The first phase effort will be performed in-house to test the capability of a combined ion exchange and membrane separation processes for purification of a Navy pickling bath/electroplating bath. An initial feasibility report will present the lab findings and define the capability.

   b. The second phase effort will concentrate on construction and test a pilot plant in the field. Operational parameters will be developed for technology transfer.

   c. The third phase effort will demonstrate and introduce the new technique to the field personnel and transfer the implementation task to NEESA.

8. BACKGROUND: Metal preparation (including stripping processes) and finishing shops generate pickling bath waste. Electroplating shops produce bath waste. It is estimated that over one half million gallons a year are generated from spent plating and stripping baths that contain concentrated amounts of cyanide. Disposal costs exceed $1 million a year and are expected to escalate threefold over the next five years as stricter disposal regulations are imposed. The conventional treatment and disposal method is generally unreliable, unsafe, and costly. An innovative and cost-effective purification effect needs to be developed to prolong bath lives and recycle

drug out chemical values.

9. PRODUCT: The product will be a series of three reports, an IFR, an FFR, and a UDP.

10. METHOD OF PERFORMANCE: The first phase effort will be performed in-house, and the second and third phases will be performed by in-house and contractor personnel.

11. NAVY NEED: The Navy needs this effort for the following reasons: to mitigate safety hazards in the working environment, to reduce hazardous waste volume and disposal cost, and to recover valuable material for reuse.

12. FUNDING:

	COST ($K)					
	FY88		FY89		FY90	
	WR	RCP	WR	RCP	WR	RCP
IFR	100					
FFR			100	100		
UDP					100	200
TOTAL	100	0	100	100	100	200

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Development of Purification and Reuse Technology for Pickling Bath/Electroplating Bath

MAJOR TASKS	FY87				FY88				FY89				FY90				FY91				FY92				FY93				FY94			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Initial Feasibility Report							===	==D																								
a. Conduct Laboratory Tests					===	===	===C																									
b. Submit IFR								===D																								
2. Final Feasibility Report											===	==D																				
a. Conduct Laboratory and Field Sample Tests										===	=C																					
b. Data Evaluation										==	==C																					
c. Submit FFR											===	==D																				
3. User Data Package															===	==D																
a. Field Pilot Plant Tests														===	==C																	
b. Tech Transfer Training															===	C																
c. Submit UDP															===	==D																
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING					100				200				30'																			
FUNDING/QUARTER					25	25	25	25																								
FUNDING RCP																																

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Development of Purification and Reuse Technology for Pickling/Electroplating Baths

	DELIVERABLE	CY88												CY89												CY90												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit IFR (MS1)									x																												
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR	Submit FFR (MS2)																					x																
DT-O	Submit DTR (MS3a)																									x												
DT-1																																						
DT-II																																						
OT-D	Submit OTR (MS3b)																												x									
OT-II																																						
OT-II-A																																						
UDP	Submit UDP (MS3)																																	x				
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 6.
Environmental Protection Technical Proposal
No. 87-020/TT

1. TITLE: Aircraft Paint Stripping

2. NCEL POC: Tom Torres
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3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NAVAIR

5. OBJECTIVE: To define treatment and disposal options for Navy Aircraft Paint Stripping Wastewaters.

6. DESCRIPTION: Chemical and biological treatment technologies were studied on synthetic and actual waste streams. Two biological treatment processes were studied. The rotating biological contactor (RBC) process was most effective in removing phenols and this process is defined in this unit.

7. TECHNICAL APPROACH: This is a follow-up of an ongoing effort. Pilot plant studies are presently being performed with the RBC unit with actual paint stripping wastewaters taken from the NADEP at Pensacola. Out-year efforts planned are to install the pilot plant unit at a NADEP site.

8. BACKGROUND: Naval installations with aircraft paint stripping facilities are within marginal compliance of the specified local regulations for the concentrations of the pollutants in the wastewaters. The present compliance status is achieved by dilution through the use of large volumes of water in the rinse processes and through mixing with other industrial wastewaters. With the tightening of effluent discharge regulations, the Naval installations lacking effective treatment options will not be in compliance with discharge regulations.

The specific discharge limit impacting the paint stripping operation is the Total Toxic Organic (TTO) limit. In the past, local municipalities that received Navy wastewater set lenient discharge limits for specific toxic organics based on the treatment capability of their wastewater treatment plants. Starting June 30, 1984, the TTO discharge limit as a pretreatment standard for the metal finishing industry will have to be met by Navy installations discharging to municipal sewers. The TTO limit has been set by EPA at 2.13 mg/l, but local municipalities may set more stringent standards. Currently, NADEPs Alameda and North Island discharge of phenols alone are at concentrations far exceeding the 2.13 mg/l level, while NADEP Norfolk is meeting present limits for toxic organics only marginally.

For Navy installations that have to meet National Pollution Discharge

Elimination Standards (NPDES) or permit limits, incorporation of TTO limits into their permits was expected in January 1985. The EPA or state regulatory agencies that issues NPDES permits will start with the 2.13 mg/l limit and then set the TTO limit based on the specific environmental protection needs of the location. Stringent TTO limits are expected to be incorporated into the NPDES permits of MCAS Cherry Point, NAS Jacksonville, and NAS Pensacola. For example, the state of Texas has set the TTO limit of 0.3 mg/l for NAS Corpus Christi, but the three Navy installations mentioned cannot meet this TTO limit.

9. PRODUCT: The following reports will be provided in this report; Developmental Test Report Operational Test Report and User Data Package.

10. METHOD OF PERFORMANCE: The work will be accomplished through in-house focus on basic research with engineering support sustained through contractor support. The planning phase will be performed in-house as well as the documentation wrap-up. The pilot plant aspect will be performed at a university research institute presently under contract with the laboratory.

11. NAVY NEED: A total of 63 aircraft paint stripping facilities are operated by the Navy: 41 are shore operations and 22 are aboard ships. Six of the 41 shore operations are at NADEPs while the remaining 35 facilities, Air Intermediate Maintenance Departments (AIMDs), are at 35 different NASs. The bulk of aircraft paint-stripping is done at the NADEPs, which produce about 300 million gallons of highly contaminated wastewater annually.

These contaminated wastewaters are highly toxic and hazardous. Most of the paint strippers and chemical compounds, used in conjunction with paint stripping operations at the Navy facilities, are on the EPA's list of priority pollutants. Effective treatment options for dealing with these wastewaters have yet to be identified and selected.

12. FUNDING

	Cost ($K)			
	FY88		FY89	
	RCP	WR	RCP	WR
Field Test of RBC Unit	150	125		
Operational Testing	50	125	250	250
Documentation		25		150
TOTAL	200	275	250	400

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Aircraft Paint Stripping

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                       |    FY87     |    FY88     |    FY89     |    FY90     |    FY91     |    FY92     |    FY93     |    FY94     |
      MAJOR TASKS     |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|

1.  Pilot/Field        |  |=======C|
     Studies
    a. Select NADEP    |  |======C
        Site
    b. Ship w/water
    c. Conduct Pilot   |  |=========C
        Studies

2.  Prepare PMP (TM)   |  |======C
    a. Submit PMP      |  |  |==C
        (TM)

3.  Operational Test   |  |  |  |====================C
    a. Prepare Site    |  |  |  |===C
    b. Conduct Test    |  |  |  |  |==============C
    c. Submit OTR      |  |  |  |  |  |  |  |  |  |  |==C
        (TM)

4.  Prepare UDP        |  |  |  |  |  |  |  |  |  |  |====C|
    a. Submit UDP      |  |  |  |  |  |  |  |  |  |  |======C
        (TM)

-----------------------|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|
TOTAL FUNDING          |    300      |     475     |    650      |
FUNDING/QUARTER        |75|75|75|75|125|100|25|25|
FUNDING RCP            |__|__|__|__|200|___|__|__|
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DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Aircraft Paint Stripping

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP	Submit PMP (MS2a)						x																															
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR																																						
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR																																						
DT-0																																						
DT-1																																						
DT-II																																						
OT-0																																						
OT-II																																						
OT-II-A	Submit OTR (MS3c)																														x							
UDP	Submit UDP (MS4a)																																	x				
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 7
Environmental Protection Technical Proposal
No. 87-005/DB

1. TITLE: Combusted Hazardous Waste Ash Hazards and Disposal Study

2. NCEL POC: Ms. Denise Barnes
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3. FAC POC: Ms. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENT: NAVFAC, NAVSEA, NAVAIR

5. OBJECTIVE: The project objectives are: to determine the hazards associated with ash residue from various Navy hazardous wastes that may be considered for combustive disposal in the future, to determine methods of disposing of those ashes shown to present significant hazards to human health, and to determine which hazardous wastes should not be considered for incineration. This information will provide guidance for the incineration of hazardous wastes and safe disposal practices.

6. DESCRIPTION: Bench scale incineration of hazardous wastes from RCRA conformative Navy processes will be performed. The remaining ash will be analyzed for composition. Each ash will be studied for potential hazards by both chemical and biological techniques. Those ashes that present hazards to human health will be further tested for the ability to be altered to a form that can be disposed of safely or tested for ways to safely contain the ashes in the hazardous form. Hazardous wastes that should not be incinerated will be identified.

7. TECHNICAL APPROACH: This effort will be completed in 2 phases:

PHASE 1: Initial Feasibility

a. Literature Search and Technical Assessment. A detailed literature search will be performed to identify the waste products associated with present day hazardous waste incineration methods. A technical assessment will be performed on new and emerging techniques in incineration. Methods for preventing the migration of buried ash constituents being studied on other NCEL projects to identify ashing environments (e.g., improved methods of vitrification, encapsulation) will be evaluated.

b. Bench Scale Studies. Candidate Navy hazardous waste types will be incinerated in a manner consistent with RCRA Destruction and Removal Efficiency (DRE) standards and the ashes and slags collected for analysis. These residues will be analyzed to identify their chemical constituents. The EPA Leachability Test will be routinely conducted on these samples.

c. Initial Feasibility Report (IFR). A summary of the first two tasks and recommendations will be submitted by NCEL as an IFR.

PHASE 2: DISPOSAL EVALUATIONS

a. Environmental Impact Evaluations. Ashes from the wastes will be passed through bench scale water columns and soil columns to simulate uncontrolled leaching through the environment. This leachate will be analyzed to determine its effect on human health by performing bioassays on both aquatic and terrestrial animals and plants and by utilizing Beckmans Microtox analyses where appropriate.

b. Containment Procedures. Based on the results of evaluations, testing will be performed to apply methods identified in Phase 1 for preventing migration of these contaminants through soil and water media.

c. Submit Final Feasibility Report. Guidance will be prepared to identify those hazardous wastes that can be incinerated with safe ash disposal and those that should not be incinerated.

8. BACKGROUND: Future RCRA regulations to minimize hazardous waste generation and disposal will restrict landfilling of many hazardous wastes. To conform with these regulations the Navy will have to lean heavily toward combustion for a solution to their disposal problems. Although the ash residue from incineration is more stable than a liquid waste, the hazards associated with these wastes require study and documentation. Costs for disposal of these residues will be $600 to $1,000 a ton for hazardous wastes (class 1 disposal) and $25 to $75 a ton for nonhazardous waste (class 2 disposal).

9. PRODUCTS: The products will be two reports: an initial feasibility report and a final feasibility report. These reports will be supplemented by contractor reports as each task is completed.

10. METHOD OF PERFORMANCE: Task 1a will be performed by contractors with experience in incineration of hazardous waste. Task 1b will be performed by a contractor (preferably a local university) having the knowledge and equipment to do bench scale incineration. Task 1c will be performed by NCEL personnel. Tasks 2a and 2b will be performed by a university and NCEL. Task 2c will be performed by a contractor and NCEL. In addition, NCEL will set all requirements and review results on all contractor reports.

11. NAVY NEED: The Navy needs this effort for the following reasons: to reduce hazardous waste disposal costs; to avoid future liabilities; to accurately identify cost savings associated with incineration.

The Navy is currently loading billions of tons a year of hazardous waste. Incineration will be relied on to reduce this volume in order to comply with RCRA requlations and to reduce the high cost of disposal. Disposal practices for combusted residue and identification of those hazardous wastes that should not be incinerated are required to identify future cost savings.

12. FUNDING

	Cost ($K)					
	FY87		FY88		FY89	
	WR	RCP	WR	RCP	WR	RCP
Initial Feasibility						
Lit. Search & Tech. Assessment	2	25				
Benchscale Studies			125			
Submit Initial Feasibility Report				25		
Evaluations						
Environmental Impacts					100	
Containment Procedures					100	
Incineration & Disposal Guidance					50	25
TOTAL	2	25	125	25	250	25

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Combusted Hazardous Waste Ash Hazards and Disposal Study

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                          |       FY87        |       FY88        |       FY89        |       FY90        |       FY91        |       FY92        |       FY93        |       FY94        |
       MAJOR TASKS        |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |

1.  Initial Feasibility   |    |    |    |============D            |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
    a. Literature         |    |    |    |===C|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
       Search and         |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
       Technical          |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
       Assessment         |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
    b. Bench Scale        |    |    |    |    |=======C       |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
       Studies            |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
    c. Submit IFR         |    |    |    |    |    |    |    |===D|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
       (TM)               |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

2.  Disposal Evalua-      |    |    |    |    |    |    |    |    |===========C       |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
    tions                 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
    a. Environmental      |    |    |    |    |    |    |    |    |======C  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
       Impact Evalu-      |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
       ations             |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
    b. Containment        |    |    |    |    |    |    |    |    |    |    ====C|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
       Procedures         |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
    c. Submit FFR         |    |    |    |    |    |    |    |    |    |    |    |===C|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

--------------------------|Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |
TOTAL FUNDING             |        27         |        150        |        275        |
FUNDING/QUARTER           | -- | -- | -- |  2 | 50 | 25 | 25 | 25 |
FUNDING RCP               | -- | -- | -- | 25 | -- | 25 | -- | -- |
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DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Combusted Hazardous Waste Ash and Disposal Study

	DELIVERABLE	CY87												CY88												CY89												CY-__
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit IFR (MS1c)																				x																	
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR	Submit FFR (MS2c)																																	x				
DT-0																																						
DT-1																																						
DT-II																																						
OT-0																																						
OT-II																																						
OT-II-A																																						
UDP																																						
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 8
Environmental Protection Technical Proposal
No. 87-033/TF

1. TITLE: Hazardous Wastes Thermal Destruction Systems

2. NCEL POC: Dr. Tim T. Fu
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3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NAVAIR, NAVSEA

5. OBJECTIVE: The effort will assess the practicality and feasibility of using HW destruction units onsite, preferably of the transportable type, to destroy industrial process HWs and possibly even contaminated soils

6. DESCRIPTION: A cost-effective thermal destruction system utilizing innovative design systems will be selected and sited at an appropriate Navy activity that generates and/or stores hazardous wastes accumulated from past operations. The T&E work could be extended to include detoxification of contaminated soils if the site is remote and other, usually preferred, approaches are not appropriate

7. TECHNICAL APPROACH: This effort will be completed in seven phases:

a. Feasibility study phase to evaluate alternate thermal destruction systems

b. Selection phase to pick most promising system

c. Site selection phase will locate a suitable Navy activity

d. Test plan/permit phase will include drafting of the Trial Burn Plan, Facility Engineering Description, Sampling and Analysis Plan, Emergency Procedures Plan, General Facilities Plan and the permitting documentation required by local jurisdictions. Actual permits application and requisite legal procedures are outside the scope of this proposal and will require additional funding

e. Pilot studies phase will scope out the economic analysis of the selected technology by performing bench burns to determine Destruction and Removal Efficiency (DRE) and Products of Incomplete Combustion (PICs)

f. Demonstration phase will incorporate design changes and needed modifications for purposes of conducting a technical and operational suitability study eventuating in trial burns. The study will examine the economics, the physical destruction capabilities, the air pollution parameters evolved, residual materials formation, and operability and maintainability factors

g. Documentation phases will wrap up the project with a formal User Data Package and a Technical Note.

8. BACKGROUND: While RCRA strongly encourages the elimination of hazardous waste generation so that ultimate disposal in any form will be minimized, some HWs will nonetheless persist. Combustion or landfilling of these materials are the only solutions and the latter imposes a liability that will exist in perpetuity. Combustive disposal will clearly emerge as an indispensable option that, as at Pearl Harbor NSY, cannot be contracted out to extramural HW combustion plants.

9. PRODUCT: The products will consist of an Initial Feasibility Report, Final Feasibility Report, a User Data Package, and a Technical Note.

10. METHOD OF PERFORMANCE: Site selection and documentation will be performed predominantly in-house. Dual responsibility between contractors and in-house personnel will exist on technology selection and test plan performance phases. Close contract monitoring will be conducted during the demonstration phase.

11. NAVY NEED: The Navy needs this effort to reduce hazardous waste disposal costs that will be entailed in meeting RCRA regulations. The project will aid users to ensure proper cost-effective disposal of hazardous wastes, particularly at remote activities where no private hazardous waste disposal facilities exist or are being planned. It will alleviate the specter of continued manifesting and transportation of HWs over long distances to private disposal sites operating combustors (including cement kilns) or HW landfills.

12. FUNDING:

	COST ($K)					
	FY88		FY89		FY90	
	RCP	WR	RCP	WR	RCP	WR
Feasibility Study		50				
Site/Technology Selection	50	50				
Plans and Permits	20	125		50		
Pilot Studies	320	35	70	70		
Demonstration Study			500	50	125	50
Documentation				10		75
TOTAL	390	260	570	180	125	125

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Hazardous Wastes Thermal Destruction Systems

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                           |   FY87    |   FY88    |   FY89    |   FY90    |   FY91    |   FY92    |   FY93    |   FY94    |
       MAJOR TASKS                     |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4
-------------------------------------------------------------------------------------------------------------------------------------

1.  Initial Feasibility                 =======D
    a. Submit IFR                       =======C
    b. Recommend                        =======C
       Technology

2.  Site/Tech Selection                 =================D
    a. Site Visits                        |====C|
    b. Tech Selection                    ===D|
    c. Plans/Permits                      |==========C|
    d. MOP                                   |====C|

3.  Demonstration                            |==========D|
    a. Pilot Studies                                    ======C|
    b. Site Prep                                           ===============C|
    c. Field Study                                         ===============C|

4.  Documentation                                           |=============C|
    a. Operational                                           ============C
       Test Report
    b. UDP                                                          ======C|

---------------------------|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|
TOTAL FUNDING              |           |    650    |    750    |    250    |
FUNDING/QUARTER            |--|--|--|--|100|100|30|30|
FUNDING RCP                |--|--|--|--| 70|320|--|--|
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DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Hazardous Wastes Thermal Destruction Systems

	DELIVERABLE	CY88												CY89												CY90												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit IFR (MS1a)					x																																
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR																																						
DT-0																																						
DT-1																																						
DT-II																																						
OT-0																																						
OT-II																																						
OT-II-A	Submit OTR (MS4a)																															x						
UDP	Submit UDP (MS4b)																																	x				
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 9
Environmental Protection Technical Proposal
No. 87-024/LK

1. TITLE: Nonpersistent Emulsifying Degreasers for Bilge Cleaning

2. NCEL POC: Leslie A. Karr
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3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NAVSEA

5. OBJECTIVE: This effort will evaluate the effectiveness of nonpersistent, or fast-breaking, emulsifying degreasers for bilge and tank cleaning operations.

6. DESCRIPTION: Common bilge and tank cleaners/degreasers produce a tight emulsion that is difficult to treat. Degreasers are emerging in industrial applications that are capable of producing a nonpersistent emulsion thus facilitating subsequent treatment and oil recovery.

7. TECHNICAL APPROACH: This effort will be completed in the shortest time period to allow rapid implementation.

   a. The first stage will determine the availability of commercial fast-breaking emulsifying degreasers. A survey will be conducted in-house that will include determining those degreasers currently in use at Naval facilities with purported nonemulsifying capabilities. The survey results will establish the foundation for subsequent tests of promising products. A final feasibility report will determine the direction of subsequent field testing.

   b. The second step will determine the effectiveness of selected fast-breaking emulsifying degreasers in bilge cleaning operations. Preliminary tests will be performed in the laboratory and those products with effective results will be field tested. Implementation procedures will be described in a User's Guide.

8. BACKGROUND: As reported in the HWM IDR (NCEL TM 71-86-03), over two million gallons per month of oily wastewater are generated from bilges, DONUTs, SWOBs, and shiptank cleaning wastewaters. This translates into nearly 100,000 tons of bilgewater wastes per year that must be treated or disposed. In 1984, over $100,000 were spent for disposal of oily wastes that were classified as emulsified and that the Navy could not treat. These costs do not include the potential revenue lost from recoverable oil. NCEL has conducted studies on emulsified wastewaters and demonstrated the value of recovering oil from these emulsions. However, many activities are not technically or physically capable to

readily implement the recommended procedures for recovery. This problem can be easily solved by altering the process of bilge cleaning and producing a wastestream that all activities can handle. By utilizing a cleaning agent that does not result in a tight emulsion, valuable fuel oil may be reclaimed while reducing treatment and disposal costs.

9. PRODUCT: The products will include an initial feasibility report (IFR), a final feasibility report (FFR), and a User's Guide (TN).

10. METHOD OF PERFORMANCE: This effort will be conducted with in-house personnel and cognizant Naval Shipyard (NSY) representatives. At the present time, there is no requirement for any substantial support from contractor personnel.

11. NAVY NEED: As recommended in the HWM IDR, the use of fast-break emulsifiers is one effort aimed at minimizing the amount of hazardous wastes generated by the Navy. The continued use of traditional degreasers will keep treatment and disposal costs high while generating a hazardous waste, according to various state and EPA regulations. Additional benefits from this effort are the enhancement of subsequent wall-recoating processes, the recovery of fuel oil, and reduced wastewater treatment and disposal costs.

12. FUNDING:

	Cost ($K)	
	FY89 WR	FY90 WR
Feasibility Study/Survey	80	
Operational Evaluation	100	80
TOTAL	180	

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Nonpersistent Emulsifying Degreasers for Bilge Cleaning

MAJOR TASKS	FY87				FY88				FY89				FY90				FY91				FY92				FY93				FY94			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Feasibility Study/Survey									===	===	===	==C																				
a. IFR									====	D																						
b. FFR										==	===	=D																				
2. Operational Evaluation Users Guide/TN												===	===	===	===	===C																
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING									180				80																			
FUNDING/QUARTER																																
FUNDING RCP																																

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Nonpersistent Emulsifying Degreasers for Bilge Cleaning

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit IFR (MS1a)																								x													
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR	Submit FFR (MS1b)																												x									
DT-0																																						
DT-1																																						
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OT-II-A																																						
UDP																																						
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 10
Environmental Protection Technical Proposal
No. 87-009/LW

1. TITLE: New Solvent Selection for Piping Cleaning

2. NCEL POC: Lisa Weir
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3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NAVSEA, NAVAIR, NADEPs, NASs, NSYs

5. OBJECTIVE: The objective of this project is to find a nonhalogenated solvent to replace the use of Freon 113 in piping cleaning operations.

6. DESCRIPTION: Piping cleaning operations involve a five-step process: precleaning (flushing or degreasing piping), cleaning (flushing piping or dip- soaking piping segments in cleaning fluid), rinsing (using water or an organic solvent), inspection, and drying. Freon 113 is used for cleaning and rinsing piping systems that require an organic solvent. Used Freon 113 is redistilled and recycled up to ten times for continued use in piping cleaning or in other cleaning operations that require lower solvent purity. Significant leakage losses occur in each cycle, resulting in CFC releases to the troposphere.

7. TECHNICAL APPROACH: This effort will be completed in two phases:

   a. The first phase will define an acceptable solvent and determine its availability. This will include characterizing systems that use Freon 113, determining the requirements for these systems, establishing criteria for the ideal substitute solvent (physical properties, chemical properties, and performance requirements), evaluating off-the-shelf chemicals and compounded solvents based on manufacturer's recommendations, and selecting the most promising candidates for testing. An initial feasibility report will be prepared, and used to decide project direction.

   b. The second phase will test and evaluate the selected solvents. This will include laboratory testing of solvent performance. A Developmental Technology Report will be prepared, containing recommendations for future work.

8. BACKGROUND: Freon 113 has been the solvent of choice for many solvent cleaning operations in the Navy and in the private sector. The characteristics that make Freon 113 so useful include its excellent solvent capabilities, low toxicity, low flammability, and chemical inertness. Freon 113, waste Freon 113, and any secondary wastes are regulated under the Resource

Conservation and Recovery Act (RCRA). Freon 113 is a fully halogenated chlorofluorocarbon (CFC). Halocarbons in general, and CFCs in particular, have been identified as major causative agents in the destruction of the stratospheric ozone layer, and as contributors to the warming of the atmosphere (the "greenhouse effect"). These phenomena are receiving a great deal of attention from the scientific community and from the public because of the extreme dangers they pose to the environment.

Because of their harmful effects on the atmosphere, CFCs have come under close scrutiny in recent years. In 1978, the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) banned the use of CFCs as aerosol propellants in almost all consumer products. In 1980, the EPA proposed to consider additional regulations on all other uses of CFCs, and will make an announcement on that proposal in May 1987. In 1986, the National Resources Defense Council called for an international agreement on a 5-year phaseout of the production of all commercially available chlorinecontaining CFCs, such as Freon 113. It is only a matter of time before Freon 113 will be unavailable for use at all, and that time is becoming increasingly short. It is imperative that an acceptable substitute for Freon 113 be found and implemented in the Navy.

9. PRODUCT: The products of this project will be two reports: an Initial Feasibility Report and a Developmental Technology Report. These reports will be supplemented by contract reports.

10. METHOD OF PERFORMANCE: Phases a and b will be performed primarily in-house, with some work performed by a contractor.

11. NAVY NEED: The Navy needs this effort to prevent costly operational delays when Freon 113 is banned and to avoid penalties for violating increasingly stringent regulations regarding the use and emission of CFCs.

According to a recent NCEL IDR on hazardous waste minimization, solvent changeover will be required at NADEPs, NASs, NSYs, and NSWs. NSY Charleston uses 18.8 tons of CFC each year. NSY Puget Sound uses 31.2 tons of Freon 113 yearly. The sudden unavailability of CFC will have a major impact on Navy operations unless a substitute solvent is found now.

12. FUNDING:

Cost ($K)

	FY90		FY91		FY92		FY93	
	RCP	WR	RCP	WR	RCP	WR	RCP	WR
Initial Feasibility Study		30	15	80				
Laboratory Evaluation					80	65		20
TOTAL	0	30	15	80	80	65	0	20

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: New Solvent Selection for Piping Cleaning

	FY87				FY88				FY89				FY90				FY91				FY92				FY93				FY94			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Initial Feasibility																		===	===	===	=D											
a. Data Acquisition Technology Assessment																		===	===	=C												
b. Submit IFR																					===D											
2. Lab T&E of Solvents																										=C						
a. Select Contractor																						=C										
b. Monitor Out-House Testing of solvents																						===	===	=C								
c. Receive CR																								=C								
d. Submit DTR (TN)																										=C						
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING													30				95				145				20							
FUNDING/QUARTER																																
FUNDING RCP																																

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE:

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
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RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR																																						
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DI-I																																						
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Number 11
Environmental Protection Technical Proposal
No. 87-008/RMR

1. TITLE: Hazardous Waste Minimization Through Used Oil Reclamation and Recycle

2. NCEL POC: Mr. R.M. Roberts
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3. FAC POC: Ms. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENTS: NAVSEA, NAVAIR, NAVFAC

5. OBJECTIVE: This project, which supports the Used Oil and Solvent Recycling Management Program, aims to identify used oils (petroleum-based lubricants, hydraulic fluids, cutting oils, etc.) that offer the potential of being successfully processed for recycle.

6. DESCRIPTION: A variety of techniques can be employed to rework used oils to bring their quality to an acceptable level for reuse in the process from which they originated, or one that is less demanding. This avoids the high cost of hazardous waste disposal through incineration or landfilling in encapsulated form. It is necessary to determine the contamination characteristics of the various used oils being changed-out and the effectiveness of various available purification techniques (e.g., chemical treatment, heat treatment, centrifugation, pressed cotton filtration, vacuum distillation, fractional redistillation, Fuller's earth filtration, enhancement with additives, blending, etc.)

7. TECHNICAL APPROACH: This effort will be completed in two phases:

a. An inventory, typology, and collection of samples representative of used oils generated and discarded by the Navy will be assembled. Candidates produced in sufficient quantities and purities to warrant evaluation will be identified. Oil quality assessments will be performed based initially on field information (QC rejection data and other test documentation). Oils not well documented or that need more detailed or confirmation testing will also be included as conditional candidates.

Used oil-reclaim technology will be accessed through literature searching and a survey of oil salvors within the related marketplace of industry service companies. From this information base, an initial feasibility report will be generated listing used oils showing promise for recycle, the type of applications best suited for such reworked materials, and the technology that should be applied to achieve reusability. If there is no opportunity for recycle beyond what is now practiced through DRMO, cancellation of the project will be recommended.

b. The second phase will consist of bench processing of the candidate materials to evaluate the clean-up technologies selected. Results of such work will be evaluated using relevant specification test procedures and other methodology standard to the trade. A final feasibility report will then be issued defining the results. Opportunities for used oil recycle by the Navy will be itemized together with the user (original or alternative) equipment appropriate to the applications. Instances where reworked oils could be used through noncritical specification modifications will be described. A program for conducting field tests for the various reuse schemes will have detailed budget and schedule requirements itemized. This planning will include appropriate guidelines and mechanisms for phasing the work into the implementation mode and implemented by NEESA.

8. BACKGROUND: The Navy uses more than 50 different types of petroleum-based lubricants, hydraulic fluids, and cutting oils at its various activities. Many of these products are specially compounded, petroleum-based items that are expensive, have short-to-intermediate service life expectations, and must be segregated on change-out if any reuse is contemplated. For many types of engine operation, detergent-dispersant additives are required in the petroleum lubricants used. These additives consist of metallic salts of sulfuric acid, phenol and phenyl sulfide derivatives, and carboxylic (e.g., naphthenic) acids; polymers of methacrylic esters and amides; and polymeric acid imides. The type and amount of additives used depends upon the severity of the application.

Cutting oils usually contain emulsifiers. These oils can be used neat or in aqueous dispersion and can contain a wide variety of chemicals, such as sulfurized and sulfo-chlorinated mineral oils, various aromatic sulfonates, and naphthenates. Another group of oils frequently used in machine shop operations is synthetic-based oils designed for severe service. Synthetic oils are also used for lubrication and for hydraulic and cutting applications when stable, fire-resistant properties are required. Machine coolants are aqueous systems containing glycolic heat exchange compounds and various bacteria inhibitors to prevent the infection of jacketed sections of machining devices and the sumps. The liquids are typically used in oncethrough cycle with considerable waste of the expensive ingredients.

Currently, the Navy is in the early phases of addressing the issue of usedoil recycling as called for in the Navy's Used Oil and Solvent Recycling Management Program. However, this effort to date has been largely limited to a first level undertaking, namely the segregation of used-oil products. The present proposal addresses the obvious corollary to such segregation attempts - oil clean-up and recycle.

9. PRODUCT: The products will consist of an initial feasibility report, a final feasibility report, and a user data package. These reports will be

supplemented by technical memoranda discussing specific aspects of the research.

10. METHOD OF PERFORMANCE: Both phases will involve joint in-house/out-of-house contributions. Phase I field surveying will be done in-house while contracted expertise will be used to develop the technology information base of used-oil rework alternatives. In Phase II, laboratory oil reclamation evaluations will be done out-of-house while the field test and implementation program will be developed in-house. Overall in-house responsibilities will include preliminary research planning, refining objectives and output requirements, and reviewing contractor work.

11. NAVY NEED: The Navy needs this effort for the following reasons: to reduce hazardous waste disposal costs, to meet the CNO hazardous waste reduction goal of 50 percent. to avoid future liability problems, and to reduce the waste of expensive products that can be recycled after reasonable rework.

Recycle may be feasible at all NSYs, NADEPs, PWD(C)s, GOCOs, and a number of specialized activities. At present, 2,681 tons per year of used oils are manifested as hazardous wastes and disposed of at an annual cost of $630,000. This involves 1985 disposal practices, which have now been partially disallowed. It is expected that disposal costs will increase by a factor of five by 1990. This increase, plus the replacement cost of potentially salvageable materials (at $5 per gallon, minimally) imposes an operating burden of roughly $6.5 million per year. If only 25 percent of the used oil were recycled at an estimated cost of $2 per gallon, an annual savings of over $300,000 would be realized.

12. FUNDING:

	Cost ($K)					
	FY90		FY91		FY92	
	RCP	WR	RCP	WR	RCP	WR
Initial Feasibility	25	50				
Final Feasibility/Field Program Design			150	50	25	75
TOTAL	25	50	150	50	25	75

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Hazardous Waste Minimization Through Used Oil Reclamation and Recycle

MAJOR TASKS	FY87				FY88				FY89				FY90				FY91				FY92				FY93				FY94			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Initial Feasibility															===	===	D															
a. Typology Inventory															==	=C																
b. Recycle Technology															==	==C																
c. Submit IFR																==	C															
2. Tech Evaluation and Field Program Planning																			===	===	===	===	===	D								
a. Bench Studies																		===	===	===	===	===	C									
b. Field Test Plan																						===	C									
c. Submit FFR																						===	===	C								
d. Submit UDP																						===	===	===	C							
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING													75				200				100											
FUNDING/QUARTER																																
FUNDING RCP																																

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Hazardous Waste Minimization Through Used Oil Reclamation and Recycle

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit IFR (MS1c)																																					8/90
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR	Submit FFR (MS2c)																																					6/92
DT-0																																						
DT-1																																						
DT-II																																						
OT-O																																						
OT-II																																						
OT-II-A																																						
UDP	Submit UDP (MS2d)																																					7/92
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 12
Environmental Protection Technical Proposal
No. 87-007/LS

1. TITLE: Identification of Hazardous Wastes for Potential Delisting

2. NCEL POC: Lynne Stauss
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3. FAC POC: Ms. Elizabeth A. Ford
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4. PROPONENTS: NAVFAC, NAVSEA, NAVAIR

5. OBJECTIVE: The objective of this research is to provide a methodology to identify any Navy wastes manifested as hazardous that can be rendered delistable.

6. DESCRIPTION: This effort will identify Navy-generated hazardous wastes that have delisting potential and will recommend ways to facilitate the delisting.

7. TECHNICAL APPROACH: This effort will be completed in three phases:

   a. The first phase will involve conducting a survey based on the NEESA Hazardous Waste Inventory and site visits to itemize hazardous wastes that are possibly delistable or contain reasonably segregatable fractions that are disposed of in Class II landfills. The criteria under which the waste was listed hazardous, the characteristics of the waste, and the lists of hazardous wastes (40 CFR 261, Subparts B, C, amd D respectively) will be the basis for classifying a waste as hazardous. An initial feasibility report will be prepared and used as a basis for deciding which wastes are subject to delisting.

   b. The second phase will identify delistable hazardous wastes according to 40 CFR 260.22. This will include the identification of delistable hazardous fractions that are carelessly mixed with nonhazardous materials and can be segregated without compromise to military mission. A final feasibility report will be prepared and used as a basis for decision making in Phase III.

   c. The third phase will identify management techniques and storage/disposal modifications to reduce the volume of wastes being classified as hazardous. A User Guide will be prepared and given to NEESA for implementation into the field.

8. BACKGROUND: Thirty-three Navy processes that generate hazardous wastes have been identified in the Hazardous Waste Minimization IDR. These

processes produce 3,997,922 tons of hazardous waste annually and require $17,201,378 in management costs. These amounts can be sharply reduced by: a) properly identifying the waste as hazardous, b) delisting inappropriately categorized wastes, and c) implementing specific storage/disposal modifications to reduce hazardous waste volume.

Besides reducing costs, such hazardous waste processing modifications will broaden the NEESA Hazardous Waste Inventory System and help the Navy comply with RCRA, Section 3002. Under this regulation, hazardous waste manifests must now contain certification that the generator has a program in place to minimize the volume and toxicity of waste to a practical extent. It does not encourage the irresponsible manifesting of wastes that are nonhazardous.

A key administrative requirement impacting hazardous waste management is proper waste segregation. Where multiple processes occur (such as fluids changeout and solvent cleaning), hazardous and nonhazardous waste materials are often mixed making reclaiming/recycling difficult if not impossible. Upon segregating waste streams, recycling can be performed, with possibly a smaller overall volume of hazardous waste left to be disposed of. A good example of this is the operation at Norfolk NSY. Machine shop used oils that were mixed with nonhazardous materials rendered greater volumes of hazardous wastes to be stored and disposed. These used oils are segregated into color-coded drums so that materials can be reworked and recycled. By doing this, only a minor fraction is buried in Class I landfills.

Some Navy-generated hazardous wastes can be delisted based on 40 CFR 260.22. This regulation excludes certain wastes from the EPA list of hazardous wastes for a particular generating, storage, treatment, or disposal facility if a petitioner can demonstrate that a waste does not meet any of the criteria under which the waste was listed as hazardous. Because there is no blanket-type delisting, each waste is required to be delisted individually. This is the key thrust of the project.

9. PRODUCT: Three reports will be produced: an inventory of hazardous wastes and segregated fractions that are potentially delistable (an initial feasibility report), a list of delistable Navy wastes and a methodology to delist (final feasibility report), and recommended management techniques and process modifications to reduce the volume of hazardous wastes created by the Navy (a User Guide).

10. METHOD OF PERFORMANCE: Phases I, II, and III will be performed in-house.

11. NAVY NEED: The Navy needs this effort to: a) reduce economic and administrative burdens associated with handling, treatment, and disposal of hazardous wastes; b) reduce or eliminate long-term liabilities associated with offsite transportation and disposal; c) maintain compliance with the 40 CFR Section 3002 by having a volume reduction plan.

12. FUNDING:

	Cost ($K)			
	FY90		FY91	
	RCP	WR	RCP	WR
Inventory		60		
Methodology		80		
Recommendations				50
TOTAL	0	140	0	50

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Identification of Hazardous Wastes for Potential Delisting

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                        |     FY87      |     FY88      |     FY89      |     FY90      |     FY91      |     FY92      |     FY93      |     FY94      |
     MAJOR TASKS    |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |
                        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
1.  Initial Feasibility |   |   |   |   |   |   |   |   |   |   |   |   |=======C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Site Visits      |   |   |   |   |   |   |   |   |   |   |   |   |=C |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Submit IFR       |   |   |   |   |   |   |   |   |   |   |   |   |   |====C  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
                        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
2.  Methodology         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |=======C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Evaluate         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |====C  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       Hazardous Waste  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       for Delist-      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       ability          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Submit FFR       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |====C  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
                        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
3.  Recommendations     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |==========C    |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Identify Manage- |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |=======C   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       ment Techniques  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       and Storage/     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       Disposal Modif-  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
       ications         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Submit Users     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |====C  |   |   |   |   |   |   |   |   |   |   |   |   |   |
       Guide (UG)       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
                        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
------------------------|Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |
TOTAL FUNDING           |_______________|_______________|_______________|______140______|______50_______|_______________|_______________|_______________|
FUNDING/QUARTER         |__ |__ |__ |__ |__ |__ |__ |__ |
FUNDING RCP             |__ |__ |__ |__ |__ |__ |__ |__ |
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DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Identification of Hazardous Wastes for Potential Delisting

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit IFR (MS1b)																																					6/90
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR	Submit FFR (MS2b)																																					3/91
DT-0																																						
DT-1																																						
DT-II																																						
OT-0																																						
OT-II																																						
OT-II-A																																						
UDP																																						
UG	Submit Users Guide (MS3b)																																					6/91
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 13.
Environmental Protection Technical Proposal
No. 87-017/JZ

1. TITLE: Third Phase Monitoring Study of Plastic Media Blasting Facilities

2. NCEL POC: Mr. Jerome Zimmerle
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4. PROPONENT: NAVAIR, NADEPs, and Intermediate Maintenance Facilities for Aircraft

5. OBJECTIVE: The objectives of this work are to define a ventilation rate for a large facility that will meet safety and productivity requirements without being an excessive rate that will increase ventilation equipment and utility costs; and to define a ventilation system that will apply to a very large facility.

6. DESCRIPTION: Plastic Media Blasting (PMB) is being developed as an alternative to chemically stripping paint from airframes and components. PMB is similar to sandblasting in that small plastic particles, driven by high pressure air, are used to strip numerous coatings from aircraft surfaces. The PMB process is faster, more economical, and produces less hazardous waste than chemical stripping. Potential savings from implementing PMB for aircraft alone range from $1 million to $2 million a year for each facility.

A key part of this process is the ventilation system. A properly selected ventilation rate is necessary to maintain adequate visibility, to protect worker safety, and to control equipment and energy costs.

Large facilities (≥ 10,000 square feet) have additional problems. These problems include very large air volumes required to meet standards, creation of still or turbulent air pockets, and lack of adequate ventilation near the blast area. The data to prevent these problems are not available.

7. TECHNICAL APPROACH: The major goal of this program will be to show that 50 fpm is an adequate ventilation rate for a large facility. The secondary goal will be to develop basic data on how to design ventilation systems for large facilities.

NCEL recommends the following program to complete the monitoring study.

a. A test plan will be developed to monitor dust, metal, and chemical concentrations, and airflow patterns and velocities for the large PMB facility at McLellan AFB in Sacramento, CA. Results of tests already conducted will be obtained and included in the study plan.

b. The test plan will be implemented and data gathered on the following items: dust, metal, and chemical concentrations; air velocity; air changes during blasting operations; airflow patterns; and noise. Concentrations will be determined and evaluated according to OSHA personnel exposure limit (PEL) testing protocol. A detailed report on the results of the monitoring effort will be prepared. The results will be analyzed to develop a set of personnel safety standards on the following: air velocity, air changeovers, maximum airborne dust, chemical and metal concentrations, dust handling procedures, and personnel safety gear and zones. The report will also include any recommendations on improving dust handling or ventilation equipment and possible concepts for a ventilation system for a large facility.

8. BACKGROUND: Specific data are needed on ventilation rates and patterns for PMB facilities to avoid excessive dust entrainment or media loss, to control room temperatures, to protect worker safety, and to control utility costs. This study is a continuation of two other monitoring studies at NADEP Pensacola, FL, and Hill Air Force Base, UT. The first phase study defined the general boundaries of the adequate ventilation rates. These general boundaries are:

75 fpm	facility with < 500 square feet of floor space
60 fpm	facility with < 10,000 square feet of floor space
50 fpm	facility with ≥ 10,000 square feet of floor space

These values apply for facilities that will have two to three blasters working at one time. If more than three blasters can work at one time, increase the ventilation to the next highest level. If only one blaster can work, decrease the ventilation rate to the next lowest level. These boundaries are draft standards only and are still subject to additional study and final approval.

The second phase study showed the upper limit of 75 feet per minute for small facilities and walk-in booths with floor space of less than 500 square feet was an adequate value.

The chemical wastes replaced by PMB are regulated by RCRA and the Clean Water Act. The PMB wastes are regulated under RCRA.

9. PRODUCT: The final product will be an evaluation report that will select a ventilation rate for a large facility and help define ventilation systems for a very large facility.

10. METHOD OF PERFORMANCE: This work will be completed through a combination of in-house work by NCEL and NEESA and work by a local contractor with experience in environmental monitoring and evaluation. In-house work will primarily consist of setting requirements and reviewing

results.

11. NAVY NEED: Chemical stripping operations are already being prohibited by state and Federal environmental agencies. Activities in California and Florida are being ordered to replace these operations with technologies such as PMB. By replacing chemical stripping operations with PMB, the Navy can save up to $1 million to $2 million a year for each facility (for aircraft) due to productivity savings and due to reducing the volumes of hazardous waste that need to be landfilled or treated.

The Navy will be designing a number of PMB facilities in the near future to replace chemical stripping facilities. Design data for very large facilities do not exist, and simple expansions of systems from smaller facilities will not be effective. The Navy needs design data on adequate ventilation rates to reduce facility equipment and utility costs and improve PMB operations.

PMB is an effective alternative to chemical stripping and mechanical sanding, and is urgently needed to prevent huge cost increases and negative impacts on returning equipment to the fleet. This project will be a necessary part of the PMB process because it will improve design and operation of PMB facilities in the Navy, reduce equipment and utility costs, help achieve cost savings in the range of $1 million to $2 million a year for each facility that is stripping aircraft, and reduce the liability from hazardous waste disposal.

12. FUNDING:

	FY87 ($K)	
	RCP	WR
1. Prepare Test Plan	20	20
2. Evaluate Large Facility	55	20
TOTAL	75	40

C=COMPLETION
O=DECISION POINT

PROJECT SCHEDULE FOR: Third Phase Monitoring Study of Plastic Media Blasting Facilities

MAJOR TASKS major tasks	FY87				FY88				FY89				FY90				FY91				FY92				FY93			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Prepare Test Plan			===C																									
a. Gather Initial Data			=C																									
b. Site Visits			=C																									
c. Submit Report (TEMP)			==C																									
2. Monitor Facility				=======C																								
a. Monitor Facility				==C																								
b. Analyze Results				====C																								
c. Submit Report (CR)					==C																							
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING, $K					115																							
FUNDING/QUARTER, $K							20	20																				
FUNDING RCP, $K							75																					

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT-TITLE: Third Phase Monitoring Study of Plastic Media Blasting Facilites

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP	Submit Test Plan (MS 1c)						X																															
TEMP-A																																						
IFR																																						
RAM																																						
ILS																																						
FFR																																						
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ILSP-A																																						
DT-0																																						
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OT-II																																						
OT-II-A																																						
UDP																																						
UG																																						
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 14
Environmental Protection Technical Proposal
No. 87-036/JZ

1. TITLE: Five Specific Tasks for Improving the Implementation and Operation of Plastic Media Blasting in the Navy

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3. FAC POC: Ms. Elizabeth A. Ford
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A/V 221-8531

4. PROPONENT: NAVAIR, NADEPs, and intermediate maintenance facilities for aircraft

5. OBJECTIVE: The principle objective of this work is to improve plastic media blasting (PMB) implementation and operations within the Navy by working on five tasks that will correct the deficiencies in current efforts. Specific objectives for five different tasks are listed below.

5.1 Developing Procedures for Using PMB on Missiles. The objectives of this task are to develop parameters and procedures for stripping coatings from missile bodies.

5.2 Developing Procedures for Automating PMB Operations in Large Facilities. The objectives of this work are to develop parameters and procedures for automating PMB operations to strip coatings from airframes in large facilities.

5.3 The Effects of PMB on Composites and Thin Metals. The objective of this work is to evaluate the effects of using PMB to strip coatings from composites and thin metals.

5.4 Developing Design Criteria for Ventilation Systems in PMB Facilities. The objective of this work is to develop design criteria that can be used by facility engineers to design PMB ventilation systems to meet safety and energy-saving criteria.

5.5 Evaluating PMB Equipment. The objective of this work is to evaluate plastic media blasting equipment, to improve performance, and set equipment standards.

6. DESCRIPTION: PMB is being developed as an alternative to chemically stripping paints from airframes and components. PMB is similar to sandblasting in that small plastic particles, driven by high-pressure air, are used to strip numerous coatings from aircraft surfaces. The PMB process is faster, more economical, and produces less hazardous waste than chemical

stripping. Potential savings from implementing PMB for aircraft alone range from $1 to $2 million per year per facility.

6.1 PMB Use on Missiles. Existing coatings on missiles need to be removed during overhaul operations to prevent coating buildup and to check for material cracks and damage. PMB is more effective at removing these coatings than chemical or mechanical stripping, if the proper procedures and equipment are used.

6.2 Large Facility Automation. Automating PMB operations in large facilities can increase productivity and reduce the potential for substrate damage. The field activities need guidance to successfully automate PMB operations in large facilities.

6.3 PMB Effect on Composites. The next generation of aircraft will be made with large quantities of composites and thin metals. Because the effects of using PMB on composites and thin metals are not clearly understood, additional research is needed before adequate procedures can be developed.

6.4 Ventilation Design. A key part of the PMB process is the ventilation system. A properly designed ventilation system is necessary to maintain adequate visibility, to protect worker safety, and to control energy costs.

6.5 Equipment Evaluation. Even though the plastic media process is similar to sandblasting, the equipment has to meet different specifications or the equipment will not operate properly. Equipment designed for sandblasting is not acceptable for PMB. The differences include feed-cone angle, feed-valve design, and cyclone design.

7. TECHNICAL APPROACH:

7.1 PMB Use on Missiles. The program goal will be to define general criteria and procedures for using PMB on missiles. NCEL recommends that currently available information on the following items be gathered and summarized in a report:

- Masking
- Material types and thicknesses commonly found on missiles
- Cost of chemically stripping the missiles
- Blast parameters and procedures for thin metals and composites
- Previous experience in blasting missiles
- Available blasting procedures for missiles.

At the end of this phase, the feasibility of using PMB on missiles and continuing this program will be determined.

A test plan will be prepared to obtain data on safe blast parameters and procedures for any missile material for which data are not available. Results should include fatigue, corrosion, surface and subsurface effects at different pressures, distances, angles, and media types. Pressures should be in the 10 to 35 psi range. Test and analysis procedures and test equipment will be specified. The plan will be submitted to the sponsor after NCEL review.

The test plan will be implemented. Results will be reported in a full engineering evaluation including a preliminary economic evaluation. A draft process specification for PMB use on missiles will be prepared, including safe blasting parameters for each missile material that has the potential to be blasted. The final report will be sent to the field activities after NAVFAC and NAVAIR approval.

A developmental test of PMB will be conducted on missiles. The test plan will be updated for a full-scale developmental evaluation. The evaluation will include, but not be limited to, RAM, economics, surface and subsurface effects, training needs, and applicability. A developmental test report will be prepared. The results of the test will be used to update the draft process specification. This report will include the proposed process specification and a thorough evaluation of the entire process.

A User Data Package (UDP) will be prepared to assist the field activities in implementing PMB use on missiles.

7.2 Large Facility Automation. The program goals will be to define general criteria and procedures for applying Air Force research to meet Navy needs and developing computer software and implementation plans for an auto mated Navy PMB facility. NCEL recommends the following program.

The feasibility of automating Navy PMB facilities will be evaluated. This evaluation will include, but not be limited to, an analysis of Air Force equipment and software research applicability of automation to Navy operations, Navy needs for implementing automation, and potential cost savings. The results will be reported in the form of an initial feasibility report.

A program will be prepared to develop draft automation procedures and implementation plans. This program will include an examination of Air Force re-search to determine what changes or additional information will be needed to meet Navy needs, an examination of Navy aircraft to develop material patterns and related computer software, development of appropriate draft blast parameters and procedures, and development of appropriate draft implementation plans. The results will be reported in the form of a final feasibility report.

The draft procedures, plans, and software will be tested and evaluated at an available facility. The evaluation will also include a review of the drafts by NAVFAC, NAVAIR, the NADEPs, and any other appropriate activity. A test plan will be developed to fully evaluate the procedures and software. After the evaluation, the procedures, plans, and software will be updated as necessary. The final results will be reported in the form of a developmental test report.

The updated procedures, plans, and software will be further evaluated in an actual operation. If an appropriate facility is not available, an additional evaluation test will be performed using an updated test plan. A final operational test report will be prepared. This report will include final procedures and software, an implementation plan for installing automated facilities at the activities, and a technical and economic evaluation of the complete process.

7.3 Effect of PMB on Composites. The program goal will be to evaluate the effects of PMB use on composites and thin metals. NCEL recommends the following program to develop the data needed to evaluate PMB effects on sensitive substrates. Currently available information on composite and thin metal blasting will be gathered and summarized in an initial feasibility report.

- Masking
- Material types and thickness commonly used
- Blast parameters and procedures for thin metals and composites
- Previous experience in blasting composites and thin metals
- Available blasting procedures for composites and thin metals.

A test plan will be prepared to obtain data on safe blast parameters and procedures for any sensitive material, for which data are not available, or adequate. This plan will be coordinated with Air Force, Battelle, NADC, and NADEP material research groups to avoid unnecessary duplication of effort. Results should include fatigue, corrosion, surface and subsurface effects at different pressures, distances, angles, and media types. Pressures should be in the 10 to 35 psi range. Test and analysis procedures and test equipment will be specified. The plan will be delivered in a contract report after NCEL and NADC review.

The test plan will be implemented. Results will be reported in a full engineering evaluation. Draft process specifications for PMB use on composites and thin metals will be prepared, including safe blasting parameters. The final feasibility report will be sent to the field activities after NAVFAC, NADC, and NAVAIR approval.

A developmental test of PMB will be conducted on composites and thin metals. The test plan will be updated for a full-scale developmental evaluation. The evaluation will include, but not be limited to, RAM, economics, surface and subsurface effects, training needs, and applicability. A developmental test report will be prepared. The results of the test will be used to update the draft process specification. The report will include the proposed process specification and a thorough evaluation of the entire process.

7.4 Ventilation Design. The program goal will be to define general criteria and procedures to guide designers to adequate ventilation systems. Specific designs will not be prepared because of the large number of variables involved, including aircraft types, facility shapes and sizes, and blasting procedures. The ventilation system design groups at NCEL and NEESA will be heavily involved in preparing and reviewing the design criteria and procedures. NCEL recommends the following program to develop the data for ventilation system design.

Currently available information on ventilation will be gathered and used to prepare draft requirements, so that proposed facilities will not be delayed. Existing rules and manuals on ventilation, including the NEESA general handbook, will also be examined. The draft requirements, in the form of a letter report, will be sent to the NADEPs after NCEL and NEESA review.

Existing ventilation systems will be analyzed to gather information on useful and poor features and designs. Three to four facilities (to be selected later) will be visited. This information will be used to prepare a report on designing ventilation systems. This report will contain data including, but not limited to, duct placement and size, equipment size, airflow requirements, exhaust size and baffling, and heating/cooling requirements. The final report will be sent to the NADEPs after NAVFAC approval.

The final report can then be modified and added to the NEESA general ventilation handbook, or made into a PMB-specific handbook, depending on which document will better meet Navy needs. The final decision on the handbook can be made after the second milestone report is completed.

7.5 Equipment Evaluation. The program goal will be to evaluate blasting equipment to develop a set of design criteria to improve equipment performance. Specific equipment designs will not be prepared because of the large number of variables involved. The mechanical engineering design group at NCEL will be heavily involved in preparing and reviewing the design criteria. NCEL recommends the following program to evaluate blasting equipment.

Currently available data and specifications on blasting equipment will be gathered and summarized. Navy needs for blasting will be determined. Three to four facilities will be visited to examine equipment, and obtain good and bad design criteria. This information will be used to prepare a set of proposed criteria. These criteria will be sent to the NADEPs after NAVFAC, NAVAIR, NCEL, and NEESA review.

Comments from the review will be added to the criteria. A piece of blasting equipment will be procured, using the modified design criteria. A test plan will be prepared to evaluate the equipment in an actual operation.

The equipment will be evaluated for RAM, effectiveness, logistics, operating and maintenance costs, and general quality of the design. This evaluation will be summarized in a report that will detail the final design criteria.

8. BACKGROUND: The chemical wastes replaced by PMB are regulated by RCRA and the Clean Water Act. The PMB wastes are regulated under RCRA.

8.1 PMB Use on Missiles. NADEP Cherry Point has been removing sealants from the inside of Tomahawk cruise missile bodies using a portable blast unit. Application to other types of thin-skin missiles is feasible, but information on blast parameters and procedures is not available. The Boeing Company is in the process of evaluating procedures for stripping operational missiles. Other private companies have been achieving good results with low blasting pressures on thin metals and composites on aircraft, but not on missiles.

8.2 Large Facility Automation. The Air Force is already developing automated equipment and facilities for PMB operations. This research will be directly applicable to Navy operations with a few modifications. However, the Navy will still need to develop the computer programs for directing the equipment in the blasting patterns required for Navy specific aircraft, and plans for implementing automation in the Navy. A specific computer program will need to be developed for each type of aircraft. The Air Force research in this area will not be applicable to Navy needs because of the different patterns of materials on the Navy and Air Force aircraft, and different Air Force implementation needs.

8.3 Effects of PMB on Composites. Private companies have been achieving good results with low blasting pressures on thin metals and composites on aircraft. Research by the Air Force and Battelle has been inconclusive, or has shown negative effects. However, the blasting pressures used in the Air Force studies have been higher than recommended by the Navy or private companies. NADC and NADEP North Island are trying to organize research efforts in this area, but funding is uncertain.

8.4 Ventilation Design. Manuals exist for designing standard ventilation systems, such as the draft NEESA handbook on ventilation system design. However, these handbooks contain very little specific data on procedures for designing a ventilation system for a PMB blasting booth. Specific data are needed on ventilation rates and patterns to avoid excessive dust entrainment, or media loss to control utility costs, and to control room temperatures. A specific procedure is needed to guide facility engineers in designing the actual system, including ductwork, blower size, vent placement and angle, and exhaust placement and baffling, to avoid poor or excessive airflow. These data and procedures need to accommodate complicating factors, such as the radical change in airflow patterns with the addition of an airframe, or large part into a booth.

NCEL is also working on a multiphase monitoring effort to develop specific data on ventilation rates. The first two phases of this effort have been completed.

8.5 Equipment Evaluation. Equipment designed for sandblasting is not acceptable for plastic media blasting. The density difference between hard media and plastic media is too great. Some of the problems with using sand blasting equipment include plastic media will not flow or feed properly, cyclones will not work, and air flow will be excessive.

There are a number of different manufacturers producing PMB equipment. Many of these manufacturers provide quality equipment, but some provide unmodified sandblasting equipment. A specific set of design criteria will help avoid the purchase of unmodified sandblasting equipment.

9. PRODUCT: The final products will depend on the specific task. The complete list of products is given below:

Project	IFR	FFR	DTR	OTR	UDP	UG	OTHER
PMB on Missiles					X		
Facility Automation	X	X	X	X		X	Software
Effects on Composites	X			X			
Ventilation Design							Handbook
Equipment Evaluation					X		

These reports will include implementation plans, blasting procedures, and finalized design criteria as needed to initiate or complete the project.

10. METHOD OF PERFORMANCE: This work will be done through a combination of in-house work by NCEL, NEESA, and work by a local contractor experienced in PMB and blasting equipment evaluations, materials engineering, and ventilation design. In-house work will include basic research, site visits, setting requirements, reviewing results, and software development.

11. NAVY NEED: Chemical stripping operations are already being prohibited by state and federal environmental agencies. Activities in California and Florida are being ordered to replace these operations with technologies such as PMB. By replacing chemical stripping operations with PMB, the Navy can save from $1 million to $2 million per year per facility, due to productivity savings, and due to reducing the volumes of hazardous waste that need to be landfilled or treated. Other benefits include improving Navy operations and reducing the future liability from disposing hazardous waste.

PMB is an effective alternative to chemical stripping and mechanical sanding. PMB is urgently needed to prevent huge cost increases and negative impacts on returning equipment to the fleet.

11.1 <u>PMB Use on Missiles</u>. Each year hundreds of missile bodies are chemically stripped during their overhaul cycle to remove various coatings. PMB can accomplish this same task at reduced cost and time with the right procedures. This basic research is necessary to develop the proper procedures and to ensure that missile performance is not affected. This project will be a necessary part of the PMB process because it will improve missile stripping operations in the Navy and help achieve cost savings in the range of an estimated $300,000 to $700,000 per year per facility that is stripping missiles.

11.2 <u>Large Facility Automation</u>. One of the major problems with PMB is the need for extensive operator training to reduce the potential for substrate damage. The Air Force is already working on automated equipment and software to correct this problem. The equipment technology can be used by the Navy, but the software cannot. The Navy needs to develop the necessary software, so that PMB automation can be used. An automated procedure for blasting an airframe will reduce damage potential, improve productivity, and reduce costs. This project is a necessary part of the PMB process because it will improve implementation and operation of PMB in large facilities, help achieve cost savings in the range of $1 to $2 million per year per facility, and reduce the potential for damage to the aircraft.

11.3 Effect of PMB on Composites. Implementation of PMB is being de layed because the effects of using PMB on composites and thin metals are not clearly understood.

The next generation of aircraft will be made with large quantities of composites and thin metals. Clearly, additional research is needed before adequate procedures to strip these aircraft can be developed. This basic research proposal is needed to develop the proper procedures to make sure aircraft performance is not effected. This project is a necessary part of the PMB process because it will improve implementation and operation of PMB in composite and thin metal blasting and help achieve cost savings in the range of $1 to $2 million per year per facility that is stripping composite aircraft.

11.4 Ventilation Design. The Navy will be designing a number of PMB facilities, in the near future, to replace chemical stripping facilities. Adequate ventilation design procedures would reduce facility equipment and utility costs and reduce the potential for costly retrofits.

For example, the ventilation system at the large booth at Hill Air Force Base, had to be modified once after installation, but still needs major redesign work to control dust levels and room temperatures. Proper design criteria would have helped prevent these problems and saved the Air Force equipment and system retrofit costs of about $300,000. The Navy will avoid similar costs by implementing the results of this project.

11.5 Equipment Evaluation. The Navy will be buying a lot of PMB equipment in the near future, as part of the effort to replace chemical stripping operations. The Navy needs effective design criteria so that accurate specifications can be prepared. This will ensure the proper equipment will be procured. This project is a necessary part of the PMB process because it will improve purchases of PMB equipment, improve operation of PMB in the Navy, reduce costs, and increase life of PMB equipment.

12. FUNDING:

			Cost ($K)			
	FY88		FY89		FY90	
	RCP	WR	RCP	WR	RCP	WR
PMB Use on Missiles						
Complete Initial Data Survey	35	15				
Prepare Test Plan	25	15				
Complete Material Research			175	50		
Developmental Test					150	20
Prepare Implementation UDP						60
TOTAL	60	30	175	50	150	80
Large Facility Automation						
Evaluate Feasibility	40	25				
Develop Automated Procedures	250	125	100	50		
Test the Procedures			140	85		
Conduct Operational Test					140	120
TOTAL	290	150	240	135	140	120
Effect of PMB on Composites						
Complete Initial Data Survey	35	15				
Prepare Test Plan	30	15				
Complete Material Research			200	50		
Developmental Test					150	60
TOTAL	65	30	200	50	150	60
Ventilation Design						
Proposed Requirements	20	20				
System Analysis	55	40				
Convert to Handbook				50		
TOTAL	75	60		50		
Equipment Evaluation						
Complete Initial Survey		35				
Prepare Test Plan		25				
Evaluate Equipment		25	100	35		
TOTAL	25	60	100	35		
Project TOTAL	515	330	715	320	440	260

C=COMPLETION
D=DECISION POINT

PROJECT SCHEDULE FOR: Five Specific Tasks for Improving PMB Implementation and Operation in the Navy

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       MAJOR TASKS       |      FY87       |      FY88       |    FY89    |    FY90    |    FY91    |    FY92    |    FY93    |
       MAJOR TASKS       |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|
                         |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
1.1 Complete Survey      |   |   |   |   |==========D|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Gather Data          |   |   |   |   |======C|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Site Visits          |   |   |   |   |======C|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Submit Report (IFR)  |   |   |   |   |   | =====D|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                         |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
2.1 Evaluate Feasibility |   |   |   |   |==========D|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Determine Needs      |   |   |   |   |=====C |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Evaluate Air Force   |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
      Research           |   |   |   |   |  =====C   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Submit Report (IFR)  |   |   |   |   |   | =====D|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                         |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
3.1. Complete Survey     |   |   |   |   |==========C|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Gather Data          |   |   |   |   |======C|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Site Visits          |   |   |   |   |======C|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Submit Report (IFR)  |   |   |   |   |   |======C|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                         |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
4.1. Set Proposed        |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
      Requirements       |   |   |   |   |======C|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Review Past Data     |   |   |   |   |====C  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Set Requirements     |   |   |   |   |   ===C|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Submit Requirements  |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
       (IFR)             |   |   |   |   |   ===C|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                         |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
5.1. Initial Survey      |   |   |   |   |==========D|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Gather Data          |   |   |   |   |=====C |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Site Visits          |   |   |   |   | ======C   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Submit Report (IFR)  |   |   |   |   |   | =====D|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                         |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
3.2. Prepare Test Plan   |   |   |   |   |   | =========C|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Determine Needs      |   |   |   |   |   | =====C|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Submit Plan          |   |   |   |   |   |   | =====C|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                         |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
4.2. System Analysis     |   |   |   |   |   |  ========D|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Site Visits          |   |   |   |   |   |  ===C |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Evaluate Needs       |   |   |   |   |   |   ====C   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Submit Report (TN)   |   |   |   |   |   |   |  ====D|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
-------------------------|---------------------------------------------------------------------------------------------------
                         | |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4
-------------------------|---------------------------------------------------------------------------------------------------
TOTAL FUNDING, $K        |_______________|      105        |    155     |____________|____________|____________|____________|
FUNDING/QUARTER, $K      |---|---|---|---| 20| 20| 20| 20|
FUNDING RCP, $K          |---|---|---|---|---|---|---| 25|
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C=COMPLETION
D=DECISION POINT

PROJECT SCHEDULE FOR: Five Specific Tasks for Improving PMB Implementation and Operation in the Navy (Con't)

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MAJOR TASKS              |       FY87        |        FY88       |    FY89   |    FY90   |    FY91   |    FY92   |    FY93   |
                         |1   |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|

5.2. Prepare Test Plan   |                              =========C
 a. Add Review Comments  |                                    ===C
 b. Submit Test Plan     |                                 ======C

1.2. Prepare Test Plan   |                                =======C
 a. Determine Needs      |                               =====C
 b. Submit Plan          |                                   ====C

2.2. Develop Procedures  |                                     ===========C
 a. Prepare Draft        |
      Procedures         |                                     ==========C
 b. Prepare Software     |                                     ===========C
 c. Prepare Implementa-  |
      tion Plan          |                                          ======C
 d. Submit Report (FFR)  |                                          ======C

1.3. Complete Research   |                                         ==========D
 a. T&E Panels           |                                        ======C
 b. Determine Parameters |
      and Procedures     |                                            =======D
 c. Submit Report (FFR)  |                                             ======C

3.3. Complete Research   |                                         ==========C
 a. T&E Panels           |                                        ======C
 b. Determine Parameters |
      and Procedures     |                                             ===C
 c. Submit Report (FFR)  |                                               ====C

4.3. Convert to Handbook |                                         ==========C
 a. Convert Report       |                                        ===C
 b. Submit for Review    |                                            ====C
 c. Submit Final (HB)    |                                                ===C
------------  ---------- |Q1  |Q2  |Q3  |Q4  |Q1  |Q2  |Q3  |Q4  |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|
TOTAL FUNDING, $K        |                   |        160        |     75    |           |           |           |           |
FUNDING/QUARTER, $K      |    |    |    |    | 15 | 25 | 25 | 20 |
FUNDING RCP, $K          |    |    |    |    |    | 75 |    |    |
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C=COMPLETION
D=DECISION POINT

PROJECT SCHEDULE FOR: Five Specific Tasks for Improving PMB Implementation and Operation in the Navy (Con't)

MAJOR TASKS	FY87				FY88				FY89				FY90				FY91				FY92				FY93			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5.3. Evaluate Equipment									===	===	===	==C																
a. Procure Equipment									===	C																		
b. T&E Equipment										==	==C																	
c. Submit Report (OT) (TN)											===	==C																
2.3. Test Procedures											===	===	==D															
a. Use in Facility											===	==C																
b. Evaluate Procedures												==	=C															
c. Submit Report (DT)													==D															
1.4. Developmental Test													===	===	===	==D												
a. Use in Actual Operation													===	==C														
b. Review Procedures														===	C													
c. Submit Report (DTR) (TN)															==	=D												
1.5. Implementation UDP													===	===	===	==C												
a. Prepare Draft UDP													===	=C														
b. Review UDP														==	=C													
c. Submit UDP (TN)															=	==C												
3.4. Developmental Test													===	===	===	==C												
a. Use in Actual Operation													===	==C														
b. Review Procedures														===	=C													
c. Submit Report (DTR) (TN)															===	==C												
2.4. Conduct Operational Test														===	===	=C												
a. Use in Facility														===	=C													
b. Evaluate Usefullness															===C													
c. Submit Report (OT) (TN)																==C												
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING, $K													250															
FUNDING/QUARTER, $K	---	---	---	---	---	---	---	---																				
FUNDING RCP, $K	---	---	---	---	---	---	---	---																				

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Five Specific Tasks for Improving PMB Implementation and Operation in the Navy

	DELIVERABLE	CY87												CY88												CY89												CY-90
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	4th
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP-0	Submit Test Plan (MS 1.2b)																					X																
TEMP-1	Submit Final Test Plan (MS 3.2b)																					X																
TEMP-2	Submit Test Plan (MS 5.2b)																					X																
IFR-0	Submit Requirements (MS 4.1c)					X																																
IFR-1	Submit Final IFR (MS 1.1c)																		X																			
IFR-2	Submit IFR (MS 2.1c)																		X																			
IFR-3	Submit Initial Survey (MS 3.1c)																		X																			
IFR-4	Submit Survey (MS 5.1c)																		X																			
RAM																																						
ILS																																						
FFR-0	Submit Analysis (MS 4.2c)(TN)									X																												
FFR-1	Submit FFR (MS 2.2d)																														X							
FFR-2	Submit Research Report (MS 1.3c)																																	X				
FFR-3	Submit Research Report (MS 3.3c)																																	X				
ILSP																																						
ILSP-A																																						
DT-0	Submit DTR (MS 2.3c)																																	X				
DT-1	Submit Final DTR (TN) (MS 1.4c)																																					X
DT-2	Submit DTR (MS 3.4c) (TN)																																					X
OT-0	Submit OTR (MS 5.3c) (TN)																														X							
OT-1	Submit OTR (MS 2.4c) (TN)																																					X
UDP	Submit UDP (MS 1.5c)																																					X
UG	Submit Handbook (MS 4.3c)																					X																
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 15
Environmental Protection Technical Proposal
No. 87-018/JZ

1. TITLE: Reducing Blasting Grit Hazards and Types

2. NCEL POC: Mr. Jerome Zimmerle
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3. FAC POC: MS. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENT: NAVSEA, the Shipyards, the NADEPs, NAS Jacksonville, and NWS Crane

5. OBJECTIVE: The objectives of this work is to evaluate ways to reduce the hazards and number of types of blasting grit in the Navy.

6. DESCRIPTION: Blasting grits are used to strip paint from ship hulls, large parts, and aircraft. The types of grit include hard media such as sand, copper/nickel slags, garnet, aluminum oxide; and soft media such as agricultural shells and plastic beads. After blasting, these grits are contaminated with fine particles, heavy metals (cadmium, chrome, and lead), and paint particles such as organotin (tributyl tin oxide).

Field activities currently use some type of sand or grit blasting to strip paint from ship hulls and aircraft. This type of blasting generates large amounts of hazardous wastes and air pollutants that are difficult to control and expensive to dispose.

Two options for reducing the volume of hazardous waste and the number of types of grit include changing from a hazardous grit such as copper/nickel slag to a nonhazardous grit, such as sand, and recycling the grit to remove the contamination.

7. TECHNICAL APPROACH: The program goal will be to evaluate grit substitution and recycling in a multiphase program that will ultimately lead to project economics and feasibility, equipment requirements, material replacement, and a plan to implement the changes.

The Air Force is evaluating plastic media disposal, and NCEL is evaluating plastic media recycling as part of the plastic media blasting project. Therefore, this work will concentrate on hard media and only reference and summarize plastic grit research.

NCEL recommends the following program to develop the data necessary for reducing the number of blasting grits and their associated hazards.

a. Currently available information on blasting grits will be gathered and summarized, including current efforts to recycle and replace the grit, levels of contamination, and overall usage. Site visits will be made to four activities to gather data and previous studies on the grit, gather samples for hazard analysis, and to examine the possibility of delisting the grits in specific areas. Results will be reported in a feasibility report.

   This first phase was started in FY87. The results from this study will be used to determine the specific study areas and Navy needs for the next phases.

b. The information from step a will be used to prepare a test plan to evaluate recycling or substituting the grit at a shipyard. This test plan will be used to measure the effectiveness of the recycling equipment or new blast material, including economics, hazard reduction, and fulfillment of Navy needs.

c. The test plan from step b will be implemented and the substituted grit and recycling systems evaluated. The final evaluation report will contain data including system performance and economics.

d. A User Data Package will be prepared as a means of implementing the results of this study. This final report will be sent to the field activities after NAVFAC and NAVSEA approval.

8. BACKGROUND: One of the Navy's largest and most expensive hazardous waste disposal problems is blasting grits contaminated with unknown quantities of heavy metals and paint chips such as organotins. It might be possible to recycle or delist these grits if more information was available on the quantities and characteristics of the hazardous wastes, and the types of surfaces and coatings being blasted.

The reduction of blasting grit generation and disposal in Navy shipyards has been funded by NAVSEA (SEA 07) and studies have been conducted by DTRC for three years. NAVSEA has rewritten the military specification (MILSPEC 22262A) for abrasive blasting grit to eliminate the hazard of the material <u>as purchased</u>. Grit generation surveys have been conducted several times by NAVSEA over the past ten years. Two commercially available recyclimng systems have been evaluated. Cavitating water jet development has been aimed at eliminating the use of abrasives for underwater hull paint removal.

There are a number of different types of blasting grits including aluminum oxide, steel shot, slag, glass beads, organic media, and sand. These grits can be contaminated with cadmium, nickel, copper, chromium, and lead from the blasted metallic surfaces; and organotin from the coatings stripped off the surfaces. Grit disposal totaled about 6,700 tons per year at an estimated cost of $900,000 in FY84. Seven activities generated the majority of this waste: NADEP Cherry Point, NADEP Norfolk, NADEP Alameda, NSY Mare Island, NSY Long Beach, NAS Jacksonville, and NWS Crane.

Some activities have tried simple changes to reduce the volume of hazardous blasting grits, such as switching from slag to sand, or segregating the hazardous and nonhazardous grits based on the surface being blasted. The Institute of Gas Technology has evaluated a thermal process to burn the paint particles and separate ash from the used grit so the grit can be recycled. The process can achieve an effective 40 to 50 percent recycling rate, but has problems removing the heavy metals. A rotary dryer/mechanical sieve has been evaluated for coal and copper slag. The equipment could economically process up to 20 tons an hour, and achieve an 80 percent recycling rate. Other activities have tried physical separation techniques with mixed results depending on the media and the concentration of heavy metals versus media size.

Sandblasting grits are regulated under the Resource Conservation and Recovery Act (RCRA). Depending on the paint type, this dust would have to be analyzed to determine whether or not it is hazardous. For paints such as those containing organotin, the waste dust is not covered under RCRA specifically but poses such National environmental questions that casual disposal of the material has now become counterindicated.

9. PRODUCT: The final product will include an evaluation of the feasibility of the process, a developmental evaluation report, and a User Data Package to implement any recommendations (TN).

10. METHOD OF PERFORMANCE: This work will be completed through a combination of in-house work by NCEL, work by a local contractor with experience in evaluating blasting operations, and in-house work by shipyard and NADEP personnel. In-house work will primarily consist of site visits, setting requirements, and reviewing results.

11. NAVY NEED: Abrasive grit blasting generates large volumes of hazardous wastes contaminated with heavy metals. The Navy needs to find replacement grits that are nonhazardous and to develop equipment and techniques to recycle the remaining wastes so that the volume of hazardous grit waste is reduced. This will save Navy funds and help achieve CNO waste reduction goals. Potential savings range from 50 to 90 percent of the costs of hazardous waste disposal for each blasting grit process, depending on the type of reduction process used.

12. FUNDING

	Cost ($K)					
	FY87		FY88		FY89	
	RCP	WR	RCP	WR	RCP	WR
Initial Data Survey	25	10				
Prepare Test Plan			30	25		
Developmental Evaluation			75	45	65	25
Prepare Implementation Plan (UDP) (TN)						70
TOTAL	25	10	105	70	65	95

PROJECT SCHEDULE FOR: Reducing Blasting Grit Hazards and Types

	FY87				FY88				FY89				FY90				FY91				FY92				FY93			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Initial Survey		===	====	===D																								
a. Gather Data		===	=C																									
b. Site Visits		==	==C																									
c. Submit Report (IFR)			===	===D																								
2. Prepare Test Plan					====	==C																						
a. Set Test Needs					===C																							
b. Prepare Plan					=	===C																						
3. Evaluate Process						==	====	====	===	===	=D																	
a. Procure Equipment						==	====	=C																				
b. T&E Equipment								===	===	=C																		
c. Submit Report (DT)									===	===	=D																	
4. Prepare UDP									===	===	===	=C																
a. Draft Implementation UDP									===	==C																		
b. Review Draft											==C																	
c. Submit UDP (TN)												==C																
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING, $K	35				175				160																			
FUNDING/QUARTER, $K		5		5	15	20	20	15																				
FUNDING RCP, $K		25			30		75																					

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Reducing Blasting Grit Hazards and Types

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP	Submit Test Plan (MS 2b)															X																						
TEMP-A																																						
IFR	Submit Survey Report (MS 1c)									X																												
RAM																																						
ILS																																						
FFR																																						
ILSP																																						
ILSP-A																																						
DT-0	Submit DTR (MS 3d)																														X							
DT-1																																						
DT-II																																						
OT-O																																						
OT-II																																						
OT-II-A																																						
UDP	Submit Implementation UDP (MS 4c)																																	X				
UG																																						
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 16
Environmental Protection Technical Proposal
No. 87-022/JZ

1. TITLE: Exploring the Use of Frozen Carbon Dioxide to Strip Paint From Ship Hulls and Bilges

2. NCEL POC: Mr. Jerome Zimmerle
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A/V 360-5085, COM (805) 982-5085

3. FAC POC: Ms. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENTS: NAVSEA and the Shipyards

5. OBJECTIVE: The objective of this work is to evaluate the use of frozen carbon dioxide pellets to strip paint from ship hulls and bilges.

6. DESCRIPTION: Carbon dioxide (CO_2) blasting is similar to sandblasting in that frozen carbon dioxide pellets, driven by high-pressure air, may be used to strip paint from ship hulls. The CO_2 process produces virtually no environmentally hazardous waste or air pollution and, as a result, would be more economical and more useful than sandblasting.

Field activities currently use some type of sand- or grit-blasting to strip paint from ship hulls. This type of blasting generates large amounts of hazardous wastes and air pollutants that are difficult to control. Frozen CO_2 pellets have the potential to strip paint from ship hulls as an effective replacement for sandblasting. The CO_2 process has the following advantages over sandblasting: potentially more economical, generates less hazardous waste, improves worker safety, and produces less air pollution.

The process has already been evaluated a number of times and the equipment developed for its use is compact and mobile. The process is slower than hard abrasives but offers distinct advantages in portions of ships hulls where composite structures are installed. There is of course a major safety question to be considered that is associated with this technique - the removal of accumulations of CO_2 building up within the ship and dry dock.

7. TECHNICAL APPROACH: The program goal will be to evaluate CO_2 blasting of ship hulls in a multiphase program that will ultimately lead to project economics and feasibility; equipment requirements; procedures for blasting hulls and bilges; and a plan to implement the process.

NCEL recommends the following program to develop the data for evaluating CO_2 blasting.

a. First, currently available information on CO_2 blast parameters, blast applications, and portable blasting equipment will be gathered and summarized. Second, site visits will be made to up to two manufacturers of CO_2 blasting equipment for at-the-plant demonstrations of the ability of the equipment to strip typical ship coating systems. Results will be reported in a feasibility report.

b. The information from the first step will be used to prepare a test plan for evaluating CO_2 blasting at a shipyard. This test plan will be used to measure the effectiveness of the equipment including potential for use in bilges and on ship hulls.

c. The test plan from the second step will be implemented. The final evaluation report will contain data including, but not limited to, blasting procedures and parameters, system performance and economics, an implementation plan, and training requirements. The final report will be sent to the field activities after NAVFAC and NAVSEA approval.

8. BACKGROUND: CO_2 blasting equipment has been manufactured in private industry. Basic operating pressures are in the 175 psi range. This high pressure would be useful for thick ship hulls, for improving surface profiles for repainting, and, possibly, for removing corrosion products. The CO_2 pellets are useful for stripping brittle coatings and may be effective on other types of coatings. The pellets will melt after use, leaving a small volume of paint chips to be disposed. Hazardous waste volumes and air pollution will be reduced.

Sandblasting grits are regulated under the Resource Conservation and Recovery Act (RCRA). Waste dust from the CO_2 process would mainly be paint dust. Depending on the paint type, this dust would have to be analyzed to determine whether or not it is hazardous. The waste dust of paints such as organotin is covered under RCRA.

9. PRODUCT: The final product will include an evaluation of the feasibility of the process and a developmental evaluation report (TN).

10. METHOD OF PERFORMANCE: This work will be completed through a combination of in-house work by NCEL, out-of-house work by a local contractor with experience in evaluating blasting operations, and in-house work by shipyard personnel. In-house work will primarily consist of site visits, setting requirements, and reviewing results.

11. NAVY NEED: Sandblasting generates large volumes of hazardous wastes contaminated with metals and is a major air pollution problem. Sandblasting is also limited to ship hulls or open tanks that contain no equipment because of the problems of hard dust contamination of equipment and waste removal. CO_2 blasting can eliminate these problems because the blast media evaporates, leaving the paint residue behind. CO_2 blasting would improve productivity and decrease costs by significantly reducing the manpower-intensive waste removal process and reducing the volume of hazardous waste generated at the shipyards. Estimated savings would be over

$300,000 per year per shipyard if the process proves feasible.

12. FUNDING:

	Cost ($K)			
	FY91		FY92	
	RCP	WR	RCP	WR
Initial Data Survey	30	35		
Prepare Test Plan	25	15		
Developmental Evaluation	75	25	85	75
TOTAL	130	75	85	75

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Evaluating Carbon Dioxide Blasting for Use on Ship Hulls or Bilges

MAJOR TASKS	FY87				FY88				FY89				FY90				FY91				FY92				FY93				FY94			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Initial Survey																	=======D															
a. Gather Data																	==C															
b. Site Visits																		==C														
c. Submit Report (IFR)																		====D														
2. Prepare Test Plan																			==C													
a. Set Test Needs																			=C													
b. Prepare Plan																			=C													
3. Evaluate Process																					==========D											
a. Procure Equipment																					===C											
b. T&E Equipment																						====C										
c. Submit Report (DTR)																							====D									
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING																	205				160											
FUNDING/QUARTER																																
FUNDING RCP																																

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Evaluating Carbon Dioxide Blasting for Use on Ship Hulls and Bilges

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP	Submit Test Plan (MS2b)																																					9/91
TEMP-A																																						
IFR	Submit Survey Report (MS1c)																																					6/91
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR																																						
DT-0	Submit DTR (MS3c)																																					6/92
DT-1																																						
DT-II																																						
OT-0																																						
OT-II																																						
OT-II-A																																						
UDP																																						
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 17
Environmental Protection Technical Proposal
No. 87-006/CAK

1. TITLE: Furnace Requirements for Burning Hazardous Wastes

2. NCEL POC: Dr. C.A. Kodres
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3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NADEPs, NSYs

5. OBJECTIVE: The goal of this work is to determine the furnace conditions required to burn the hazardous wastes encountered by the Navy. The objective is to provide an information base for confronting such problems as:

- Landfill disposal
- Equipment purchase decisions
- Equipment modifications decisions
- Energy costs
- Operating and maintenance costs
- Recycling

6. DESCRIPTION: The plan of attack is to determine what happens to the waste when subjected to a particular furnace environment. Definition of the word furnace is broadened to include both boilers and incinerators. Co-firing is assumed. Chemical compositions of the ash and stack gases are the dependent variables.

This is an emerging technology. There are three distinct problem areas: the chemistry involved, the time-temperature behavior of the furnace, and the testing, whether experimental, in the field, or a commercial system.

The EPA has been funding work on the chemistry of hazardous substances for over a decade. Most of the projects have involved tracing the evolution of a single substance under controlled and usually constant laboratory conditions. Recently, the National Bureau of Standards (NBS) has started assembling the results of this work into chemical kinetic data bases that can be used to theoretically "burn" other substances and under varying conditions. These data bases have reached about the C4 hydrocarbon level at the present time.

There are six or seven mathematical models capable of describing the timetemperature behavior of a furnace and are flexible enough to include hazardous waste chemistry. The PHOENICS code, used by NCEL for the last 2 years to analyze AETF, is a leading candidate.

Experimental testing of hazardous waste combustion systems has progressed further than either of the other two problem areas faced in this work. The obstacles to be overcome, however, are still formidable. Furnace time-temperature histories have been examined only under laboratory conditions. Products of incomplete combustion and intermediate products of combustion, knowledge of which is a key to this work, have been studied only under controlled conditions, and rarely in the presence of a co-fuel.

7. TECHNICAL APPROACH: The work will begin with a literature study, compiling and analyzing the work to date on the combustion of Navy-type hazardous wastes and its close cousins. Both hardware and theory will be reviewed.

This study will provide a foundation for the next phase of the work: a theoretical parametric examination of furnaces and other devices considered as candidates for the burning of hazardous substances. A chemical kinetics data base will be coupled to one of the general heat transfer/fluid flow mathematics models and used to stimulate a furnace or incinerator. Existing combustors (those with sufficient published design specifications) will be used as the vehicle for the study. Navy combustors will be studied, but no emphasis will be placed upon them. Various wastes will then be "burned" in different furnaces, under different operating conditions, in the presence of other fuels, and the results tabulated.

Finally, significant observations will be confirmed and perhaps amplified by making one or more instrumented trial burns.

8. BACKGROUND: Considered a last resort, thermal destruction is, at times, the only satisfactory solution to the problem of disposing hazardous waste.

Regulations pursuant to RCRA typically require hazardous waste combustion facilities to operate at destruction and removal efficiencies of 99.99 percent and higher. Although there are furnaces/incinerators that can meet this requirement, there is little understanding of the fundamentals of hazardous waste combustion. Use of a particular furnace for the destruction of a particular waste depends upon precedent.

As a result, the Navy and other agencies cannot take advantage of the inherent destruction flexibility of their furnaces and incinerators. Current operating constraints prohibit the use of Navy boilers and incinera-tors for the destruction of hazardous wastes.

9. PRODUCT: The literature study will be summarized in a TA; then pending decision points, the following will occur: CR on hazardous waste combustion chemistry, TN on the theoretical parametric study, TEMP for field test burns, TN on the results, and, if practical, a UG for burning hazardous wastes in furnaces and incinerators.

10. METHOD OF PERFORMANCE: An update of the hazardous waste combustion hardware state-of-the-art will be contracted out. Work involving the chemistry of hazardous wastes will be performed by the NBS. No decision on who does the testing can be made before the results of the parametric study

are available. Information such as what systems look the best, the number of different tests required, aspects to be examined, instrumentation must be made available. Field tests will be contracted out; experimental and prototype tests will be conducted in-house.

11 NAVY NEED: A capability for thermal destruction benefits the Navy in terms of convenience, possible safety, and possibly economics. Actual economic benefits will have to be determined individually. Factors such as type of waste, disposal options, available equipment, costs of modifying the equipment, and the potential of energy recovery will have to be considered.

12. FUNDING:

Cost ($K)

	FY87		FY88		FY89		FY90		FY91	
	RCP	WR	RCP	WR	RCP	WR	RCP	WR	RCP	WR
Literature Study		20		10						
Hardware Survey			40							
Hazardous Waste Chemistry		20		50		50				
Parametric Study				110		150		120		
Test Burn							150		150	100
TOTAL		40	40	170		200	150	120	150	100

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Furnace Requirements for Burning Hazardous Wastes

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                            |      Y87      |      Y88      |      Y89      |      Y90      |      Y91      |      Y92      |      Y93      |      Y94      |
MAJOR TASKS                 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |

1.  State-of-the-Art        |   |   |   |=================================================D   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Lit Search           |   |   |   |===========C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Hardware             |   |   |   |   |===============C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    c. Prepare TEMP         |   |   |   |   |   |   |   |   |   |   |=======C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

2.  Theoretical             |   |   |   |=====================================================================C   |   |   |   |   |   |   |   |   |   |   |   |
     Parametric Study       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Chemistry            |   |   |   |=================================================C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Modeling             |   |   |   |   |   |   |=========================================================C   |   |   |   |   |   |   |   |   |   |   |   |

3.  Experimental            |   |   |   |   |   |   |   |   |   |   |   |   |===============================================C   |   |   |   |   |   |   |   |
     Parametric Study       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    a. Trial Burns          |   |   |   |   |   |   |   |   |   |   |   |   |===============C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    b. Data Analysis        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |=======C   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    c. Optimization         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |=======================C   |   |   |   |   |   |   |   |   |   |   |
    d. Prepare UG           |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |===============C   |   |   |   |   |   |   |   |

                            |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |
TOTAL FUNDING               |      40       |      210      |      200      |      270      |      250      |               |               |               |
FUNDING/QUARTER             | --| --| --| 40| 45| 45| 40| 40|
FUNDING RCP                 | --| --| --| --| 40| --| --| --|
```

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Furnace Requirements for Burning Harzardous Wastes

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA	Submit Tech Assessment (MS1a)																					X																
PMP																																						
PMP-A																																						
TEMP	Submit TEMP (MS2a)																																				X	
TEMP-A																																						
IFR																																						
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR																																						
DT-0																																						
DT-1																																						
DT-II																																						
OT-O																																						
OT-II																																						
OT-II-A																																						
UDP																																						
UG	Submit Users Guide (MS3d)																																					9/92
AFP																																						
CR	Submit CR (MS2a)																																	X				
TN	Submit TN (MS3a)																																					7/91
TN	Submit TN (MS3c)																																					3/92
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 18A
Environmental Protection Technical Proposal
No. 87-010/BYKP

1. TITLE: Reduction of Naval Shipyard Cleaning Wastes Containing Citric Acid

2. NCEL POC:

Bingham Y K Pan	R M Roberts
Code L71	Code L74B
Port Hueneme, CA 93043	Port Hueneme, CA 93043
A/V 360-4193	A/V 360-5085

3. FAC POC: Ms. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENT: NAVSEA

5. OBJECTIVE: To reduce the volume and disposal cost of the Naval shipyard hazardous wastewaters containing citric acid (C.A.) and other rust removal/inhibition constituents that are produced from the cleaning and derusting of ship bilges and tanks.

6. DESCRIPTION: The U.S. Navy generates C.A. contaminated wastewater when depainted ship bilges and tanks are derusted using solutions of that chemical. These wastewaters contain chelating chemicals, heavy metals, and oil & grease. The exisiting Naval Industrial waste treatment plants (IWTPs) do not afford the capablility of treating these wastes such that expensive contractor services must be purchased in order to eliminate this particular hazardous waste.

NCEL has done some preliminary work. It includes ion exchange (IX), ultraviolet light/hydrogen peroxide (UV/H_2O_2), reverse osmosis (RO), and removal of oil and grease. Different types of technology and levels of efforts are required for treating these hazardous wastes and reducing their volumes. pretrearment

7. TECHNICAL APPROACH: Because of the previous development work at NCEL, a full scale system would be designed and operated. Based on the testing results using small scale units in the previous year, the technology to treat the C.A. waste will be chosen from between two promising technologies that involve ion exchange (IX) and UV catalyzed peroxidation. The full scale system will be designed for the chosen technology and will be installed at a Naval shipyard. Operating procedures and limitations will be established initially. Test work will be pursued using actual ship cleaning wastes. Process optimization requirements will be determined to the extent possible and the available enhancements identified. A final feasibility report (FFR) will be prepared.

The preferred technology will be identified and justified based on appropriate engineering criteria, with particular emphasis on recycle potential. If the ion exchange method is chosen, requirements for effective regeneration of IX bed and the elimination of triethanolamine interference must be determined. Similarly, for the assessment of the UV/H_2O_2 process, UV intensity and critical residence time must be defined.

After the above feasibility tests have been completed, the performance of the full scale preferred system will be: (1) parametrically analyzed; and (2) optimized for a broad range of wasterwater characteristics and operating conditions. The former will include feed composition, pH, total suspended solids, viscosity, oil and grease. The latter will include flow rate, pressure, and temperature. Life cycle costs of the full scale system will be be calculated.

A User's data package (UDP) will be published that will enable Naval shipyards to treat and, if practical, to recycle values in C.A. wastes. Procurement guidelines will be supplied. Modifications required for commercial hardware, if utilized, will be detailed; equipment costs will be estimated and scaled. Performance and system specifications will be developed and included. Safety precautions that must be observed will be explained in detail. Any system variants that may be required as a result of waste differences noted for particular shipyards shall be addressed with specific design/operating information furnished explaining how such site-specific matters can be managed.

8. BACKGROUND: The Navy reported generating 1045 tons of citric acid-containing wastewaters in 1984 from bilge derusting operations. The derusting process was used by Shops 56 and 71 at NAVSHPYDs Puget Sound, Long Beach, Norfolk, and Pearl Harbor. Aqueous citric acid solution (5 to 10 percent) is sprayed onto bilge or tank walls that had been manually cleaned of paint. The citric acid preferentially chelates the oxidized iron form, although some base metal is also lost in the process. As a result, difficult rust deposits are dissolved, as is the thin film of rust that covers the entire bare surface.

The citric acid, contaminated with iron and traces of other chelatable heavy metals present in the carbon steel walls, is flushed with water out of the structure being derusted and is collected for disposal. To avoid flash rusting of the now white metal, the walls are immediately sprayed with an inhibitor solution containing triethanolamine. This oxygen-getter adheres to the surface, protecting it until a primer can be applied. The latter is done without removing the amine film.

The chemical costs to the Navy for employing the citric acid process were approximately $400,000 in 1985 and the disposal costs were $194,000.

9. PRODUCT: There are three major products. They are a FFR, a CR (contract report), and an UDP.

10. METHODS OF PERFORMANCE: The FFR will be prepared in house. The CR and UDP will be prepared by contractors under NCEL supervision. Several important methods are required as follows:

- Review IX, and UV/H_2O_2 RO technologies and equipment
- Contacts with NAVSEA and EPA
- Design, install, and operate test systems
- Make cost analysis
- Prepare reports

11. NAVY NEED: The U.S. Navy produces annually about two hundred and fifty thousand gallons of hazardous C.A.-containing wastewater from cleaning and derusting operations. A majority of this wastewater is outhauled by contractors who claim to detoxify the waste, although relatively little is known as to what actually happens to such shipments once they have left the gate. The Navy is of course liable for such material in perpetuity if indeed it remains in a hazardous waste form. The IWTP cannot separate the heavy metals from this wasatewater because they are solublized through chelation with the C.A. The costs and difficulties associated with the present disposal techniques are expected to increase significantly within next few years as stricter disposal regulations are enforced.

12. FUNDING:

	$K					
	FY88		FY89		FY90	
TASK	RCP	WR	RCP	WR	RCP	WR
1) Citric Acid Waste						
Final feasibility	90	80				
Full scale system			70	60		
USER data package			20	20	70	70
Total ($ 480)	90	80	90	80	70	70

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: REDUCTION OF NAVAL SHIPYARD CLEANING WASTES CONTAINING CITRIC ACID

	DELIVERABLE	CY88												CY89												CY90												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP	Submit CR																					X																
TEMP-A																																						
IFR																																						
RAM																																						
ILS																																						
FFR	Submit FFR										X																											
ILSP																																						
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DT-1																																						
DT-1A																																						
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OT-O																																						
OT-II																																						
OT-II-A																																						
UDP	Submit UDP																																	X				
UG																																						
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

C = COMPLETION
D = DECISION POINT

PROJECT
SCHEDULE: REDUCTION OF NAVAL SHIPYARD CLEANING WASTES CONTAINING CITRIC ACID

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                        |---FY88----|---FY89----|---FY90----|---FY91----|---FY92----|---FY93----|---FY94----|---FY95----|
------MAJOR TASKS-------|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|
                        |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
1. FEASIBILITY STUDY    |  |  |===========|D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  a. Design sytems      |  |  |==C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  b. Erect equipment    |  |  | ===C|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  c. Perform field tests|  |  |  ===C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  d. Evaluate results   |  |  |  |======C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  e. Prepare FFR        |  |  |  |  | ====|D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                        |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
2. SYSTEM OPTIMIZATION  |  |  |  |  |  |  |===========|D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  a. Make eqpt mods     |  |  |  |  |  |  |===C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  b. optimize performance  |  |  |  |  |  |  |  ======C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  c. Life-cycle analysis|  |  |  |  |  |  |  |  | ===C|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  d. Prepare TEMP       |  |  |  |  |  |  |  |  |  ===|D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                        |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
3. USERS DATA PKG       |  |  |  |  |  |  |  |  |  |  |  |===========|C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  a. Prep procurement pkg  |  |  |  |  |  |  |  |  |  |  |======C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  b. Safety guidelines  |  |  |  |  |  |  |  |  |  |  |  | ====C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
  c. Finalize UDP       |  |  |  |  |  |  |  |  |  |  |  |  |=====|C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
                        |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
------------------------|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|
TOTAL FUNDING           |___170_____|___170_____|___140_____|___50______|___________|___________|___________|___________|
FUNDING/QUARTER         |__|__|__|__|__|__|__|__|
FUNDING RCP             |__|__|__|__|__|__|__|__|
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Number 18B
Environmental Protection Technical Proposal
No. 87-010/BYKP

1. TITLE: Reduction of Naval Shipyard Hazardous Wastes Containing Nitrite

2. NCEL POC:

Bingham Y K Pan	R M Roberts
Code L71	Code L74
Port Hueneme, CA 93043	Port Hueneme, CA 93043
A/V 360-4193	A/V 360-5085

3. FAC POC: Ms. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENT: NAVSEA

5. OBJECTIVE: To reduce the volume and cost of treating and disposing of Naval shipyard nitrite-containing wastewaters that are produced from the cleaning and lay-up of marine boilers.

6. DESCRIPTION: The U.S. Navy generates various types of hazardous waste during ship cleaning and maintenance operations. The sodium nitrite wastewaters are largely produced during boiler hydroblasting and the lay up of boilers in berthed ships.

The wastewater contains low levels of heavy metals (other than iron); nitrite, while easily converted to nitrate, is undesirable in either form since it contributes to the eutrophication of surface water systems.

An NCEL project titled " Recycling of Hydroblasting Wastewater" started in FY 88 has been aimed at reducing up to 90% of the sodium nitrite wastewater generating during boiler hydroblasting. Boiler lay-up using nitrite solution has also been evaluated and recommendations presented to NAVFAC for abandoning the practice in favor of steam lay-up. The latter concept can only be realized after dockside steam quality is significantly improved. It is clear therefore that a nitrite problem will likely exist at some level of volume for some time.

7. TECHNICAL APPROACH: While nitrite wastewaters can be easily converted to nitrate form, say, simply by air-blowing, the conversion may not satisfy future regulatory pressures. For example, Norfolk NSY is not now allowed to discharge such wastewaters into the James River. The approach should therefore not be addressed to some simple form of oxidative chemistry such as is now practiced by contractors who are now processing such Navy wastes. An ideal approach would be to evaluate and exploit the best of several biological processes availing nitrification/denitrification of aqueous systems. These are considerably more cost-effective than chemical denitrification in which nitrogen gas is produced. The EPA has studied both type of processes in the interest of reducing the introduction of nutrient species into water bodies receiving treated nitrogenous wastewater, including agricultural runoff water.

The thrust will be to perform treatability studies leading to the selection of a culture that is relatively insensitive to the dissolved heavy metals in the feed and that can be supported without excessive nutrient input. Conventional biological reactors will be evaluated, including the rotating biological contactor and (preferably) the immobilized bed configuration. Denitrified effluent from the reactor would be further detoxified by heavy metal removal involving standard IWTP chemistry. Because the precedent work is rather extensive and technologically mature, the initial bench work can probably be graduated with low risk to early full scale piloting. Thus, feasibility proving at bench level would be immediately followed by the design of a full scale system for evaluation by NCEL at a suitable NSY.

After the above feasibility tests have been completed, the performance of a full scale biological reactor designed for the project will be: (1) parametrically analyzed; and (2) optimized for a broad range of wasterwater characteristics and operating conditions. The former will include feed composition, pH, total suspended solids, biomass nutrient requirement and any other parameters that may have developed as being of interest during the bench phase of work. The Item (2) parameters will include flow rate and temperature. Life cycle costs of the full scale system will be calculated.

A User's data package (UDP) will be published that will enable Naval shipyards to treat nitrite wastewater completely on site to furnish an effluent that can be discharged to sanitary sewers. Procurement guidelines for the treatment system will be supplied. Modifications required for commercial hardware, if utilized, will be detailed; equipment costs will be estimated and scaled. Performance and system specifications will be developed and included. Safety precautions that must be observed will be explained in detail. Any system modifications that may be required as a result of waste differences noted for particular shipyards shall be addressed with specific design/operating information furnished explaining how such site-specific matters can be managed.

8. BACKGROUND:

a. Hydroblasting nitrite wastewaters: Most of the NSYs perform boiler hydroblasting operations by Shop 41. In the hydroblasting operation, a high-pressure jet of dilute sodium nitrite solution is sprayed into shipboard boiler tubes to remove scale hydraulically. The insides of the water tubes are subjected to a 5,000 to 10,000 psig water stream emitted from a lance nozzle at the rate of 20 gpm. The water jet lance and 1 1/2-inch hose are passed through the length of the tube at a rate of 20 sec per tube. Sodium nitrite ($NaNO_2$) is added to the hydroblasting solution to maintain a passive surface on the boiler tubes and thus reduce corrosion. During the hydroblasting process, this dilute $NaNO_2$ solution (carrying scale particles) is allowed to overflow from the boiler into the ship's bilge after one pass. It is combined with the contents of the bilge, which could contain anything from dirt to oily waste to heavy metals, and then transferred to a waste tank on shore. An estimated 1,916 tons of wastewater are generated from this process annually. At three NSYs (Norfolk, Charleston, and Long Beach), these wastewaters must be treated and are reported as hazardous wastes.

Charleston, and Long Beach), these wastewaters must be treated and are reported as hazardous wastes.

b. <u>Boiler Lay-up:</u> NSYs use a wet lay-up process for shipboard boilers. A dilute sodium nitrite solution is pumped into the drained, laidup boiler as a short-term protective measure to prevent steam-side tube corrosion. On light-off, the boiler is drained and the steam circuitry rinsed with some feedwater which is drained and combined with the lay-up water. During 1984, an estimated 2975 tons of wastewater generated from this process were either trucked to IWTPs, discharged to STPs, or contract hauled to special contractor treatment plants for a total cost of $236,800. Chemical costs for the process were an additional $14,000. Other Naval activities also generate some sodium nitrite. San Diego PWC, for example, received 12,000 gal of the solution in 1984 from Navy ships.

9. PRODUCT: There are three major products. They are an FFR, a CR (contract report),and a UDP.

10. METHODS OF PERFORMANCE: The FFR will be prepared in house. The CR and UDP will be prepared by contractors under NCEL supervision. Several important methods are required as follows:

- Review biological denitrification process engineering data
- Conduct bench work on preferred cultures
- Design, install, and test full-scale facility
- Develop cost analysis
- Prepare reports

11. NAVAL NEED: The U.S. Navy produces annually about 1.2 million gallons of hazardous nitrite wastewater from boiler cleaning and lay-up operations. The current disposal costs by contractor haul and IWTP treatment are over half a million dollars annually. Present technology practiced by the Navy and its contractors probably include practices that will eventually be prohibited, if they are not already. The costs and difficulties are expected to increase within the next few years as stricter constraints are enforced. Thus, better technologies to treat these wastes are urgently needed.

12. FUNDING:

	$K					
	FY88		FY89		FY90	
	RCP	WR	RCP	WR	RCP	WR
Feasibility studies	45	30	25			
System scale-up and testing			80	50		
System optimization			75	40	25	45
User data package					30	50
Total ($495)	45	30	180	90	55	95

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: REDUCTION OF NAVAL SHIPYARD HAZARDOUS WASTES CONTAINING NITRITE

	DELIVERABLE	CY88												CY89												CY90												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
IA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR																																						
RAM																																						
ILS																																						
FFR	Submit FFR & system dwgs															X																						
ILSP																																						
ILSP-A																																						
DT-1	Submit test eval DT																					X																
DT-1A	Submit system optimization DT																												X									
DT-II																																						
OT-O																																						
OT-II																																						
OT-II-A																																						
UDP	Submit UDP																																	X				
UG																																						
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

C = COMPLETION
D = DECISION POINT

PROJECT
SCHEDULE: REDUCTION OF NAVAL SHIPYARD HAZARDOUS WASTES CONTAINING NITRITE

	FY88				FY89				FY90				FY91				FY92				FY93				FY94				FY95			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Feasibility Study			===	===	===	==	D																									
a. Select bioprocesses			==C																													
b. Conduct lab trials			==	===	=C																											
c. Design pilot system					==C																											
d. Dev. prelim costs					==	=C																										
e. Prepare FFR						==	C																									
2. System Scale-up & Testing					===	===	===	==C																								
a. Erect system on site					==C																											
b. Conduct tests						===	==C																									
c. Prepare DT1								==C																								
3. System optimization									===	===	==C																					
a. Effect system mods									===	==C																						
b. Parametric testing									===	===	=C																					
c. Design finalization											=C																					
4. User Data Package											===	===	==C																			
a. Dev procurement pkg											===	=C																				
b. Safety guidelines												=	==C																			
c. System specs & dwgs												===	=C																			
d. Finalize UDP													==C																			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING		75				270					150																					
FUNDING/QUARTER																																
FUNDING RCP																																

Number 19
Environmental Protection Technical Proposal
No. 87-032/JZ

1. TITLE: Developmental Evaluation of Distilling Spent Torpedo Solvents

2. NCEL POC: Mr. Jerome Zimmerle
Code L71
Port Hueneme, CA 93043-5003
A/V 360-5085, COM (805) 982-5085

3. FAC POC: Ms. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENTS: NAVSEA, NUWES Keyport, Other Intermediate Maintenance Activities for torpedoes

5. OBJECTIVE: This effort will evaluate the feasibility of using distillation to recover spent solvents from cleaning MK-48 torpedoes.

6. DESCRIPTION: Distillation is a proven technology for recovering solvents from cleaning operations. A two-step distillation process will be used to recover the torpedo solvents. First, the solvent will be heated in a reflux mode to decompose the remaining otto fuel and drive off the resulting hydrogen cyanide gas. Second, the solvent will be distilled and recovered.

7. TECHNICAL APPROACH: This effort will be completed in four phases:

   a. The first phase will evaluate the need for distillation. Data will be gathered on waste volumes; disposal costs; tank, piping, and shop redesign; waste characteristics and specific contaminants; and potential problems with distillation. An initial feasibility report will be prepared to determine if the project should be continued.

   b. The second phase will involve actual equipment tests using simulated and actual wastewaters. The goals of this phase are to set operational parameters and to detail system performance and economics. A final feasibility report will be prepared to determine if the project should be continued.

   c. The third phase will involve field tests of the equipment to confirm system performance, logistics, and economics. An operational test report will be prepared and given to the field after review. The equipment can be placed in the field if this phase proves the feasibility of the process.

   d. The fourth phase will involve preparing a User Data Package to assist the activities in implementing a full-scale distillation unit.

8. BACKGROUND: D. Knudsen of NSWC estimated that 125,000 gallons of MK-48 torpedo solvents and 10,000 gallons of MK-46 torpedo solvents were produced throughout the Navy. These wastes cost a total of almost $370,000 for disposal (1985).

Spent torpedo solvents are a problem hazardous waste for the Navy due to their low flash point, the heavy metal and fuel concentration, and the potential release of cyanide as the fuel decomposes. Because of these problems and the increasing restrictions and cost of land disposal, the Navy decided to co-fire or reclaim the solvents. NSWC Dahlgren was tasked to evaluate reclamation, and a private company, EER, Inc., was contracted to evaluate co-firing. Laboratory evaluations of both of these technologies were conducted, and based on the results, reclamation in the form of distillation was selected for further study.

NSWC has published a report on the laboratory evaluation, completed a study on the waste characteristics, and prepared a TEMP. These documents will be used as references in this effort. The waste solvent and any secondary wastes are regulated under the Resource Conservation and Recovery Act (RCRA).

9. PRODUCT: The products will be a series of four main reports: an initial feasibility report, a final feasibility report, an operational evaluation report, and a User Data Package (TN). These reports will be supplemented by contract reports on specific aspects of the research.

10. METHOD OF PERFORMANCE: Phases 1 and 4 will be performed in-house, Phases 2 and 3 will be performed out-of-house by contractors with experience in evaluating hazardous waste treatment systems. In-house responsibilities will include basic research, setting requirements, preparing implementation plans, and reviewing results.

11. NAVY NEED: The Navy needs this effort for the following reasons: to reduce hazardous waste disposal costs, to meet hazardous waste reduction goals, to avoid future liability problems, and to reduce waste of usable solvent.

Distillation may be feasible at up to four Navy activities (NUS Charleston, SUBASE Pearl Harbor, NAS North Island, and NUWES Keyport) that generate a total of 90,000 gallons of waste solvent at a disposal cost of almost $2.50 per gallon (1985 dollars). Estimated savings from distillation range from $2.65 to $8.90 per gallon depending on the location of the activity, for a total savings of $570,000 (derived from the NSWC laboratory evaluation). Depending on current disposal costs, up to three other Navy activities could be distillation candidates (NSSF New London, NWS Yorktown, and AUTEC Andros Island, Bermuda).

12. FUNDING:

	Cost ($K)					
	FY87		FY88		FY89	
	RCP	WR	RCP	WR	RCP	WR
Initial Feasibility	35	35				
Full Scale Laboratory Evaluation			75	60		
Operational Evaluation					75	30
Prepare Implementation UDP						70
TOTAL	35	35	75	60	75	100

C=COMPLETION
D=DECISION POINT

PROJECT SCHEDULE FOR: Developmental Evaluation of Spent Torpedo Solvents

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---------------------------------------------------------------------------------------------------------------------------
                            |      FY87       |      FY88       |    FY89    |    FY90    |    FY91    |    FY92    |    FY93    |
        MAJOR TASKS         |Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|

1. Initial Feasibility      |   |   |======D|   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Site Visits             |   |   |===C   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Submit IFR (TM)         |   |   |  ====D|   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

2. Developmental            |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    Evaluation              |   |   |   |   |   |===========D  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Procure Unit            |   |   |   |   |   |====C  |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Test Simulated          |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
     Wastewater             |   |   |   |   |   |   |===C   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Test Actual             |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
     Wastewater             |   |   |   |   |   |   |   |===C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 d. Submit DT (CR)          |   |   |   |   |   |   |   |====D |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

3. Operational              |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    Evaluation              |   |   |   |   |   |   |   |   |===========C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Setup Unit @ Keyport    |   |   |   |   |   |   |   |   |===C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Operational Test        |   |   |   |   |   |   |   |   |  | ====C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Submit OT (CR)          |   |   |   |   |   |   |   |   |  |  |  ===C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

4. Submit Implementation    |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
    Plan (UDP)              |   |   |   |   |   |   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 a. Prepare draft plan      |   |   |   |   |   |   |   |   | ==C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 b. Review plan             |   |   |   |   |   |   |   |   |  |  ==C|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
 c. Prepare Final (TN)      |   |   |   |   |   |   |   |   |  |  |  |==C  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

----------------------------|Q1 |Q2 |Q3 |Q4 |Q1 |Q2 |Q3 |Q4 |Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|Q1|Q2|Q3|Q4|
TOTAL FUNDING, $K           |      70         |      135        |    175     |            |            |            |            |
FUNDING/QUARTER, $K         |---|---|20 |15 |15 |15 |15 |15 |
FUNDING RCP, $K             |---|---|---|35 |75 |---|---|---|
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DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Developmental Evaluation of Spent Torpedo Solvents

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
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IFR	Submit IFR (MS 1b)									X																												
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ILS																																						
FFR																																						
ILSP																																						
ILSP-A																																						
DT-0	Submit DTR (MS 2d)																					X																
DT-1																																						
DT-II																																						
OT-0	Submit OTR (MS 3c)																																	X				
OT-II																																						
OT-II-A																																						
UDP																																						
UG	Submit Implementation Plan (MS 4c)																																	X				
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 20
Environmental Protection Technical Proposal
No. 87-030/JLK

1. TITLE: Operational Testing of Cyanide Oxidation System

2. NCEL POC: Ms. Jennie L. Koff
NCEL Code L71
Port Hueneme, CA 93043-5003
A/V 360-5308, COM (805) 982-5308

3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NAVFAC, NAVSEA, NAVAIR

5. OBJECTIVE: This effort will provide operational testing and evaluation of an electrolytic system that provides metal recovery and cyanide oxidation for source minimization of cyanide-laden plating wastewaters.

6. DESCRIPTION: In the electrochemical process, a dc current is passed between an anode and cathode placed in an aqueous ionic solution. Metal ions present in the solution are reduced and plated out on the cathode while cyanide is oxidized at the cathode. The system circulates wastewaters from a still rinse tank, used for primary rinsing of plated parts through an electrolytic cell to provide continual purification. Final rinsing is accomplished in an overflow rinse. The electrolytic system reduces cyanide wastewater discharges by up to 99 percent.

7. TECHNICAL APPROACH: The operational test and evaluation will involve field testing of the system. A Navy plating shop will be selected for the field tests. The system will be installed and monitored to collect data for confirming system performance, logistics, reliability, maintainability, and economics. An operational test report (OTR) will be prepared documenting results of the field tests.

8. BACKGROUND: The Navy owns and operates electroplating shops as part of its shore support establishment. Various metals are plated at these facilities, which have a wastewater generation of over 575 million gallons a year. These wastestreams contain hazardous contaminants that are regulated under Federal, state, and local requirements. Pretreatment of plating wastestreams is required to need discharge criteria. End-of-pipe treatment, typically accomplished at industrial waste treatment plants, costs the Navy millions of dollars a year.

NCEL has been tasked by NAVFAC Code 03 to investigate alternative pretreatment systems for plating shop wastestreams. Under this program, an electrolytic system for source pretreatment of cyanide wastewater is being developed. Budget constraints have led to a decrease in NAVFAC 03 funding of this project. Additional support is required to complete FY87, tasks which include system operational testing and evaluation and preparation of a User Data Package (UDP). Planned FY88 funding levels from Code 03 ($150,000) will be used to prepare a UDP. Requested funding from Code 112 ($250,000) will provide system operational testing and evaluation at a Navy Field site. The system will provide minimization of wastewater generation and toxic discharge by up to 99 percent.

9. PRODUCT: The product is an operational test report. A UDP will be prepared and funded by NAVFAC Code 032.

10. METHOD OF PERFORMANCE: The site selection, operational test plan, design, and equipment specifications will be performed in-house. System installation, operation, data collection, and evaluation will be performed by contractors with expertise in electroplating and pretreatment systems.

11. NAVY NEED: Pretreatment of cyanide wastewaters by conventional techniques has posed a cost burden on Navy plating shops and present potential safety hazards from the storage of chlorine gas and caustic solutions. In addition, some Navy plating shops do not have adequate treatment capability for these wastewaters, which will lead to increased violations as environmental regulations become stricter. An electrolytic system used to provide source pretreatment could minimize cyanide wastewater generation and discharges of toxic contaminates by up to 99 percent. This will result in reduced pretreatment costs, reduced hazardous sludge disposal generation and disposal costs, and increased compliance with discharge requirements.

12 FUNDING/TASK:	COST ($K)			
	FY87		FY88	
	RCP	WR	RCP	WR
Operational Test and evaluation (OT&E)			200	50
TOTAL FAC 112 Funding			200	50
Under FAC 03 funding				
DTE II		270		
UDP (and OTR at present)				150

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Operational Testing of Cyanide Oxidation System

	Y87				Y88				Y89				Y90				Y91				Y92				Y93				Y94			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Operational Evaluation					====	===	==C																									
a. Identify Test Site & Requirements					==C																											
b. Perform Testing					==	==C																										
c. Prepare and Submit OTR							==C																									
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING	270				400																											
FUNDING/QUARTER	60	70	70	70	50	50	50	50																								
FUNDING RCP					200																											

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Operational Testing of Cyanide Oxidation System

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
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Number 21
Environmental Protection Technical Proposal
No. 87-029/JLK

1. TITLE: Ion Exchange/Metal Recovery System

2. NCEL POC: Ms. Jennie L. Koff
   Mr. Daniel Zarate

3. FAC POC: Ms. Elizabeth A. Ford
   Code 1121A
   AV 221-8531

4. PROPONENT: Other than 112 NADEP Alameda, NAVAIR, other activities that operate plating shops

5. OBJECTIVE: The objective of this effort is to develop a treatment system for dilute wastewaters generated from cadmium cyanide plating operations utilizing ion exchange and electrolytic metal recovery technologies that will provide source minimization and zero sludge production.

6. DESCRIPTION: Ion exchange is a technology that is suited to pretreatment of dilute ionic contaminants. In conjunction with this technique, a novel approach using electrolytic treatment of the ion exchange backflush solution would provide a means to eliminate sludge production. The only residual wastes produced would be solid metals that can be sold to a reclaimer. Using a combination of ion exchange units, the potential for reuse of rinsewaters is available; however, the cost/benefits associated with providing the level of treatment required for reuse must be evaluated.

7. TECHNICAL APPROACH: This effort will be completed in two phases. In the first phase, development of the ion exchange/metal recovery system will be accomplished. Specific tasks include the following.

   a. NCEL will identify resin types appropriate for treatment of final rinsewaters generated from cadmium plating operations at NADEP Alameda. Resin types will be investigated for the design of a system that will provide polishing treatment to levels below discharge criteria and for the design of a system that can provide reuse of rinsewaters for zero discharge. NADEP Alameda will be requested to provide an analysis of the wastewaters for characterization.

   b. NCEL will conduct laboratory tests to evaluate the performance of selected resins.

   c. NCEL will determine design criteria that will include removal rates per square foot of resin, volume of resin required to attain desired waste quality, frequency and type of backflush solution or resin disposal requirements, and bed size requirements.

d. NCEL will investigate the feasibility of treating ion exchange backflush by electrolytic techniques so that the only residual waste generated would be a recoverable metal solid. Requirements for an electrolytic system appropriate for use with an ion exchange unit will be identified where applicable.

e. Cost analysis, design criteria, alternate system designs, and recommendations will be prepared in a technical report along with results of the laboratory tests.

In the second phase, field testing of the system will be accomplished. Specific tasks include the following.

a. NCEL will develop a field test design. All parameters to be evaluated will be identified. Final system specifications will be identified, and a field site selected for testing.

b. Equipment for the system will be procured and installed at the selected test site.

c. Field testing will be performed. Parameters will be monitored to evaluate and confirm system performance and suitability. Reliability, availability, and maintainability (RAM) characteristics will be identified.

d. Results will be documented in a technical report (OTR).

8. BACKGROUND: NADEP Alameda was selected as the field site for a demonstration project conducted by NCEL to test and evaluate electrolytic oxidation of cyanide wastewaters. Results obtained utilizing a commercially available unit indicate that the technology can provide a 99 percent reduction in both wastewater generation and contaminant discharges. The commercial unit, however, did not perform consistently and was not capable of zero discharge source pretreatment as expected from manufacturer information. NCEL has been tasked and funded to continue developmental efforts that will lead to the design of an electrolytic treatment system that will meet Navy performance and suitability requirements. While this technology has shown the potential to provide cost-effective minimization, a polishing treatment system for removing residual dilute contaminants in the final discharges may be required to meet increasingly stringent regulations. An ion exchange system with metal recovery of the backflush solution is being developed to accomplish this polishing treatment while providing a pretreatment method that does not produce hazardous sludge.

9. PRODUCT: Products will include a technical memorandum (TM) covering the system development and an OTR documenting field test results of the system.

10. METHOD OF PERFORMANCE: In the first phase, all work will be performed in-house with the exception of laboratory analysis of wastewater samples during laboratory tests of the resins. In the second phase, procurement of equipment will necessitate out-of-house spending. Installation, operation,

and data collection for the system will be performed by contractors. Test design and system specifications and operational evaluation of field tests will be conducted in-house.

11. NAVAL NEED: The Navy generates up to 1 million gallons per day of cyanide-laden wastewaters from electroplating operations. These wastewaters additionally contain toxic heavy metals such as cadmium, copper, nickel, and silver. Discharges of cyanides and heavy metals are regulated under the Clean Water Act. Pretreatment of these Navy wastewaters is typically accomplished using alkaline chlorination followed by metals precipitation in an industrial waste treatment plant (IWTP). However, some Naval facilities do not have an IWTP or have inadequate treatment and must meet regulations by dilution. One such activity suffering from problems due to inadequate treatment capability is NADEP Alameda.

At NADEP Alameda cyanide wastewaters are partially oxidized to cyanate using a system that is comparable to a pool chlorinator. These partially treated wastewaters are discharged to the publicly owned treatment works (POTW) without further treatment for heavy metals removal. Electrolytic technology is being used to provide minimization of wastewater generation and contaminant discharges through source pretreatment of a still rinse or dragout rinse. Wastewaters have been reduced from 12,000 gallons per day to about 150 gallons per day. Continued violations for cadmium discharges have still resulted, despite a reduction in cadmium discharges that is estimated at up to 99 percent obtained with the commercially purchased electrolytic recovery system.

The need for a system to provide polishing treatment of final discharges is evident. Continued violations at NADEP Alameda can lead to a cease and desist order of plating operation. NADEP Alameda requested NCEL's assistance in designing a system that, coupled with the electrolytic metal recovery, will provide cost-effective treatment to consistently meet environmental regulations. A zero discharge system is preferred if proven to maintain product quality while providing cost-effective pretreatment. Development of a source pretreatment system that utilizes ion exchange and electrolytic technologies can provide an alternative method for cyanide wastewater treatment applicable to many Navy plating shops.

12. FUNDING:

	Cost ($K)			
	FY87		FY88	
	RCP	WR	RCP	WR
System Development Operational Evaluation		60	300	150
TOTAL		60*	300	150

*Existing Funds

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Ion Exchange/Metal Recovery System

MAJOR TASKS	**FY87**				**FY88**				**FY89**				**FY90**				**FY91**				**FY92**				**FY93**				**FY94**			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Ion Exchange/ Metal Recovery System Development		========C																														
a. Identify Resin Types		==C																														
b. Conduct Lab Tests			==C																													
c. Develop Design Criteria & estimate System Costs			===C																													
d. Evaluate Metal Recovery Potential of Backflush Solutions			===C																													
e. Prepare TM				==C																												
2. Operational Evaluation					===========C																											
a. Test Design					=====C																											
b. Procure and Install Equipment					=====C																											
c. Conduct Tests						=====C																										
d. Prepare OTR							====C																									
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING	60				450																											
FUNDING/QUARTER	--	20	20	20	40	40	35	35																								
FUNDING RCP	--	--	--	--	300	--	--	--																								

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Ion Exchange/Metal Recovery System

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
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AFP																																						
ANU																																						
TM	Prepare and Submit TM (MS1e)									x																												
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 22
Environmental Protection Technical Proposal
No. 87-040/BYKP

1. TITLE: Supercritical Fluids

2. NCEL POC: Bingham Y.K. Pan and D.B. Chan
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Port Hueneme, CA 93043
A/V 360-4193, COM (805) 982-4193

3. FAC POC: Ms. Elizabeth A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NSYs, NADEPs, NSCs, others

5. OBJECTIVE: To investigate the supercritical fluid (SCF) technology for applications to the treatment of hazardous and toxic wastes. Work will be expanded to explore the advantages of SCF and to coordinate the state-of the-art research for Navy use.

6. DESCRIPTION: An SCF is a substance that is heated above its critical temperature and compressed beyond its critical pressure. Consequently, it exists as a single phase, but possesses characteristics of both liquid and gas. Several significant advantages are as follows:

a. Liquid-like density: The density of a substance at a supercritical region can become very high at moderate pressure. A high density enhances the solubility of a solute. For example, the solubility of the solute phenanthrene in supercritical ethylene can increase 1,000 times with a 150-bar (1 bar = 0.987 atm) charge in pressure.

b. Gas-like viscosity: The viscosity of a supercritical substance is very low and so facilitates both pumping and natural convection.

c. Cost-effectiveness: A significant saving can be realized for many separation processes. Usually the recovery of the extracting solvent is very costly but when an SCF is used as solvent, it can be easily recovered by reducing the pressure. Under these conditions, the SCF undergoes phase transition and solubility change.

d. Various applications: The SCF technologies have had or will have applications in food, pharmaceutical, and chemical industries. Two potentially broad applications to Navy environmental protection are given in the Technical Approach section.

7. TECHNICAL APPROACH: The following four stages are planned:

a. Initial Study (1 man-month). Literature and patents in the SCF field will be reviewed. Theoretical considerations for wastewaters to be treated using the SCF method will be made. Experimental techniques will be proposed.

b. Selection of an SCF system (3 man-months). Carbon dioxide, ethylene, and/or water will be studied as an SCF for environmental control.

Some aromatic hydrocarbons may also be chosen for study. The operating variables and performance limitations should be established.

c. SCF as a Mobile Phase in Gas Chromatogrphy (4 man-months). Currently, gas chromatography and mass spectrometer are the major analytical tools. For example, they are used for the determination of total toxic organics in wastewaters (one complete analysis costs $1,000). If an SCF can be adapted as mobile phase in gas chromatograph, it is expected that the retention time could be greatly reduced.

d. SCF as an Agent to Regenerate Spent Adsorbent (4 man-months). Activated carbon and synthetic resins have been used as adsorbents for purification in many industrial processes and for removal of pollutants in wasterwaters. Study will be conducted to determine if certain types of SCF could be used to regenrate the spent adsorbents more efficiently.

8. BACKGROUND: SCF technology has been recognized to have great value by academic researchers. Many industries are interested in its potential applications. The success of SCF processing requires a thorough understanding of the thermodynamics of the system. Phase equilibrium will be the key to correlate data for targeting applications. In the environmental protection field, it is desirable that the substances selected as SCFs be nontoxic and have low critical temperature.

9. PRODUCT: A technical report will be issued to cover the investigation and findings. The accomplishment of this research project is to establish two broad areas of applications (stages b and c) and understand the basic nature of the SCF for other applications.

10. METHODS OF PERFORMANCE: Stage a work will be conducted in-house. Stages b, c, and d will be carried out by contractors under the supervision and coordination of NCEL.

11. NAVY NEED: The U.S. Navy and Marine Corps generate more than 4 million tons of hazardous wastes annually and have 7,100 facilities or sources that could produce toxic industrial wastewaters. Alternate technologies are needed to treat these hazardous and toxic wastes. The SCF technology has great potential to be developed to meet the needs.

12. FUNDING (6.2 Fund):

FY88 ($K)	
RCP	WR
65	50

Manpower: $100K (1 man-year)
Equipment and materials: $10K
Support Services: $5K

TOTAL: $115K

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: Supercritical Fluids (SCF)

MAJOR TASKS	FY87				FY88				FY89				FY90				FY91				FY92				FY93				FY94			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Initial Study					=C																											
2. Selection of One or more RCF Substances					===	C																										
3. SCF for Gas Chromatography						==	C																									
4. SCF for Spent Adsorbent							==	===	C																							
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING					115																											
FUNDING/QUARTER	--	--	--	--	10	15	10	15																								
FUNDING RCP	--	--	--	--	65	--	--	--																								

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Supercritical Fluids (SCF)

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR																																						
RAM																																						
ILSP																																						
ILSP-A																																						
ILS																																						
FFR																																						
DT-0	Submit a Detailed Report																								x													
DT-1																																						
DT-II																																						
OT-0																																						
OT-II																																						
OT-II-A																																						
UDP																																						
UG																																						
AFP																																						
ANU																																						
TN																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

Number 23
Environmental Protection Technical Proposal

1. TITLE: Development of Non-Cyanide Electroplating Processes

2. NCEL POC: Dr. D. B. Chan
Code L71
Port Hueneme, CA 93043-5003
A/V 360-4191/4173, COM (805) 982-4191/4173

3. FAC POC: Ms. Elizabeth A. Ford
Code 1121A
A/V 221-8531

4. PROPONENT: NAVSEA, NAVAIR, AND MARCORPS

5. OBJECTIVE: This effort will explore and develop new non-cyanide and non-acid electroplating processes for Navy applications. To investigate other alternatives to direct current plating for high efficiency, quality and durability. The main objective is to develop a process which will minimize or eliminate toxic cyanide waste generated from the Navy electroplating processes.

6. DESCRIPTION: The Navy uses cyanide-containing solutions for cadmium, copper, nickel, silver and gold electroplating processes and also in metal stripping processes for removal of copper, nickel and zinc. The wide spread use of cyanide-containing solutions generates over half million gallons per year of high concentration spent, highly toxic cyanide solutions, along with one million gallons daily of low concentration but still toxic cyanide waste from rinse operation. The Navy spends millions of dollars annually to dispose of the cyanide waste. The new non-cyanide and non-acid plating processes proposed to be developed ill minimize/eliminate the cyanide problem and save the Navy significant operational costs.

7. TECHNICAL APPROACH: A pulse plating technique has been found to improve the current efficiency for cadmium plating, deposit quality, and reduce hydrogen absorption. This technique will be explored for application in developing non-cyanide plating processes. Electroless and molten salt bath plating will also be investigated. Efforts will also be dedicated to non-acid processes. It is observed that use of acid systems necessitate more re-working of parts, producing more waste requiring treatment.

Attempts will be made to develop innovative bath systems that can be continuously regenerated over prolonged use and contamination. Preliminary efforts will be directed to investigating pulse plating of cadmium on steel specimens. The tests will be statistically designed to optimize plating parameters, such as current, bath composition, anode material and pulse width. Current efficiency, hydrogen absorption and throwing power of bath will be quantified and optimized. Successful methods will be studied for the plating other metals. In the last phase of the project, the recommended procedures will be scaled-up to permit shop evaluations.

8. BACKGROUND: EPA and local state regulations limit the amounts of toxic chemicals discharged in wastewaters; these constraints will doubtless become more stringent. Cyanide solutions are widely used in the Navy and other DOD activities for metal electroplating and stripping. The current cost of cyanide waste disposal is very high. It is anticipated that these costs will escalate three fold over the next five years.

In confronting the cyanide waste problem, some DOD electroplating facilities have gone to cyanide free plating operations. A recent survey of such plating shops indicate a great deal of dissatisfaction with the cyanide free methods currently used. Generally, these techniques are very acidic and corrosive, are difficult to maintain, and have poor tolerance for contamination. Often, these processes produce more waste than the cyanide processes they replace because of the need of re-working of parts of poor plate quality. Current research has shown that superior plating processes can be developed to eliminate the problems while furnishing excellent plating quality.

9. PRODUCT: The products will be a series of reports, annual reports in TM form and a final report in TN form which will include shop-use manuals.

10. METHOD OF PERFORMANCE: The efforts will be conducted mostly in-house with low level of contractor assistance in fabrication of test systems.

11. NAVY NEED: The Navy needs this effort for reducing plating operation costs and for mitigating hydrogen embrittlement problems on critical tactical parts used on Navy aircraft and ships.

12. FUNDING/TASK:	FY 88	FY 89	FY 90
Lab development	$300K		
Alternatives techniques		$300K	
Shop tests and report			$400K

Total: $1,000k

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: DEVELOPMENT OF NON-CYANIDE ELECTROPLATING PROCESSES

	DELIVERABLE	CY88												CY89												CY90												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR	Submit Concept IDR (MS1)						X																															
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Submit Initial FR (MS1)									X																												
RAM																																						
ILS																																						
FFR	Submit Final FR (MS2)												X																									
ILSP																																						
ILSP-A																																						
DT-1	Submit 1st DT Rept (MS2)																					X																
DT-1A																																						
DT-II																																						
OT-O	Submit 1st OT Rept (MS3)																									X												
OT-II																																						
OT-II-A																																						
UDP	Submit UDP (MS3)																																	X				
UG																																						
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

C = COMPLETION
D = DECISION POINT

PROJECT
SCHEDULE: DEVELOPMENT OF NON-CYANIDE ELECTROPLATING PROCESSES

	FY88				FY89				FY90				FY91				FY92				FY93				FY94				FY95			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Lab Development		=======C																														
2. Alternative Techniques					==========C																											
3. Shop Tests & Rpts									==========C																							
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING	300				300																											
FUNDING/QUARTER	--	20	80	200	75	75	75	75																								
FUNDING RCP	--	--	--	--	--	--	--	--																								

Number 24
Environmental Protection Technical Proposal

1. TITLE: Navy Hazardous Waste Concentration Systems

2. NCEL POC: R.M.Roberts
Code: L74B
Port Hueneme, CA 93043

T.A. Kuepper
Code: L66
Port Hueneme, CA 93043

3. FAC POC: Ms. Elizabeth. A. Ford
Code: 1121A
A/V 221-8531

4. PROPONENT: NAVSEA, NAVFAC

5. OBJECTIVE: To reduce the quantity of liquid, industrial hazardous waste generated at Navy activities that currently must be processed by contractors or costly on-site treatment procedures.

6. TECHNICAL APPROACH: More cost-effective, state-of-the-art liquid waste minimization techniques, such as reverse osmosis (RO) and ultrafiltration (UF) membrane processes, will be evaluated and tested to determine their ability to effectively concentrate and reduce hazardous waste streams at their source of generation.

7. BACKGROUND: Federal and State regulations require that hazardous materials generated at Navy activities meet very stringent guidelines before disposal is allowed. These regulations have already translated into very high costs and will continue to increase by an estimated threefold for generators of hazardous wastes. It is well known that a number of Navy industrial processes generate large quantities of rather dilute, wastewaters that must be generically considered as hazardous wastes until otherwise modified. Typically, where an activity has no means of processing certain types of liquid wastes, it consequently must store such liquids for eventual pick-up by a State licensed contractor. In California, for example, the quantities of these liquid wastes at some Navy activities are substantial and are extremely difficult to reduce because of Naval readiness requirements.

A process that has been discussed as a concentration technique for Naval Hazardous Wastewater is freeze crystallization (FC). This process may be necessary for some of the Navy's more exotic hazardous waste streams but it is anticipated that other more conventional state-of-the-art liquid processes can concentrate the majority of the Navy's hazardous waste streams more economically, using less energy, while requiring less floor space.

State-of-the-art liquid processes, especially membrane separation techniques, have tremendous potential for concentrating solutions so that the quantity of waste that must be disposed of on-site or via contractor can be reduced substantially. This in turn will greatly reduce disposal costs because of the reduced quantities involved. During a membrane separation process, solutions are divided into two streams: a relatively concentrated hazardous waste liquid portion and a liquid effluent suitable for disposal via a relatively inexpensive method, such as sewer disposal. As an example, a hazardous waste stream that normally generates 100,000 gallons of liquid solution per month could be concentrated to only 20,000 gallons while allowing inexpensive sanitary sewer disposal of 80,000 gallons. Effecting such a scenario would reduce monthly disposal costs for an activity from at least $100,000 to $20,000 since in many cases a fee of $1. to $3. per gallon of liquid waste is the typical disposal cost regardless of concentration. This would translate to a yearly cost savings of $960,000 for the activity. Multiply this one activity with the many within the Navy and the overall benefit becomes quite apparent.

A number of such concentrative membrane processes exist but two are particularly attractive in terms of Navy requirements. These are reverse osmosis (RO) and ultrafiltration (UF). The RO process, in particular, has undergone tremendous technological advancements in recent years, rendering invalid previous cost comparisons with FC. The most significant of those advancements are the introduction of extremely stable synthetic membranes that are capable of separating up to 99.9% of most dissolved substances in a liquid, and the introduction of low pressure membranes that require about half the energy necessary to purify water using conventional RO membranes. This combination of technological advances has promoted the RO process to a status of application for a wide variety of aqueous systems that can be concentrated at a cost competitive with what is considered normal for more conventional water treatment processes, and substantially cheaper than such relatively exotic processes as Freeze Crystallization.

9. PRODUCT: FY88- Initial and Final Feasibility Reports, including literature review and market survey

FY89- Developmental Test Report; based on concentration test stand equipment; survey for potential Navy industrial facilities sites

FY90- Operational Test and evaluation report; NSY or NADEP pilot work

FY91- User Data Package

10. METHOD OF PERFORMANCE: The tasks for fiscal years 88 through 91 will be conducted through both in-house and contractor efforts. The anticipated ratio of in-house to contractor labor is about 50%.

11. NAVY NEED: Hazardous waste disposal costs are high today and represent a significant portion of the budgets of Navy Public Work Centers and related Navy industrial operations. Furthermore, these costs are expected to increase by a factor of three over the next six years as approved disposal sites become more remote and are more stringently monitored. Concentrating hazardous wastewater along with other minimization techniques will eventually save the Navy many times over the investment cost to implement these technologies and allow the Navy to continue functioning in an ever increasing era of environmental awareness.

12. FUNDING/TASK: FY88-$75K Feasibility Study - Including literature review and market survey

FY89-$340	Developmental Testing - Design/build/operate concentration test stands; Survey Navy industrial activities locations for application suitability
FY90-$925	Operational test and evaluation on-site of selected hazardous wastestreams
FY91-$550	Prepare UDP - Design/write specifications and users' manuals for Hazardous Wastewater Concentration System

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: Navy Hazardous Waste Concentration Systems

	DELIVERABLE	CY88												CY89												CY90												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR	Initial Feasibility Report							X																														
RAM																																						
ILS																																						
FFR	Final Feasibility Report										X																											
ILSP																																						
ILSP-A																																						
DT-1	Developmental Test Report																						X															
DT-1A																																						
DT-II																																						
OT-I	Operational Test Report																																		X			
OT-II																																						
OT-II-A																																						
UDP	User Data Package																																					10/91
UG																																						
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

C = COMPLETION
D = DECISION POINT

PROJECT
SCHEDULE: Navy Hazardous Waste Concentration Systems

	FY88				**FY89**				**FY90**				**FY91**				**FY92**				**FY93**				**FY94**				**FY95**			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Feasibility Study			=====D																													
2. Developmental Testing					===========D																											
a. Conc. Test Stand					===========C																											
b. Survey Activities					===========C																											
3. Operational Testing									===========C																							
4. Develop UDP													===========C																			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING	75				340				925				550																			
FUNDING/QUARTER	--	--	50	25	25	25	25	25																								
FUNDING RCP	--	--	0	0	19050		50	50																								

Number 25
Environmental Protection Technical Proposal
No. 87-045/RMR

1. TITLE: Updated Survey of SGCCWs Generated at Five NSYs

2. NCEL POC: Mr. R.M. Roberts
Code L74
Naval Civil Engineering Laboratory
Port Hueneme, CA 93043-5003
A/V 360-5085/4516, Comm'l (805) 982-5085/4516

3. NAVSEA POC: Mr. J. V. Tashijan
Code 08
Comm'l (202)692-8713

4. PROPONENTS: NAVFAC

5. OBJECTIVE: This project, which supports the CNO Hazardous Waste Minimization (HWM) Program, is aimed at acquiring updated data from Navy activities generating Steam Generator Chemical Cleaning Wastes (SGCCWs).

6. DESCRIPTION: Surveys will be conducted at all major generators of SGCCWs to determine production rates for five types of SGCCWs, waste characteristics, current methods of treatment/disposal, and RCRA-liability of each before and after mixed storage. Per NAVFAC instructions, the survey will be end-of-pipe only, with no attempt being directed at studying the cleaning processes themselves for possible modification opportunities that would promote HWM. Coordination of this work will be through Mare Island NSY (MINS) Code 2300.

7. TECHNICAL APPROACH: This effort will be accomplished in two phases:

   a. <u>Phase I</u> - On the first phase, arrangements will be made, with MINS' assistance, to survey SGCCW production at the Portsmouth, Norfolk, Charleston, Puget Sound and Mare Island NSYs. At each activity, appropriate POC's will be contacted and a complete inventory developed on the annual output of each of the five types of SGCCW, the typical analyses of these wastes (if available from the activities), and the practices observed at each activity for the isolated or mixed storage of the wastes. Data will also be collected on the techniques employed at each NSY for the treatment/disposal of such collected wastes. An accountability chain will be determined for all such operations so that residual liability situations will be clearly identified. Mass-flow diagrams identifying the overall path of treatment/disposal will be developed for each NSY.

   b. <u>Phase II</u> - On the second phase of work, a study will be conducted to verify that all five SGCCWs, with and without mixing per the present NSY storage practices, are hazardous by RCRA definition or the more stringent definitions (if any) of the local jurisdictions. Each SGCCW system, including mixed wastes, will then be systematically classified in terms of RCRA/local-jurisdiction regulations to show which waste characteristic(s) or ingredient(s) are responsible for a hazardous waste designation. Any opportunities for delisting such wastes will be identified, particularly where this can be achieved merely through the avoidance of mixed storage of these wastes.

As a final undertaking, the now on-going SGCCW reduction studies at NCEL will be modified if necessary to address any new findings resulting from the above survey. If possible, the project scope and descriptive documentation will also be revised so that its continuation can be pursued without classifying the project CONFIDENTIAL. An over-all, revised program plan (to be supported with NAVFAC funds previously assigned to the same project) will be presented in the summary survey report to MINS/NAVSEA. Included there will be proposed test mechanism, such as on-site pilot studies, that will permit project staff to access SGCCW samples without incurring the security difficulties previously encountered.

8. BACKGROUND: In 1985, NCEL conducted a survey of five NSYs (Portsmouth, Norfolk, Charleston, Puget Sound and Mare Island) to determine the amounts and compositions of the various types of SGCCWs generated, the storage (mixing) practices, the disposal mechanisms employed, and the costs associated with these hazardous waste management operations. This information was required to support the development of an Initiation Decision Report (NCEL TM No. 71-85-46, dtd Jan 1986) aimed at identifying best available technology for minimizing SGCCWs and other key NSY wastes.

NAVSEA now desires that the SGCCW aspects of that precedent work be updated with stress being placed on current disposal practices, the RCRA status of these wastes (delistability potential), and the modifications needed, if any, in the work on-going at NCEL to achieve a capability of minimizing SGCCWs in conformance with CNO policy.

9. PRODUCT: The products will consist of a series of monthly progress reports, as requested by NAVSEA, and a final survey summary report.

10. METHOD OF PERFORMANCE: With the exception of commercial laboratory support, the project will be performed either entirely in-house or with NEESA support in the field survey activities.

11. NAVY NEED: The need for a hazardous waste reduction in the Navy of at least 50% has been promulgated by CNO and NAVSEA on several occasions. The magnitude of the SGCCW element of that problem has been explained in the HWM Initiation Decision Report (NCEL TM No. 71-86-03, dtd June 1987) and amounts to some 1,555 tpy (1984 data) at an annual disposal cost of $372,695 excluding Navy administrative and storage costs. It is projected that such costs will increase by a factor of at least three over the next six years, which with excluded operating costs, would represent an annual burden of about $1.5 million.

12. FUNDING:

Burdened NCEL Labor ---------------	$ 48,966
Commercial Lab Support ------------	8,750
Travel ----------------------------	9,075
Program Management Surcharge ------	5,409
Total	$72,200

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE: UPDATED SURVEY OF SGCWWs GENERATED AT FIVE NSYs

	DELIVERABLE	CY87												CY88												CY89												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA																																						
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR																																						
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ILS																																						
FFR																																						
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ILSP-A																																						
DT-1																																						
DT-1A																																						
DT-II																																						
OT-O																																						
OT-II																																						
OT-II-A																																						
UDP																																						
UG																																						
AFP																																						
ANU																																						
Progress Report, Monthly to MINS																X	X																					
Summary survey Report																		X																				
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE: UPDATED SURVEY OF SGCCWs GENERATED AT FIVE NSYs

	FY88				FY89				FY90				FY91				FY92				FY93				FY93				FY95			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Field Survey		==	C																													
2. Data Analysis & Test Plan Revision			=C																													
3. Final Survey Report Preparation			=C																													
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING	75																															
FUNDING/QUARTER	--	26	49	--	--	--	--	--																								
FUNDING RCP																																

Number 26
Environmental Protection Technical Proposal
No. 87-046/JZ

1. TITLE: Innovative Aircraft (A/C) Paint Systems Removal

2. NCEL POC: J. Zimmerle
Code L74B
Port Hueneme, CA 93043
A/V 360-5085

3. FAC POC: Ms. Elizabeth Ford
Code: 1121A
A/V 221-8531

4. PROPONENTS: NADEPs

5. OBJECTIVE: Provide the Navy a technology assessment of emerging techniques for removing A/C paint systems.

6. DESCRIPTION: NCEL is developing improved systems for removal of A/C coatings by non-chemical means and for the treatment of wastewaters that are now generated in using conventional chemical paint stripping procedures. In the former category, NCEL has been investigating the capability of utilizing plastic media blasting (PMB) for removing A/C paint. This approach has demonstrated a dramatic potential for minimizing chemical paint stripping and the attendant copious quantities of wastewater that are generated. The present effort aims at the study of alternative emerging techniques that might also be considered with PMB as suitable HWM candidates for A/C depainting.

7. TECHNICAL APPROACH: Initially, NCEL will conduct a thorough literature search, particularly including pertinent trade journals, to identify alternative emerging technologies of potential interest. The application slant will be emphatically towards NADEPs and the regulatory problems these activities now face. A portion of the study will be accomplished by contacting the principals developing and/or investigating the technologies whether within Industry, Academia, or government. Upon completion of the data collection phase, NCEL will project the impact of utilization of the various depainting techniques on HWM. A final report will be prepared that will contain information on the technological alternatives and a discussion of critical application factors, as well as concerns and uncertainties as to the use of such emerging processes.

8. BACKGROUND: Wet chemical paint stripping historically has been the means for removing coatings from thin skinned structures, such as A/C surfaces. While there are numerous commercial strippers available, mixtures based on phenol and methylene chloride (dichloromethane) are the most popular among users. These chemicals represent a hazard to the applicators and to the water supplies that are contaminated with paint stripping wastewaters that are inadequately treated. Treatment can become complex since this wastewater is

generally mixed with other industrial wastewater which is subjected to processing that does not chemically involve the toxic paint stripper constituents carried into the treatment works.

As a result of this situation, there has been a determined effort at the NADEPs to find alternative stripping procedures . These have included the use of automated techniques involving (peelable) dip coating and the introduction of non-phenolic paint strippers.

Research has been promoted for the development of even more advanced concepts. These include xenon flash lamp and laser techniques for removing paint films. Such techniques are still under development and require engineering solutions to bring down the costs of these man-power intensive processes.

Concurrently with these research efforts, the impact of utilizing PMB on A/C has begun to be demonstrated. A complete facility for stripping paint from tactical fighter planes has been put into operation at Hill AFB. While the appraisals of the PMB process have generally been favorable, some questions persist as to the aggressiveness of the plastic media on composite surfaces situated on A/C outer bodies. Fuller implementation may result when this and related problems involving industrial hygiene and explosion hazard are settled.

9. PRODUCT: A report in the form of a technology assessment will document the potential application of alternative emerging techniques for A/C depainting.

10. METHOD OF PERFORMANCE: This work will be accomplished essentially through application of in-house resources, although some contractual support may prove desirable.

11. NAVY NEED: The Navy, in its move away from chemical paint stripping, needs this project in order to adequately prepare criteria for the construction and conversion of depainting chambers to optimum non-chemical modes of operation. The information contained in the final report will also assist Navy personnel in achieving compliance with existing and future water discharge regulations dealing with both TTOs and VOCs.

12. FUNDING, ($K)/TASK

	FY88	
	WR	RCP
LITERATURE SEARCH	58	
TECHNOLOGY ASSESSMENT	65	
IMPACT ASSESSMENT/POLICY ANALYSIS	80	
DOCUMENTATION	27	
TOTAL:	230	

DELIVERABLE DOCUMENTATION SCHEDULE

PRODUCT TITLE:

	DELIVERABLE	CY88												CY89												CY90												CY-
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
IDR																																						
IDR-A																																						
TA	Technology Assessment									X																												
PMP																																						
PMP-A																																						
TEMP																																						
TEMP-A																																						
IFR																																						
RAM																																						
ILS																																						
FFR																																						
ILSP																																						
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UDP																																						
UG																																						
AFP																																						
ANU																																						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	

C = COMPLETION
D = DECISION POINT

PROJECT SCHEDULE:

	FY88				FY89				FY90				FY91				FY92				FY93				FY94				FY95			
MAJOR TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. Literature Search		==C																														
2. Technology Ranking		===	C																													
3. Impact Assessment/ Policy Analysis			==C																													
4. Report Preparation				==C																												
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL FUNDING	230																															
FUNDING/QUARTER		78	125	27																												
FUNDING RCP																																

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