

N00174.AR.000587
NSWC INDIAN HEAD
5090.3a

FINAL REPORT FOR ORDNANCE DISPOSAL STUDY 1 NOVEMBER 1983 WITH APPENDIX
NSWC INDIAN HEAD MD
11/1/1983
NAVFAC CHESAPEAKE

OLD

503
~~COMPLETED~~

FINAL REPORT

MAY - 2 1984

Ordnance Disposal Study Naval Ordnance Station Indian Head, Maryland

~~OFFICIAL USE
ONLY~~

~~COMPLETED~~

MAY - 2 1984

Prepared for

Department Of The Navy
Chesapeake Division
Naval Facilities Engineering Command
Washington, D.C.
November 1983

Booker
Engineers Architects Planners

Booker Associates, Inc.
St. Louis, Missouri

Prime Consultant

EDE

El Dorado Engineering Inc.
Salt Lake City, Utah

Sub-Consultant

TABLE OF CONTENTS

	<u>Page No.</u>
I. Authority and Scope	I-1
II. Background and History	II-1
III. - Executive Summary of Results	III-1
IV. Detailed Task Breakdown	IV-1
V. Glossary of Acronyms and Abbreviations	V-1
VI. Evaluation of Existing Facilities and Potential Modifications	VI-1
A. Feed Conveying and Grinding	VI-1
B. Slurry Weighing, Concentrating, Holding, Feed	VI-21
C. Wet Air Oxidation	VI-34
D. Fluidized Bed Incineration	VI-77
E. Wastewater Treatment	VI-90
VII. Analysis for Energy Recovery From the Facility	VII-1
VIII. Water Balance Analysis for Wastewater Treatment Facility	VIII-1
A. Increment I - Water Balance	VIII-1
B. Increment II - Water Balance	VIII-6
C. Alternate Wastewater Treatment Methods	VIII-10
IX. Economic Summary	IX-1
X. Additional Modifications for Disposal of 100 Percent of Ordnance Related Waste	X-1
A. Introduction	X-1
B. Waste Stream Definition and Characteristics	X-3

TABLE OF CONTENTS (continued)

	C. Pollution Control Requirements	X-5
	D. Disposal/Destruction Options	X-7
	E. Comparison of Thermal Destruction vs. Other Candidates	X-21
	F. System Plan for 100% Disposal	X-34
	G. Site Layout	X-54
	H. Recommendations	X-56
	I. Additional Options	X-56
XI.	Search for Alternate Off Base Disposal Sites	XI-1
	A. List of Materials	XI-1
	B. Survey of DOT Regulations and Transportability	XI-14
	C. Discussion of Off Site Disposal Possibilities and Costs	XI-17
	D. Permits and Five Year Projection	XI-24
XII.	Open Burning Option	XII-1
	A. Current Air Pollution Regulations	XII-1
	B. Background and History	XII-3
	C. Alternatives to Open Burning/Likelihood That it Will be Banned	XII-7
XIII.	Alternate Uses for All or Part of the PDF Facility	XIII-1
XIV.	Economic Summary - Alternate Disposal Methods, Alternate Uses	XIV-1

I. Authority And Scope

I. AUTHORITY AND SCOPE

This work was authorized by Contract N62477-80-C-0441 between the Chesapeake Division, Naval Facilities Engineering Command (CHESDIV), and Booker Associates, Inc.

This project very generally consists of providing A&E services for the evaluation of the disposal of propellant and explosive related waste generated at the Naval Ordnance Station (NOS), Indian Head, Maryland, with particular attention to the full scale demonstration Propellant Disposal Facility (PDF). The final report includes recommendations, based on economic analyses, for the NOS to meet its existing and future propellant and explosive material disposal requirements.

The project included field visits by the A&E to obtain information necessary to perform the engineering analysis, a preliminary draft report with briefing, a final report after incorporation of review comments, and a final briefing.

II. Background And History

II. BACKGROUND AND HISTORY

The Propellant Disposal Facility at the Naval Ordnance Station, Indian Head, Maryland was designed and constructed to demonstrate two alternative techniques for the disposal of scrap, excess, reject, and over-age solid propellants. Traditionally, these materials have been destroyed by open-air burning, which generates smoke, particulates, and creates environmental concerns for gaseous emissions, ground, and groundwater contamination.

The Clean Air Act of 1970 as amended implied the prohibition of open air burning of explosives and propellants. Passage of Public Law 94-580K known as the Resource Conservation and Recovery Act (RCRA) instigated the promulgation of the Hazardous Waste Regulations. Initial drafts of these regulations banned all open burning. This created severe problems for the Department of Defense (DOD).

A joint services panel, JCAP (Joint Conventional Ammunition Panel) provided review of the EPA draft and provided official DOD comment. In 1978 the EPA contracted with the American Defense Preparedness Association to study the state of the art in munitions demilitarization. One conclusion was that until other means exist open air burning was a simple and cost effective method of disposal. The JCAP panel ultimately recommended that EPA allow open burning of Propellant and Explosive (PEP) materials where developed alternatives did not exist. This recommendation was incorporated in the final regulations as 40 CFR 265.382. The state of Maryland Air Regulation 10.18.04B (3) similarly permits open burning of PEP material under certain conditions.

NOS has officially requested concurrence by both EPA and the state of Maryland as to this interpretation of the regulations as they apply to Indian Head PEP materials. Both agencies agree, and at the recommendation of the EPA, NOS has requested written permission of the Charles County Health Department (serving as Public Officer) to open burn waste munitions. No written permission has been received to date from Charles County. NOS does, however, operate under Permit No. A223 (Designated Hazardous Substances Facility Permit) issued by the State of Maryland through April 29, 1985. However, the continuing pressure to eliminate air pollution has led to the feeling that any exemption would not continue indefinitely, and from the start has given impetus to planning for eventual elimination of open-air burning entirely.

In Fall 1970, NAVORDSYSCOM funded a study of alternate disposal systems in an attempt to select a process that would provide for pollution-free disposal of these waste materials. The possibility of reclaiming wastes and/or propellant ingredients before or after treatment was also considered, but a market was never developed. The Propellant Disposal Facility (PDF) was the end result of these initial studies.

The original plan called for the PDF to be constructed in two phases, funded by separate Military Construction Projects. Phase I (or Increment I) has been constructed but not operationally tested. Phase II (or Increment II) is partially constructed. These first two phases even if operational, would be capable of disposing of only a portion of the total waste generated.

The first phase, MILCON Project P-879, constructed for disposing of single and double-base propellant wastes in a safe manner while meeting applicable solid waste, water and air pollution regulations and laws, utilizes wet air oxidation (WAO). When operational, the facility is intended to be capable of processing 10,000 lbs/day on three shifts. Construction was begun in 1975 and substantially completed in 1977.

The second phase, MILCON Project P-947, consists of a fluidized bed incinerator (FBI) for disposing of waste composite propellant formulations. These propellants contain aluminum, ammonia perchlorate, HMX, nitroguanidine, plastics, etc. When operational, the facility is intended to be capable of processing 20,000 lbs/day on three shifts. Construction was begun in 1977 and was halted prior to completion.

Additional MILCON phases have been proposed by the NOS which would enable the finished facility to dispose of additional propellant wastes now open-burned on station. These projects include:

- P-003 Propellant Disposal Sowing Facility;
- P-013 Contaminated Waste Flashing Furnace;
- P-014 Pyrotechnics Disposal Kiln.

In addition, small non-MILCON projects have also been proposed to correct deficiencies in the original designs of the first two phases.

As problems developed with initial testing of Phase I subsystems, and questions regarding the likelihood that Phase II components would perform satisfactorily with live propellants, it was decided to halt development and construction of both Phases pending further studies.

The basic objective of this project included performance of a study to include a complete review of the facility as designed and constructed to determine how it might be modified to be usable. An even more basic purpose was to determine a valid and reasonable approach for ultimate disposal of all propellant and related waste.

III. Executive Summary Of Results

III. EXECUTIVE SUMMARY OF RESULTS

We rec. constructing — etc.

The following is a brief summary of the results of studies addressing the specific areas which were investigated.

Evaluation of Existing Facilities and Potential Modifications

The current conveying system will not work as presently configured and would require substantial modification to replace certain of the elements with those of different design to produce a functional system. Suggested modifications would involve replacement and/or reconfiguration of vibrating conveyors which are intended to convey propellant uphill while under a water spray. Several conveyors would be changed to a horizontal configuration and others would be replaced by entirely different kinds. One option was evaluated which would make use of a type of grinder used elsewhere for explosives grinding. The proposed changes would, of course, require additional detailed design, and replacement conveyors and grinders would require an extensive safety analysis prior to purchase. If different types of conveying or lifting equipment were judged not acceptable by detailed analysis, the only alternative would be complete reconfiguration or replacement of Building 1569 to enable conveying by gravity in conjunction with vibrating conveyors. To modify the current conveying system to produce a working system does not, however, appear to be insurmountable if the considerable effort and expense could be justified by other decisions regarding the WAO or FBI. In other words, there does not appear to be a significant technology gap if the expense could be justified.

The slurry weighing, holding, and feed systems are judged to be basically functional, although since these systems have not been tested with propellant, unanticipated modifications could still be required. One area of concern is the centrifugal pumps which may or may not be suitable for pumping explosive slurries. Although we understand NOS has successfully used centrifugal pumps for similar applications in the past we feel additional investigation would be justified. It is also known, as revealed in furnished data, that the pumps which feed slurry to the high pressure WAO pumps develop insufficient suction head for the high pressure pumps under certain conditions. Again, modifications to produce a working system do not seem insurmountable from a technical standpoint.

The Wet Air Oxidation System (WAO) and its ancillary equipment have certain deficiencies which must be corrected prior to operating with propellant. The most important shortcoming is, we believe, scarcity of controls and instrumentation which are needed to enable a remote operator to prevent either bed dry-out or slurry carry-over as a result of process upsets. Because of minimal controls and informational data, we feel it

would now be difficult to correctly diagnose a problem and take corrective action. Adequate process control is essential due to the necessity for entirely remote operation. Other required modifications are considered minor. Furnished to us was a hazards analysis prepared on the WAO system by Hercules, Inc., Allegheny Ballistic Lab. This report identified twenty-eight (28) potentially hazardous situations. Ten (10) were judged sufficiently hazardous to analyze in depth. Results were that four situations were potentially hazardous enough to warrant design changes. Five other relatively minor changes were recommended. The report concludes that no significant uncorrectable problems exist. In general, it is our opinion that the WAO unit is not too far from being an operating unit to render successful modification impossible. It is recommended that if the further expense can be justified, it is feasible for work to continue on the system in an attempt to make it operational in the future.

The Fluidized Bed Incinerator system is only partially installed and totally untested. Furthermore, to our knowledge, this type of system has never successfully been used to dispose of composite or high energy propellants. Pilot scale and even full scale units have, however, been tested using propellant with varying success. The system existing at NOS has many obvious shortcomings, which would have to be corrected prior to operation. The technology to eliminate these problems has not been developed to the point that modifications could be designed and implemented with confidence that a safe, reliable, operational system would result. Furthermore, the expense can at this point be only grossly estimated, but would be very high. For these reasons (and others discussed more fully in the text), we do not recommend further development at this time.

The problems associated with the Wastewater Treatment systems do not appear to be fundamental in nature, but more in the nature of improvements and troubleshooting which would be necessary to learn the operating characteristics of the system. Problem areas still exist regarding ultimate sludge and blowdown water disposal, several key pieces of equipment are missing, and the plant, if operational, would consume much energy.

Although modifications are recommended, if the far more complex problems associated with other key portions of the facility were overcome, modifications associated with wastewater treatment could be achieved relatively easily and at relatively moderate cost by comparison. An alternate treatment system without the high energy costs associated with the wiped film evaporators was developed to see if it would be practical. Order of magnitude cost estimates for an alternate treatment system are very high.

Analysis for Energy Recovery from Facility

Assuming that the WAO unit and/or the FBI unit will someday be operational, several opportunities exist for energy conservation: (1) heat recovery from hot gas leaving the FBI to heat incoming air; (2) heat recovery from the FBI catalytic oxidizer leaving air to preheat the entering air; (3) recovery of heat from the vapor condensing side of the wiped film evaporator; (4) use of air preheaters on boilers; (5) heat recovery from WAO afterburner gas discharge to heat incoming air; (6) heat recovery from the FBI gas quench system; (7) energy recovery from the WAO liquid/gas separator pressure reducing system. Analyses for economics of the modifications indicate that items (1), and (4) would be worthwhile provided the facility could be made operational for ten years at the projected rate. *Since we do not feel they are multi-ite, etc -*

Water Balance Analysis for the Waste Treatment Facility

Under this task, all water transferred to and from the treatment facility for each Increment was examined. Our conclusion was that although initially much water is required for propellant slurring and, by nature of the process, much water is evaporated in the FBI, water is handled in a conservative manner. Nearly all the water handled in the water treatment plant is recovered and made available for reuse for producing additional slurry or for initial filling of chemical treatment tanks within the water plant. As previously mentioned, one hypothetical alternate treatment process was investigated.

Study for Disposal of 100 Percent of Ordnance Related Waste

During this phase, alternate propellant disposal equipment combinations were evaluated which would be capable of disposing of all ordnance related waste generated at NOS. The present Propellant Disposal Facility would dispose of only a relatively small fraction of the total waste generated even if entirely functional.

The thrust of this task was modified somewhat just prior to the draft submitted in September. Originally we were to determine that additional equipment required for and capable of 100 percent waste disposal. By modification we were asked in addition to determine the optimum combination of methods such as use of the existing PDF, continued open burning, new facilities, and off base disposal to handle all wastes. This was a formidable task because of the enormous number of combinations and difficulty in estimating all costs accurately. However, we have succeeded in developing eight options ranging from continued open burning, to shipping most material off base, to construction of major new facilities at NOS for thermal destruction of the NOS waste load. Equipment system

combinations evaluated included a Contaminated Waste Processor (CWP), an Explosive Waste Incinerator (EWI), a Wet Air Oxidizer (WAO), a Fluidized Bed Incinerator (FBI) and a Deactivation Furnace (DF). These would be used in conjunction with size reduction facilities (SRF) to handle the entire waste load. The recommended ultimate solution features a size reduction facility, a contaminated waste processor, and a modified explosive waste incinerator. We would recommend stepped implementation, with continuation of open burning for the present and gradual elimination of open burning as new facilities are constructed. Our recommended priorities would be to first initiate design and construction of a CWP. At the same time, begin to determine positively which wastes can be shipped elsewhere for disposal and negotiate with other sites and/or agencies so that this option may be started. Next, design and construct a SRF. When in place, a greater portion of the waste load may be disposed of by shipping off post. Finally, construction of an EWI will enable 100 percent disposal at NOS.

Search for Alternate Off-Base Disposal Sites

This task involved surveying private industry and government agencies to determine if NOS originated waste could be practically disposed of elsewhere. The scope of work was modified during the study to include a transportability study of NOS wastes, a comprehensive study of Department of Transportation Regulations and investigation of whether potential off site disposers could obtain a Phase B RCRA permit. Results indicate that although packaging and transportation costs would be high, nearly all of the material can be transported in accordance with DOT regulations if properly packaged. Numerous possible sites exist which may be able to accept a portion of the waste. This option has been included in our recommended long-range disposal plan.

Continuation of Open Burning

A survey of current and future probable air pollution regulations was performed and correspondence with persons knowledgeable in the field was sought in an attempt to determine how long open burning was likely to be permitted. The conclusion is that open burning is likely to be permitted for at least the next five years.

Alternate Uses for All or Part of the PDF

As part of this task, various alternates were examined which could utilize any or all of the components in the PDF. Alternates studied included silver recovery from film, sludge disposal, solid waste disposal, steam production, etc. Results show that silver recovery could be cost effective depending

risk
factor →

upon the amount available for processing. Other alternatives are currently being handled in a more cost effective manner than would result from using the WAO or FBI.

Economic Summary

The cost for implementing all modifications to produce a PDF facility which would perform as desired is estimated to be greater than \$3,800,000. This includes development of a fully functional Fluidized Bed Incinerator, the cost of which is a very gross approximation at best (since a totally successful unit has never been developed despite much effort). If the expected cost of commissioning and spare parts is added using previous NOS estimates, the total cost would be greater than \$6,500,000. Implementing energy recovery where cost effective would result in a total cost of approximately \$100,000 but would pay back in less than 10 years if operational.

On the other hand, abandoning this PDF for other purposes, and instead, building new facilities including size reduction facilities for disposal of 100 percent of ordnance related waste would cost approximately \$3,800,000. This breaks down as \$1,200,000 for Size Reduction Facilities, \$1,400,000 for a Contaminated Waste Processor, and \$1,200,000 for a modified Explosive Waste Incinerator. Thus, for the same construction dollars, a facility for disposal of 100 percent of NOS waste could theoretically be constructed; whereas, a modified PDF would destroy only a portion of the waste load.

The eight options were analyzed in accordance with NAVFAC P-442, Economic Analysis Handbook. The options range from continued open burning to construction of new facilities for 100 percent on base disposal, and included options for modification of the WAO and ~~WFI~~ as well as shipping varying percentages of the waste off base. Of course, the most cost effective choice was continued open burning. The most cost effective first option was construction of a CWP and shipping some waste off base in conjunction with some open burning. The minimum effort to eliminate open burning entirely would be to add a SRF to enable more waste to be packaged for off base disposal.

IV. Detailed Task Breakdown

IV. DETAILED TASK BREAKDOWN

The project work was organized along the lines of the tasks presented in the Scope of Work. These major task items were supplemented by and broken down into numerous sub tasks. These subtasks were defined during the project negotiating phase, and formed the basis of the work plan. These tasks and subtasks are listed hereinafter.

TASK OUTLINE

A. Evaluate Existing Facilities Including Funded Mods

1. Initial scoping meeting and field work.
2. Obtain/review drawings, specs, design and resource documents, environmental requirements.
3. Evaluate waste stream input (type, size, shape, quantity).
4. Evaluate feed, conveying, grinding systems.
5. Evaluate slurry weighing, concentrating, holding, and slurry feed systems.
6. Evaluate wet air oxidation systems and ancillary equipment.
7. Evaluate fluidized bed incinerator systems and ancillary equipment.
8. Evaluate wastewater treatment equipment and interfaces with WAO, FBI, etc.
9. Follow-up field visits.

B. Propose Additional Modification and/or Process Alterations to Enable Operation as Intended

1. Develop mods to feed, conveying, grinding systems (if any).
2. Develop mods to slurry weighing, concentrating, holding, and slurry feed systems (if any).
3. Develop mods to wet air oxidation system and ancillary equipment (if any).
4. Develop mods to fluidized bed incinerator system and ancillary equipment (if any).

5. Develop mods to wastewater treatment facility (if any).
6. Develop mods to utility systems (if any).
7. Develop mods to process control and instrument systems (if any).
8. Develop process mods (if any).
9. Develop building mods (if any).

C. Additional Mods for Disposal of 100% of Ordnance Related Waste

1. Evaluate propellant size reduction facility.
2. Evaluate contaminated waste flashing furnace.
3. Evaluate explosive waste incinerator.
4. Evaluate pyrotechnics disposal kiln.
5. Evaluate recycling facility.
6. Develop proposed site layout and block diagrams.

D. Evaluate Other End Uses for Facility

1. Survey other potential wastes for disposal (sludges, hazardous wastes, etc.).
2. Screen and select potential candidates for further study.
3. Evaluate additional process requirements.
4. Prepare block diagrams and schematics.

E. Analysis for Energy Recovery from Facility

1. Study potential energy recovery from wet air oxidation systems.
2. Study potential energy recovery from fluidized bed incinerator systems.
3. Evaluate recovery equipment options.
4. Compute energy/cost, benefit/cost and payback periods for promising opportunities.

5. Conclude and recommend.

F. Search for Alternate Off Base Disposal Sites

1. Survey military and government sites.
2. Survey private industry sites.
3. Conduct transportability analysis of NOS waste stream.
4. Survey DOT regulations and potential transportation problems.
4. Survey federal, state, and local laws at potential sites.
5. Evaluate ability of potential sites to obtain Phase B RCRA permit.
6. Conclude and recommend with five year forecast for off site disposal.

G. Water Balance Analysis for Water Treatment Facility

1. Analyze treatment plant water balance in various operating modes.
2. Develop potential equipment or process mods for water conservation and reuse.
3. Propose and recommend.

H. Economic Analysis of All Functions Considered

1. Prepare construction cost estimates for Potential Modifications Required for:
 - a. Complete facility as-is.
 - b. Modify to fulfill initial intent.
 - c. 100% disposal methods.
 - d. Other end uses.
 - e. Energy recovery.
 - f. Alternate disposal sites.
 - g. Water conservation methods.
2. Perform appropriate economic analyses for promising options.
3. Conclude and recommend.

I. Open Burning Option

1. Study current air pollution regulations.
2. Study proposed draft air pollution regulations.
3. Evaluate probability of continued open burning allowability.
4. Study costs to open burn increments up to 100% of propellant and explosive waste.
5. Propose and recommend.

J. Reporting and Briefing Phases

1. Prepare plan of action and schedule.
2. Prepare monthly status reports.
3. Prepare draft report.
4. Draft briefing.
5. Prepare final report.
6. Final briefing.

V. Glossary Of Acronyms And Abbreviations

V. GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ARRADCOM	Army Research and Development Command
CHESDIV	Chesapeake Division, Naval Facilities Engineering Command
CF	Chemical Feed
CPVC	Chlorinated Polyvinyl Chloride Plastic
CCTV	Closed Circuit Television
CP	Composite Propellant
CWP	Contaminated Waste Processor
CW	Cooling Water
COE	Corps of Engineers
DF	Deactivation Furnace
DLA	Defense Logistics Agency
DOD	Department of Defense
DOT	Department of Transportation
EW	Effluent Water
EPA	U. S. Environmental Protection Agency
EWI	Explosive Waste Incinerator
FRP	Fiberglass Reinforced Plastic
FBI	Fluidized Bed Incinerator
GPM	Gallons Per Minute
HEP	High Energy Propellant
HP	Horse Power
JCAP	Joint Conventional Ammunition Panel
MILCON	Military Construction
NOS	Naval Ordnance Station

NAVORDSYSCOM	Naval Ordnance System Command
NPSH	Net Positive Suction Head
N.I.C.	Not In Contract
OESO	Ordnance Environmental Support Office
OS	Oxidized Slurry
OSV	Oxidized Slurry Vapor
PCV	Pressure Control Valve
PRC	Pressure Regulation Controller
PDF	Propellant Disposal Facility
PEP	Propellant, Explosives, Pyrotechnics
PSI	Pound Per Square Inch
RAAP	Radford Army Ammunition Plant
RCRA	Resource Conservation and Recovery Act
RPM	Revolutions Per Minute
RW	River Water
RKI	Rotary Kiln Incinerator
SDW	Scrubber Discharge Water
SRF	Size Reduction Facility
SW	Slurry Water
TDH	Total Design Head (Total Discharge Head)
TW	Treated Water
WDF	Western Demilitarization Facility
WW	Well Water
WAO	Wet Air Oxidation
V	Vacuum

**VI. Evaluation Of Existing Facilities
And Potential Modifications**

VI. EVALUATION OF EXISTING FACILITY
AND POTENTIAL MODIFICATIONS

A. Evaluate Feed, Conveying, and Grinding Systems. Develop Modifications to Feed, Conveying, and Grinding Systems (if any)

General. All propellant feed and grinding equipment is associated with Building "F", number 1569 Shredder Building, a tri-level, three bay structure (with an additional bay added as part of Increment II).

The Increment I feed system consists of a truck weigh scale, receiving hopper, nine vibrating conveyors, one vertical spiral vibrating conveyor, one primary grinder, one final fine grinder, and two 8" pneumatic pinch valves at conveyor transfer points. Under Increment II, an additional bay was constructed to house several more conveyors, a relocated grinder, and several additional pinch valves. This equipment was not installed. All conveying and grinding is done under a continuous water spray. The ground propellant is slurried with water in the last bay in preparation for transfer to Building 1570 where the slurry is adjusted to produce the proper solids concentration and stored for thermal destruction.

Feed and Grinding System Components - Increment I

- 1) Truck weigh scale
- 2) Material receiving hopper T-100
- 3) Vibrating feeder M-100
- 4) Vibrating weigh conveyor M-101
- 5) Vibrating conveyor with metal detector M-102
- 6) Vibrating conveyor M-106
- 7) Vibrating conveyor M-107
- 8) Vibrating conveyor M-108
- 9) 8" pneumatic pinch valve
- 10) Vibrating twin deck screen conveyor M-103
- 11) Vibrating conveyor M-109
- 12) Primary grinder G-100
- 13) Vibrating conveyor M-110
- 14) Vibrating spiral vertical conveyor M-104
- 15) Vibrating conveyor M-105
- 16) 8" pneumatic pinch valve
- 17) Final fine grinder G-101
- 18) Sizing screen
- 19) Crusher tank T-101
- 20) Dewatering pump P-100

- 21) Dewatering screen H-100
- 22) Slurry tank T-102
- 23) Slurry pump P-101

Summary - Increment I

Propellant conveying, grinding, initial propellant slurring systems housed in Building #1569 (Shredder Building) have been installed and essentially are complete including the building.

Since the system was completed, many tests have been conducted in an effort to make the conveying and grinding system operational. Tests conducted to date have had negative results. Parts of the system tested have been the initial feed conveyors, the vertical spiral conveyor, primary grinder, and water spray system. The only piece of equipment which performed in accordance with design requirements was the primary grinder. The single most significant problem is that of conveying a wide variety of propellant shapes and sizes up hill under a water spray.

All vibrating conveyors were furnished by "Rexnord" vibrating equipment division. In June of 1979, Rexnord conducted several tests on site and in their laboratory. These tests had negative results. At this same time several design changes were recommended and tried. Some improvement was achieved in performance of the inclined conveyors but none performed entirely satisfactorily. The vertical spiral conveyor was entirely unsatisfactory for this use. Several changes in the water spray system were incorporated but the system as a whole is still inoperable.

In February of 1981, NOS stopped any further construction or testing on the facility leaving a facility which is nonfunctional.

Evaluation of the components and overall system indicates very basic changes would be necessary to provide an operating system. The most fundamental would involve major modification of the building and conveying equipment to enable downhill material progression. Site topography would limit the options to either raising the first bay and hopper loading area considerably, or lowering the elevation of the third bay by 10 to 15 feet, or some combination of these. In addition modifications to all or most equipment arrangements and elevations would be required. This option would be extremely expensive.

A second possibility is replacement of the vibrating spiral conveyor with a different type of conveyor entirely, and reconfiguration of other conveyors to the horizontal. Two alternatives have been developed using this approach for purposes of determining order of magnitude costs. The systems developed feature lift type belt conveyors. It is realized and understood that the proposal to use this type of conveyor would require extensive examination from a safety standpoint, and much resistance may be encountered. However it is felt that development of some type of conveyor along this line could be achieved which could be designed to achieve basic safety requirements if operation of the entire PDF depended on it. To repeat, the systems proposed illustrate types of changes and order of magnitude costs rather than a concrete proposal for use of this particular equipment.

Description of Process

Propellant is conveyed from the receiving hopper by a vibrating feeder M-100 to a vibrating weigh conveyor M-101 which then feeds vibrating conveyor M-102 which contains a fiberglass metal detecting section. If propellant contaminated with metal is detected in the propellant the propellant is diverted to a three vibrating conveyor loop (M-106, M-107, M-108) for removal of the metal. The system is stopped, metal removed, re-started and the metal free propellant is conveyed to the second bay of the Shredder Building through an 8" pneumatic pinch valve to a double deck screen vibrating conveyor M-103 for further sizing. Propellant smaller than 1-1/2" in size is passed along to the vertical spiral vibrating conveyor M-104. Propellant larger than 1-1/2" in size is diverted to another vibrating conveyor M-109 which feeds the propellant into the primary grinder G-100.

The primary grinder reduces the propellant in size to 1-1/2" discharging the propellant to vibrating conveyor M-110 which then conveys the propellant back upon the double deck conveyor. Ultimately, when properly sized, all of the propellant is conveyed to the vertical spiral vibrating conveyor.

The propellant is to be lifted by the spiral vibrating conveyor approximately 9'-10" and discharged onto vibrating conveyor M-105 which conveys the material into the third bay of the Shredder Building, discharging the propellant through another 8" pneumatic pinch valve into the propellant final fine grinder G-101.

The propellant final fine grinder is to reduce the propellant size to 1/16" or less. The grinder is installed in such a way that material is fed from the grinder over a 1/16" mesh screen. Propellant larger than 1/16" is recirculated through the grinder until all propellant is reduced in size to 1/16" or less.

The fine ground propellant is discharged from the final grinder and screening into a storage tank (T-101) where water is added creating the propellant slurry.

Tank T-101 acts as a slurry recirculating tank and the newly created propellant slurry is pumped by pump P-100 into slurry collection tank T-102. Pump P-101 pumps the slurry to the propellant slurry storage building "A" number 1570.

The complete conveying and grinding system is designed to be operated under a continual water spray to prevent any propellant heat build-up and/or ignition.

Component Evaluation

1) Truck Weigh Scale

Description. The scale is 22'-0" long and 9'-0" wide with a capacity of up to, but not exceeding 30,000 pounds. The scale platform is of reinforced concrete construction with channel framing. The scale is installed in a pit with platform at grade level. The scale indicating mechanism is installed next to the platform upon the necessary foundation.

Evaluation. The scale is installed in accordance with good engineering practice, and should operate satisfactorily.

Potential Modification. As installed, no modifications would be required.

2) Material Receiving Hopper, T-100

Description. The hopper is of rectangular inverted pyramidal design with a capacity of 100 cubic feet. The hopper is fabricated of stainless steel, all welded construction and supported by four legs of carbon steel.

Evaluation. As installed, it appears the hopper would meet design and functional criteria.

Potential Modifications. None anticipated. However, the hopper discharge opening is mounted very close to the feeder. A full hopper of material may block the opening. Reconfiguration of the hopper and conveyor system may correct this problem. If not, it may be desirable to reduce maximum propellant size from 8" cube to 5" cube. Further testing is advisable, with subsequent modifications based upon results.

3) Vibrating Feeder M-100

Description. The feeder has a 12" wide, five foot long stainless steel trough with structural components of carbon steel. The feeder is of the coil spring suspension eccentric shaft vibrator type. Feeder will receive a 1500 pound charge of material and will feed the material at a rate of 500 pounds per hour, with the rate controlled in response to weigh conveyor M-101.

Evaluation. The feeder is mounted horizontally and should function in accordance with the design requirements.

Potential Modification. None anticipated.

4) Vibrating Weigh Conveyor M-101

Description. The conveyor has a stainless steel trough with mechanical and structural conveyor components of carbon steel. Conveyor is coil spring mounted with eccentric shaft vibrator. Weigh cells with necessary electronic equipment for continuing feed, weight read out and set to convey 500 pounds per hour of material control feed speed of Feeder M-100.

Evaluation. Conveyor should function per design requirements. However this conveyor is several inches wider than conveyor M-102 which it feeds. It appears propellant being conveyed will spill over upon the floor at this transfer point.

Potential Modifications. See Item 5 below.

5) Vibrating Conveyor M-102, with Metal Detection Section

Description. Conveyor has a stainless steel trough except where the magnetic metal detector is located.

This section of the trough is of fiberglass. The trough also has a deflection gate to divert the conveyed propellant to Conveyor M-106 if metal is detected. The mechanical and structural components of the conveyor are of carbon steel. Vibration is of the leaf spring type suspension with excentric shaft vibrator. Rate of feed is constant at a nominal 500 pounds of material per hour maximum.

Evaluation. During performance tests, this conveyor did not perform adequately. The tests were performed using inert materials with similar characteristics and sizes as live propellant. The water spray system designed for the conveying and grinding system was also utilized during testing.

This Conveyor (M-102) like conveyors M-106, M-108, M-109, and M-110 are intalled on a slope, feeding up hill. When tested the large pieces of material were conveyed slowly (or not at all) often tumbling towards the low feed end. The very small pieces of material were washed to the feed end of the conveyors by the water spray system. The spray system was modified and the amount of water spray reduced. This resulted in a slight improvement of conveyor performance, but not enough to make the system functional.

Potential Modifications. This conveyor would probably operate properly if it were installed level or feeding slightly down hill. It would also be advisable to install a product chute large enough to receive material from Conveyor M-101 to prevent product from spilling upon the floor.

It must be noted that modifications recommended for individual pieces of equipment in order to make them function according to design specifications would not necessarily make the entire system function properly. Descriptions of several potential overall system modifications are presented hereinafter.

6) Vibrating Conveyor M-106

Description. Conveyor has a stainless steel trough with mechanical structural components of carbon steel. Vibration is of the leaf spring type suspension and eccentric shaft vibrator. As installed, it must also feed up hill. Feed rate is constant at system design capacity.

Evaluation. Performance tests conducted on this conveyor were similar to those for conveyor M-102.

Potential Modifications. See Item 5 above.

7) Vibrating Conveyor M-107

Description. Conveyor is of same construction as conveyor M-106 above.

Evaluation. This conveyor during tests appeared to function properly. However, this unit is mounted horizontally.

Potential Modifications. None recommended.

8) 8" Pneumatic Pinch Valve

Description. The pinch valve is a standard manufactured unit with the body of aluminum and valve sleeve of rubber. The valve operates on plant compressed air which closes the valve when released by a solenoid valve activated by the deluge system. Under normal conditions, material fed from conveyor M-102 passes through the valve to conveyor M-103.

Evaluation. Feeding material up to 8" in size through an 8" valve at 500 pounds per hour will very likely cause a blockage. The purpose of this valve was to prevent the spreading of an incident from one section of the building to another.

Potential Modifications. Replace valve with larger unit (12" valve) or reduce maximum feed size to 5" cube. An alternate is major reconfiguration of system as discussed hereinafter.

10) Vibrating Twin Deck Screen Conveyor M-103

Description. The conveyor has a stainless steel trough with a depth great enough such that the upper portion of the trough contains a scalping screen to pass 1-1/2" propellant size, and a diverter gate to divert larger propellant to conveyor M-109. The mechanical and structural components of the conveyor are of carbon steel the vibrator is of leaf spring suspension with eccentric shaft vibration.

Evaluation. This unit as installed (which is essentially level) should operate in accordance with design requirements.

Potential Modifications. None anticipated. However, unit must be performance tested if feed system is put into operation.

11) Vibrating Conveyor M-109

Description. Conveyor is of same construction and operating characteristics as M-106 above.

Evaluation and Potential Modifications. Same as far conveyor M-102 above.

12) Primary Grinder, G-100

Description. This unit was furnished by the Government. It is a Rietz Extractor Model RE-IS-K7E-328. All parts which contact the product are of 304 stainless steel. Grinder is essentially a meat grinder type. Unit has a screw which feeds the material through a slotted disc with a rotating blade which chops the material to the desired size. The drive is a chain and sprocket type providing a final grinder speed of 15 RPM from a 15 HP motor.

Evaluation. On tests with inert material it reduced the material to the required size. It is understood that this type of grinder has been previously approved from a safety standpoint. If not, additional controlled testing of an identical unit using live propellant is recommended. Our experience with other grinders indicates that this unit may be somewhat under powered for the variety of shapes, sizes, and consistencies it must grind.

Potential Modifications. None recommended at this time pending further operating experience.

13) Vibrating Conveyor M-110

Description. Conveyor construction and performance same as conveyor M-102.

Evaluation. See Item 5 above.

Potential Modifications. Several alternatives are discussed in later sections.

14) Vibrating Vertical Spiral Conveyor M-104

Description. The conveyor trough and all components which come in contact with the propellant are fabricated of stainless steel. All mechanical and structural components are of carbon steel. Vibrating unit is of coil spring suspension, ceiling hung, with floor mounted stabilization, and an eccentric vibrator.

Evaluation. Performance tests on this unit in the field and in the laboratory indicated the unit was not satisfactory for the intended use. Many suggested modifications or substitutes including a fluidized bed were tried all with negative results. Tests conducted on the vertical conveyor with water spray off gave positive results. However, since wet material tends to adhere to the conveyor even without water spray, to successfully operate in this mode would require elimination of the water spray throughout the building, not just at the vertical conveyor. Previous safety analysis have judged this to be unacceptable. It is, therefore, mandatory that this unit be replaced by a different type of conveyor, or the entire building must be reconfigured.

Potential Modifications. See discussion under overall system modifications.

15) Vibrating Conveyor, M-105

Description, Evaluation, Potential Modifications. Conveyor construction, evaluation, and recommended modifications are the same as for Conveyor M-102 above.

16) 8" Pneumatic Pinch Valve

Description. Material from Conveyor M-105 passes through valve to Final Grinder G-101. This valve is identical to Item 9.

Evaluation and Potential Modifications. The pinch valve is fed by Conveyor M-105. Propellant being fed by M-105 is 1-1/2" minus in size so passing material through the valve should pose no problem. No modifications recommended.

17) Final Fine Grinder, G-101

Description. The grinder is a Rietz Angle Disintegrator, Model RP-12-K122. All parts which contact the product are of 304 stainless steel. The unit has 12" diameter rotor, with 6-1/4" high screen and 20" diameter fabricated bowl. Grinder is driven by a 25 HP motor through a gear reducer.

Evaluation and Potential Modifications. Grinder should be capable of meeting performance criteria. Recommend no modifications, but grinder should be performance tested. No evidence to date that this has been done.

18) Sizing Screen

Description. The sizing screen is a functional part of final fine grinding. Three sizes of sizing screens are provided. A 1/2 inch round hole full circle, 3/8 inch round hole full circle, and 1/4 inch round hole full circle screen.

Evaluation and Potential Modifications. Screen should function in conjunction with grinder as required. Since no performance tests have been performed, no modifications recommended.

19) Crusher Tank, T-101

Description. This tank is vertical with a 4'-0" nominal diameter and 3'-0" high on the straight side, with a open top and cone bottom. The tank is fabricated of 316 stainless steel with A36 carbon steel supporting legs. On the side of the tank is one 3" nozzle and a 6" level instrument spud. In the center of the cone bottom is a 1-1/2" drain nozzle. Top rim of the tank has a reinforcing angle ring and into the top of the tank are three 1-1/2" slurry recirculating pipe lines, one 1" water pipe line and the conduit for propellant from grinder G-101. The 1-1/2" bottom drain discharges to pump P-100 and the 3" side nozzle discharges to tank T-102. The nominal slurry capacity of the tank is 300 gallons. Instrumentation includes a liquid level transmitter and controller which control water flow into the tank.

Evaluation. Slurry is formed in this tank by mixing water with the propellant from the grinder. The slurry is continually circulated through the grinder and tank over a dewatering screen which removes the correctly sized propellant sending it to tank T-102. All valving for the system is manual and it may be difficult to balance the recirculating slurry piping as new material is continually being added. However it does appear the tank will function properly if balanced.

Potential Modifications. It seems that more instrumentation would be advisable, but to determine exactly what kind and how much would require additional testing. An allowance for some additional instrumentation has be included in the cost estimates. Piping and recirculating pump P-100 seem adequate for amount of material being handled.

20) Dewatering Pump P-100

Description. This pump is a Goulds horizontal centrifugal model No. 3196 constructed of 316 stainless steel and mounted upon a carbon steel base. The pump size is 1 x 1-6 with a 4.06" diameter impeller delivering 30 GPM at a 70 ft TDH, and powered by a Westinghouse 3 HP, 3515 RPM motor.

Evaluation. Pump should perform its design function, but selection of pumps for pumping a PEP slurry is important from a safety standpoint. The pumps moving parts should have ample clearance to prevent pinching of energetic material particles. Also moving parts contacting the slurry should be nonsparking. It is assumed the pumps selected have been used elsewhere for pumping the same type of material as being handled in this system. If not, considerable evaluation and testing of the specific unit will be necessary for usage approval.

Potential Modifications. None anticipated, however if pumps have not been tested for this type of service, they will require testing or replacement by a previously qualified pump.

21) Dewatering Screen, H-100

Description. The screen is a vibrating type, consisting of three sections clamped together with quick disconnecting clamps. The base section is of carbon steel and includes the drive system. The middle section is the collection pan and the top section is the screen, both are 304 stainless steel. The screen is 1/4" mesh and with an area of 4 square feet.

Evaluation. As constructed, it appears the screen should perform satisfactorily.

Potential Modifications. None anticipated.

22) Slurry Tank, T-102

Description. This tank is vertical with a 6'-0" nominal diameter and 4'-0" high on the straight side with an open top and cone bottom. The tank is fabricated of 316 stainless steel with A36 carbon steel supporting legs. The top rim of the tank has a reinforcing angle ring. On the side of the tank for a level instrument is a 6" nozzle and in the center of the cone bottom is a 1-1/2" drain nozzle. The

dewatered propellant from screen H-100 flows by gravity into the top of tank and a 3" pipe line from tank T-101 and 1" and a 1-1/2" pipe line for recirculated slurry also enters the tank top. Through the bottom 1-1/2" nozzle the slurry is removed by pump P-101A or P-101B. The nominal slurry capacity of the tank is 1000 gallons. Instrumentation includes a level transmitter, level indicator high and low level.

Evaluation. The slurry created in tank T-101 is stored in this tank T-102 for delivery to slurry storage tanks in Building 1570. This tank and necessary components should function to system requirements. However it appears more instrumentation could make the system easier to operate.

Potential Modifications. Instrumentation is an area where some modifications would be beneficial. All flow to and from tank T-102 is essentially controlled using manual valves. This could make the system tedious to balance. One instrumentation improvement would be a low slurry level shut off switch for pump P-101A and P-101B which would prevent pumping the tank and part of the system dry. Additional instrumentation is probably desirable, but to determine exactly what kind is difficult without operating the system. If the system were operated, instrumentation needs could be more easily determined.

23) Slurry Pump, P-101A

Description. This pump is a Goulds horizontal centrifugal model No. 3196, constructed of 316 stainless steel and mounted upon a carbon steel base. The pump size is 1 x 1-6 with a 4.68" diameter impeller, delivering 33 GPM at a 98.2 ft TDH and powered by a Westinghouse 5 HP, 3505 RPM motor.

Evaluation and Potential Modifications. See Item 20 above.

24) Slurry Pump, P-101B

Description. This pump is a Durco horizontal centrifugal model Mark II constructed of Alloy D (316 stainless steel) and mounted upon a carbon steel base. The pump size is 1 1/2 x 1 6/57 delivering 36 GPM at a 134 ft TDH, and powered by a Westinghouse 7.5 HP, 3500 RPM motor.

Evaluation and Potential Modification. See Item 20 above.

Feed and Grinding System Components - Increment II

- 1) Pinch Valves
- 2) Feed Conveyor M-815
- 3) Special Conveyor M-814
- 4) Precrusher Feed Conveyor M-811
- 5) Precrusher G-811
- 6) Precrusher Return Conveyor M-812

Summary - Increment II

Findings during study of Increment II systems are essentially the same as those for Increment I. The entire conveying and grinding systems need redesign to function as intended.

Description of Process

The exact purpose of this equipment is not clear from study of the plans and specifications. The equipment was not installed. Late in Increment I design, Conveyors M-109 and M-110 were extended to serve equipment to be located in the new bay to be added during Increment II.

A second primary crusher or grinder (G-811) located in the new bay was to be added served by the added conveyors and valving.

Evidently, a diverter gate located near the G-100 primary grinder could be actuated resulting in delivery of propellant to either the G-100 grinder or a series of conveyors leading to the G-811 precrusher. After crushing, the material would be returned to conveyor M-110 and back to the main flow stream.

The added bay is essentially complete from an architecture/structural standpoint, but is empty.

Component Evaluation

- 1) Pinch Valves

Description. The pinch valves are 12" and 8" diameter, respectively, with 125 lb. flanged ends. Valve body material is 304 stainless steel, with non-combustible or flame retardant rubber liner. Valve is operated by 100 psig air. The first valve accepts material from conveyor M-109 and transfers it to feed conveyor M-815. The second valve accepts material from conveyor M-812 and returns it to M-110.

Evaluation. If the system were installed and operational (which it isn't), it appears that these individual components would perform satisfactorily.

Potential Modifications. See general discussion herinafter.

2) Feed Conveyor M-815

Description. This conveyor (as well as all others) is designed to convey material ranging in size from 6", 50 pound cubes to 1/2 inch diameter by 2 inch long long grains. The design conveyor rate is 1000 lb/hr. The conveyor was to be suitable for corrosive and explosive material. The conveyor feeds Special Conveyor M-814.

Evaluation. Equipment is not installed so evaluation not really possible. Conveyor is shown installed horizontally so probably would function if installed.

Potential Modifications. See general discussion hereinafter

3) Special Conveyor M-814

This unit is designed to lift material 8'-0" to feed the precrusher G-811. Materials of construction are identical to the other conveyors. Conveyor is a special vibrating type hung from ceiling structural steel.

Evaluation. Based upon experience with Increment I conveyor, there is no chance that the conveyor would work if installed.

Potential Modifications. See general discussion hereinafter.

4) Precrusher Feed Conveyor M-811

Description. Conveyor is similar to others except ceiling hung. Length is 3'-9".

Evaluation. Would be installed horizontally so would work if installed.

Potential Modifications. See general discussion hereinafter.

5) Precrusher G-811

Description. This unit is government furnished and no data is available to describe it.

6) Precrusher Return Conveyor M-812

Description. This conveyor is a floor-mounted vibrating type of the same material as the others. Unit has screened section for water draw off at crusher discharge. Unit is 15'-0" long.

Evaluation. Unit was to have been installed on an incline so probably would not have worked satisfactorily.

Potential Modifications. See general discussion hereinafter.

Potential Increment II System Modifications - General

As previously stated, this equipment has not been installed. It was not installed because it is highly doubtful that it would have worked. We concur that this portion of the work was rightfully abandoned. Potential system modifications are discussed in the next section considering the overall mission and not with regard to the two separate increments.

Potential Systems Modifications

1) Discussion of Past Modification Attempts

In August 1978, a functional test of the conveyor system was conducted at NOS. The test used inert propellant representative of the full range of sized to be disposed of except 8" cubes.

The conveyor system did not meet the required performance in several ways. The material would not convey properly upon the inclined conveyors or spiral conveyor. In some areas, water spray was excessive and other areas, such as the grinders, the water spray was inadequate.

Several modifications to the conveyor system were tried. The water spray was modified reducing spray on the conveyors. The conveyors were tried with a nonskid surface, and guided lengthwise in the conveyor trough. None of the modifications were entirely satisfactory. It was apparent that although some improvement could be made, difficulties would continue

to exist conveying wet propellant uphill. Operation of vertical vibrating types with water spray appears impossible.

2) Discussion of Potential System Modifications

As previously discussed, the major difficulty is encountered when trying to convey propellant through increasing elevations. The single most rigid constraint on elimination of this problem is the building construction itself. Since major changes in building elevation to permit progressive material movement in a horizontal or downhill plane would be prohibitively expensive, major building reconfiguring was not considered further. Since operating problems exist in other areas, great risk would be involved in making major building changes in one part of the facility without assurances that problems were solved in other areas. For this reason only potential modifications which did not involve major building modifications were considered.

Two possible methods of accomplishing the loading, conveying, and grinding functions have been examined. One utilizes as many of the existing components as possible (modified system). The other proposes a simplified system with only one grinding stage (redesigned system). These options are discussed in the following pages.

Modified System

It appears that if as a minimum the following essential modifications were incorporated the existing propellant conveying and grinding system could be made functional. All existing equipment would be utilized except the spiral vertical vibrating conveyor. This unit would be replaced with a Loft Belt Conveyor. This type of conveyor is described in detail later. The other system components would be reused as installed, modified, or relocated. Also some components would be eliminated.

Receiving hopper T-100, Feeder M-100, and vibrating weigh conveyor M-101 would remain as installed. Conveyor M-102 with metal detection section would be modified and installed horizontally rather than inclined. If metal were detected in the propellant by M-102, the entire building with minor exceptions would be immediately shut-down. The metal could then be found and removed from the detection section. Vibrating conveyors M-106, M-107, and M-108 which were installed as a diversion loop to remove any metal in the propellant would be eliminated. This side loop conveying system would not perform properly.

as designed and built. If further analysis indicated that it was not certain that all metal could be removed with 100 percent assurance, a second metal detector section could be placed in series with the first.

Conveyor M-102 would discharge directly into relocated primary grinder G-100. The pneumatic pinch valve which conveyor M-102 initially discharged through could now be eliminated or replaced with a larger valve if mandatory from a safety standpoint. Our Figure VI A-1 shows an automatic fire gate in place of the pinch valve. Grinder G-100 would operate under a deluge of water.

The primary grinder would be relocated and mounted to discharge the propellant onto conveyor M-108 which would be relocated also. Since the primary grinder would be relocated, vibrating conveyors M-103, M-109, and M-110 would no longer be needed. Conveyor M-103 would be replaced by M-108. M-109 fed material to the grinder and M-110 received the material from the grinder. These two conveyors could be eliminated as a result of the grinder relocation.

The modified and relocated conveyor M-108 would discharge onto a new belt lift conveyor (the belt lift conveyor replaces the vertical spiral vibrating conveyor) which would in turn discharge onto vibrating conveyor M-105. An additional fire gate would be required at the wall. From this point on the system would remain virtually as installed.

The water spray system as well as other mechanical and electrical utilities would have to be completely reconfigured to meet the needs of this system.

The new belt lift conveyor considered as a replacement for the vertical spiral vibrating conveyor is similar in configuration to a standard belt conveyor except the belt. The belt of the belt lift is a special construction, which includes a heavy duty base belt with cleats and corrugated side walls. The belt is available in a variety of widths up to 72". The belt cleats and corrugated sidewalls are available in any height up to 15". Belting material is available in several types, including food grade. Belting material would be determined by product being conveyed. Due to the unique belt construction, the belt lift has the ability to move product vertically. The belt lift is also very similar to a type of belt that is in use at Lone Star Ammunition Plant in Texas. Refer to the enclosed belt lift conveyor catalog cuts and flow sheet illustrating the foregoing modified system. As previously mentioned, for this application the conveyor might have to be redesigned for safety but basic type is believed to be usable.

Redesigned System

Another potential modification which was examined (and has desirable features) consists of replacing portions of the existing propellant conveying and grinding system with different components.

This system offers a straight through material flow using a minimum number of components. The final propellant slurry produced should meet design criteria. The system is also designed to use as many pieces of existing equipment as possible.

The initial part of the system would consist of receiving hopper T-100, vibrating feeder M-100 and vibrating weigh conveyor M-101 utilized essentially as installed. Conveyor M-101 would feed the propellant onto a modified and relocated vibrating conveyor M-102. Conveyor M-102 (which contains a metal detecting section) would immediately shut the complete system down if any metal were detected. The metal could be removed and the system re-started.

The propellant would be fed from conveyor M-102 into a new grinder. This type of grinder would have the capability of reducing 8" size material to 1/16" or less in size in one pass.

The propellant would feed from the new grinder onto an existing modified vibrating conveyor M-106, which then would feed the propellant to a new belt lift conveyor which would discharge the material into the relocated Slurry Tank T-102. The slurry would then be pumped from tank T-102 by relocated Slurry Pump P-101 to Slurry Storage Building No. 1570 or building No. P-947B depending upon which type of propellant was being processed.

The complete system would operate under a redesigned water spray system. The system would require the necessary controls to meet all safety operating functions.

One type of grinder which is a possible replacement for the two grinders now installed in the system would be the type currently being used at Radford AAP for reducing explosives in a single pass on the feed to their rotary kiln. The grinder is known as a flying knife type.

Catalog cuts presenting this type of grinder, which is manufactured by Mitts and Merrill, are included. As shown, these grinders are capable of handling relatively large materials through feed openings ranging from 10" x 11" to 20" x 54" and power input ranges from 25 HP to 500

HP. Feed rates (depending on grinder size) range from 300 lb/hr to 20 tons per hour. Available screen sizes go down to 0.045" or less than the current final grind size of 1/16".

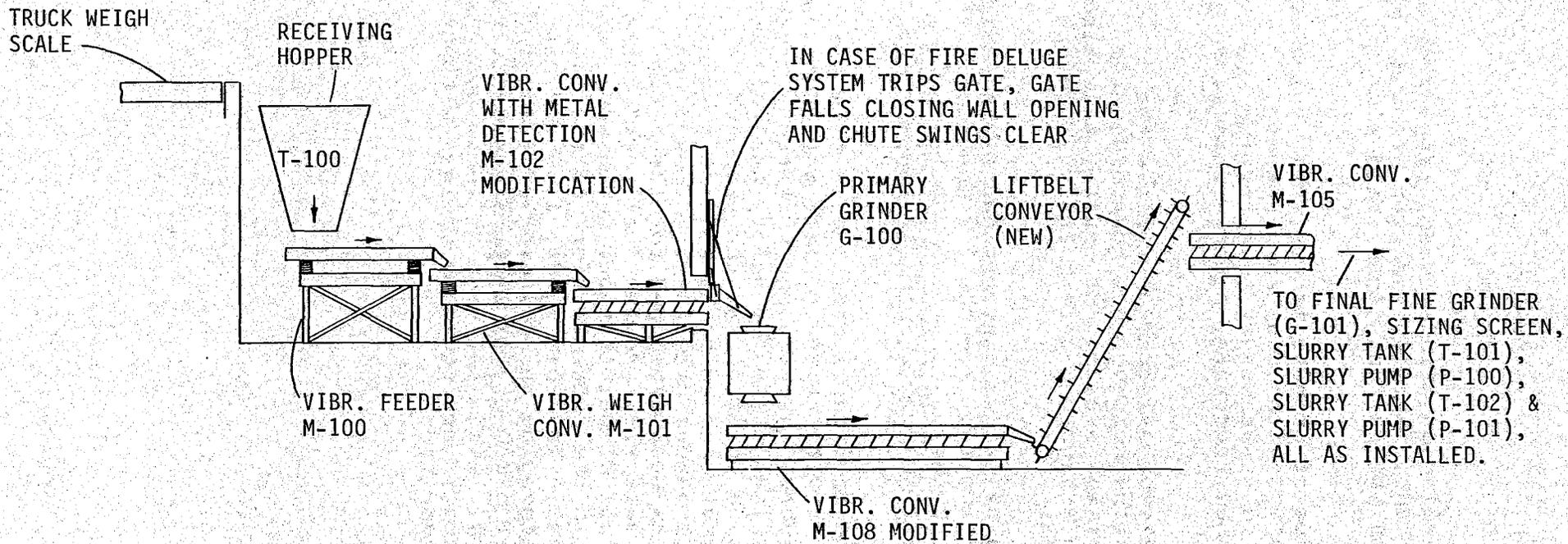
As indicated, this type of grinder is currently being used successfully in the ammunition industry. However, extensive testing would be necessary to determine the proper compromises among feed rate, power, total size reduction and safety.

The new belt lift conveyor selected to replace the vertical spiral vibrating conveyor has been discussed earlier under the modified system. Of course, this also would have to undergo a rigorous safety analysis before proceeding with design.

Refer to the enclosed belt lift conveyor and flying knife grinder catalog cuts plus the flow sheet illustrating the potential redesigned system.

Conclusion

Either of the proposed modified systems would eliminate the problems associated with trying to lift wet propellant using vibrating conveyors. As previously stated, before proceeding with design, an extensive safety analysis would be required, although we believe that the proposed components could be developed to be as safe as current components. Although numerous other systems could be proposed, cost data has been developed for these two modifications. This data will provide "ballpark" costs for conveying and grinding modifications which would only be worth considering if the other portions of the overall PDF could be functional. In other words, it would make no sense to modify the conveying and grinding systems if practical changes to the WAO or FBI systems could not be economically justified. Likewise, even if those systems could be made functional, they would be useless without the proper slurry preparation.

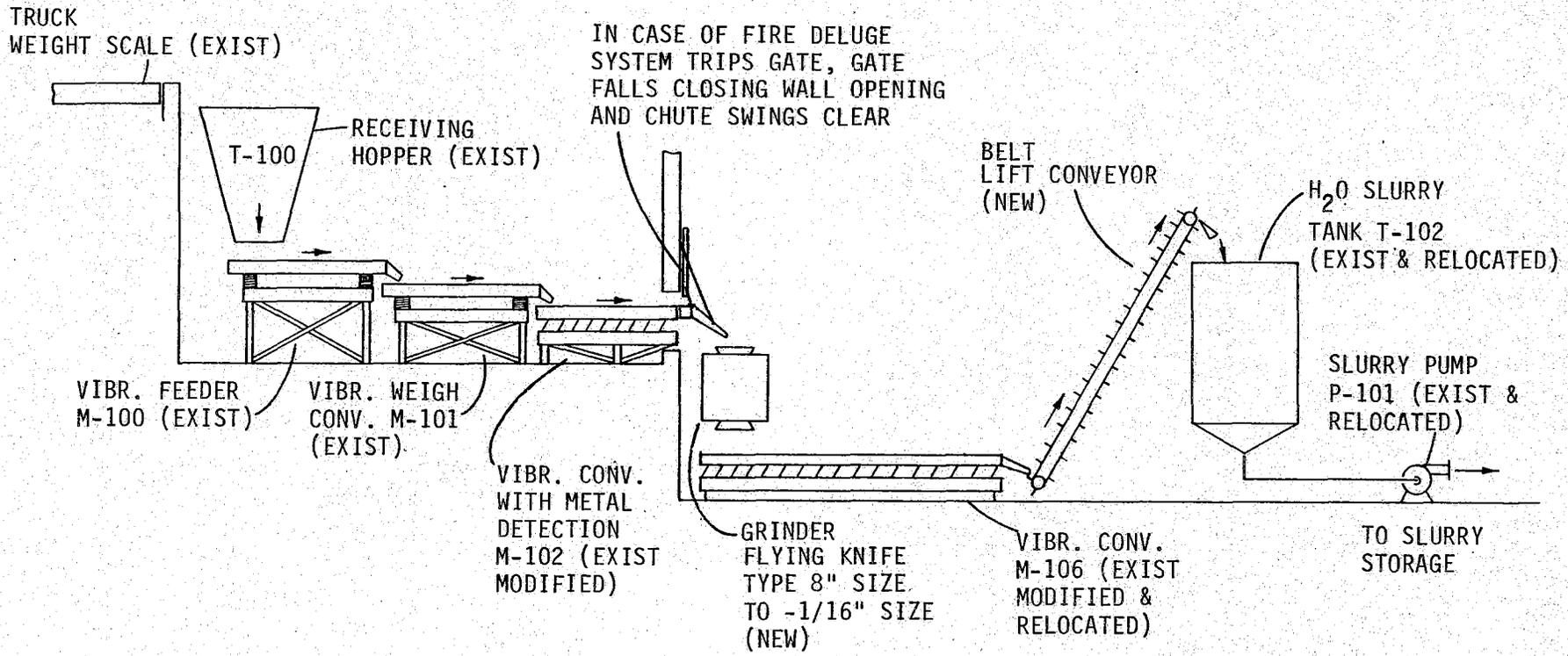


NOTES:

- 1) ALL EXISTING EQUIPMENT REUSED EXCEPT SPIRAL VIBRATING CONVEYOR. SPIRAL CONVEYOR REPLACED BY NEW LIFT BELT CONVEYOR.
- 2) EXISTING SPRAY SYSTEM MODIFIED TO SERVICE MODIFIED SYSTEM.

EXISTING SYSTEM MODIFIED

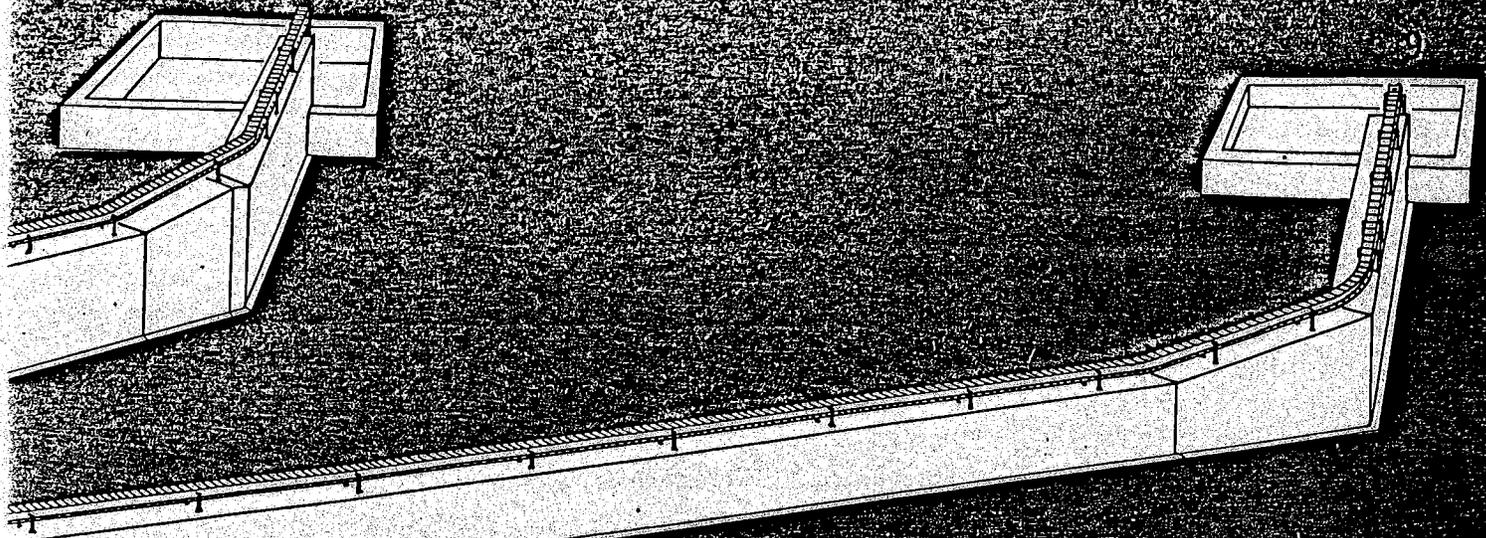
Figure VI A-1



NOTE:
 THE COMPLETE SYSTEM IS TO HAVE A
 WATER SPRAY SYSTEM TO PREVENT
 TEMPERATURE RISE OF PROPELLANT.

REDESIGNED SYSTEM
 Figure VI A-2

CATALOG CUTS



Convoluteds Belts Prevent Explosive Propagation At Lone Star Ammunition Plant In Texas

**Three-Dimensional Capability
Eliminates Need For Thirteen
Conventional Conveyors**

Three Serpentine continuous belts conveyor system, almost 4000 feet in length, have been installed to handle production of the Lone Star Army Ammunition Plant in Arkana, Tex.

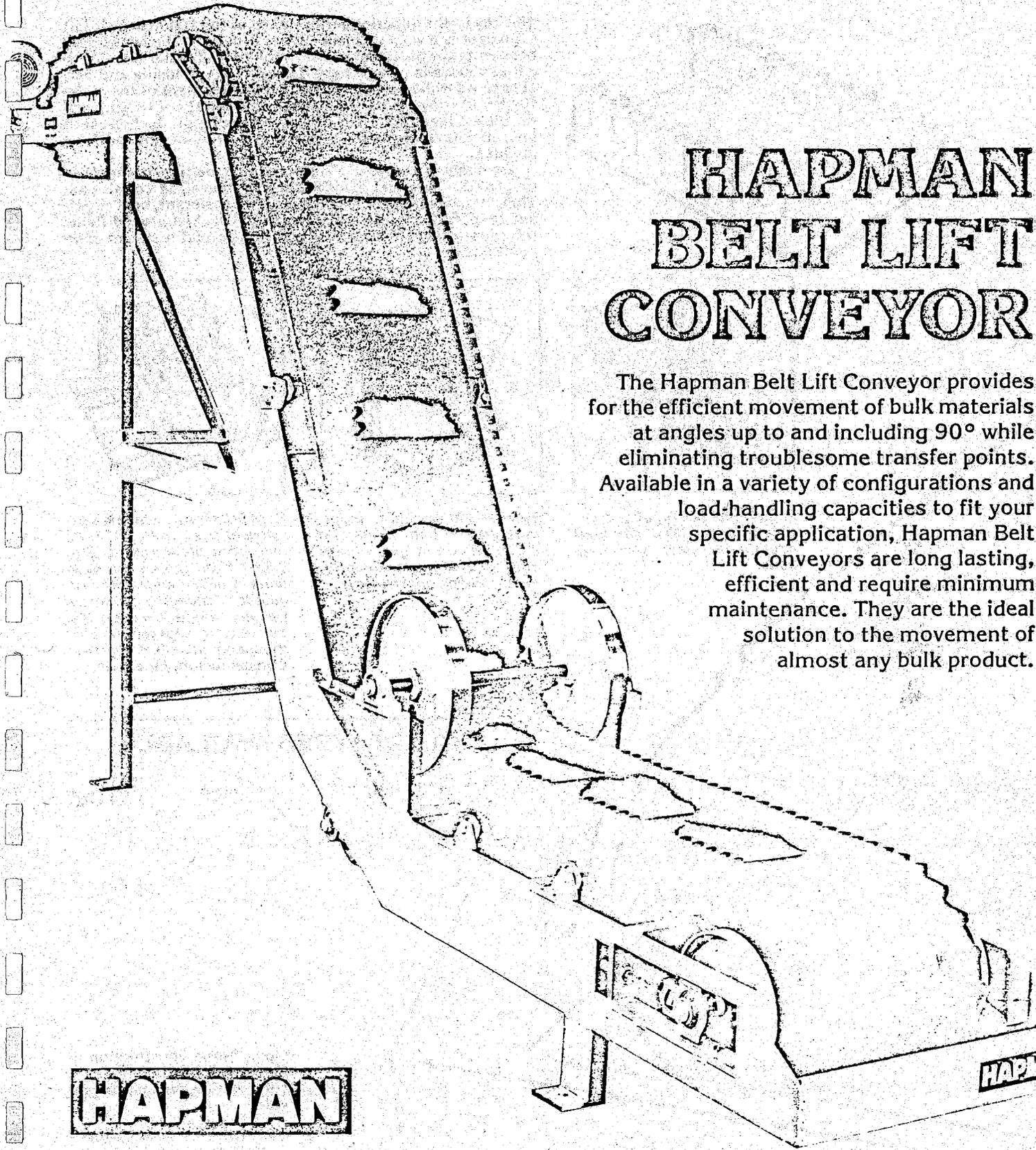
The conveyors (main) secondary, and tertiary conveyors) combination of 1000000 lbs. selected primary material, and 1000000 lbs. convoluted belts provides a safe and efficient means of handling and conveying explosive materials.

The system is the world's longest of its kind and is the only one of its kind in the world. It is the only one of its kind in the world. It is the only one of its kind in the world.

It is the only one of its kind in the world.

HAPMAN BELT LIFT CONVEYOR

The Hapman Belt Lift Conveyor provides for the efficient movement of bulk materials at angles up to and including 90° while eliminating troublesome transfer points. Available in a variety of configurations and load-handling capacities to fit your specific application, Hapman Belt Lift Conveyors are long lasting, efficient and require minimum maintenance. They are the ideal solution to the movement of almost any bulk product.



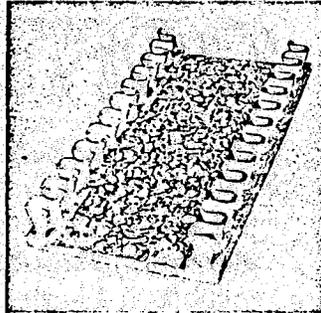
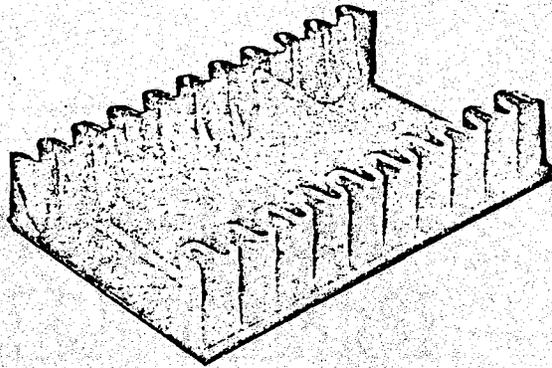
HAPMAN

HAPMAN

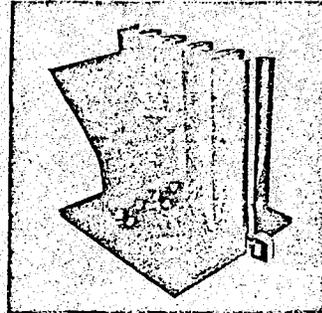
BELT LIFT CONVEYOR

The key to the superior performance of the Hapman Belt Lift Conveyor is a very special belt construction. The heavy-duty base employs the latest belt technology and materials. Corrugated sidewalls permit easy flexing through inside and outside turns while providing positive containment of the material being conveyed. Cross cleats, in a variety of heights and profiles to meet the needs of your particular product, create a box structure to propel material and prevent flow-back on inclines.

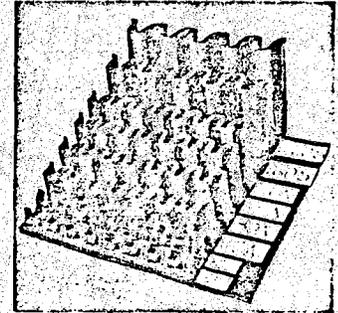
Available in a variety of compositions, belting material can be provided to meet a wide range of operating conditions. They include standard black, oil and fat resistant, heat resistant to 275°F., flame resistant and MSHA-approved flame retardant plus FDA-approved white oil and fat resistant compositions.



Food grade belting also available in all widths, sidewall heights and cleat configurations.



Mechanical fastening incorporated into both cleats and sidewalls on larger, heavy-duty belts for greater durability in demanding applications.



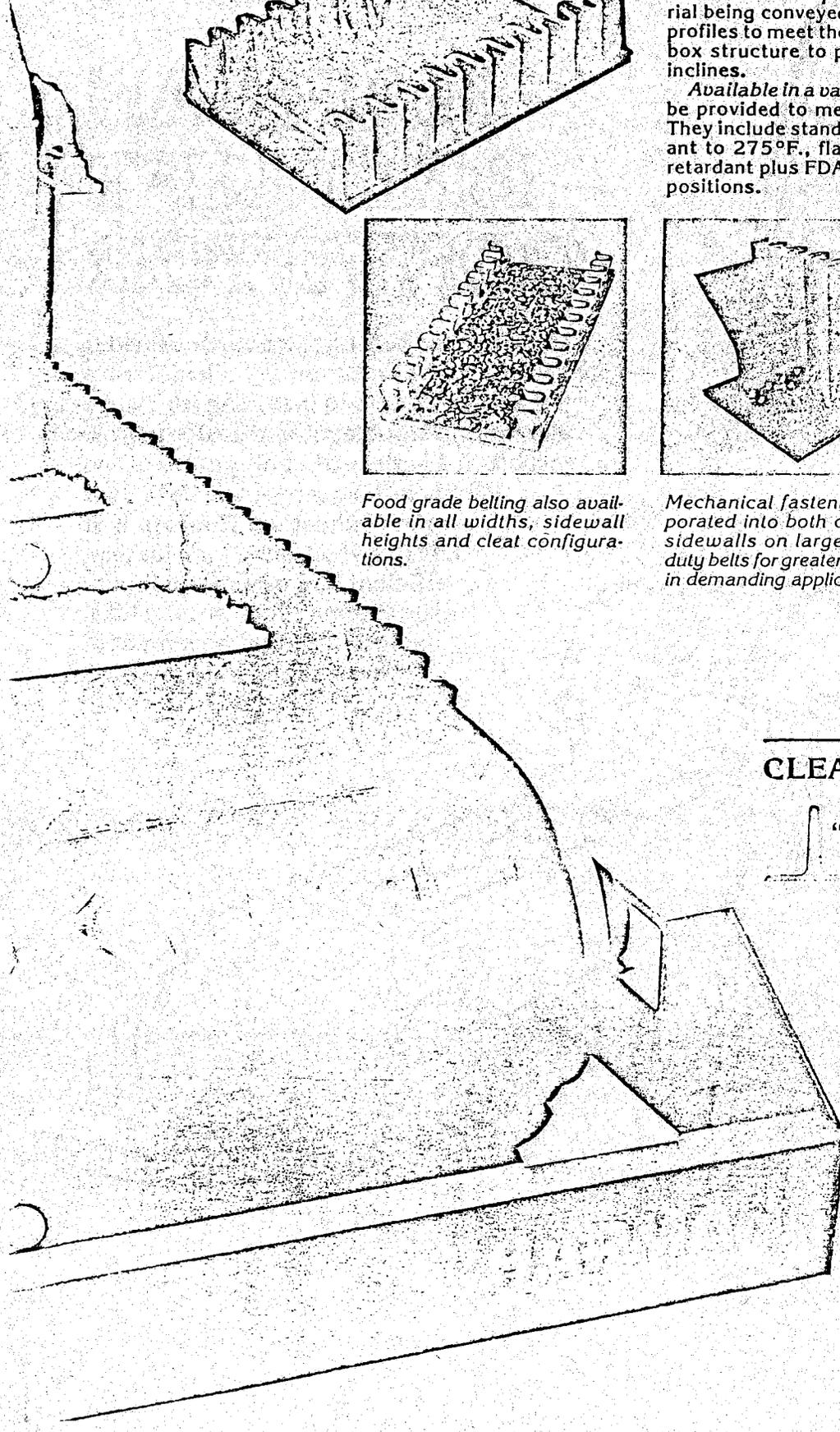
Base belts are available in a full range of sizes up to 72" wide with sidewalls and cleats up to 15 3/4" high. Various combinations of height and width provide for conveying capacities ranging from a few cubic feet per hour to several hundred thousand cubic feet per hour. Consult factory for details.

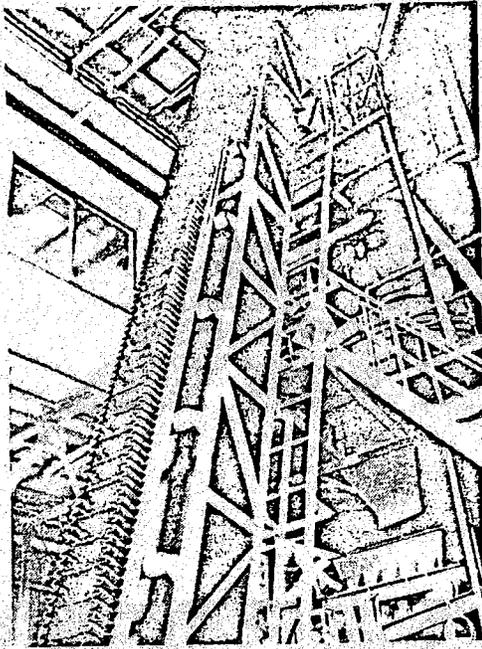
CLEAT TYPES AVAILABLE



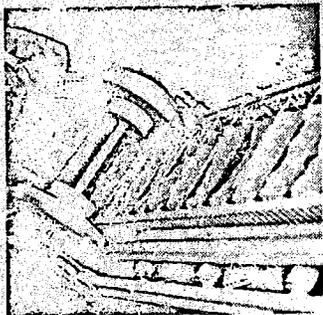
Open frame construction illustrated. Enclosed frame construction can also be provided.

Conveyors are shown without appropriate safety guards for illustrative purposes. Proper guards must be in place during operation.

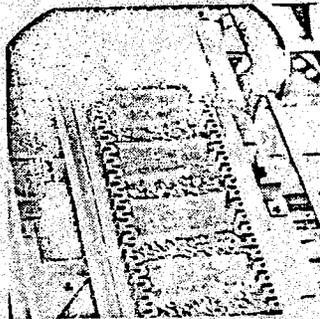




The ability to operate efficiently on steep inclines makes the Hapman Belt Lift an ideal substitute for bucket elevators, eliminating the problems of jammed and broken buckets.

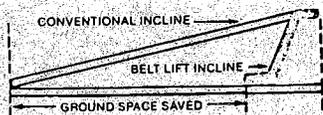


Transferring material from horizontal to a steep incline, with no transfer point, insures superior material handling.



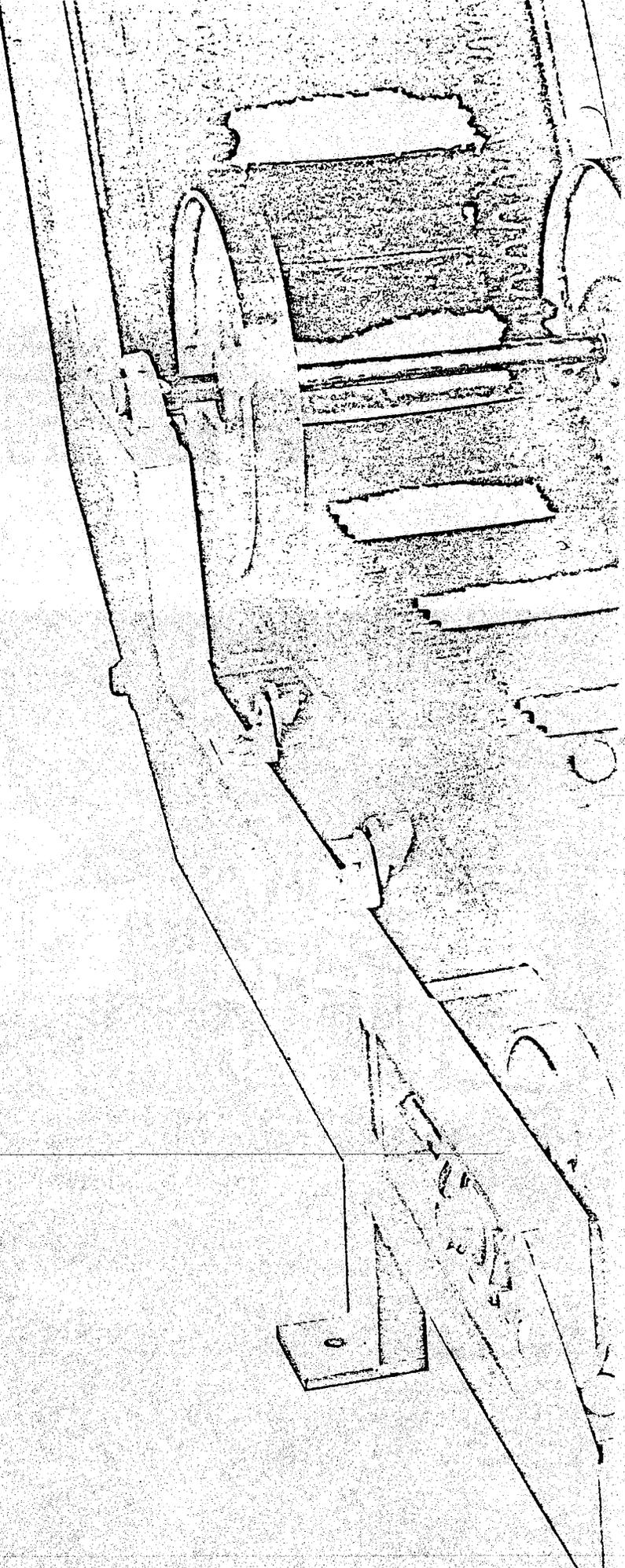
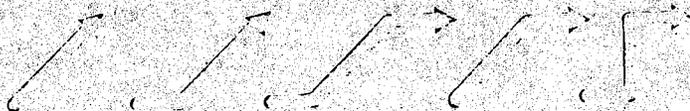
Corrugated sidewalls and cross cleats form 'pockets' to provide positive movement of bulk materials through the continuous conveying path.

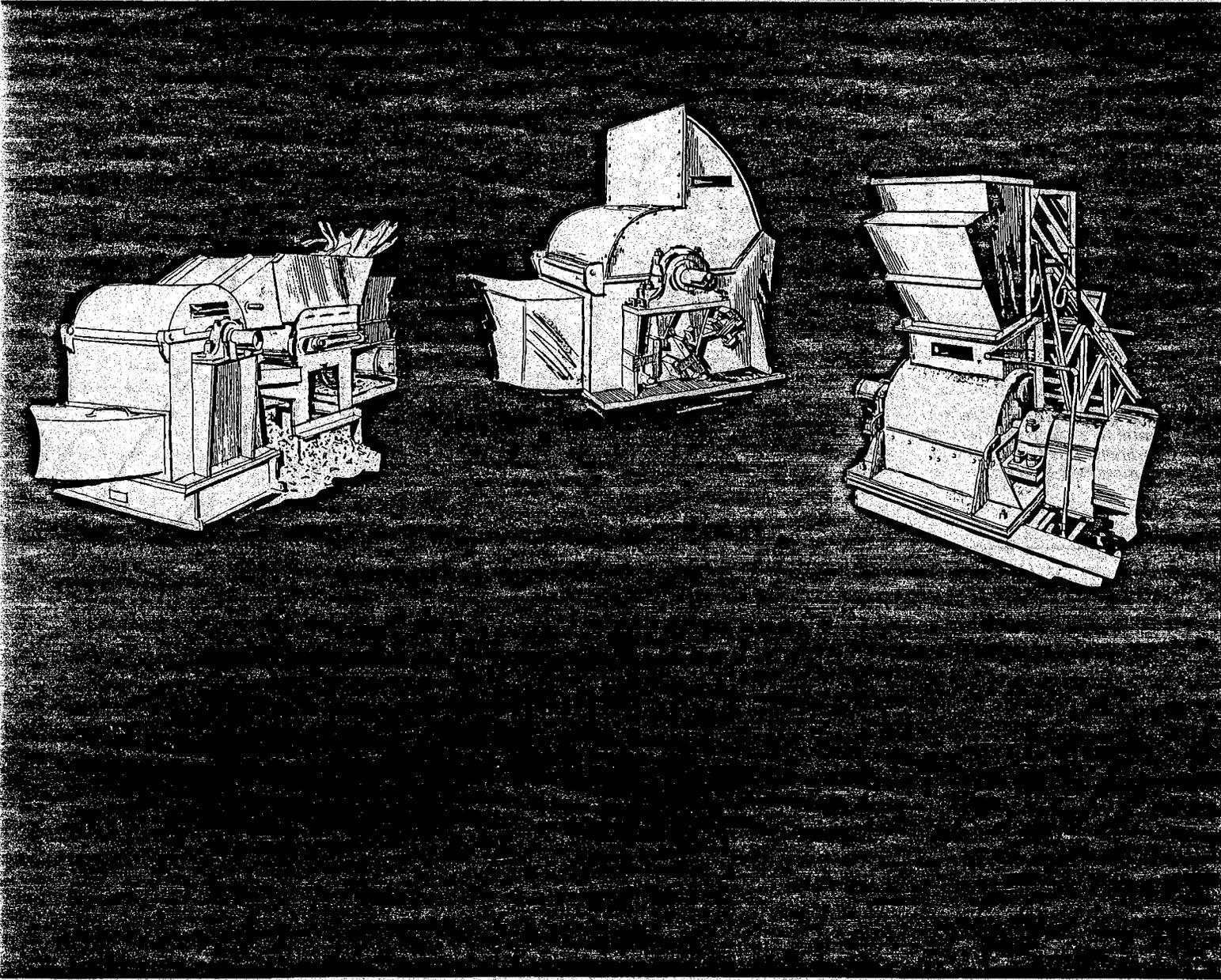
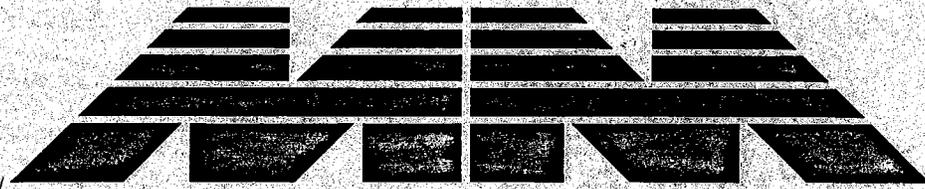
SPACE SAVING



Its unique ability to elevate flowable bulk materials through severe inclines lets the Hapman Belt Lift Conveyor be designed into much less space than conventional belt conveyors, saving more than half the floor space and $\frac{2}{3}$ the moving parts.

TYPICAL CONFIGURATIONS







Paper rolls with core through 1 1/4" screen

Here's MONEY-SAVING MATERIAL REDUCTION



Baled rubber through 1" screen



Polyethylene plastic through 1/4" screen



Granulated rubber through $\frac{1}{4}$ " screen



Wood chips through $1\frac{1}{4}$ " screen

High capacity...greater versatility



Aluminum wire through 1" screen

MITTS & MERRILL offers the widest selection of rotary-knife material reduction machines of any manufacturer in the United States. This equipment reduces raw and scrap material to the size required for cost-saving processing, transportation, reclamation and disposal. They provide top efficiency and high volume production rates with all materials that can be cut by a rotating knife machine.

There are 31 types and sizes of standard Mitts & Merrill Cutters, including the strongest, heaviest-duty units available. Capacities range from 300 pounds per hour to more than 20 tons, depending on the material processed. Typical end-product sizes include from 3" to 4" chunks down to grain-sized material that will pass through a $\frac{1}{16}$ " perforated screen. Sizing capabilities are, of course, contingent upon the physical properties of the material.

INDUSTRIES SERVED—AND MATERIALS HANDLED

Mitts & Merrill "Hogs" have been serving the lumber industry for more than 100 years—since 1854—reducing bark, trimmings, slab and scrap to a readily-handled size suitable for boiler fuel. Cutters manufactured today are used in the chemical, plastics, rubber, paper and animal-products industries and many others.

Materials Now Handled Include:

- Asphalt tile
- Cardboard
- Glass
- Leather scrap
- Non-ferrous metals
- Paper
- Plastics in process
- Plastic scrap—including film, fiber, chunk and pipe
- Rubber in process—synthetic and natural
- Rubber scrap
- Scrap meat, bones, hide
- Waste matter
- Wood

Typical Uses in Various Industries

Here are some of the more common uses of Mitts & Merrill Cutters:

In veneer and plywood plants: High speed economical reduction of wood wastes, including wet veneer, cores, log ends and round-up.

In lumber or paper mills: Reduction of oversize chips from bull screens to proper size for processing. Shredding used paper stock, including newspapers, books, magazines.

Reduction of pulp in dry, wet, roll or frozen form. Reduction of bark and other wood refuse for fuel. Reduction of scrap into sawdust or controlled particle size.

In rubber plants: Reduction of bales of raw rubber for further process handling.

Rubber scrap reclamation for compounding, conveying and handling, preparatory to reprocessing. Reduction of natural latex at original plantation site for handling and washing.

In C. P. I. plants: Reduction of raw materials and chemicals to uniform size for processing.

Reduction of waste or trim.

Material reduction where special tolerance designs, resistance to corrosion problems and explosion-proof installations are required.

In plastics plants: Reduction of large and irregular plastic shapes to uniform granules to facilitate accurate measuring of loads for molding machines.

Reduction of scrap for reprocessing back into the pre-molding mix.

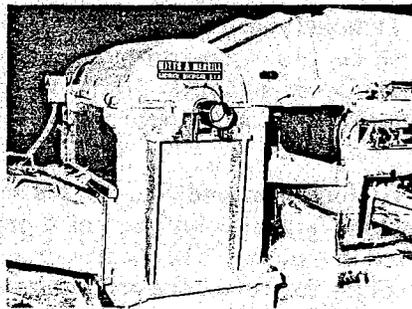
Reduction of thermo-plastics and some thermo-setting materials for reprocessing purposes.

In animal-products processing: Reducing carcasses, fat, bone, slaughter house offal, etc., to sizes convenient for rendering.

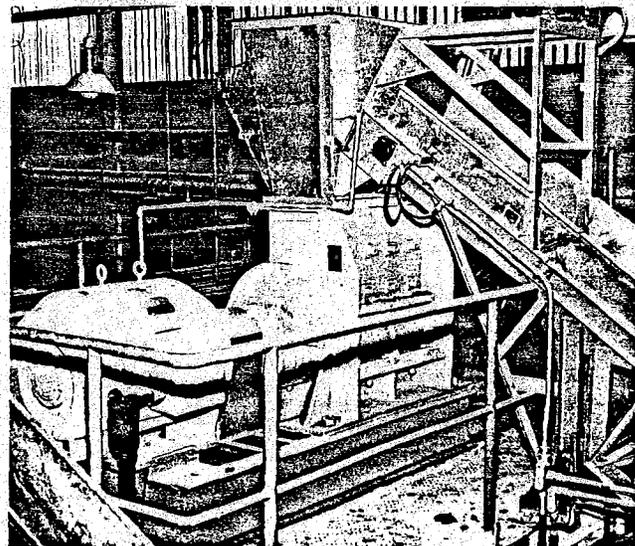
Whatever requires size reduction in processing: From corn cobs and husks to aluminum wire . . . used boxes, barrels, waste paper and other light material to heavy rubbish . . . Mitts & Merrill Cutters are used for size reduction applications. Cutters of extra-heavy construction are available, equipped with safety doors that open automatically to discharge tramp metal.

Names of user companies, large and small, throughout North America and abroad, are available on request. Just tell us the industry or the S.I.C. category of interest to you.

Mitts & Merrill Series III Cutter reduces wet fibrous green veneer to uniform fuel chips

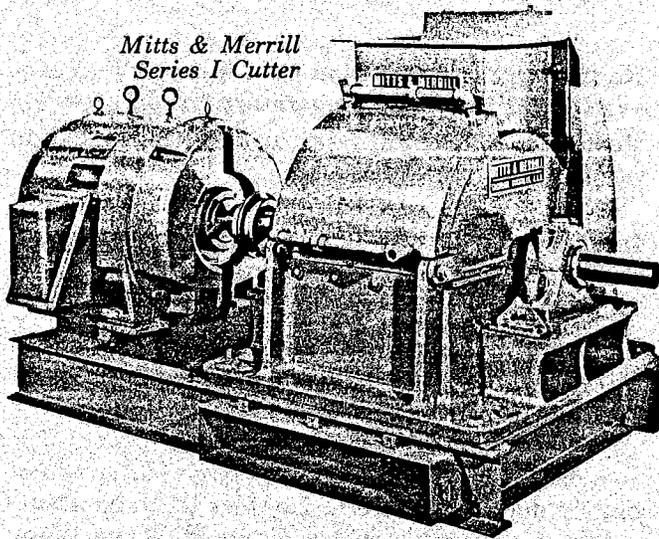


Mitts & Merrill Series I Cutter permits leading plastic processor to reclaim material



3 TYPES OF CUTTERS AVAILABLE

Mitts & Merrill
Series I Cutter

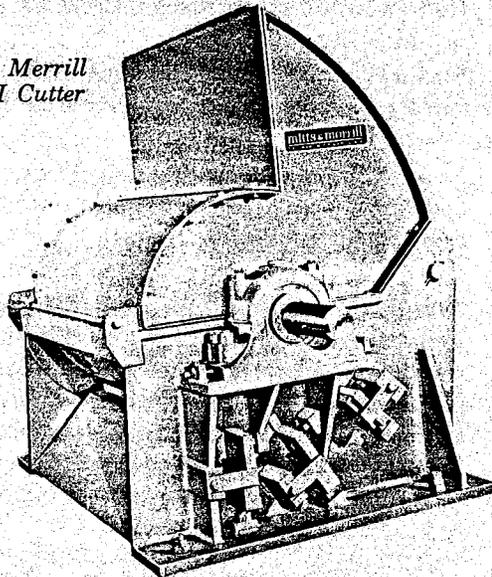


The Mitts & Merrill line includes 31 basic models of Cutters.

Series I Cutters meet the majority of needs. These are available in 14 models, with or without a screen. Feed openings range from 10" x 11" to 20" x 54", and maximum power input ranges from 25 to 500 hp.

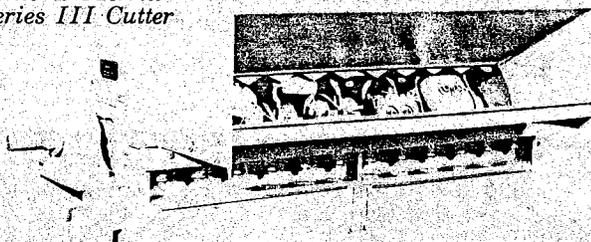
Without a screen these cutters are widely used by rendering plants for grinding animal carcasses, meat scraps and related material. With a screen, these cutters are recommended for a wide variety of other applications.

Mitts & Merrill
Series II Cutter



Series II Cutters may be used for applications where tramp or scrap metal presents a problem. They feature extra-heavy construction and optional safety doors that automatically discharge tramp metal pieces that are too hard to be cut by the knives. These Cutters are available in 12 models, with or without a screen — with feed openings ranging from 10" x 11" to 20" x 54" and maximum power input from 50 to 500 hp.

Mitts & Merrill
Series III Cutter



Series III Cutters are designed specifically for plywood and veneer industries. There are five models, with feed openings from 7" x 18" to 7" x 66", and corresponding power input from 20 to 60 hp. An in-feed conveyor attachment is available.

Detailed specifications on all models of each of the three types are provided in separate bulletins, available on request. Major features of construction and operation are described on the following pages.

All highly dependable. A material-reduction machine is commonly part of a production line operation—most often, the first machine in the system. Thus, to protect the entire plant or process against shutdown, such machines *must* be ruggedly built for dependable long-term, continuous hard service. All Mitts & Merrill Cutters meet this requirement in every respect, as explained on the following pages.

How the Machines Operate

Essentially, all Mitts & Merrill Cutters consist of a series of knives mounted horizontally on a rotor that turns in a fabricated steel housing. The housing includes (1) an inlet chute or hopper to suit your application; (2) one or more stationary knives (called cutter bars); and (3) an opening at the bottom for horizontal or vertical discharge. In most cases, a screen is securely mounted within the discharge area for size control of the cut-up material prior to actual discharge.

Use of knives in a staggered pattern on the rotor of all Mitts & Merrill Cutters breaks the cutting action down into many small cuts per revolution. This provides smoother action with less noise, shock and vibration, and affords very high production capabilities.

Extra-Sturdy and Durable Rotors for Series I & II Cutters

The rotor of these machines consists of steel sections with 20", 26" or 30" diameters and 4" or 9" increments of lengths up to 54" over-all. These sections are press-fitted and keyed on a rugged shaft to form one unit or rotor. The assembled rotor is precision-turned and dynamically balanced to run with a minimum of vibration. The balanced mass provides the flywheel effect required for reducing the toughest materials, and eliminates need for an independent flywheel outboard of the bearings.

The rotor shaft is of alloy steel and of adequate diameter to hold shaft and rotor to minimum deflection.

The keyed shaft extends at each side of the machine to permit either right- or left-hand drive, and to facilitate removal of the rotor for refinishing.

Rotor drive may be by direct-coupled motor or by V-belt.

Long-lived, heavy-duty bearings. These size-reduction cutters have the rotor shaft mounted in heavy-duty, double-row tapered precision roller bearings.

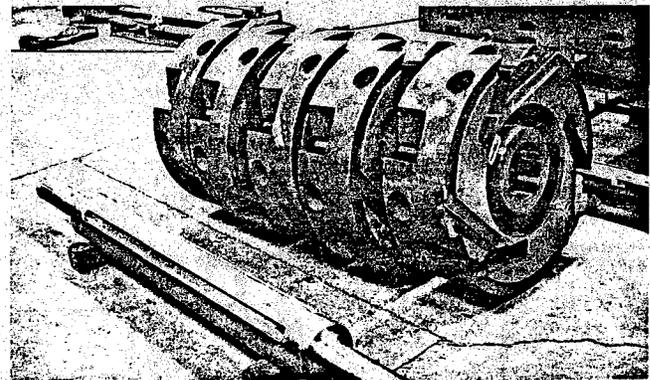
Rotor knives securely fastened. The knives are held in the rotor cylinder by heat-treated screws and solid steel blocks, as illustrated. The knives are easily adjusted radially.

Cylinder pockets aid processing. The cylinder has pockets adjacent to the knives for material circulation.

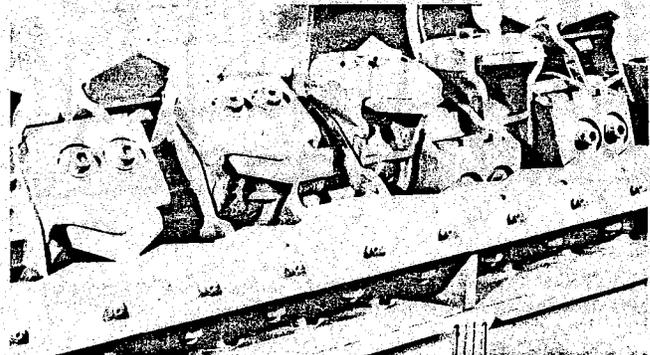
Staggered knives provide higher cutting efficiency; pockets adjacent to knives allow material circulation

For Series III Cutters

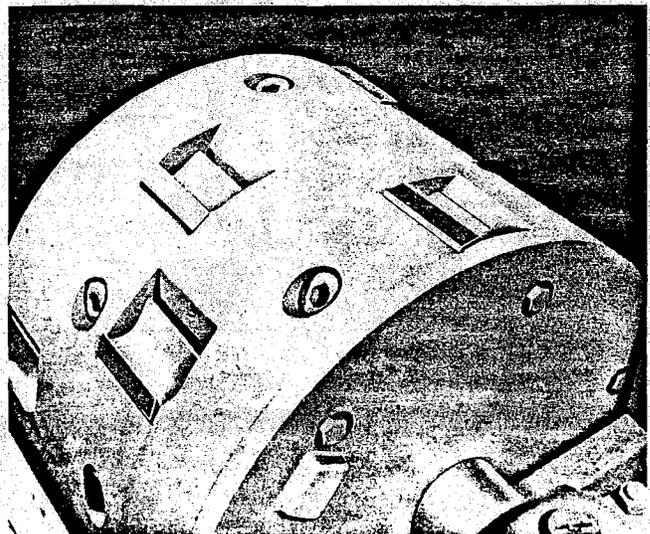
In these cutters the V-shaped knives are on the ends of the rotor heads. Each rotor head is a fabricated box-like frame of steel plate. The rotor heads are keyed in a staggered pattern on the rotor shaft. This construction, as opposed to Series I & II Cutters, allows the cut material to be circulated through the rotor heads in the air stream produced by the rotor, with no risk of clogging or jamming the machine.

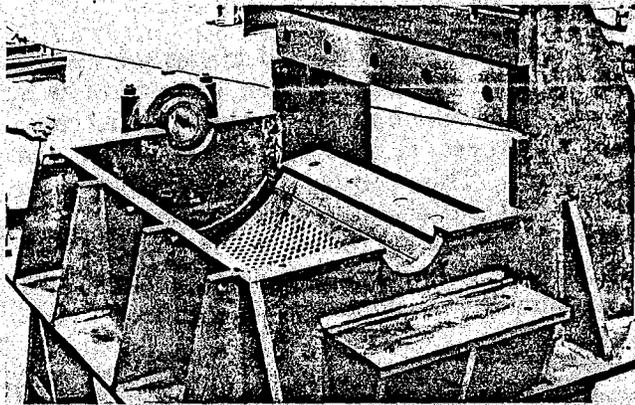


Heavy-duty rotor sections and shaft before assembly

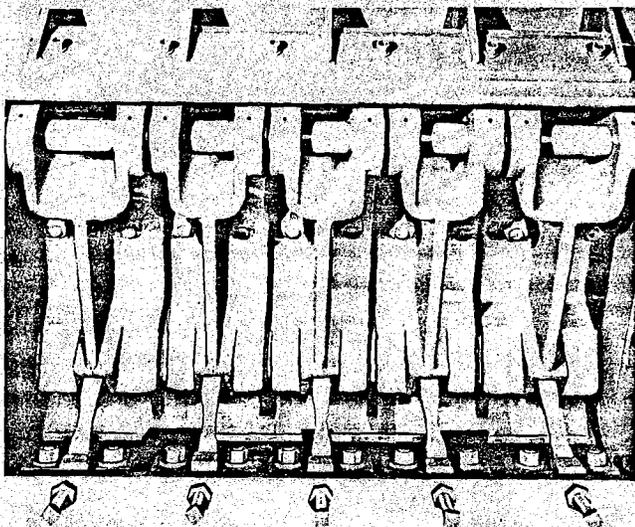


Each heavy duty cylinder head on Series III Cutters has two specially designed hardened steel knives which cut against a series of hardened steel stationary plates for maximum efficiency





Stationary cutting bars mounted in housing are adjustable for maximum cutting control; screen is easily removed



Series II Cutters may have special "swing doors" to protect knives and throat bars from tramp metal

Stationary Cutting Bars

Series I and II Cutters have straight-edged cutting blades of heavy cross-section, mounted in the housing parallel to the axis of the rotor. In addition, Series I Cutter can be ordered with an optional auxiliary throat bar mounted in the feed opening, with a straight horizontal knife edge at the bottom.

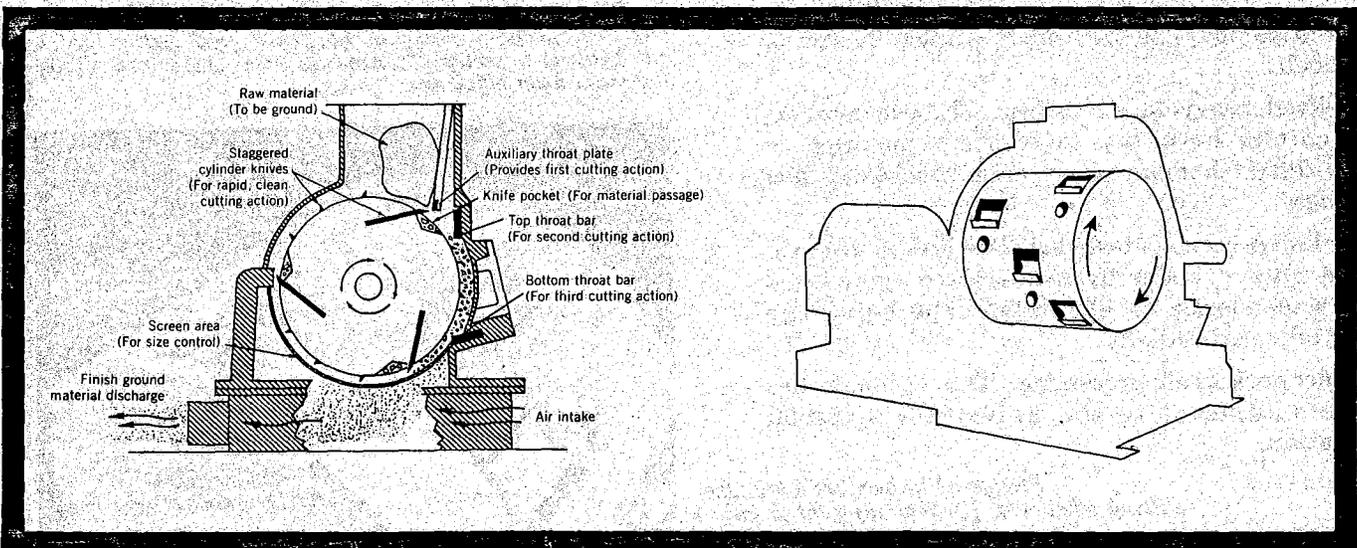
All stationary cutting bars are adjustable radially (in and out) to the rotor knives to provide the most efficient clearance for the material being processed. In addition, all stationary cutting bars are readily removable for sharpening.

Series III Cutters have segmented stationary cutter bars made of a series of V-shaped plates.

The very slight clearance between cutting edges of bars and rotor knives, plus the V-shaped contour, provides the tearing action needed to process both dry and wet veneer efficiently.

Safety-swing doors. On special order, Series II Cutters may have two or more safety-release doors. Each door is horizontally pivoted at the top, and has a cutting bar the full width of the door. These are the initial stationary cutter bars.

Each door is held shut by a break-away member. When the raw material includes a piece of tramp metal too hard for the knives to cut, the break-away member snaps when the metal hits the cutter bar, and the door swings open to discharge the tramp metal. Break-away members are inexpensive and quickly replaced.



Extra-Sturdy Frame and Housing

The frame of Mitts & Merrill Cutters is the heaviest in the industry. It is fabricated entirely of heavy steel plate, welded at the joints, and stress relieved. All designs provide for floor or base mounting.

To expose the top half of the rotor for cleaning and knife-changing, the entire upper assembly is released simply by removing two bolts, and can then be swung toward the rear to expose the rotor. There is ample working room for adjusting or removing the knives.

Series I Cutters are provided with an additional clean-out door at the front for easy access to the lower cutting bar.

Series II Cutters may be ordered with safety swing doors at the front. These are opened automatically when tramp metal too hard to be cut is ingested in the cutter. These safety swing doors also make the interior readily accessible.

All frames can be clad with abrasion-resistant and corrosion-resistant coatings.

Water-cooling available. For Series I Cutters, water-cooling jackets can be applied to minimize undesirable heat build-up of material.

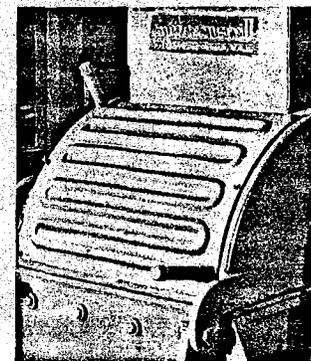
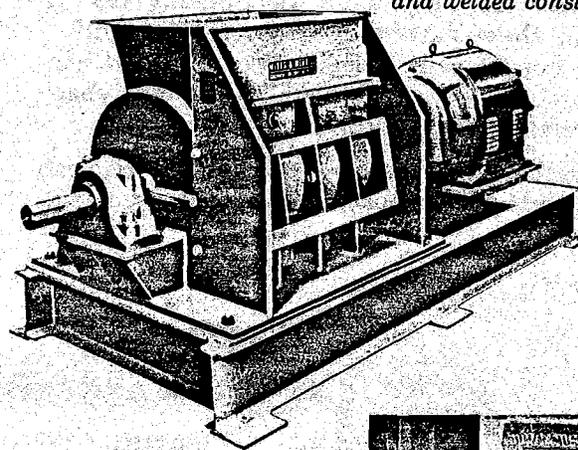
Screens Provide Close Size Control

Screens can be furnished for the cutting chamber of all Mitts & Merrill Cutters. The screen perforations serve to prevent the discharge of material-in-process larger than the finished size desired. Size ranges are from 0.045" to 3" diameter perforations.

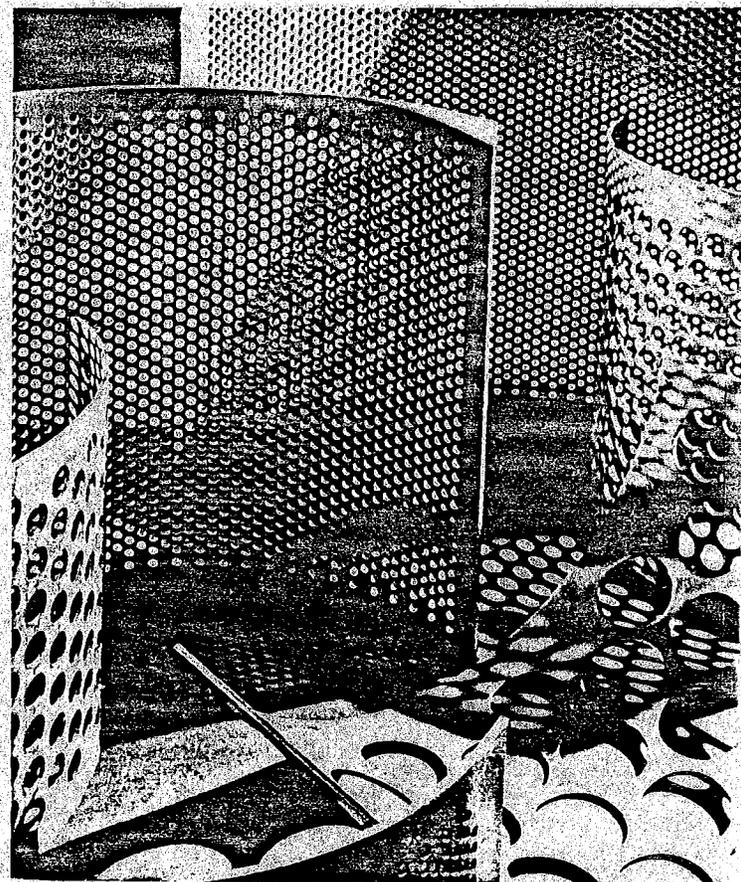
All screens are semi-cylinders of perforated plate, with a choice of carbon, alloy and stainless steels. A complete screen change takes only about five minutes.

Knife and cutting bar materials for every job. Mitts & Merrill offers a selection of rotating-knife and cutting bar materials to suit every requirement. These include—tool steel, high-carbon high-chrome steel, and knives flame-coated with abrasion resistant material.

Frame and housing of all Cutters are of heavy steel plate and welded construction



Water-cooling plate coil does not touch material, keeps machine cool



Screens with various sized holes control end product size

OPERATION Assure Money-Saving Performance

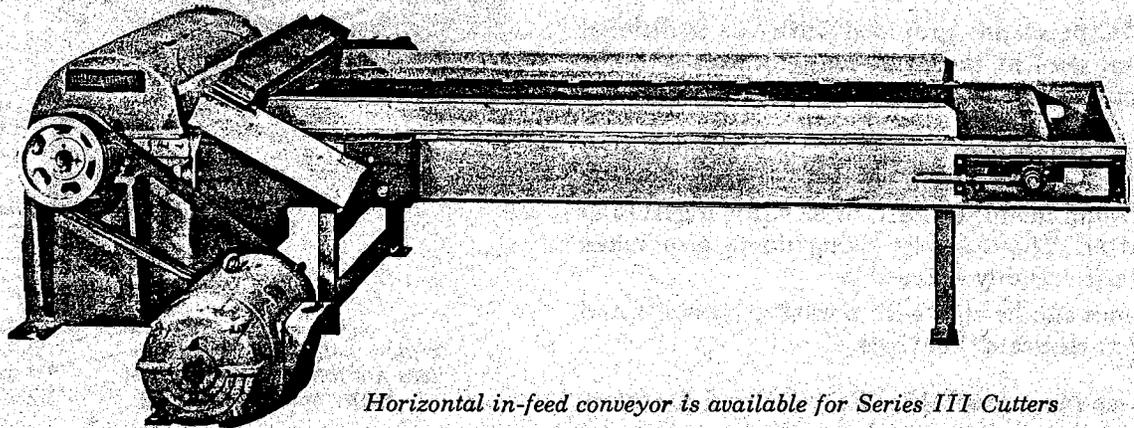
Choice of Feed Arrangements

Mitts & Merrill Series I and II Cutters are gravity-fed. Series III Cutters are horizontally fed. In addition, these cutters can be provided with a vertical hopper or horizontal feed table. All hoppers have a safety swing door to prevent flyback of material from the rotor chamber.

Horizontal in-feed conveyor. Series III Cutters can be furnished with a horizontal feed arrangement,

shown in the illustration. The roller feed mechanism provides for moving odd-sized pieces of wet veneer from cross conveyor to cutting chamber.

Choice of mounting arrangements. All Mitts & Merrill Cutters are furnished with a base. In addition, a sub-base can be provided for: (1) unitizing the drive source with the cutter; (2) connection to an air conveyor system; and (3) bottom discharge to conveyor or hopper.



Horizontal in-feed conveyor is available for Series III Cutters

Here's the one sure way to *see for yourself* what Mitts & Merrill Cutters can do for you:

Send us a sample of the material that you want to reduce—and tell us the desired maximum size after reduction. As an initial recommendation, we suggest you ship us 50 to 100 lbs. of material for our preliminary testing. We will promptly process your sample and return it for your evaluation. All recommendations will include the horsepower, drive requirement, the size and type of cutter machine, the production lbs./per hr. rates you can expect and partitioning agents needed or peculiarities in handling your material. We can then offer you our test laboratory facilities for complete volume testing under your visual inspection.

Mitts & Merrill Engineering for Materials Handling

If a fully automated system is desired and you will provide us the needed facts about your present production facilities and requirements, we will recommend auxiliary handling equipment . . . a complete materials handling system engineered to do the job most efficiently. Our engineering experience includes both air and mechanical equipment for the feeding and removal of material in process. For example, in air-conveyor systems for handling material in process, our engineering has included matched blower, cyclone separator and all ducting.

Recent typical examples of engineered components for leading manufacturers:

- Horizontal infeed material conveyor
- Custom designed feed hopper
- Partitioning agent monitoring device
- Water spray manifold system
- Custom ground & specially coated flying knives
- Hard weld stationary knife applications
- Armor-plate cladding or corrosion-resistant interiors
- Stainless or alloy perforated screens for intensive product sizing
- Custom designed mounting base and unit base for motor mounting and unitizing material reduction cutter with drive unit
- Air discharge system including fan, blower and all ductwork
- Filtering system at exhaust end of cyclone
- Perforated screen vibrating conveyor system to separate solids



Virtually every type of material that requires size reduction has been tested in the Mitts & Merrill research laboratory

Other Mitts & Merrill Materials Reduction Cutters

Plastic Granulators. These machines are designed specifically for grinding plastic materials, both new and scrap, to precise size for batch mixing. Granulators feature high throughput, low heat buildup and quiet operation, plus speed and ease of between-batch cleaning. For more details ask for our bulletin on Plastic Granulators.

Brush Chippers. Portable Brush Chippers are trailer-mounted, diesel- or gas-engine powered machines that reduce tree limbs and other brush trimmings to chips, which are blown from a discharge chute into the truck. These machines are in nationwide use by arborists, municipalities and public utilities. For full details ask for the bulletin on Brush Chippers.

Mitts & Merrill Cutters Can Fill Your Needs Precisely

Mitts & Merrill Also Engineers Custom Designed Cutters for Specific Needs

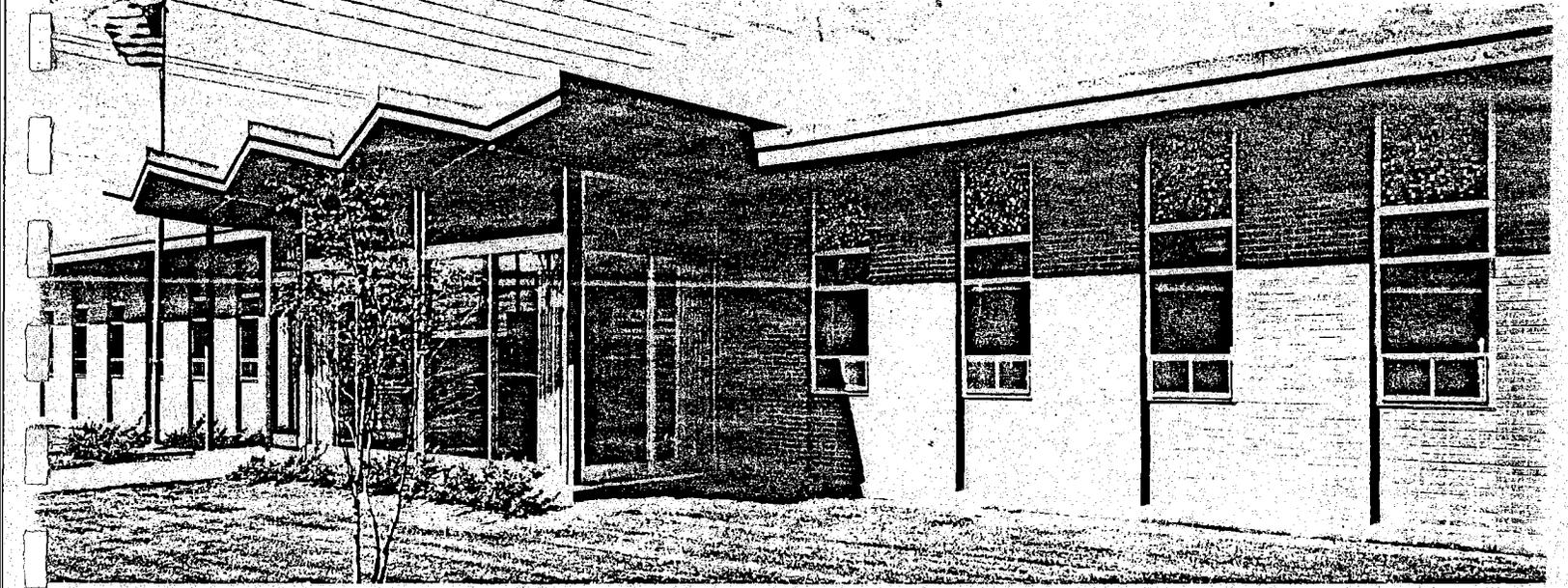
Our engineering experience in material reduction and related equipment areas permits us to provide a fully integrated, creative engineering service involving, if necessary, the custom designing of specialized cutters and related handling equipment into fully automated systems that tie into your present or planned production facilities. Bring your problem or plans to our engineering force

... we're geared, staffed and equipped to design for you the most efficient and complete materials reduction system, however complex or new your requirements may be.

Customer service. Mitts & Merrill also can provide direct factory service in your own plant through our field engineers who are fully qualified to solve production problems. A large selection of spare parts, screens and knives is maintained at strategic locations in the field for shipment to our customers.

Typical Users of Mitts & Merrill Cutters

Plastics	Rubber	Wood
E. I. Du Pont Parlin, N.J.	General Tire & Rubber Co. Columbus, Ohio	National Gypsum Co. Mobile, Alabama
Naval Ordnance Station Indian Head, Maryland	Haveg Industries Wilmington, Delaware	Roy O. Martin Lumber Co. Alexandria, La.
Koppers Company Mexico City, Mexico	Avery Label Co. Monrovia, Calif.	Ternstedt Div., GMC Detroit, Mich.
B. F. Goodrich Co. Marietta, Ohio	Coleman Cable & Wire Co. River Grove, Ill.	Riggs Veneer Co. Pulaski, Virginia
Coleman Wire & Cable River Grove, Ill.	Garlock, Inc. Palmyra, New York	Birchwood Mfg. Co. Rice Lake, Wis.
American Can Co. Neenah, Wis.	Goodrich-Gulf Chemicals Port Neches, Texas	Wisconsin Timber & Land Mattoon, Wis.
Dow Chemical Co. Gales Ferry, Conn.	Gates Rubber Co. Denver, Colorado	Ford Motor Co. Shreveport, La.
Eastman Kodak Co. Rochester, New York	Fasson Products Cucamonga, Calif.	Staniforth Lumber & Veneer Co. Kiosk, Ontario
Texas Eastman Co. Longview, Texas	Morgan Adhesives Stow, Ohio	Burkeville Veneer Co. Burkeville, Virginia
Celanese Plastics Co. Houston, Texas	Goodyear Tire & Rubber Co. Houston, Texas	Nutone Wood Carving, Inc. Bingham, Maine
Tote Bulk Handling Burnsville, Minn.	Goodyear Tire & Rubber Beaumont, Texas	Georgia Pacific Corp. Conway, N.C.
Carlson Products Aurora, Ohio	Firestone Synthetic Rubber Lake Charles, La.	Consolidated Paper, Inc. Wisconsin Rapids, Wis.
General Tire Plastics Div. Columbus, Mississippi	Ford Motor Co. Shreveport, La.	C.C.I. Forest Products Div. Munising, Mi.
	Firestone Tire & Rubber Akron, Ohio	
	Humble Oil & Refining Baton Rouge, La.	



Mitts & Merrill provides a complete cutter application service—Summary

1. Broad experience throughout industry in material reduction—over 80 years of cutter manufacturing know-how.
2. If your material is adaptable to reduction by rotating (flying) knives, Mitts & Merrill can recommend how to do it more efficiently, more profitably, whether it's an end-product, in-processing or scrap-saving application.
3. Your production capacities, whether measured in pounds or tons, can be handled faster, better with a Mitts & Merrill Cutter . . . the power capacities of our various models—20 to 500 hp.—gives you greater selection.
4. Versatile equipment—your desired material reduction may vary from 3" to 4" chunks, down to grained size, $\frac{1}{16}$ " in diameter.
5. Complete engineering service . . . from machine recommendation to full system designing . . . our bank of diversified experience is your assurance of a more profitable material reduction operation.
6. Test facilities at our plant permit you to observe, time and inspect your material being processed on a recommended cutter *before* you buy.

For further information on our test-facilities service, engineering service and products, write to Mitts & Merrill, Inc., 109 McCoskry, Saginaw, Michigan 48601. Or telephone (517) 752-6191—or contact our distributor near you.



SUBSIDIARY **VALVED** National Corporation

Mitts & Merrill

109 McCOSKRY STREET, SAGINAW, MI 48601
(517) 752-6191 • TELEX 227-460 • Cable MAMSAG

Economic Summary - Feed, Conveying, Grinding

1) Modified System (essential)

a. Estimated Construction Cost	\$172,000
b. Design Cost at 6%	10,332
c. SIOH at 5%	8,610
d. Additional Costs - studies, field verification, etc. at 10%	<u>17,220</u>

Total Cost \$208,362

2) Redesign System (desirable)

a. Estimated Construction Cost	\$274,200
b. Design Cost at 6%	16,452
c. SIOH at 5%	13,710
d. Additional Costs - studies, field verification, etc. at 10%	<u>27,420</u>

Total Cost \$331,782

- Notes:
1. See Appendix for backup cost data.
 2. These costs include Design and Construction only, and not proveout and commissioning costs.
 3. Since Increment I and Increment II processes use essentially the same equipment, costs have not been attributed to either.

B. Evaluate Slurry Weighing, Concentrating, Holding, and Slurry Feed Systems and Develop Modifications to Slurry Weighing, Concentrating, Holding and Slurry Feed Systems

General. After the propellant has been processed by the conveying and grinding system the propellant is turned into a slurry to be handled by the slurry system. The slurry system was installed in two increments (Increment I and Increment II). Both increments have been installed with all necessary tanks, pumps, piping, controls and instrumentation.

The major pieces of equipment of both systems consist of 16 tanks, (7 of these with agitators) and 12 pumps.

The slurry system is for the storage of propellant in slurry form until ready for disposal of either by wet air oxidation or fluidized bed incineration, assuming both these disposal systems to be functional.

Slurry System Components - Increment I

- 1) Density Transmitter DF 100
- 2) Slurry Weigh Tanks T-103A & B
- 3) Overflow Tank Transfer Pumps P-102
- 4) Slurry Transfer Pump P-103
- 5) Slurry Storage Tanks T-104A, B & C
- 6) Agitators A-100A, B & C for Storage Tanks
- 7) Slurry Pumps (N.I.C.) 2
- 8) Slurry Overflow Tank T-105

Summary - Increment I

The tankage, piping, pumps, instrumentation and controls which make up this system are relatively conventional, and have been used for similar functions many times in the past. Although the slurry consists of propellant and explosive, which must be handled carefully, no significant technological gaps exist preclude successful operation.

The areas of concern which may result in problems under operating conditions are difficulties due to slurry settling out in piping with resultant line clogging, and use of centrifugal pumps. It is understood that NOS has used this type of pump in the past with success, but pumping will nevertheless have to be proven in operation. The piping systems have been designed and installed with care, and provisions have been made for line flushing to prevent propellant from remaining in lines to dry. Nearly all pipes have been connected in some way to provide maximum versatility.

This could result in operator confusion and increases the chance for error in valve setting, etc. It appears that a relatively large amount of operator attention will be required.

To conclude, however, compared to the technological gaps which exist in other areas, this portion of the PDF is straightforward and after a certain amount of learning should operate properly. Additional changes required should be minimal.

Description of Process, Increment I

The Shredder Building 1569 containing the equipment which reduces solid pieces of waste propellant to the size necessary to form a slurry when water is added. Slurry equipment in Building 1569 consists of crusher tank T-101, dewatering pump P-100, dewatering screen H-100, slurry tank T-102, slurry pump P-101, piping, controls and instrumentation. All other equipment relating to the slurry system is located in Building 1570. The slurry is created by the equipment in Building 1569, then transferred by slurry pump P-101 to slurry equipment in Building 1570 for storage.

Slurry pump P-101 transfers the propellant slurry from slurry tank T-102 to slurry weigh tanks T-103A or T-103B located in Building 1570, passing the slurry through a gamma ray density transmitter DT-100 before the slurry enters the weigh tanks.

In the weigh tanks, slurry density is established for storage, then transferred by the slurry transfer pump P-103 to slurry storage tanks T-104 A, B, C (all with agitators) or slurry overflow tank T-105. Slurry from overflow tank T-105 can be transferred by the overflow transfer pump P-102 to any tank in the Increment I installation.

The processed slurry being stored in the storage tanks T-104A, T-104B, T-104C would be continually agitated until ready for disposal. When ready for disposal, the slurry would be pumped by two slurry transfer pumps to the disposal system (either Wet Air Oxidation or Fluidized Bed Incineration).

Evaluation of Slurry System Components, Increment I

Tank T-101 and T-102 plus pumps P-100 and P-101 have been evaluated in this conveying and grinding section of this report under Evaluation of Components. Therefore, refer to that section of the report for these components.

1) Density Transmitter, DT-100

Description. This unit is a glass lined, tee-shaped spool section mounted in the pipeline to the weigh tanks. The unit has a 1-1/2" 150 pound flanged inlet and outlet. The density of the propellant slurry flowing through the transmitter would be measured by the use of a gamma ray.

Evaluation. Although never tested, this unit should operate effectively because this is a common way of determining the density of a slurry flowing through a piping system.

Potential Modifications. None anticipated.

2) Slurry Weigh Tanks T-103A & B

Description. These are vertical, flat top, cone bottom tanks, 3'-6" O.D. by 9'-0" straight side with four mounting lugs equally spaced. The nominal capacity is 650 gallons. These tanks are fabricated of 316 stainless steel with carbon steel lugs. The top has a reinforcing ring with bolted cover. On the top are three 1-1/2" nozzles. On the shell is one three-inch nozzle and in the center of the cone bottom is a 1-1/2" nozzle. All nozzles have 150 lb. flanges.

Slurry is introduced into two of the top nozzles from slurry transfer pumps P-101 and P-102. The third 1-1/2" nozzle is a spare. The 3" nozzle in the side shell is for slurry overflow by gravity to overflow tank T-105. From the bottom 1-1/2" nozzle, slurry is transferred to the storage tanks by transfer pump P-103. Tank controls and instrumentation for each tank are minimal, consisting of four weigh cells (one under each tank mounting lug) and flow control valves on bottom cone 1-1/2" nozzle.

Evaluation. As installed, the weigh tanks should fulfill the function which they were designed to perform.

Potential Modifications. None recommended at this time.

3) Overflow Tank Transfer Pump P-102

Description. This is a horizontal centrifugal pump with a pumping capacity of 33 GPM at 31.8 PSI TDH driven by a 3500 RPM electric motor. The pump is constructed of 316 stainless steel throughout and mounted upon a carbon steel base. The manufacturer and pump model number is unknown at this time. This information will be determined during the final field visit.

Evaluation. The function of this pump is to pump propellant slurry from overflow tank T-105 to any other selected tank in the Increment I system. This is accomplished by manually operating the valving in the piping system. Control for the pump is manual start/stop switch. This pump can empty the overflow tank in approximately one hour which would appear to meet the slurry system design criteria. Pump must be certified for use with hazardous slurries.

Potential Modifications. None anticipated at this time. Pump's suitability for pumping hazardous slurries must be determined.

4) Slurry Transfer Pump P-103

Description. This pump is a Gould horizontal centrifugal model No. 3196 constructed of 316 stainless steel and mounted upon a carbon steel base. The pump size is 1 x 1-6 with a 4.81" diameter impeller delivering 44 GPM at a 19.8 ft. TDH, and powered by a Westinghouse 1 HP, 1750 RPM motor.

Evaluation. The purpose and function of this pump would be to transfer the propellant slurry from weigh tanks T-103 A & B to storage tanks T-104A, B & C or overflow tank T-105. The weigh tanks with a capacity of 650 gallons, and this pump with the capability of delivering 44 gpm could empty one weigh tank in 15 minutes or both weigh tanks in 30 minutes. This type of performance should satisfy the slurry system requirements. Control of the pump would be by manual start/stop switch. Pump must be certified for use with hazardous slurries.

Potential Modifications. None anticipated at this time. Check pump's suitability for pumping hazardous slurries.

5) Slurry Storage Tanks T-104A, B & C

Description. These are vertical tanks with a dished head top and bottom, supported by four structural steel legs. The tanks are 6'-0" O.D. and 8'-0" high on the straight side with a nominal capacity of 2000 gallons. Internally on the vertical shell are mounted four 1/4" thick x 2" wide x 7-10" high baffles spaced 90° of each other. In the top head are three 1-1/2" nozzles (in the center for an agitator) and one 1/2" coupling with plug. In the shell are one 24" manhole and a 6" diameter hole for a level instrument spud. In the center of the bottom head is a 1-1/2" tee nozzle with side 1-1/2" nozzle of the tee blanked. All nozzles are 150 lbs. flanged except the manway which is per the drawings. The tanks are fabricated of 316 stainless steel with the structural legs of A36 carbon steel.

Evaluation. The purpose of these tanks are to store the propellant slurry prior to deposition. The tanks receive slurry for storage from transfer pump P-102 which would pump the slurry from overflow tank T-105 and transfer pump P-103 which would pump the slurry from weigh tanks T-103A & B. The storage tanks have agitators. When slurry is stored in the tanks, the slurry is continually agitated to prevent settling; however, unless agitation is very good, propellant could settle out in 1 1/2" bottom outlet. When the slurry is to be disposed of it would be removed by one of two transfer pumps through the bottom 1-1/2" center nozzle to the disposal system (Wet Air Oxidation or Fluidized Bed Incineration).

Instrumentation and controls for each of the storage tanks consists of remote control valves on both top 1-1/2" slurry inlet pipelines and the bottom 1-1/2" outlet pipe line. In the side of the tanks is a level transmitter, level indicator and high/low level signal.

These three storage tanks have a total capacity of 6000 gallons of propellant slurry. Assuming the propellant would be disposed of by Wet Air Oxidation, it would take approximately 10 hours to dispose of the 6000 gallons of slurry. Therefore, to continue operation for one week as planned new slurry must be prepared while oxidation is taking place.

Potential Modifications. Addition of air or water for fluidization of settled propellant at 1 1/2" bottom outlet nozzle would be desirable especially prior to pumping. Tee currently exists which could be adapted to this purpose.

6) Agitators A-100A, B & C

Description. These agitators mount upon the 10" top center nozzle of storage tanks T-104A, B & C. All parts of the agitators wetted by propellant slurry are of 304 stainless steel, the other components, housing drive, etc., are of carbon steel. The agitator axial flow impeller would turn at 100 RPM through a right angle spiral bevel and helical combination gear reducer, driven by a 10 HP electric motor. The manufacturer and agitator model number is unknown at this time. This information will be determined during the final field visit. Control would be by manual start/stop button or switch.

Evaluation and Potential Modifications. These agitators have never been operated with the tank filled with a propellant slurry. It would be fair to assume the agitators would perform the job required. If and when the agitators are operated under actual process conditions, it may be necessary to make some modifications but at this time, none anticipated.

7) Slurry Pumps (N.I.C.) A and B

Description. These pumps are Durco horizontal centrifugals, model Mark II constructed of Alloy D (316 stainless steel) and mounted upon a carbon steel base. Each pump is size 1 1/2 x 1 6/76 delivering 50 GPM at a 255 ft. TDH, and powered by a Westinghouse 15 HP, 3515 RPM motor.

Evaluation and Potential Modifications. The function of these two pumps is to transfer the propellant slurry from the storage tanks T-104A, B & C to the appropriate disposal system. From correspondence provided, it is known that these pumps do not supply slurry to the high pressure WAO pumps at sufficient head at maximum flow. They will require replacement. From correspondence reviewed as part of supplied data package, specifications were prepared for purchase of replacement pumps.

8) Slurry Overflow Tank T-105

Description. This is a vertical bolted flat top, cone bottom tank supported by four equally spaced structural legs. The tank is 6'-6" O.D. and 8'-0" high on the straight side, with a nominal capacity of 2000 gallons. The tank is fabricated of 316 stainless steel and the structural legs are A-36 carbon steel.

In the flat head are five 1-1/2" nozzles, two 3" nozzles and one 2" nozzle. In the shell on the side of the tank is a 6" diameter hole for a level instrument spud. In the center of the cone bottom are two 1-1/2" nozzles of a tee configuration with the size nozzle blanked. All nozzles are 150 lb. flanged.

Evaluation. The basic function of this tank is to receive excess propellant slurry from weigh tanks T-103A & B. From the weigh tanks, the slurry transfers by gravity into the two 3" top nozzles. Slurry water flows into the tank, through one of the 1-1/2" top nozzles. Three of the 1-1/2" top nozzles are for recirculated slurry. The fifth top 1-1/2" nozzle is blanked. Through the top 2" nozzle well water can be added. From the bottom cone 1-1/2" nozzle the slurry is pumped by slurry transfer pump P-102 to the slurry storage tanks T-104A, B and C or any other tank in the Increment I Slurry System.

Tank controls and instrumentation consists of a control valve on the well water pipeline, the recirculating slurry line to the storage tanks and the bottom line to pump P-102. On the side shell through the instrument spud is a level transmitter, level indicator and a level high/low signal.

This tank, with a capacity of 2000 gallons, has the capability of holding three weigh tanks of slurry, which apparently is more than adequate to satisfy the slurry system requirements or balance.

Potential Modifications. This tank, with a 2000 gallon capacity, and no agitation, offers the possibility of propellant settling out of the slurry if it is retained for any length of time. Perhaps adding an agitator should be a consideration. However, this can only be determined by putting the slurry system into operation.

Slurry Systems Components - Increment II

- 1) Density Transmitter DT-851
- 2) Slurry Weigh Tanks T-873A & B
- 3) Slurry Transfer Pump P-873
- 4) CP Slurry Storage Tanks (T-874A, B, C & D)
- 5) Agitators A-874A, B, C & D for CP Storage Tanks
- 6) CP Slurry Feed Pumps, P-874A & B
- 7) Slurry Overflow Tank T-875
- 8) Overflow Tank Transfer Pump P-875
- 9) HEP Slurry Storage Tank T-854
- 10) Agitator A-854 for HEP Slurry Storage Tank
- 11) HEP Slurry Feed Pumps P-854A & B

Summary - Increment II

The conclusions drawn regarding Increment II are essentially the same as for Increment I. Please refer to the previous section.

Description of Process Increment II

The slurry equipment in Building 1569 is common to both increments. Slurry pump P-102 would also transfer the propellant slurry to the Increment II installation, Building 947B. The slurry would be pumped from slurry tank T-102 by slurry pump P-101 to slurry weigh tanks T-873A or T-873B located in Building 1570 passing the slurry through a gamma ray density transmitter DT-851 before the slurry enters the weigh tanks. In the weigh tanks, slurry density is established for storage then transferred by slurry transfer pump P-873 to composite propellant (CP) slurry tank storage tanks T-874A, B, C, D, or high energy propellant (HEP) slurry storage (all with agitators) depending upon the type of propellant slurry processed. Slurry which is put into slurry overflow tank T-854 from the weigh tank can be transferred by slurry overflow transfer pump P-875 to any other tank in Increment II installation.

Composite propellant (CP) slurry is stored and continuously agitated in storage tanks T-874A, B, C and D. When ready for deposition, the slurry would be pumped by composite propellant (CP) slurry feed pumps P-874A and B to the disposal system. HEP slurry is stored and agitated in HEP storage tank T-854, then pumped by HEP slurry feed pumps P-854A and B to disposal system when ready.

The complete slurry system has been installed including components, piping, controls and instrumentation. However, the system to date has not been tested.

Evaluation of Slurry System Components Increment II

1) Density Transmitter DT-851

This unit serves the same function in Increment II installation as DT-106 serves in Increment I installation. Refer to Item 1, Evaluation of Component Increment I.

2) Slurry Weigh Tanks T-873-A & B

Description. These are vertical flat top cone bottom tanks, 3'-6" O.D. by 9'-0" on the straight side with four mounting lugs equally spaced. The nominal capacity is 650 gallons. These tanks are fabricated of 316 stainless steel with carbon steel lugs. The top has reinforcing ring with bolted cover. On the top are three 1-1/2" nozzles. On the shell side is one 3" nozzle. In the center of the cone bottom is one 1-1/2" nozzle and on the side of the cone bottom are two 1" nozzles with one of these nozzles installed at 45° to the vertical centerline of the tank. All nozzles have 150 lb. ASA flanges.

Evaluation and Potential Modifications. These tanks are installed and are of the same size as the weigh tanks of the Increment I installation. Therefore, see Item 2 of Increment I Evaluation of System Components.

3) Slurry Transfer Pump P-873

Description. This pump is Durco horizontal centrifugal model Mark II constructed of Alloy D (316 stainless steel) and mounted upon a carbon steel base. The pump size is 1 1/2 x 1 6/45 delivering 50 GPM at a 75 ft TDH, and powered by a Westinghouse 3 HP, 3515 RPM motor.

Evaluation. The purpose and function of this pump would be to transfer the propellant slurry from weigh tanks T-873A & B to CP storage tanks T-874A, B, C, & D, HEP storage tank T-854, or overflow tank T-875. This pump has the capacity to empty one weigh tank in approximately 13 minutes or both weigh tanks in 26 minutes. Considering the rate at which propellant slurry can be produced, this pump has more than adequate capacity.

Control of the pump is by manual start/stop button or switch. Pump needs further study as to adequacy for pumping hazardous slurries.

Potential Modifications. None at this time.

4) CP Slurry Storage Tanks T-874A, B, C & D

Description. These are vertical tanks with a dished head top and bottom supported by four structural steel legs. The tanks are 12'-0" O.D. by 14'-0" high on the straight side with a nominal capacity of 11,700 gallons. Internally on the vertical shell are mounted four 1/4" thick x 2" wide x 13'-10" high baffles spaced 90° of each other. In the top head are three 1-1/2" nozzles, one 2" nozzle, one 18" nozzle (in the center for an agitator) and one 1/2" coupling with plug. In the shell are one 24" manhole and a 6" diameter hole for a level instrument spud. In the center of the bottom head is a 1-1/2" by 1" tee nozzle, the side 1" nozzle of the tee is blanked. Also in the bottom head is a 1" nozzle set at a 15° angle to the vertical center line. All nozzles are 150 lb. flanged except the manway which is per the drawings. The tanks are fabricated of 316 stainless steel with the structural legs of A36 carbon steel.

Evaluation. The purpose of these tanks are to store the propellant prior to disposition. Slurry for storage would be pumped by transfer pump P-873 from weigh tank T-873A & B and also by transfer pump P-875 from overflow tank T-875. The storage tanks have agitators. When slurry is stored in the tanks, the slurry is continually agitated to prevent propellant from settling out of the slurry. When the slurry is to be disposed of, it would be removed by one of two transfer pumps P-874A or B through the bottom 1-1/2" center nozzle to the disposal system.

Instrumentation and controls for each of the storage tanks consists of a remote control valves on both top 1-1/2" slurry inlet pipe lines and the bottom 1-1/2" outlet pipe line. In the side of the tank is a level transmitter, level indicator, and high/low level signal.

These four storage tanks have a total capacity of 46,800 gallons of propellant slurry or approximately 97,600 pounds of propellant at 25% by weight. However, the explosive limit for the building as located is only 30,000 pounds; therefore, all four slurry tanks could not be filled simultaneously. Assuming the propellant would be disposed of by Fluidized Bed Incineration at 1000 pounds per hour, it would take 30 hours to dispose of the 30,000 pounds of propellant.

With this amount of propellant storage capacity, the FBI system could not be operated for five days with approximately 20 hours of productive operation per day, which was the design goal unless slurry was continually prepared while being incinerated.

Potential Modifications. None at this time.

5) Agitators A-874 A, B, C, and D

Description, Evaluation and Potential Modifications. These agitators mount upon the top center 18" nozzle on storage tanks T-874A, B, C & D. These agitators will turn at 68 RPM and be driven by a 50 HP electric motor.

See Item 6 of Increment I Evaluation of Slurry System Components for data pertaining to the agitators other than that given above.

6) CP Slurry Feed Pumps P-874A & B

Description. These pumps are Durco horizontal centrifugal model Mark II, constructed of Alloy D (316 stainless steel) and mounted upon a carbon steel base. Each pump is size 2 x 1 10/86 delivering 50 GPM at a 308 ft. TDH, and powered by a Westinghouse 20 HP, 3505 RPM motor.

Evaluation and Potential Modifications. The purpose of these pumps would be to transfer the propellant slurry from the storage tanks T-874A, B, C, & D for disposition by the Fluidized Bed Incineration System. Pumping at a rate of 50 GPM, the actual pounds of propellant in the slurry being delivered would be approximately 104 pounds per minute. The FBI can dispose of the propellant slurry at a rate of approximately 8 GPM and about 17 pounds per minute of propellant. It appears each pump can deliver over six times the amount of waste than could be disposed of so recycle to the storage tanks will be required at all times. No modifications recommended at this time.

7) Slurry Overflow Tank T-875

This tank is the same construction, size, and capacity as Slurry Overflow Tank T-105 of Increment I Component Evaluation. The purpose and function of this tank is also the same as T-105. The comments in Item 8 of Increment I Component Evaluation would apply to this tank.

8) Overflow Tank Transfer Pump P-875

Description. This pump is a Durco horizontal centrifugal model Mark II, constructed of Alloy D (316 stainless steel) and mounted upon a carbon steel base. The pump size is 1 1/2 x 1 6/52 delivering 36 GPM at a 105 ft. TDH, and powered by a Westinghouse 5 HP, 3505 RPM motor.

Evaluation. The function of this pump is to pump propellant from Overflow Tank T-875 to any other selected tank in the Increment II system. Control for the pump is manual start/stop switch. This pump can empty the overflow tank in approximately one hour, which would appear to meet the slurry system design criteria. Pump must be certified for use with hazardous slurries.

Potential Modifications. None anticipated at this time. Pump's suitability for pumping hazardous slurries must be determined.

9) HEP Slurry Tank T-854

Description. This is a vertical tank with a dished head top and bottom with four structural supporting legs. This tank is 5'-6" O.D. by 6'-0" on the straight side with a nominal capacity of 1080 gallons. The tank is fabricated of 316 stainless steel with A36 carbon steel legs. Internally on the straight side are four baffles 1/4" thick by 2" wide by 5'-10" high. On the top head are three 1-1/2" nozzles, one 2" nozzle, one 1/2" coupling and in the center a 10" agitator nozzle. In the side of the tank is a 24" manhole and 6" diameter hole for a level instrument spud. In the bottom head in the center is one 2" nozzle with a side 1" nozzle tee configuration and a 1" angled nozzle. All nozzles have 150 lbs. flanges.

Evaluation and Potential Modifications. This tank serves the same function for HEP slurry as the storage tanks do for the CP slurry. See Item 4 above.

This tank stores the HEP slurry from the weigh tanks prior to disposition. Since there apparently would be small amounts of HEP propellant waste generated, this tank would be adequate to satisfy the needs of the disposal system. No modifications anticipated at this time.

10) Agitator A-854

Description, Evaluation and Potential Modifications.

This agitator mounts upon the top center 10" nozzle of storage tank T-854. This agitator will turn at 84 rpm and be driven by a 5 HP electric motor.

See Item 6 of Increment I Evaluation of Slurry System Components for data pertaining to the agitator other than that given above.

11) HEP Slurry Feed Pumps P-854A & B

Description. These pumps are Durco horizontal centrifugals, model Mark II, constructed of Alloy D (316 stainless steel) and mounted upon a carbon steel base. Each pump is size 2 x 1 10/86 delivering 50 GPM at a 292 ft. TDH and powered by a Westinghouse 20 HP, 3505 RPM motor.

See Item 3 above for other pertinent pump data.

Evaluation and Potential Modifications. The same comments apply for these two pumps as for the CP slurry pumps, Item 6 above.

Economic Summary - Slurry Weighing, Concentrating, Holding, and Feed

- 1) Miscellaneous modification which will be determined during startup (assumed).

Increment I

a. Estimated Construction Cost	\$25,000
b. Design Cost at 6%	1,500
c. SIOH at 5%	1,250
d. Additional Costs - studies, field verification, etc. at 10%	<u>2,500</u>
Total Cost	\$30,250

Increment II

a. Estimated Construction Cost	\$15,000
b. Design Cost at 6%	900
c. SIOH at 5%	750
d. Additional Costs - studies, field verification, etc. at 10%	<u>1,500</u>
Total Cost	\$18,150

C. Evaluate Wet Air Oxidation Systems and Ancillary Equipment
Develop Modifications to Wet Air Oxidation Systems and
Ancillary Equipment (If Any)

General. The attached material covers the evaluation of the Wet Air Oxidation (WAO) system. The WAO equipment is situated essentially at two locations of the PDF; at the Reactor Building (#1571) and at the Equipment Building (#1573). The only exception is the pair of slurry supply pumps which transfer slurry from storage to the inlet of the high pressure slurry pump. These supply pumps are located in the Storage Building (#1570). Equipment is controlled from the Control Building (#1572).

System Components - Phase (Or Increment) I

To facilitate evaluation of the existing WAO process, the system was divided into the following discreet categories, by equipment/function:

- 1) steam generator
- 2) process heat exchanger (2)
- 3) solvent system
- 4) slurry system (including reactor, pumps)
- 5) process/plant air
- 6) electrical and instrumentation/controls
- 7) slurry cooler
- 8) process control valves (slurry)
- 9) high pressure water pump
- 10) separator tank
- 11) afterburner
- 12) vapor scrubber

Each of the above areas was evaluated and the results are presented herein. Some of the systems were found to be satisfactory as-is and this finding is so indicated. Areas found to be unsatisfactory as designed, are discussed and the inadequacies are detailed. Recommended modifications to remedy the problem areas are included.

Those areas of the WAO system found to be deficient were analyzed and the corrective modifications proposed are presented herein.

The analysis considers the WAO system exclusive of other supporting systems, such as slurry preparation and water treatment. Analysis of these systems is presented elsewhere in this report.

Summary - WAO

In general, the WAO process, exclusive of external supporting systems, appears to be a viable system for destruction of Propellant and Explosive wastes. The several problem areas found and the proposed fixes are not judged to be major drawbacks to being able to use the process for its intended purposes. The fact that the WAO system is not too far away from being operational, and the fact that a considerable monetary outlay has already been made are major influences upon the recommendation that the system be completed. We would, however, expect that the WAO process would be used initially as a pilot operation, and proceed incrementally toward use as a production facility. Since the WAO process has never been used for PEP processing, (except for small runs during initial process test work) the completion/use of this facility as a large scale pilot operation is a very desirable end product, and we so recommend.

The decision as to whether or not the WAO should be completed will most likely be based, in part, on cost considerations. We believe that if the unit is completed for use initially as a pilot operation (in the interest of furthering disposal technology or any other reason), there is a good chance that it will remain a pilot unit and never be used for production. This should influence the decision as to whether the expenditure to complete the unit can be justified.

Another factor which should strongly influence the decision regarding completion of the WAO is the viability of necessary external support systems, the most important of these being the water treatment facility and the slurry preparation system. Even if the WAO system itself were operational today, it would be virtually useless without these two support systems, which are evaluated elsewhere within this study.

Process Description

The wet oxidation process (also referred to as the Zimmerman Process) is an aqueous phase oxidation reaction of suspended or dissolved organic substances at elevated temperatures and pressures. Any substance capable of burning, that remains dissolved or suspended in water, can be oxidized at temperatures between 100°C and the critical temperature, 372°C, at which water ceases to exist in the liquid phase. The process is well suited to the oxidation of waste liquors, slurries, and sludges where the oxygen-demanding organic matter is only a small portion of the predominant water stream. The water in the waste stream serves to modify the oxidation reaction so that it

proceeds at a relatively low temperature, usually under 325°C, and at a low rate. The water provides an excellent heat transfer medium which enables the process to be thermally self-sustaining, even with the low concentration of organic material in the feed stream. The oxygen required for the reaction is normally provided by introduction of an oxygen-containing gas, usually air, which is pumped into the reaction vessel (reactor). The reactor is simply a pressure vessel used to bring the components together for the WAO reaction, and is operated at sufficient pressure to prevent excessive evaporation of the liquid phase, normally in the range of 150 to 4000 psig. The WAO process has been used world-wide, for many years, to treat municipal sewage and industrial wastes. In recent years, WAO has been applied to mixed waste streams to facilitate recovery/reuse of valuable inorganic components. Also, recent applications have allowed use of heat from the reaction to produce steam and co-generate electrical power. Certain reactions have been enhanced by the addition of catalysts in the reactor.

The NOS WAO UNIT was designed to process PEP slurry at a rate of 10 GPM (550 # of PEP per hour) and will reduce the chemical oxygen demand by 98%. Slurry is prepared at a ratio of 10:1, by weight, of water to PEP, at a separate location within the PDF and pumped to the WAO process. Slurry preparation is discussed elsewhere within this evaluation.

The majority of the WAO equipment is located in Buildings #1571 and #1573. The process is controlled from Building #1572, the site central control building.

The WAO process is shown in the referenced Zimpro drawings, and the operation is described below.

Double base propellant is oxidized as a 10 percent slurry in a titanium lined vertical reactor at 800 psig and 450 to 500°F. The reactor is sized to provide a residence time of 30 minutes. By a variable speed, positive displacement pump, the slurry is fed into the bottom of the reactor where high pressure air is also injected. Reactor effluent is cooled in a titanium coil heat exchanger and passes through a control valve which regulates the system pressure. The oxidized slurry water empties into a separation tank for removal of gases. An oxygen analyzer on the separation tank is used to adjust the air feed so that the reaction products contain only 1 to 2% residual oxygen.

The primary constraint on the operation of this Wet Air Oxidation system is that there must be a constant liquid overflow from the top of the reactor. At steady state,

should water leaving the reactor as a vapor exceed that entering as a liquid in the slurry and formed by the reaction, then the reactor will ultimately dry out and allow the temperature to rise rapidly as accumulated propellant continues to oxidize, and possibly result in a fire or explosion. To avoid this condition, a careful thermodynamic analysis of the energy content of the feed material, operating conditions and products of the reaction is required. The equipment in the system is designed to operate up to 575°F and 2,400 psig. Reactor dry out condition is a function of the amount of water vapor removed by non-condensable gases at the specific operating conditions selected. As the rate of energy input is increased, either as higher slurry concentration or feed rate, effluent temperature will increase and result in a higher water vapor pressure. Reactor operating pressure can be increased to reduce the proportion of water vapor in the gaseous effluent. Analysis of the system indicates that 500 lb/hr of double base propellant in a 10% slurry is well within the safe limits for the design operating conditions. A feed of 1,000 lb/hr in a 10 percent slurry is extremely marginal at the maximum temperature and pressure rating of the system. In order to avoid dry out at a higher propellant throughput, it would be necessary to proportionally increase the water in the slurry feed. However, the high pressure slurry feed pump is limited to 10 gpm, which for a 10% slurry equals a rate of 500 lb/hr of propellant.

During start-up, water is recirculated from the separation tank at 4 gpm and pumped counterflow to the reactor effluent through a double piped heat exchanger. A small package boiler provides 600 psi steam to a second double pipe heat exchanger that supplies the necessary heat input to bring the system up to a temperature for propellant oxidation to become self-sustaining (approximately 250°F at 800 psig). To avoid thermally stressing the thick reactor walls, the heat-up period is limited to 50°F/hr rate of increase. After the minimum reaction temperature is achieved, slurry feed is started and gradually increased while water recycle is reduced.

The Wet Air Oxidation system can also significantly reduce the chemical and biological demand in other organic feeds. However, the materials of construction significantly affect the efficiency of other types of feeds. Chlorinated organics, such as composite propellants and many pesticides, could be processed. The corrosion rate of the titanium clad reactor, discharge piping, and discharge cooler, is essentially zero when nitrated esters are processed. However, chlorinated feed materials would result in a rate of over 50 mils per year and cause pitting and intergranular cracking in titanium. In

addition, because the two double piped heat exchangers that provide heat to the reactor are constructed of stainless steel, which cannot withstand the hydrochloric acid produced by the reaction, water from the separator tank cannot be recycled. Fresh water must be used in its place, and would greatly increase the amount of water that must be treated. In the case of pesticides where the heat value is low, water flow through the double pipe heat exchangers must be maintained throughout the run to provide the additional heat input necessary for sustained reaction. Titanium cannot withstand hydrofluoric acid that would be liberated by the oxidation of fluorocarbon propellants.

The gases from the separation tank are ducted to an oil fired afterburner operating at 1,200°F. With minimum excess air maintained in the wet air oxidation reaction, the level of carbon monoxide generated is unusually large. The afterburner completes the conversion of the carbon monoxide, along with any volatile organics, to carbon dioxide.

The liquid effluent is pumped to the Water Treatment Building to several storage tanks. The water treatment system with a capacity to process 10 gpm, is sized to match the operation of the Wet Air Oxidation system. As each tank is filled, the pH is adjusted from 2 to 7 using a 5 percent aqueous ammonia solution. The primary neutralization product is ammonium nitrate, with a smaller portion as ammonium acetate. Lead oxidation products from certain double based formulations are largely precipitated out when the pH is adjusted, but a residual of about 200 ppm remains in solution.¹ After treatment, the water is fed through a vacuum filter to remove insoluble salts and ash. The filtrate is then fed to a wiped film evaporator. The ammonium nitrate solution is concentrated from about 1 percent to 50 percent in the evaporator bottoms, which is then cooled to 120° and drummed. The evaporated water is condensed and either stored in a 5,000 gallon tank, recycled to the Shredder Building for slurry make-up, or discharged. The building also contains a package boiler to provide steam for the process and building heat, along with a cooling tower, and equipment for the treatment of sanitary effluent from the facility. The water treatment facility is evaluated elsewhere in this report.

¹Zimpro, Inc. Propellant Disposal Demonstration by Wet Air Oxidation, Contract N00174-72-C-0043, Nov. 71.

The Shredder and Reactor Buildings are completely remotely operated. The Shredder Building contains TV monitors in each bay. The Slurry Storage Building is also remotely controlled, but since it is classified as a Class I Division 3 hazard, transients are permitted. The Water Treatment Building is largely manually operated with automatic controls only for the evaporator and neutralization operations.

Current Status - NOS WAO Unit

Most of the system is installed and connected, but has never been used to process PEP materials. The piping system is in place, and has been pressure tested, as has the reactor. A number of problems have been encountered in the system, as detailed, along with suggested modifications, in tasks A and B of this evaluation.

The status of the WAO system, exclusive of supporting systems, can be summarized as being marginally operational. An evaluation of the subelements follows.

1) Steam Generator

Description. The boiler system is very straightforward and simple. The boiler supplies steam up to 600 PSIG and 485°F primarily to the steam heat exchanger and also back to the boiler head tank. Steam also supplies the heat required to heat the feed-water through a coil where it is condensed in a steam trap and is then recirculated back into the feed water supply. The major portion of steam is delivered to the steam heat-exchanger where the process water is heated prior to the reactor to initiate the wet air oxidation process. The steam is regulated by a control valve that senses the oxidized slurry and vapor (OSV) temperature. As the temperature of OSV rises, the control valve closes. Eventually, the boiler flame control is lowered until the boiler is set back to pilot flame. Once the wet air oxidation process is started, the boiler is not required. To remove deposits formed in the boiler, a blow down pot has been provided.

Referring to Figure WAO-1, potable water is brought in, mixed and treated chemically before being discharged into the boiler head tank. There it is preheated prior to entering the boiler. The boiler head tank insures that there is a constant water supply to the boiler and monitors the water condition with various level controls and indicators, and temperature indicators and sensors. The feed water is provided from the boiler head tank to the boiler by a

feed water pump. The chemical treatment system is used to treat the water prior to entering the boiler. The treatment chemicals are manually fed into a 55 gallon drum where water that has been previously softened is mixed with the chemicals and is eventually pumped into the boiler feed water tank.

Evaluation and Potential Modification. The steam generator system as provided is adequate. It does, however, rely heavily on maintenance personnel to operate properly. Improvements could be made to reduce the need for maintenance personnel and increase system reliability.

Improvements could be made to the chemical treatment system by using an automatic feeder which is a more accurate means to meter the chemical into the feed water. This would eliminate any chemical "shocking," and maintain a constant pH balance and require less operator attention. However, since this system is small, the existing system is more than adequate.

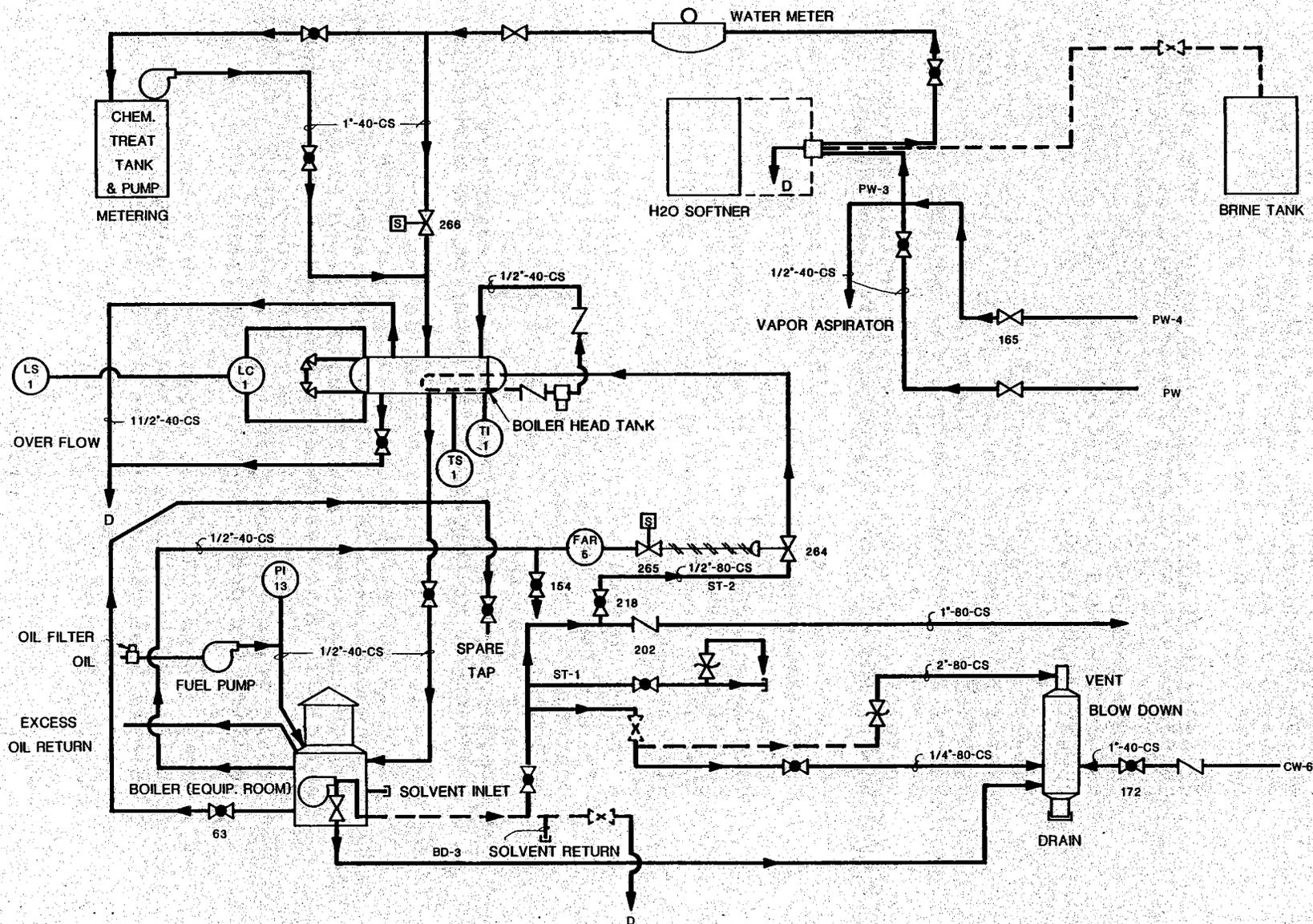
The condensate currently being discharged from the steam heat exchanger could be returned and reused, saving costs involved in the constant addition of chemicals. Since live slurry can never enter into the steam heat exchangers, this may be a valid option that would require a safety analysis to justify the alterations.

A boiler control schematic was not provided. There was no direct indication on how the boiler is controlled. It appears the only way to turn down the boiler is manually. This is not recommended. If not already provided, there must be safety interlocks that preclude any possible case of boiler explosion or overheating of process water entering the reactor.

The boiler system is installed in the equipment building which enables personnel to perform any maintenance required. All systems, such as fuel pumps and chemical treatment are also located in this building. This leaves only the steam heat exchanger and control valve that is operated in an unauthorized area. It is assumed that there are provisions in this building for operator manuals and spare parts.

There are no additional requirements to make the boiler system operate. There are, however, some changes that would make the system safer. These are outlined along the flow path. Refer to Figure WAO-1.

FIGURE MAO-1



WET AIR OXIDATION SYSTEM EQUIPMENT - BOILER AND ACCESSORIES

As the potable water enters the water softening system, on line PW-3 leading to the vapor aspirator, there should be a check valve installed to prevent any contamination from the vapor aspirator. Even though the chance of contamination of the potable water is very minimal, the effluents produced in the aspirator are toxic and no chances should be taken.

Downstream, just prior to the chemical treatment system and after the water meter, another check valve should be installed. This is to prevent any contamination from the chemical treatment system back into the potable water.

On the boiler head tank, we recommend that a strainer be added prior to the steam trap. This is common practice and will increase the life of the trap. Since the condensation from ST-2 discharged back into the boiler head tank there is a slight possibility that if the tank overfilled the water would back up and flood the trap. Therefore, a check valve would be recommended to prevent this.

Also on the boiler head tank, a pressure relief valve mounted on it to relieve an excessive pressure build-up would seem appropriate.

Downstream of the boiler, there is an item with perhaps a bit of discrepancy in design philosophy. The relief valve is mounted on a branch mounted from the main steam line. A globe valve is mounted between the relief valve and main steam line. The design philosophy of this arrangement allows the globe valve to be closed shutting off the steam being released by the relief valve. The globe valve should either be omitted or the relief valve leg should be mounted before the globe valve, enabling steam to act on the relief valve at all times. Since the globe valves can be inadvertently closed by accident, the relief valve would not serve its purpose. The safety of the system is more important than the clean up of condensate.

Another check valve could be installed in line CW-6 to prevent any contamination of water from flowing back and contaminating the cooling water. Since the blowdown port is probably drained prior to allowing the cooling water to enter, this isn't required, but is desirable.

2) Process Heat Exchanger

Description. The Process Heat Exchangers are used to heat the process water, prior to the reactor. Two

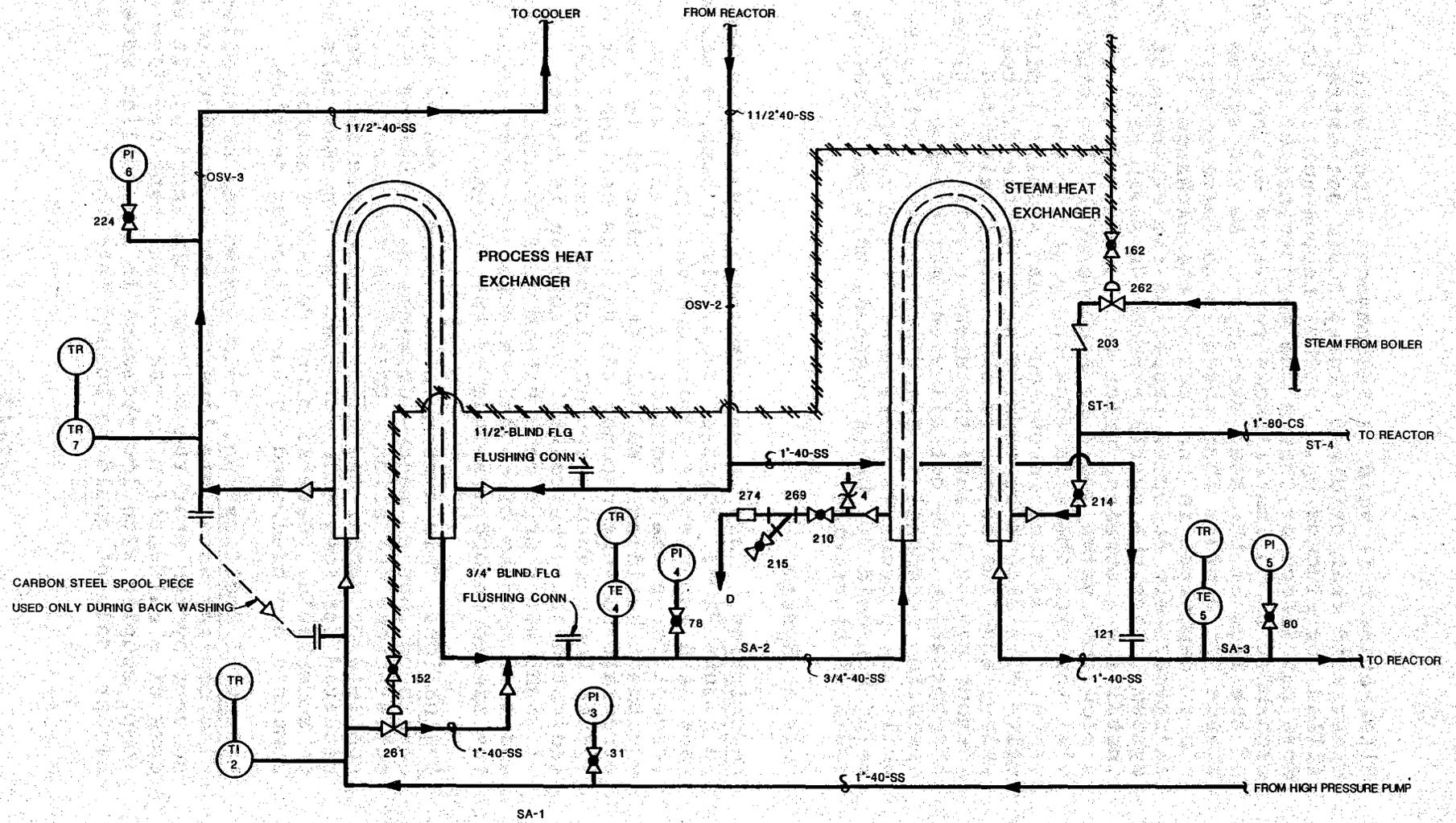
heat exchangers are used; a steam heat exchanger and a process heat exchanger. Each exchanger consists of a series of loops with a pipe within a pipe. The outer pipe serves as a shell while the inner pipe serves as a tube. The entire exchanger is insulated and enclosed in an outer casing to keep heat losses down and prevent damage to the insulation and exchangers. The heated process water is used to initiate and maintain the temperature of water needed for oxidation of the PEP slurry in the reactor. The Steam Heat Exchanger is used only for startup. Steam is injected in the shell side of the exchanger, heating the process water in the tubes. As the reaction or oxidation takes place, the steam slowly modulates down as the temperature and pressure increase. When the oxidation process is fully operational, the steam is completely shut down.

As the hot slurry flow from the reactor is circulated through the Process Heat Exchanger, the process heat exchanger is used to either preheat the process water or keep it to the desired temperature.

Evaluation and Potential Modifications. No calculations verifying the size of the heat exchangers has been performed. It is assumed that Zimpro with its many years of experience has properly designed the heat exchangers. There are no major modifications or requirements to make the heat exchangers operable. However, there are a few items concerning the design and controls used. The system was not entirely designed for the oxidation of PEP wastes. Therefore, the following discussion describes some modifications and items that should be checked before operation begins.

From the process flow diagram, Figure WAO-2, the heat exchangers are adequate to handle all normal operations. One problem noticed is the corrosiveness of the oxidized slurry. The slurry in time will eventually corrode through the Process Heat Exchanger. If it has not already been done, coating the walls with a titanium clad will increase the life expectancy. One problem area in the design (that is not clear by this review) is a pipe adjoining the legs of the Hex's near the bottom. This horizontal pipe acts as a support brace and appears to be open on one end and closed on the other end. If this is the case, then assuming worst case, if the reactor oxidation balance is upset and unoxidized slurry entered the exchanger, this void would fill up the HEX with the PEP wastes making it very difficult to clean out and may present a hidden danger that could not be detected in its present state.

FIGURE WAO-2



WET AIR OXIDATION EQUIPMENT - HEAT EXCHANGER FLOW DIAGRAM

Eliminating this void is recommended along with any other void that oxidized slurry could get entrapped, filled, or plugged up. Another recommendation that does not affect or change the performance of the exchanger is to install some automatic drains in each of the legs of the heat exchanger. As the system stands, it appears that there is no valve to drain slurry deposited in the legs of the exchanger if an emergency were to occur requiring the drainage of the system. When the system enters the steam HEX, installing a strainer prior to the control valve with a blow down valve would be recommended. The strainer will increase the life expectancy of the control valve. It is also recommended that a valve similar to valve #214 should be mounted prior to the control valve, enabling access to the control valve and HEX without having to shut the steam supply off. Although the operation does not allow any maintenance or operating personnel in the plant process "hot" area while the process is operating; if the system was being run cold or, being cleaned, this modification could be beneficial.

3) Solvent System

Description. This is an independent system, as shown in Figure WAO-3, composed of a solvent pump, a solvent tank, and appurtenant piping and valving, located (except for a small portion of the piping) within the equipment building. We understand that it is used to circulate solvent through the various portions of the system for cleanup purposes. Information available indicates that the solvent circulated is either straight water or a weak nitric acid solution. Valve and line numbers cited herein refer to those shown on the Zimpro record drawings of the system.

Evaluation. This system is very simple and we have concluded that no major revisions are required for satisfactory operation. Operation and control are complete by manual and minor field connections are required for some modes of use. We consider this to be acceptable. Several minor revisions and/or comments are discussed in the following section.

Potential Modification. This system can be supplied with cooling water via line CW-3 which connects to the solvent system near the solvent pump section. In the case of a malfunction in the solvent tank overflow loop, coupled with low pressure in the cooling water header, solvent could be pushed into the cooling water

TO SEPARTOR

INLET

SOL

FIELD CONN.

1"-10-SS

REACTOR BLDG WALL

SOL

EQUIP. BLDG WALL

1"-10-SS

VENT

1"-10-SS

SOLVENT

TANK

(IN EQUIP. BLDG.)

2"-10-SS

FIGURE MAO-3

SOLVENT
PUMP

SOL

1 1/2"-10-SS

1"-10-SS

2"-10-SS

1/2"-40-CS

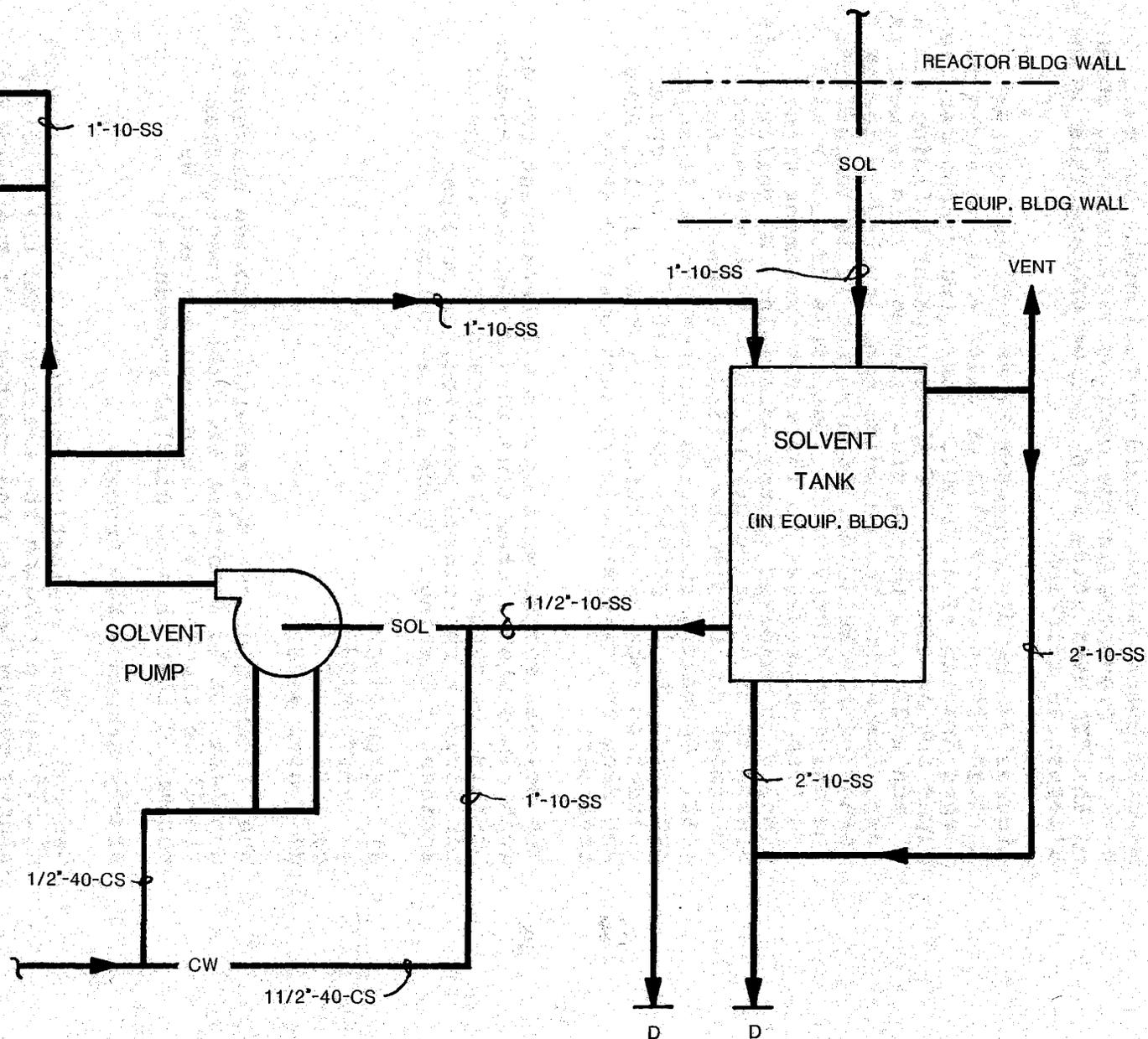
CW

1 1/2"-40-CS

D

D

WET AIR OXIDATION EQUIPMENT - SOLVENT SYSTEM



line. Although not a likely occurrence, this could be precluded by installation of a check valve in CW-3, and we so recommend. Elsewhere in this evaluation, we have recommended check valves for several of the CW supply lines. A viable alternative which would provide the same protection as the installation of several check valves, would be to install one main backflow preventer in the cooling water header, ahead of the "T" near valve #106, and we propose this as an alternative solution.

Liquids can be discharged from the solvent system through either valve #111 or valve #109, as shown on Zimpro drawing #I-18-D-301. These two discharges are piped across the floor of the equipment building via a 1" and a 2" line to the floor trench. This trench, in turn, dumps into the building sump located in the NW corner of the building, from whence it is pumped into the oxidized slurry tank. Materials from this tank are then pumped over to the water treatment plant along with oxidized slurry materials. We believe this system to be satisfactory provided that the water treatment can handle the periodic volume of nitric acid. Operating procedures for the system flushing operation should provide for transfer of the spend solvent as soon as practical from the building sump, and from the oxidized slurry tank over to water treatment.

The solvent system will only see intermittent use at such times when system flushing is required. Because of this, we recommend that certain manual valves be tie-wired in the closed position, to preclude accidental opening. These are as follows:

- a) valve #100
- b) valve #109
- c) valve #107
- d) valve # 93

When flushing of the system with corrosive solvents is complete, it is important that the solvent system itself be flushed with water, and drained. We recommend that this be handled procedurally.

4) Slurry System - WAO Process

General. This evaluation considers both the incoming slurry system feeding the reactor, and the oxidized slurry system leaving the reactor. Of the complete slurry system, only the Zimpro supplied portion is considered herein; i.e., that portion downstream from valve #255. Other portions of the slurry system, such

as preparation and storage, are addressed elsewhere in this report. Certain specific Zimpro supplied equipment within the slurry system, such as heat exchangers, coolers, and pressure control valves are addressed elsewhere in this evaluation. Also, instrumentation, controls, and electrical pertaining to the slurry system are covered by a separate section. Valve and line numbers cited herein refer to those shown on the Zimpro record drawings of the system.

Summary. The slurry system as designed is judged to be operable in its present configuration; however, there are a number of safety related short-comings which must be addressed. It is recommended that correction, as detailed hereinafter, be made prior to live PEP operation.

The analysis is based upon the assumption that the WAO system is installed as designed, and that components are in working order. It is beyond the scope of this evaluation to determine if this is, in fact, the case. Since much of the equipment, although new, has been installed for several years, a detailed field examination/checkout should be conducted for all components, prior to live startup.

Evaluation. Slurry is pumped from storage in Building #1570 by one of two slurry feed pumps located in that building on the suction side of the high pressure slurry pump located in the reactor building. A return line from a point near the high pressure pump suction permits recirculation of excess slurry back to the storage tank in Building #1570. Design calls for slurry to be maintained at a 10:1 ratio. (10 lb water to 1 lb PEP).

It is our understanding that a problem exists in that the slurry feed pumps in Building #1570 (rated above) are not capable of supplying enough net position suction head (NPSH) to the high pressure slurry pump suction to enable it to feed the reactor at rated capacity. Some corrective design analysis has been performed by NOS personnel, but has not been completed. We have addressed this problem later in this evaluation, under the paragraph entitled "Pumps".

The WAO process to be used is based upon proven technology and many such systems are currently operational. What makes this installation unique is the type of the materials to be processed, i.e., slurried propellants. To our knowledge, very little

WAO work has been done with these materials, and most of this has been pilot operation. Consequently, we believe that if problems are to be encountered in the Indian Head WAO process, they will be due to the material itself, rather than the process.

Since the material itself is hazardous from an ignition standpoint, the current design calls for the process to operate remotely. System operation, monitoring, and control is accomplished remotely from a control house over 100 ft. distant from the reactor building. This situation is perfectly acceptable provided sufficient equipment is provided to properly control the process. We view the monitoring and control system, as installed, to be marginal. The system appears to be a standard WAO plant with slight modifications for remote operation. We believe there is a need for more automatic control and better process condition monitoring. Almost all process conditions presently monitored are indicated at the control panel and are subject to proper operator response. We recommend inclusion of more automatic controls, as discussed elsewhere in this evaluation. Any problems caused by dependence of the process on operator response are magnified by the fact that the system is expected to operate only for about one week, six times a year, causing a reduction in operator familiarity. This intermittent operation calls for increased automatic control and a reduced operator response requirement.

In summary, we believe that the remote operation of this plant will require considerable more monitoring and control capability than has been provided.

In addition to the expected processing variation and upsets, equipment breakdowns and malfunctions will be difficult to detect, and may require some time period to show up on process monitoring equipment. Malfunctions such as broken lines, plugged valves, broken sensing devices, etc., may not cause a fast response at the control panel. We believe that a CCTV system with at least two cameras (with pan/tilt and zoom capabilities) should be located within the reactor building, and so recommend. This will not cure all of the anticipated problems, but will alleviate some of them.

The above constitutes our evaluation of the existing slurry system, and contains some observations and recommendations relative to the WAO installation in general. The following section is devoted to our recommendations concerning modifications to the existing slurry system.

Potential Modifications

General. Considerable design work related to PEP (Propellants, Explosives and Pyrotechnics) slurry disposal system was done by the Navy during the late 1970's for the Western Demilitarization Facility (WDF) at Hawthorne, Nevada. In the WDF Bulk Explosive Explosive Disposal System, PEP slurries are prepared and burned in two Radford-type rotary kilns. Design work done for the WDF slurry systems should be applicable to this project, and such design work is cited herein, whenever applicable.

Valves

Valves for use in PEP slurry lines require careful selection because of the potential for plugging and abrasion problems associated with any slurry application. However, the major problem relates to the hazards due to the energetic solid material present, and valves must not accumulate this material or apply undue forces to it. PEP slurry valves should be soft seated to minimize the potential for initiation of the solids by pinching or friction. At the WDF, the Navy adopted soft seated butterfly valves for use in all slurry lines, such as manufactured by Hills-McCanna (McCannalok) or ITT Grinnell (Dynalok).

In the WAO process, incoming slurry from storage to the supply pumps #1 and #2, passes through Valve #245 which, according to the Zimpro valve schedule (Drawing I-18-D-304, Sht. 2 of 2), is an ASCO, normally open 2-way solenoid valve with a Buna N diaphragm. This valve is actuated upon emergency shutdown, at which time the valve energizes and closes, thereby shutting off slurry feeding the pumps.

Since this valve is to close on emergency shutdown, it is recommended that it be configured as a normally closed valve instead of normally open, which will ensure fail-safe operation. In this mode, a continuous duty coil will be required since it will be energized any time slurry is flowing through the valve.

The use of this particular valve for propellant slurry control is not recommended, in that slurry can enter the solenoid core tube through the diaphragm bleed orifice, whenever the valve is closed. In time, propellant particles may accumulate in this space and dry out due to the solenoid generated heat. Since there are moving parts within the core tube, it is conceivable that an initiation of dry propellant could occur due to friction, even though the valve component materials are all non-sparking.

This valve must be remote controlled. There are four major types of remote control valve activators to choose from: (1) direct-acting solenoid; (2) solenoid actuated pilot, line fluid operated; (3) solenoid actuated pilot, pneumatically powered; and (4) air actuated pilot, air powered. The direct acting solenoid (in the explosion proof model) is large, expensive, and availability is somewhat limited. Solenoid actuated pilot, line fluid operated, is not desirable for use on slurry lines because the small holes in the valves (used to direct line fluid to the internal operating elements of the valve) will clog with the particles of the slurry. This is similar to the problems described above for the ASCO valve, solenoid actuated pilot or air actuated pilot, air powered valves can readily be used in PEP slurry lines, and these types of actuators were adopted at the WDF.

For Valve #245, we would recommend a solenoid actuated air powered actuator. All other valves (excluding one relief) in this slurry system upstream of the reactor are manually actuated. There are some 15 of these valves, and they are either plug, globe, check, or ball types. Use of most of these valves is contrary to the philosophy used at the WDF, which mandates use of soft-seated valves in PEP slurry lines and does not discriminate between manned or unmanned operations. Consequently, we recommend that all of these valves be considered for replacement with soft-seated types.

Relief Valve #1 is a 1" Kunkle (Figure 71-S) with cast iron body and stainless steel trim. This valve for metal-to-metal contact between the plug and the seat, and as noted previously for other valves, is not a good choice for PEP slurry use. We recommend use of a soft-seated valve for this application. Kunkle does make soft-seated relief valves which would be suitable. It may be possible to replace the internal parts of the existing valve to accomplish this purpose.

Whether or not a real hazard is presented by the use of PEP slurry valves with metal-to-metal wetted parts contact is subject to question. However, in our opinion, the precedent set at WDF should not be ignored, and any design contrary to this should be backed by substantiating data. We know of no such data.

An additional factor to be considered regarding propellant slurry piping systems as used in this WAO process is that slurry pressures are quite high and can reach 2400 psi. We know of no hazard analysis data for slurry systems which consider this elevated operating pressure.

The case can be made that even if an initiation of propellant solids does occur within a valve due to pinching or friction, it will not propagate through the slurry provided it is at a proper propellant-water ratio. The quality of energetic material involved in such an occurrence would be quite small, and would probably result in only a deflagration or very low order detonation.

Despite the above arguments and the use of remote operations, we believe that soft-seat valves should be used in all PEP slurry lines.

The above valve discussion applies to the portion of the system designed to convey unoxidized slurry (i.e., upstream of the reactor) during the operation.

There are several manual valves within the entire slurry piping system including both before and after the reactor which are important to proper operation of the process, but which are rarely used. No remote valve position indicators are used with these, and since this is a personnel exclusion area, and since there is no CCTV system, there is no way to determine valve positioning during live processing. In most cases, improper positioning of the valve would be noticed during startup (while personnel were present); however, there are several which could be overlooked. We suggest these be tie-wired in their normal position, as follows:

- (a) Valve #23 (2) - tie closed
- (b) Valve #26 (2) - tie closed
- (c) Valve #205 - tie open
- (d) Valve #28 - tie closed
- (e) Valve #30 - tie closed
- (f) Valve #61 - tie open
- (g) Valve #91 (2) - tie open
- (h) Valve #95 (2) - tie closed

Unoxidized Slurry Carryover

Based upon recent discussions with Zimpro personnel, the existing system is not designed to automatically preclude the possibility of unoxidized slurry entering the piping system downstream from the reactor. This presents hazards, as discussed below, and could occur through operator error, or equipment malfunction, wherein slurry could pass through a cold reactor and leave essentially unoxidized. In this situation, the live material could conceivably pass through the complete system from the reactor to the separation tank and beyond. Also, even with the system operating at proper temperature and pressure, system upsets could cause partially unoxidized material to exit the reactor and carryover into the equipment

building. The degree of hazard in this case would be related to the degree of oxidation of the material.

Several hazards are apparent if this occurs, as follows:

- (a) The slurry piping system downstream from the reactor contains some 20 valves of various types. The argument made above for use of soft-seated valves can be applied to this situation. A procedural solution could be applied to minimize this hazard, wherein these valves cannot be operated until the system is flushed of unoxidized slurry.
- (b) Unoxidized slurry cannot be permitted to enter the equipment building because the electrical equipment at that location is not rated for hazardous areas, and personnel are not excluded from this area during operations.
- (c) If unoxidized slurry were allowed to enter the separation tank, it could exit the bottom of the tank and flow to the recirculation pump. We do not believe this pump is a proper selection for handling PEP slurries for reasons discussed later in paragraph "Pumps".

This possibility could be precluded procedurally by mandating that this pump not be operated at times when unoxidized slurry is present at the pump. This fix would require the detection of unoxidized slurry within the equipment building and execution of a proper response to this situation. This would solve the immediate problem at the pump, but the major problem is the presence of unoxidized slurry within the equipment building as noted above. We believe the proper solution to safety problems of the slurry system downstream from the reactor is to address the real problem, i.e., provide the means to ensure that significantly unoxidized slurry does not leave the reactor.

If this cannot be done, a special problem is presented at Valve #263, analysis of which is beyond the scope of this assessment, but which will have to be addressed. This valve (two are installed but one is a back-up) is a Fisher #667DA model with air topworks, and is the system pressure control element. The valve is remotely operated by the controller located in the main panel of the control room, and is installed for fail-safe operation (loss of air signal closes the valve) so as to preclude dry-out of the reactor.

It would be extremely difficult (or impossible) to find a soft-seated replacement valve for this application. The

service is severe from a standpoint of pressure, abrasion, corrosion, and to a lesser extent, temperature and metal-to-metal sealing is vital. As noted previously, the best solution is to exclude unoxidized slurry from the system downstream from the reactor, which includes these valves.

A discussion of these valves related to their use in the process is included elsewhere in this evaluation.

Pumps

Within this system, unoxidized slurry is pumped at two locations. At the storage building, it is pumped at low pressure by one of two Goulds pumps (one pump is a stand-by) over to the reactor building, and delivered to the suction side of the high pressure slurry pump. The high pressure pump, in turn, delivers the slurry to the reactor at process pressure of up to 2400 psig.

The selection of pumps for PEP slurry has considerable importance from a safety standpoint, but is not an exact science. Such pumps should feature ample clearances between moving parts so as to preclude pinching of energetic material particles. Slurry wetted parts should be resistive to corrosive attack by the materials being pumped, and moving parts contacting the slurry should be non-sparking.

Radford Army Ammunition Plant has considerable experience with pumping of explosive liquids and slurries. Discussions with Radford personnel have indicated that they use great care in selecting pumps for applications of this type, and that they try to use pumps with successful past experience.

The WDF uses Galigher Vacseal Model VRb200 dual centrifugal pumps in all PEP slurry mixing and circulating applications. These pumps had been used successfully at RAAP in pilot tests for the Radford rotary kiln, and were recommended to the Navy for use at WDF for the following reasons:

- (a) The application (i.e., pumping water containing significant amount of PEP) is unique.
- (b) The pumps have proved their applicability for the intended use over a reasonable trial period.
- (c) Qualification of another unit would require significant time and cost.

The Goulds Model 3196 "MT" pumps used in the WAO process to supply slurry to the reactor building is difficult to appraise due to our limited knowledge of the reasons for selection of these units. However, it is recommended that this application be studied in depth from a safety standpoint. If these are standard, off-the-shelf centrifugal pumps, we question their applicability, unless a proven background of successful PEP slurry use can be documented.

Notwithstanding the above safety-related problems which show these pumps to be questionable, operational problems have been encountered which indicate that they should be replaced.

The two Goulds slurry supply pumps are located in Building #1570 and are connected in parallel, such that one pump is on standby while the other is on line. A single 1-1/2" CS slurry supply line (S-4) connects the pump discharge to the suction of the Zimpro high pressure slurry pump in the reactor building (#1571). A single 1-1/2" CS slurry return line runs from the Zimpro pump suction side back to the storage tank in Building #1570 and is provided to return excess slurry to supply and to maintain a velocity high enough to prevent settling out of PEP solids in the lines. Zimpro drawing #I-18-D-570 shows the piping details at the Building #1570 end of the system, and drawing #I-18-D-558 shows such details of the Building #1571 end. The two lines are routed between the two buildings through a below-grade pipe trench, and are each about 200 ft. in length.

In operation, the centrifugal supply pump operates at a constant speed, pumping slurry to the Zimpro pump suction. If the Zimpro pump is not operating, all flowing slurry enters the return loop and recirculates back to tankage in Building #1570. The Zimpro pump is a variable speed, variable flow unit. When it is operating (supplying high pressure slurry to the reactor), the return loop flow varies, depending upon the output flow to the reactor. When the Zimpro pump is operating at maximum output, the return loop flow is at a minimum, and vice versa.

We understand that two problems have been apparent during testing. One problem is that when the return loop flow is at a minimum, the slurry velocity in it is so low that the solids settle out, causing restriction and plugging. The other problem (also at high Zimpro pump output flows) is that suction pressures become too low, the pump runs starved, and output flow cannot achieve maximum rated capacity.

It is beyond the scope of this evaluation to propose a detailed redesign to correct the above slurry problems. However, we do offer the following information and general guidance which should prove useful in formulating solutions.

The two problems are interrelated, and we submit that a single solution cannot solve both problems. Based on available information, the Zimpro pump requires 40-60 psig NPSH, and previous calculations (by others) have shown that only 35 to 28 psig is available when output flow from this pump is 0 to 10 GPM, respectively. From the above, it is obvious that the slurry supply pumps in Building #1570 are not properly sized for the application, and must be resized to provide the minimum of 40 psig NPSH when the Zimpro pump is operating at the maximum output of 10 GPM.

The related problem of low slurry velocity in the return loop must also be analyzed concurrently with the NPSH problem. We believe that the solution is to reduce the return loop line size, select supply pumps which will operate at a fairly constant output flow while providing the required minimum NPSH, and hose flow is sufficient to maintain the minimum velocity in the return loop when the Zimpro pump is operating at maximum flow. The supply pumps must be carefully selected in that the pump curve should be relatively flat (approximately constant flow) at a pressure band centered on the required supply pressure.

This will cause the return loop flow to vary as the Zimpro pump output flow varies, but the proper sizing of this line will maintain the required minimum velocity, and simultaneously allow the supply pumps to operate at fairly constant output flow and pressure.

The above approach is recommended over adding restrictors (valves or orifices) to the present system to regulate flow and/or pressure, because this solution does not correct the low velocity problem in large cross-sectional portions of the system. In fact, restrictor devices may create areas of slurry solids accumulation.

A similar analysis can be made for the recycle pump in regard to pumping PEP slurry. This, of course, becomes a moot point, as discussed above, if unoxidized slurry is not allowed downstream from the reactor.

The high pressure slurry pump is a Zimpro ZHP-24-15 unit, electric motor driven. This pump is a proven unit for slurry handling, and the only comments we are providing pertain to the safety aspects of this unique application of pumping propellant slurry.

The pumping action used by this pump to move slurry appears to be reasonably safe for PEP materials. The slurry is moved by the squeezing action of a rubber boot within the pressure chamber and has no metal-to-metal contact of moving parts. This appears to be safe since the action is similar to a peristaltic pump, which has been successfully used for PEP slurries. We are not aware, however, of any proven operations wherein slurry is pumped at this high a pressure level.

The squeezing action of the boot is imparted by hydraulic pressure. The rubber boot separates the two fluids. Pressure is supplied by hydraulic pump, and is transmitted across a free piston to the hydraulic system connecting to the boot. This is an attractive feature in that if a leak occurs in the boot, only the quantity of hydraulic oil in the boot loop would be leaked into the slurry system.

Two pressure chambers are used with this unit; one pumps while the other fills. During the attending fill/discharge cycle of each pumping chamber, fluid is directed through the product check valves. Details of these valves were not available for our examination, and we would recommend that these be evaluated since it is a potential area for pinch points and solids accumulation.

In general, the high pressure slurry pump appears to be well suited for the application; however, since we are unaware of any proven history of this pump in handling PEP slurries (except for the limited pilot test work) it would be prudent for the Navy to conduct some live testing prior to operating as part of the WAO system. As noted previously, pump selection for PEP slurries is not an exact science, and most of the people in the business rely heavily on live remote testing to establish confidence, and we so recommend.

The high pressure water pump is discussed elsewhere in this evaluation.

Sumps are located in both the reactor building and the equipment building. These sumps are equipped with standard centrifugal submerged sump pumps. No energetic material should be allowed to enter these pumps. Based on our information, this will never occur under normal operations. However, we do not have sufficient information on intermittent procedures (such as draining/flushing of equipment and piping) to determine if live slurry can ever reach the building sumps. In any event, we recommend that the means be provided to ensure that no slurry enters the sumps.

If this cannot be done, then the sump pumps should be replaced by diaphragm (or other) type pumps which are accepted for energetic material use.

Drains

Live slurry piping in the vicinity of Pumps #1 and #2 (in Building #1570) show four drain connections. In the reactor building, two live slurry drains are shown near the high pressure slurry pump, and the reactor blowdown pot connects to the drain. Oxidized slurry lines are tied to drain at several points within both the reactor building and the equipment building.

The piping details provided us for review do not show the final connection for any of the above drain lines; consequently, it is impossible to determine whether these tie to building sumps, building trenches, sanitary or industrial sewer or other.

It is important that this drain system be reviewed, since it is vital to safety that PEP materials be allowed in only those systems designed for it. If the details required to make this review are not shown on drawings, then field examination should be performed to complete the evaluation.

As noted in several places previously, if provision is made to ensure that live slurry cannot enter the system downstream from the reactor, then that portion of the drain system need not be assessed.

CW Connections

Cooling water is tied directly to the slurry piping (via Valve #27) at the discharge of slurry Pumps #1 and #2. These lines should contain a check valve (or other backflow preventor) to prevent accidental backup of slurry into the CW lines. The same situation exists at Valve #246. This CW line should also have a check valve installed.

At the high pressure slurry pump, cooling water line CW-8 connects to the oil heat exchanger. We recommend a check valve be added to this line ahead of the cooler to prevent oil contamination of the CW line, should a rupture occur within the cooler shell.

We make the same recommendation as above for the recycle pump aftercooler CW line (CW-9). A check valve in this line would preclude oxidized slurry backup into the CW system, if a tube rupture occurred within the aftercooler.

Piping

Based on previous PEP slurry piping designs done for the WDF, and work done by Radford AAP relative to their slurry incinerator, we are aware of the importance of ensuring that solids accumulation points are eliminated from the system. It is not within the scope of this evaluation to detail all points within the system at which settling may occur, but several such points are readily apparent, such as the pipe immediately ahead of Valves #28 and #30. We recommend that a field survey be performed, prior to operation of the system, to locate solids accumulation points, and that piping modifications be made to eliminate these to the extent possible.

We expect line plugging to be a fairly common occurrence in the slurry system. At WDF, use of "food industry type quick-disconnect couplings" was incorporated to the maximum extent possible. These are not available for use in the high pressure WAO lines; however, they could be employed in the slurry system upstream from the high pressure slurry pumps, and we so recommend.

Threaded piping components are not recommended for PEP slurry lines. Based upon the piping drawings available for this review, we find that this philosophy has been adhered to throughout the system. The reason threaded connections are not used in that energetic material can accumulate in the thread and could be friction-initiated during disassembly. We found only one screwed device in the line slurry system, that being Valve #1, the relief valve in the slurry pump discharge line. We recommend that this valve be either replaced or modified to preclude it from being unscrewed.

The piping system (and equipment) must be completely grounded, and bonded in accordance with OP-5, Vol. 1, Ammunition and Explosive Ashore, Safety Regulations for Handling, Storing Renovation and Shipping", paragraph 4-7 entitled, "Grounding Requirements". Based upon the slurry piping drawings available for our review, the flanged and welded connections presently used should provide good continuity for grounding. The titanium portion of the piping (and the reactor itself, since it is titanium lined), even though not as conductive as the rest of the system, is conductive enough to provide an adequate grounding path.

This evaluation shows that the slurry system is sufficiently conductive throughout to lend itself to proper grounding; however, details of this grounding were not shown in our review package. Consequently, we

recommend that the entire piping system (including equipment) be field inspected and tested prior to operation, in accordance with OP5, Vol. 1, paragraph 4-8, "Inspection and Tests of Ground Systems".

The slurry system contains various sensing elements (pressure, temperature, and flow) throughout, and the instrumentation for these is discussed elsewhere within this report. However, several comments can be made herein as pertains to portions which are a part of the piping system, as follows:

- (a) PS-4 is a Mercoid pressure switch reading slurry pressure ahead of the high pressure slurry pump. Although this switch is equipped with a pigtail siphon, slurry could conceivably reach the interior of the brass bourdon tube. We recommend that this device be provided with a stainless steel tube (either 304 or 316) and that consideration be given to providing the switch with a diaphragm seal to prevent the slurry from entering the pressure power element, similar to that used at PE-1 in the reactor discharge line.
- (b) FE-2 is a Foxboro #2801 magnetic flowtube used to measure slurry flow into the reactor. The body of this unit is made of fiberglass reinforced epoxy and is non-conductive; consequently, a bonding strap should connect across the metallic mating flanges on either side of this unit, to provide grounding continuity. The design of this device makes it well suited for hazardous locations (considering both the internal flowing fluid and the surrounding external atmosphere) and also for use with fluids containing solids. The pressure rating of this unit could not be ascertained from information made available to us. This application calls for a working pressure of up to 2400 psig; however, the local Foxboro vendor states that the usual Model 2801 flow tube would only be rated for under 500 psig, and that the body would have to have a special rating to be used at 2400 psig. If this unit has a special pressure rating, it is not so indicated on the Zimpro process drawings and device schedules.

PEP slurries have been proven to be non-detonable and non-propagating when maintained at least at a 3:1 ratio by weight, i.e., 3 lb. of water to 1 lb. of energetic material. This ratio has been used successfully by RAAP and was formally proven by NAPEC. This was officially reported in "Hazards Analysis Report on Bulk Explosive Incineration System for Hawthorne Demilitarization Facility" by Naval Sea Systems Command (NAVAMPROENGLN), Naval Weapons Support Center, Crane, Indiana, September,

1977, by Kenneth L. Kluemper. The line slurry system for the WAO process contains a considerable length of piping running from the process pumps in Building #1570 to the reactor in Building #1571, plus the return loop piping from near the high pressure slurry pump back to the storage building. Nowhere within the above system is there any means of sensing slurry composition. Since maintaining a proper PEP/water ratio is important to the safety of the operation, we recommend that consideration be given to providing such monitoring equipment. A non-contact density meter could be used for such purpose. Density meters were installed at the WDF following the original design, when it was determined that they were vital to system safety. For our system, a suggested location for this equipment is in S-4, just ahead of the high pressure slurry pump.

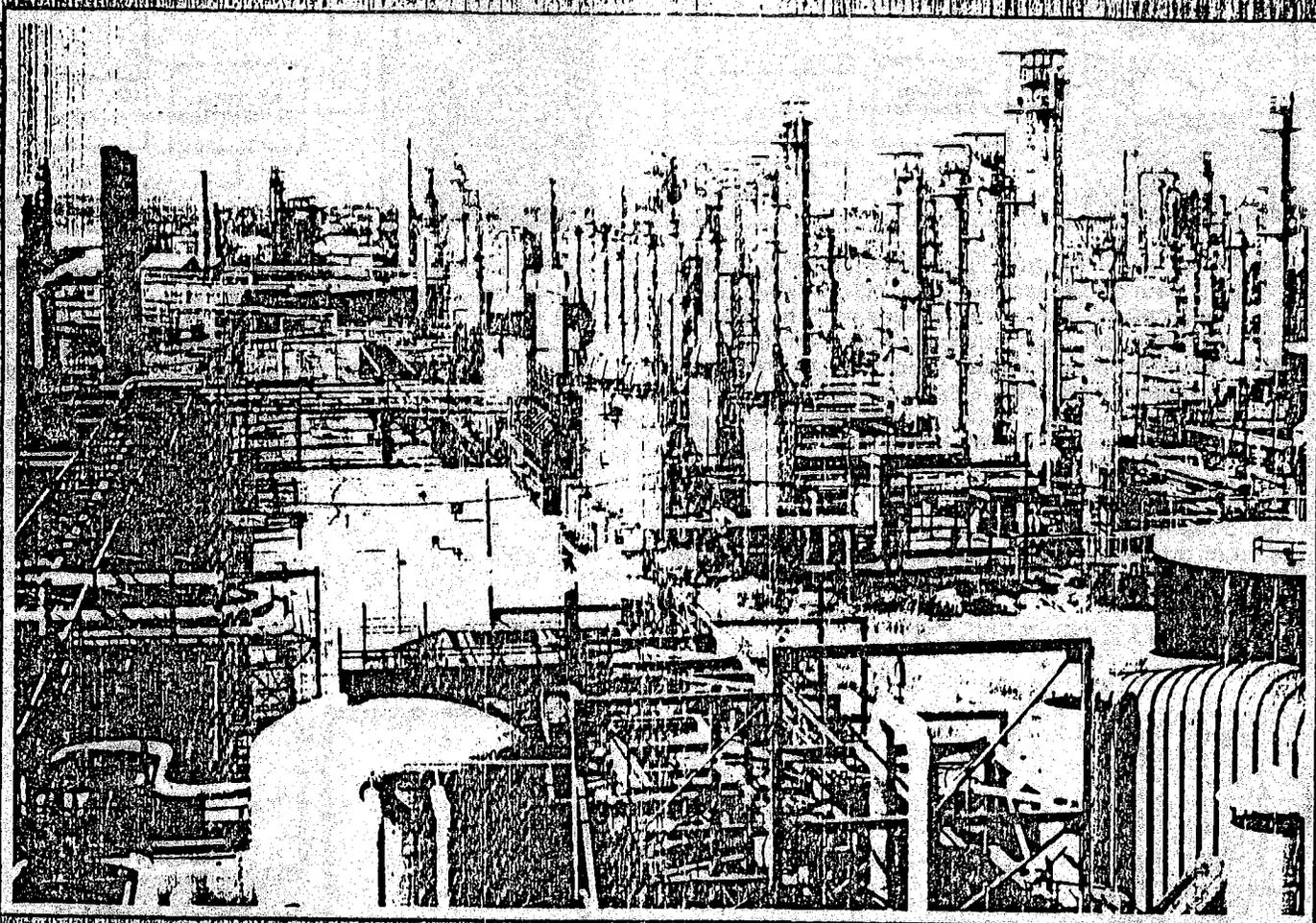
Reactor

Heat-up and cool-down of the reactor is to be accomplished at a rate not to exceed 50° F per hour. We understand that this is critical to avoid undue thermal stresses within the vessel. At present, the heat-up/cool-down control is manual and depends upon the operator attention for uniformity. Based on the fact that the reactor is a very expensive equipment item, we conclude that automatic control of heat-up and cool-down may very well be cost effective. Therefore, we recommend consideration be given the inclusion of such automatic control equipment.

During normal operation of the WAO process, it is important that the liquid level of material within the reactor be maintained. At present, there is no equipment installed to monitor this level. Based on information available to us, extreme loss of water within the reactor can result in a hazardous situation. Evaluation of this situation is beyond the scope of this analysis. We do, however, recommend that consideration be given to the implementation of a two step study to determine (a) the severity of the problem, and (b) the solutions that may be appropriate.

Liquid level monitoring within the reactor appears to be a difficult task, due to the high pressure, fairly high temperature, corrosivity, and the nature of the material; however, it can probably be accomplished with state-of-the-art monitoring equipment, such as the Kay-Ray, Inc., Model 4100P neutron level measurement system, brochure attached. Once the relative importance of level monitoring has been established, a decision can be made as to whether or not to incorporate it.

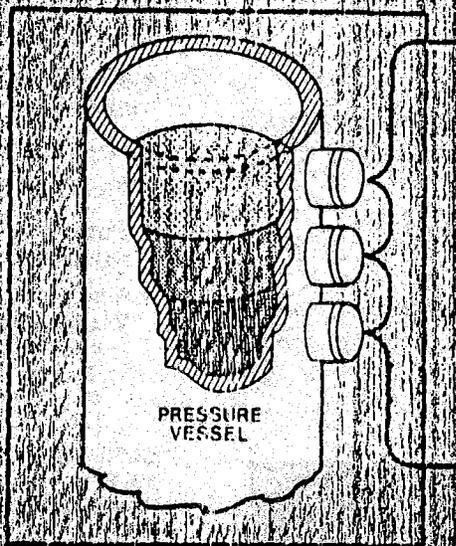
MODEL 4100F neutron level measurement system



MEASURES LEVELS OR INTERFACES FROM OUTSIDE VESSELS HAVING UP TO SIX INCH STEEL WALLS WITHOUT WALL PENETRATIONS!

In many refineries, pulp and paper, syn fuel and other processes, large heavy walled steel vessels are required. Reliable determination of levels and/or interfaces within these vessels is often critical. Mechanical or other contacting type level sensors either cannot function or cannot withstand the conditions within the vessel. Even gamma level sensors which measure levels from outside of a vessel have limitations: the walls may be too thick, the required radiation fields for proper measurement may be too high, or wall buildup may interfere with the measurement.

The Model 4100F Neutron Level Measurement System measures levels, interfaces, or density gradients



in vessels containing hydrocarbons or water bearing liquids, solids, or slimes. The measurements are made totally outside of the vessel, no wall modifications or intrusions are required.

FEATURING:

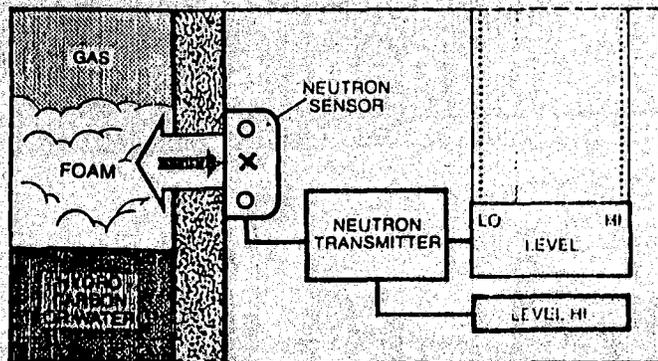
- No vessel intrusion
- Rugged construction
- No electronics at the measuring point
- No downtime installation
- Measures through several inches of steel
- No wall modifications
- Continuous detection of foams, liquid/solid interfaces, density gradients
- No moving mechanical parts
- Dirt free measurement



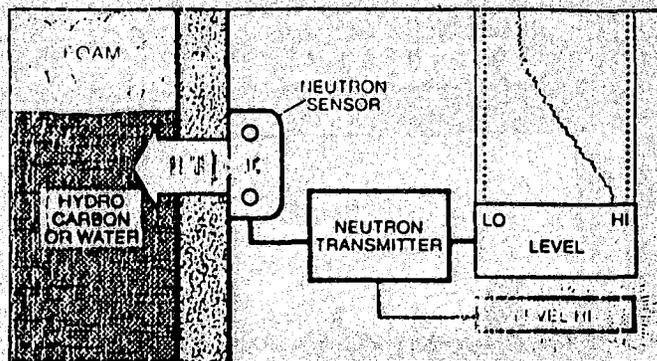
OPERATION

Typical coke and foam levels over time as measured at one point.

LEVEL LOW



The Model 4100F Neutron Level Measurement System utilizes a neutron backscatter principle to detect levels and interfaces in heavy walled vessels. The neutron source directs *fast* (high energy) neutrons through the essentially transparent vessel walls into the interior. If hydrogen bearing material is present, the *fast* neutrons are converted into *slow* (low energy) neutrons which pass back through the vessel wall to the neutron sensor. If



hydrogen bearing material is not present, *slow* neutrons will not return to the neutron sensor.

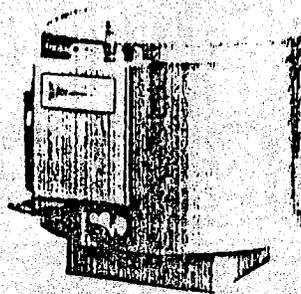
A signal directly related to the hydrogen content of the hydrocarbon or water bearing material is sent to the neutron transmitter, which develops continuous and alarm outputs.

In this way, solid, liquid, and/or foam levels, interfaces, or density gradients can be continuously monitored.

SPECIFICATIONS

The following specifications describe the major components of the Model 4100F Neutron Level Measurement System.

NEUTRON LEVEL SENSOR



- Accuracy: ± 1 inch
- Construction: Welded steel air purged or Class I Groups D, E, G Division I Hazardous Environments
- Electronics: None
- Surface Radiation: Less than 7.5 mR/hr
- Source Size: 500 mCi $Am_{241}Be$
- Ambient Temperature: -20 to 250°F (-29 to 121°C)
- Weight: 121 lbs. (55kg)

NEUTRON LEVEL TRANSMITTER



- Enclosure: NEMA 4 or Class I Groups A & B Division I explosion proof
- Power: 120/240VAC 50/60 Hz 300VA maximum
- Ambient Temperature: 0-120° (-17° to 40°C)
- Outputs: 0-100VDC 5mA maximum, 4-20 mADC floating or isolated 0-1000 ohms
- Alarms: Optional dual SPDT 6A resistive @ 120/240 VAC or 28VDC



CORPORATE HEADQUARTERS
 516 W. Campus Dr., Arlington Heights, IL 60004 U.S.A.
 Phone (312) 259-5600
 Toll Free (Continental U.S., except Illinois): 800-323-7594
 Cable Address: KAYRAY Telex: 281-085

SALES & SERVICE OFFICES WORLD WIDE

A very cursory analysis was made as to the consequences of reactor dry-out. Assuming that a reactor completely filled with propellant slurry is allowed to dry out to 10% moisture, this would yield an energetic material weight of about 3800.

Studies of various propellant yield have shown a wide range of TNT equivalency under varying conditions of temperature, pressure confinement, etc., ranging from 10% to around 150%. If we assume a TNT equivalency of one (which is probably conservative) then the reactor would qualify as a Class 1, Division 1 (mass-detonating) item. Based upon the required intraline (unbarricaded) distance of $D = 18W^{1/3}$, as prescribed in OP5, Vol. 1, Chapter 5, the separation between the reactor Building (#1571) and the control house (#1572) should be about 280 ft. Actual distance is about 125 ft. This analysis does not prove that a hazard exists, but rather points out that the safety of the process is not obvious, and merits a deeper examination.

5) Process Plant Air

Description. Plant air is supplied by a Worthington tandem three stage air compressor. It is powered with a 75 hp motor. The compressor comes complete with features such as a thermometer, moisture trap, level gage, high water sight flow glass, high water temperature switch and relief valves for each of the stages. The instrument air is supplied by a 25 hp Ingersol Rand air compressor. An aftercooler has been provided for each compressor. The plant and instrument air is dried through a Pall air dryer. The air compressors and attached equipment are mounted in the mechanical building with all the air distribution lines and air conditioning accessories branched out throughout the WAO system as required.

Evaluation. The compressed air system is comprised of all the necessary items required to make the system completely operable. We did not observe any complications or discrepancies with the compressed air systems. The air compressors were equipped with adequate control gauges and proper materials. Therefore, no major recommendations for modification of the plant air distribution system are made.

Potential Modifications. Since air lines for both instrument and plant are run between buildings, it is assumed that they are protected to some degree for winter. However, the lines should be checked to make sure that the air is properly treated. Water legs should be provided to insure proper water drainage

between instruments and panels and between buildings. One of the largest contributors of moisture is from adequate forming inside lines that are exposed to the outside air. Filters that automatically remove moisture should be used and, if they are located in areas exposed to cold environments, they should be insulated. Filters that provide ultrafine filtration are not needed. Filtration down to 5 microns should be more than adequate. It is recommended that lubricators have a remote auto fill device to reduce maintenance. Micro mist lubricators work better for longer pipe lengths and better distribution of lubricating oil.

It might be noted also that it is an operational advantage that the performance of a filter regulator piggyback is approximately 12% better than a filter and regulator mounted in series because there is one less body casting and one less nipple connection through which the air must flow.

Since the compressed air system for the wet air oxidation process has been idle for several years, all the lines should be checked and blown out removing rust scale and other deposits. The compressors should be dismantled, cleaned and inspected. Gaskets that have dried out should be replaced.

In general, the compressed air system should perform all that it is required to.

6) Electrical Systems

General. The following discussions pertain to the existing electrical system ancillary to the Wet Air Oxidation System (WAO) at NOS. The existing electrical system includes the control and instrumentation system, such as sensors, transmitters, controllers, and final control elements and the supporting "building system" (i.e., power, lighting, lightning protection, grounding, and heavy electrical equipment).

The design criteria for electrical system design for explosive operations includes several important concepts:

1. Provide operational safety by minimizing the possibility of human error and/or minimizing requirements for personnel access to hazardous areas.

2. Provide "Fail-to-Safe" design which will allow safe equipment shutdown in the event of equipment or power failures.
3. Provide adequate instrumentation to allow all necessary automatic functions and concurrently allow operating personnel to fully recognize the process status and easily react as required to any possible occurrence.

Adherence to the above criteria allows a higher level of operational safety and minimizes hazards to both personnel and the environment.

The design criteria for "building systems" more closely follows normal design practice for hazardous location installation, and therefore is more easily defined and analyzed.

The section following provides a general summary of the WAO electrical systems evaluation results. Later sections contain detailed comments and proposed modifications.

Summary

A review of the existing electrical control and instrumentation system reveals no major design errors in basic concepts. The systems used are basic in design and appear to be common industrial practice. The typical operating parameters associated with most processes using WAO systems lend themselves to this type of simplified design, i.e., the normal process, once started up and operating, is a slowly changing quasi-steady operation, requiring little control interaction other than maintaining utility type parameters. However, as previously mentioned, processing of explosive compounds requires some special considerations, especially in the areas of safety and automatic controls.

The analysis of the existing WAO electrical systems indicates that many of these considerations are not provided for. The primary concern is in the area of instrumentation and controls. Although total automatic control may not be warranted, automation should be considered for all functions related to transfer and processing of the explosive slurry where operator error could result in hazardous situations. In addition, automated control functions are advisable for systems that cannot be accessed by personnel during operations.

The analysis of the WAO electrical system, based on pinpointing problem areas regarding operational safety, ease of equipment operation and maintenance, and improved efficiency, has identified a number of items which are limited in adherence to explosives operations design criteria. As a result, a number of proposed modifications have been developed which alleviate the problem areas identified.

It should be noted that the implementation of these modifications are highly dependent on the outcome of other WAO design reviews and the overall applicability of the WAO system to processing of wastes at NOS.

Description. In order to identify the specific points of evaluation, a general description of the existing WAO electrical systems follows:

Electrical controls are primarily limited to standard motor control circuits and utility valve switching circuits. There are no provisions for proportional electric controls; most proportional controls are via pneumatic systems.

Pneumatic controls are used to adjust pumping rates via air driven vari-drive adjustments. These controls are located at the remote control panel for operator adjustment based on instrumentation readouts.

Two proportional controllers are located at the control panel for control of the steam pre-heating system and the pressure control systems. These controllers modulate the associated valves during startup operations.

Other pneumatic controls are located at the equipment to be controlled (e.g., pressure regulators). These items are not typically adjusted except during setup preparations.

Instrumentation systems are comprised of standard type sensing elements (flow, pressure and temperature) coupled to transmitters and recording instruments (or indicator lights in the case of alarms). Instrumentation systems do not provide automatic control functions, but are limited to providing indications of process status to the operators. The operators are required to analyze the incoming data, determine the necessary corrective procedures (if any) and manually adjust the system controls. If certain parameters exceed alarm setpoints, provision is made to provide total system shutdown.

Building systems are comprised of standard and/or explosion proof lighting and power equipment, with wiring

installed in conduit. Installation of the existing equipment follows normal design practice for electrical equipment in hazardous locations.

Evaluation.

Controls Design. The fact that all process controls are manually adjusted by operator personnel may be perfectly acceptable for most WAO systems; however, in dealing with explosive operations totally manually controlled operations is of some concern. For sewage sludge, the WAO system has been tested to the point that the adequacy of total manual control has been proven. However, for explosive operations, automatic control of at least critical functions such as slurry feed rates and water make-up is highly advisable. In order to ensure maximum safety of operations, automatic control should be provided on all explosives operations which could become hazardous due to operator error, or which have limited or restricted access during process operation.

Instrumentation Design. The selection of monitoring points in the general instrumentation design appears to be adequate in most cases; additions to the instrumentation equipment to provide automatic control functions would be minimal. One area of concern, however, appears to be a lack of indication of slurry concentration in the reactor. This may be provided indirectly by the flow transducers or both the slurry and the makeup water; however, changing conditions in the reactor could result in gradual water loss and potential hazards for increased "oxidation" rate. Perhaps the system automatically compensates for water loss by the nature of the process but this compensation needs to be verified and tested.

Control and Instrumentation Equipment. The control and instrumentation equipment, including sensing elements, transmitters, indicator/recorders, switches, and relays are selected from major equipment manufacturers. Although a review of each item should be performed to verify applications and possible improvements, the equipment appears to be properly selected for the functions indicated. Since the existing equipment was designed a number of years ago, state-of-the-art measurement systems may be a desirable upgrade. This may be particularly true in the slurry handling system, since a number of slurry flow measurement devices have been developed in recent years.

Equipment Hazardous Location Ratings. The existing Zimpro drawings specify "all equipment located in hazardous areas shall be explosion proof." However, the drawings do not identify which components must meet these requirements,

nor are specific NEMA standards or NEC classifications given. Instrumentation and control component schedules do not contain any reference to explosion proof equipment ratings.

Alarm System. The alarm system consists of high/low pressure, temperature, and flow indicators with silencing audible alarms. The general alarm network is a standard design which provides total WAO system shutdown in the event of alarm conditions. (Does not shut down afterburner for upstream failures.)

On drawing No. 2329-E1, there are five emergency shutdown lights which are energized simultaneously. These lights have conflicting legends (e.g., "emergency shutdown open" and "emergency shutdown close"). These functions need clarification. Perhaps they are coordinated with the flow diagram and show actual required valve positions in various locations. If this is the case, a better design would utilize valve position limit switches for light control and actual valve position indication. The common bussing of status indicators opens the possibility for valve failure to go unnoticed.

System Interlocks. Safety interlocks for process operation should be provided to preclude any potential for deviation from normal processing procedures. The system as designed does not show any interlocks of this nature. In particular, we found no interlock to preclude pumping of explosive slurry into a cold reactor; this allows erroneous starting of slurry pumps and could result in passing of unoxidized slurry throughout the system. Lack of this interlock is considered to be a major deficiency.

Operating Manuals. No operating manuals were provided for review by this office. If operating manuals exist, they may contain information which would alleviate some of the above concerns. In any event, operation manuals should be generated which detail system operating procedures and parameters.

Building Systems

The Day and Zimmerman drawings available for review are considerably more detailed regarding the building system electrical equipment (as opposed to WAO drawings). The building electrical systems (i.e., power, lighting, lightning protection, grounding and heavy electrical equipment) are consistent with general design practice, including provisions for installation in hazardous locations. Design drawings are well documented as to equipment classifications, types and wiring systems.

Any proposed modifications, if followed through to actual installation, will require at least some coordination with the building electrical systems. Determination of the actual impact of modifications is not within the scope of this review.

Potential Modifications. The following eight line items are proposed as minimal additions to the WAO instrumentation and control systems. No major modifications to the existing building systems are identified; however, the building electrical systems will require minor coordination with the modifications listed. In addition, other modifications may be required in conjunction with process modifications developed in other sections.

Item 1. Provide automatic control of hot water startup, including the following functions:

- a. Control of steam heat input as required to ensure that the "temperature rise per unit time" specification for the reactor is not exceeded.
- b. Interlock to preclude any possibility of pumping raw explosive slurry until the system is at operating temperature and pressure.
- c. Additional instrumentation to indicate water flow (and/or slurry flow) at various points in the circulation system.

Item 2. Provide additional valving and semi-automatic, interlocked control for the pressure control valve (PCV1, PCV2), including the following functions:

- a. Additional instrumentation for pressure indication of the valves. This indication would automatically indicate impending blockage and allow automatic or semi-automatic switchover to the standby valve prior to the necessity of a total system shutdown.
- b. Incorporate additional valving for isolation of PCV1 and PCV2, with appropriate valve position indicators and interlocks to preclude any possibility of pumping slurry through a valve with an open drain. This modification involves installation of additional isolation valves on the exit of the PCVs which operate in conjunction with valve number 242 and installation of a remote operator on the drain valve (#95) from each PCV for operation 180 degrees out of phase from the isolation valves.
- c. Consideration should be given to installation of

flushing connections to these PCVs which would allow remote flushing during operational periods, especially in the event of a plugging situation which has caused switchover to the standby PCV.

Item 3. Provide additional instrumentation on the oxidized slurry cooler to indicate presence and/or flow of cooling water. Present instrumentation indicates water temperature only; this is insufficient as the absence of flow could result in erroneous temperature indication.

In addition, provide automatic proportional cooling water flow adjustment (valve #268) based on temperature readout from TE8.

Item 4. Add additional instrumentation for indication of air flow at the point of injection into the reactor and into the high pressure water line. This indication will provide much faster indication of air system failure than the present system utilizing the oxygen analyzer downstream (OA1).

Item 5. Additional instrumentation to indicate level in the separation tank.

Item 6. Consider additional instrumentation for analysis of afterburner effluent; this modification may be limited to provision for sampling ports, depending on local regulations and sampling requirements. The extent of additional instrumentation requirements may also be keyed to experimentation with other waste materials in evaluation of the WAO system capabilities.

Item 7. Investigate possible methods of determining the ratio of water and explosive in the reactor. This ratio could be critical in controlling oxidation rates, and could be affected by the oxidation process itself. Loss of water content in the reactor for any process could lead to detonation, and seems to be a critical process parameter.

Item 8. Modify control panel. The primary change required consists of wiring modifications and/or additions to provide indications from added instrumentation, interlock functions, and additional automatic functions.

Two methods should be evaluated in developing the control panel modifications: (1) using additional hardwired relay logic and (2) installation of a programmable controller.

The control modifications proposed in items 1 through 7 above are not extensive; hence, installation of additional hardwired controls would not be difficult. However,

future logic modification requirements which tend to surface during startup and debug functions become increasingly difficult and costly to implement.

Installation of a programmable controller would be advantageous since logic modifications or additions is a simple matter of re-programming. However, the typical drawback of programmable controllers is that program memory requires constant power. Most systems available come standard with battery backup for memory protection over short term power shutdown. The planned operation of the WAO system appears to be intermittent with periods of extended shutdown, which could result in loss of system memory. An alternative would be to utilize non-volatile memory storage devices; however, this should not be implemented until final system shakedown has been accomplished.

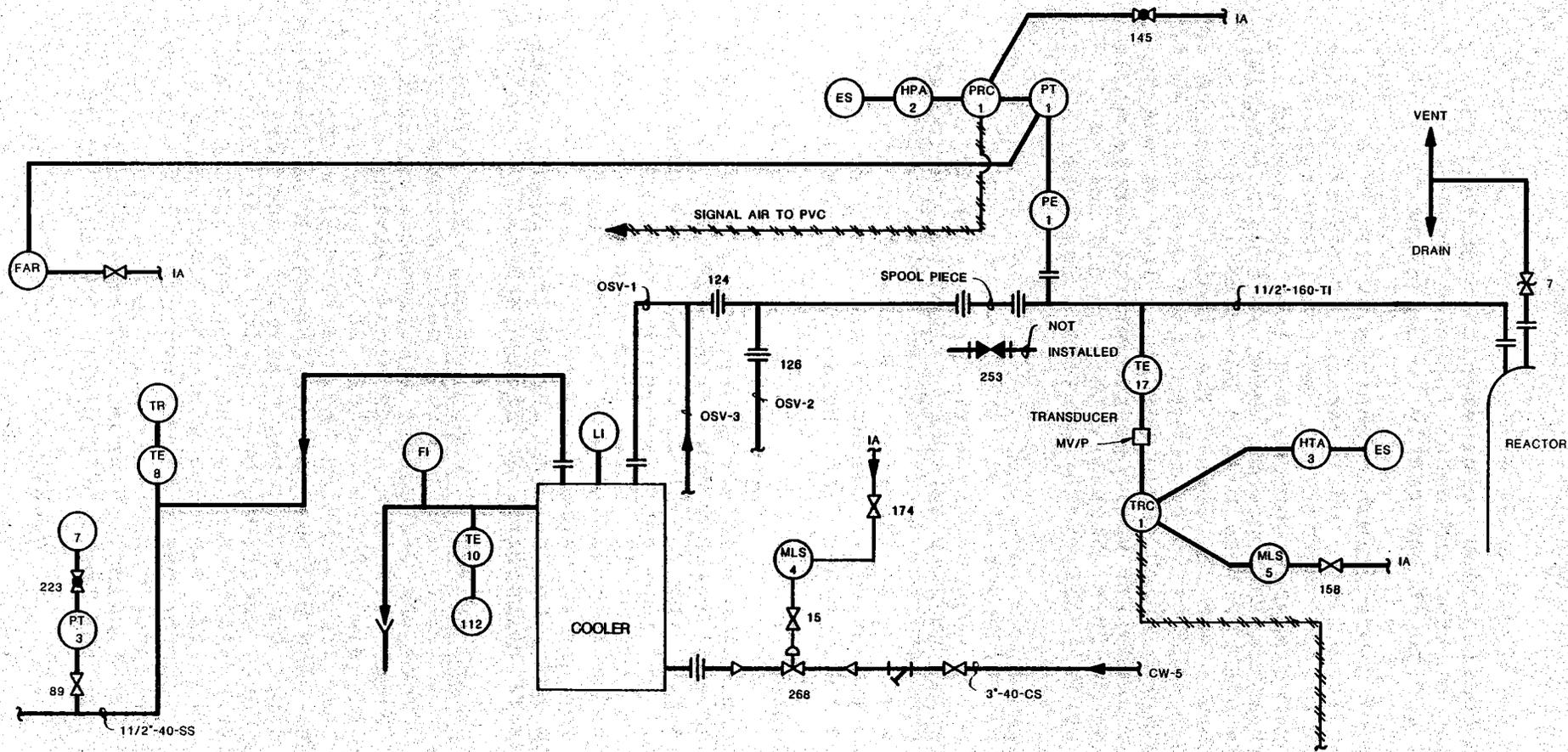
One additional advantage of utilizing a programmable controller is the ease of interfacing to other system operations (e.g., utility controls, fluid bed incinerator system (if required), or a centralized control/data center). This may be an important consideration when the entire facility control is evaluated and facility systemization takes place, and should not be overlooked.

7) Slurry Cooler

Description. The oxidized Slurry Vapor (OSV) cooler is used to cool the OSV down from 572°F maximum to 120°F minimum, the cooler functions in the same manner as a shell and tube heat exchanger. The OSV is circulated through the tubes releasing heat to the cooling water that is being circulated about the tubes. The heated water is discharged from the cooler to a sump and from there to the cooling tower. This subsystem is illustrated in Figure WAO-4.

Evaluation and Potential Modification. The oxidized slurry vapor (OSV) cooler should perform the necessary cooling before the OSV enters the pressure control valves. Since there are no drawings available that indicate the size of the cooler, it can only be assumed that Zimpro, which has had several years of experience with WAO plants, has adequately sized the system. Since the cooler was originally designed for sewage sludge, modifications should be made to accommodate safety requirements for PEP wastes and increase the life expectancy of the slurry cooler controls. In the past, Zimpro obviously has believed that the operator could walk over to the drain and see if fluid was flowing. A remote TV camera could be installed in the operator's place, but this would not

FIGURE MAO-4



WET AIR OXIDATION EQUIPMENT - OXIDIZED SLURRY COOLING SYSTEM

alert the operator as quickly as a flow indicator that is attached to an alarm. The flow indicator should be installed on the discharge or outlet of the OSV cooler for best results. If it were mounted on the inlet, then a level indicator and alarm should be mounted on the top of the cooler to ensure that the cooler has the proper water levels and the flow indicator indicates constant water flow.

The only other recommendation is with regard to the piping details of the cooling water supply (CW-5). It is a generally accepted practice to install a gate valve and strainer prior to the control valve (valve 268).

Naturally, this feature is not needed and does not enhance the safety of the cooler, but it would increase the life expectancy of the control valve and reduce maintenance costs.

The control valve should be checked to make sure that it is normally open in case the valve were to fail, allowing cooling water to continue to circulate through the cooler.

If the wet air oxidation system were being used to dispose of materials that allowed personnel to be in the reactor building the PCV could be observed; however, this is not the case. The only provisions that are made available for the detection of a PCV that has failed is a pressure regulation and controller (PRC) upstream. The same PRC could also be used to detect any OSV cooling system failure. Therefore, the entire line from the PRC would have to be inspected to find where the slurry was plugged up, increasing shutdown time and maintenance costs. Therefore, it would be desirable to have pressure gauges and recorders mounted near the PCV.

It is assumed that all the valves except the drain valves would fail in the open position. More data is required to verify this. Also, it is assumed that PCV valves should be made out of stainless steel or some other non-sparking material.

8) Process Control Valve (Slurry)

Description. The Process Control Valves (PCV) are used to control the slurry flow rate and regulate the operating pressure, throughout the entire system. By controlling the pressure and slurry flow rate, the PCV actually controls the rate of oxidation taking place in the reactor. Therefore, the operation of these valves is essential. Two PCV's as provided modulate open and closed to maintain a constant pressure and flow rate. Figure WAO-5 has been provided to show where the pressure control valves are located in relation to the rest of the WAO system.

Evaluation. In general, the pressure control valve system is adequate. It is assumed that Zimpro, which has had several years of experience in sizing valves for slurry, has properly sized the valves. However, there are a few modifications recommended for the use of these valves with PEP wastes.

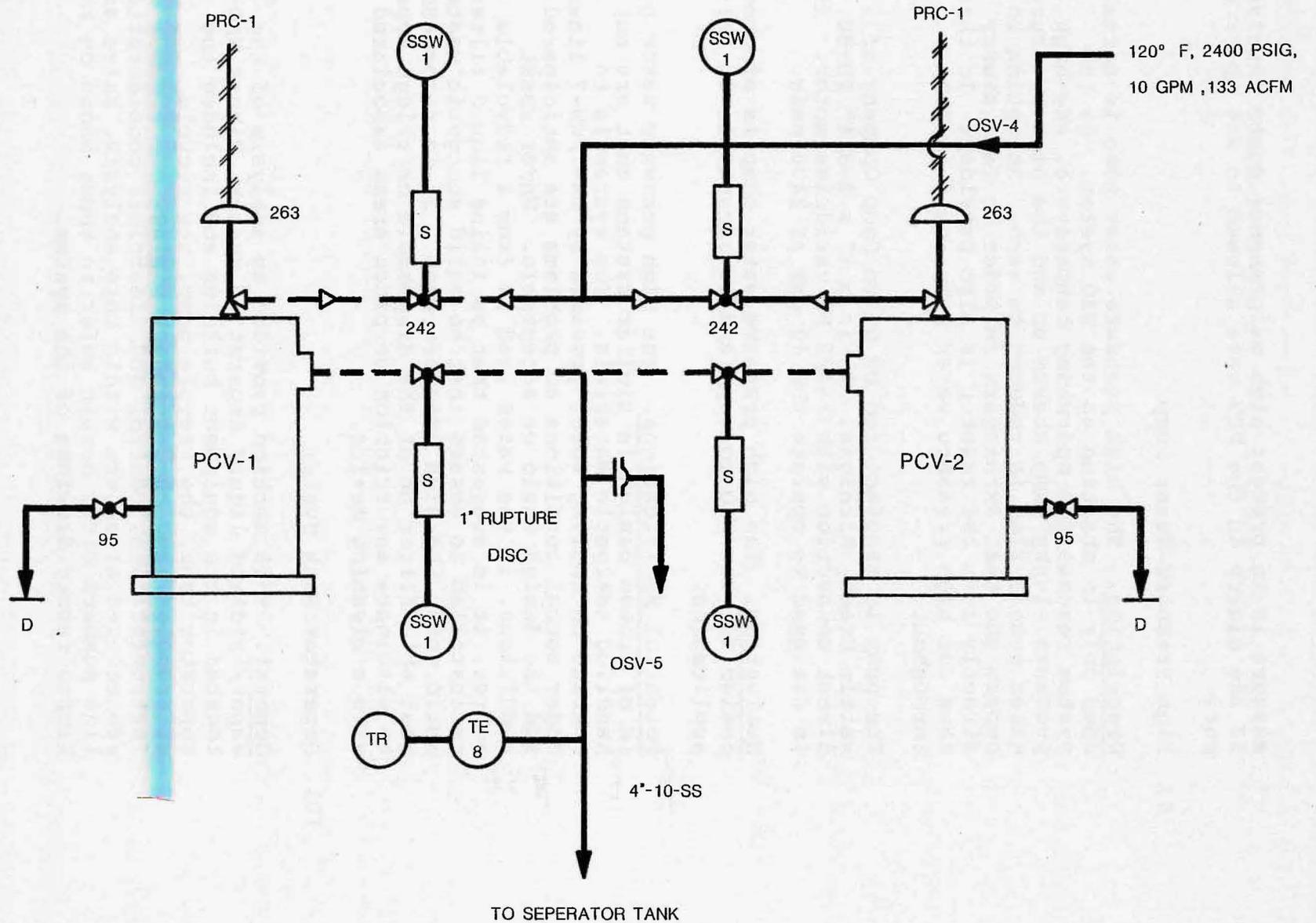
Potential Modifications. Most of the modifications and recommendations presented allow greater versatility and control of the slurry. The overall performance and efficiency will not change much.

As we understand how these PCVs are used, there is one PCV that is used as a standby: a selector switch operates the solenoid valves that determine which PCV will control flow. The pressure control valve is essential for process operation, therefore, if one valve were to fail, the selector switch would send a signal to close the solenoid valve to that PCV and send a signal to open the other PCV simultaneously, even when the one PCV is not being used. If the valves modulate often, the life expectancy would be lower than if the control valves were operated independently.

On the outlet of the PCV, there is no solenoid valve. If by accident the ball valve to the drain or cleanout to the PCV was opened it would discharge slurry out the drain. A more complex but better system would have a solenoid actuated ball valve on the outlet of the PCV. This valve would be actuated simultaneously with the inlet solenoid valve to the PCV.

Also a solenoid ball valve should be installed on the drain discharge. Thus if the valve would fail midstream in operation, the inlet and outlet valves would close while the drain valve opens to all the slurry contained in the valves to drain out. This

FIGURE MAO-5



WET AIR OXIDATION SYSTEM EQUIPMENT - PROCESS CONTROL VALVE SYSTEM

measure is to prevent high maintenance costs involved if the slurry in the PCV were allowed to set up or dry out.

9) High Pressure Water Pump

Description. The high pressure water pump is normally used only in starting up the WAO system. As the system reaches its operating temperature, the high pressure slurry pump starts up and the high pressure water pump's flow is reduced to zero. An option to bypass the heat exchangers in order to feed slurry directly into the reactor is also provided. In that case the high pressure water pump would operate throughout.

The pump is manufactured by Union Pump Company of Battle Creek, Michigan. It is a 1" x 2-3/4" TD-30 direct connection with 7-1/2 HP varidrive motor. It is designed to operate the 10 gpm at 2400 psig.

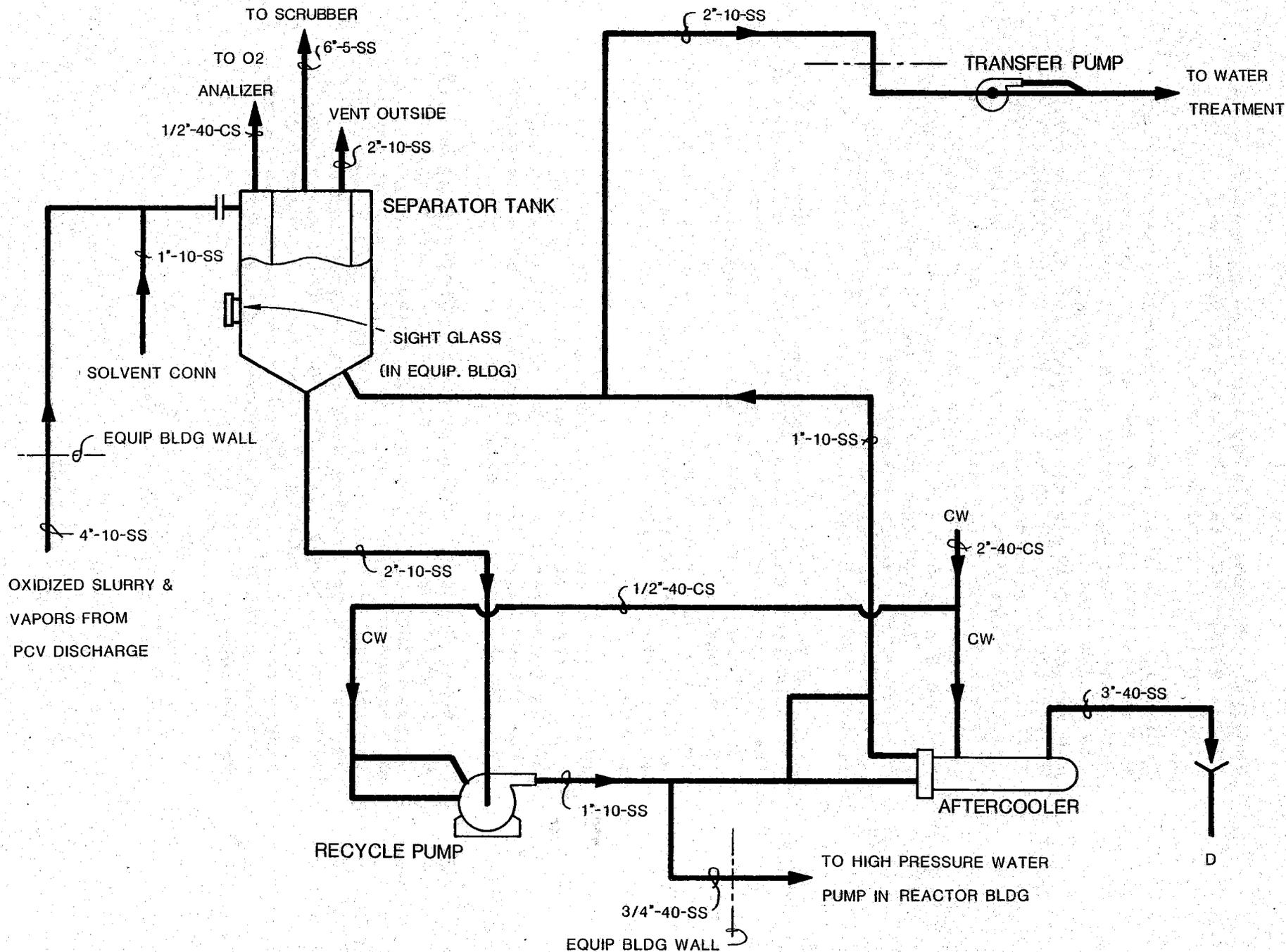
Evaluation. The high pressure water pump is of proven design for the WAO concept and is acceptable in this application.

Potential Modifications. The high pressure water pump is of proven design in similar systems that are not handling energetic materials. The system is to operate on cooling water provided by CW-1/CW-7 lines. Under normal conditions no problems are anticipated and the design would be acceptable. Under upset conditions, if the water feed is from a recyclable source, it is suggested that an inline liquid filter be installed to ensure that no solid energetic wastes would enter the high pressure pump. It is recommended that this filter be of the disposable cartridge type to eliminate any friction or pinch areas associated with a cleaning device.

10) Separator Tank System

General. This section provides an analysis of the vapor/oxidized liquid separation system, Figure WAO-6, located in the equipment building and includes the separator tank, the recycle pump, the recycle aftercooler, and the attendant piping. Instrumentation, control and electrical considerations are covered elsewhere within this analysis. Valve and line numbers cited herein refer to those shown on the Zimpro record drawings of the system.

FIGURE MAO-6



WET AIR OXIDATION SYSTEM EQUIPMENT - VAPOR OXIDIZED SLURRY SEPARATOR SYSTEM

Summary. We judge this system to be acceptable with no revisions required; however, an optional modification is described herein.

Evaluation. This is a very straight-forward system, and we see no major problems in it. The major component is the separator tank into which the feedstream flows, and in which separation of the liquid and vapor phases is accomplished. This tank is a vertical, 4-ft. diameter cylinder approximately 6 feet high fabricated of 316 stainless steel. The oxidized slurry/vapor mixture enters the vessel sidewall tangentially near the top through a baffled port. Vapors are drawn from the top of the tank through two connections; one line feeding the oxygen analyzer (for process control) and the other (main line) feeding vapors through the scrubber to the afterburner. The scrubber and afterburner system analysis is included elsewhere in this evaluation.

Oxidized liquid which accumulates in the lower part of the separator tank exits from the bottom and passes to the recycle pump from whence it can either recirculate through the aftercooler back to the separator tank (for temperature conditioning) or can pass to the suction of the high pressure water pump in the reactor building. The above routing option is selected by appropriate valve positioning within the recycle loop piping.

Additionally, an overflow connection in the separator tank sidewall allows the oxidized liquid to pass out of the reactor system to the water treatment plant. Flow through this line is governed by solenoid valve #244 located near the tank.

The separator tank and attendant piping system should not handle unoxidized (or partially unoxidized) PEP slurry, since the equipment is located in the non-hazardous area. From the available operational information this will not normally occur; however, we believe that the system does not include the means to positively preclude this during abnormal operations or system upset. Additional discussion of unoxidized slurry carry-over from the reactor is included in the section entitled "Slurry System - WAO Process," evaluation.

Within the oxidized slurry system of the separation tank, there are over 15 valves (all manually operated except for one solenoid actuator), one pump, and several indicators (including tank liquid level). Since there are no automatic controls in this area, proper operation depends upon operator attention. Based upon the simplicity of the equipment, we judge this to be acceptable; however, we have described a minor optional change later in this evaluation.

There is a portion of this system which was unclear, due to a discrepancy in the drawings, which, however, did not result in any recommendations, but which should be clarified. The Zimpro schematic drawing #I-18-D-303 shows one vent connection to the separator tank. The piping detail, drawing #I-18-D-502 shows what appears to be two flanged vent lines from the tank through the roof; one vent connects to the tank top (shown in Section C-C) and the other connects to the tank side (Section A-A). The tank detail, drawing #I-18-D-216, shows no flanged vent connection to the top of the tank.

Potential Modifications. Liquid level in the separation tank is presently monitored by visual observation of a sight glass attached to the tank. The sight glass range is only about 18 inches which covers a very short span relative to the total tank height. As an option, we recommend that an automatic level indicator/control device be installed in this tank to provide automatic control of tank discharge. This feature would also require replacement of several existing manual valves with automatic actuation valves, probably solenoid. For level sensing, we recommend a probe type device such as manufactured by Warrick, Endress-Hauser, or Combustion Engineering, Natco Division, (conductance, capacitance, sonic or nuclear). Installation of this automatic system would lessen operator responsibilities within the equipment building and would definitely improve operational reliability.

The above option is the only modification recommended for the separation tank system.

11) Afterburner

Description. The purpose of the afterburner in the Wet Air Oxidation system is to complete the destruction of the fumes or gases coming off from the liquid gas separation tank. These fumes first go through a wet scrubber and then to the afterburner.

The afterburner operates at 1200°F to ensure destruction of carbon monoxide and to eliminate any visible water vapor plume from the stack.

The afterburner is a Zimpro Model ZIFI 800-0, and is shown in drawing numbers I-18-D-701 and 717. Its overall height is 14'0" including the 37" high stand. It has an interior diameter of 22-1/2". It is insulated with 3" of Babcock and backed with an additional 4" of Griptex Block insulation. There are two inch flame inspection port for visual inspection located 65-1/2" from the ground.

The only information given on the burner is that it operates on #2 fuel oil at a rate of 2.56 to 7.0 gallon per hour.

Summary. The afterburner has been evaluated from the standpoint of heat capacity, residence time design and pressure drop. The supporting calculations and assumptions made are included in the Appendix. Based on the information available, the existing afterburner is acceptable with only minor modifications to the exhaust stack and possibly the burner system as suggested.

Evaluation. The size and capacity of the afterburner was evaluated and the detailed calculations are in the Appendix.

The afterburner is expected to be able to heat 375 SCFM up to 1200°F. Based on the available heat at this temperature and a maximum fuel flow rate of 7.0 gallons per hour, the afterburner could operate at flows of more than 500 SCFM. The calculated residence time within the afterburner is 1.05 seconds. At 1200°F, this will be adequate to destroy the carbon monoxide formed.

The inlet/outlet duct was examined as far as proper sizing. The estimated pressure drop across the afterburner at 500 SCFM was only 2-1/2 inches of water. The inlet/outlet ducting sizes are adequate.

The exhaust stack for the afterburner as shown in drawing #I-18-D-511 has a funnel shaped weather cap. This is not a recommended method by either the American Conference of Governmental Industrial Hygienists or Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) as shown in Figure 6-13 "Ductwork Design Data" of Industrial Ventilation. Figure 6-22 "Principles of Duct Design" shows the effects of the weather cap on the velocity

distribution curve. It deflects the emissions down to the ground rather than up in the air for good dispersion. This would increase the ground level concentrations to a point that the allowable emission in the stack would have to be lowered.

The refractory used to line the afterburner is listed as Babcock and Wilcox Kaocrete D. This refractory is rated good for HCE and should hold up well.

No information was available on the existence of a flame detection system for the burner or if there is a mandatory purge cycle in the event of flame out.

Potential Modifications. The weathercap should be replaced with a vertical discharge stackhead of the type shown in Figure 6-24 "Stackhead Design" taken from the 17th edition of Industrial Ventilation. This design consists of an extension tube at least 38" long by 9" in diameter. This will mount directly over the existing stack and will allow for proper dispersion of the exhaust gases. The annular space between the ID of this extension and the stack will act as a drain for rain protection. The rain protection of this design is superior to the deflecting cap located 0.75 diameter from the top of the stack.

A portion of the wastes slated for disposal will be flammable liquids. It is recommended that the possibility of burning these as a fuel in the afterburner be explored. Because of the viscosity and heating value of these liquids, it may be desirable to mix them with number 2 fuel oil. Minor modifications may be required to the burner or the combustion air blower to handle the new combination fuel. Temperature control for the fuel storage tanks and lines may be necessary to maintain proper viscosity levels.

From the propellant disposal demonstration tests conducted in the early 70's, it was observed that the available oxygen content directly affected the NO_x and CO quantities. The lower available oxygen produces substantially less NO_x but about 3 times the CO.

It is suggested that it is best to operate under the low oxygen condition. This reduces the potential for NO_x formation yet is still effective in destroying CO.

Details of the burner system were very limited. A UV detector capable of continuously scanning for flame

and a mandatory purge system before the afterburner can be reignited is suggested as a safety feature if they are not now provided.

12) Vapor Scrubber

Description. The packed wet scrubber is detailed in drawing number 1-18-D-702. The scrubber's overall vertical height is 11' 6-1/2" and has a 12" inside diameter. The entrance port is 6" diameter schedule 10 pipe and its centerline is located 26" from the ground. The bed height is 60 inches, however, no information is given on type or size of packing material. The liquid flow into the packed bed is 2 gallons per minute and is introduced through a single nozzle located 12" above the bed.

The purpose of the scrubber is to clean the gas stream coming off the separator tank of harmful gases such as acid mists or halogens.

Summary. Based on the given information and flow assumptions developed from the preliminary test data, the packed scrubber designated for this system is too small. Based on sizing information for the EPA, the recommended tower diameter should be 22.4". Due to time constraints, the recommended tower heights and optimum packing type were not determined.

Evaluation. The packed wet scrubber for the wet air oxidation (WAO) unit was analyzed based on the following information:

Inside Diameter - 12"
Liquid Flow Rate - 2 gpm
Packing Material - Assumed 1" Raschig Rings
Gas Flow - 500 SCFM

The scrubber was sized per guidance from EPA's "Air Pollution Engineering Manual." Based on the above data, calculations were performed to determine the required diameter. The recommended tower size was computed to be 22.4 inches, therefore, the existing 12" ID tower on the WAO is not recommended. Back calculations showed that the 12" tower was rated for approximately 110 SCFM.

The height of the bed for this tower was not calculated. Based on the assumption that the tower would be used to scrub HCl fumes from the air stream, the required calculated efficiency should be 97.4%. The plot of the equilibrium line for HCl in air/water was not linear; therefore, Henry's law was not

applicable. Additional data was required before the tower's height could be calculated. Time available for this analysis did not permit the in-depth study required to specify the actual performance.

If this system is used, the scrubber design must be updated to ensure that HCl emissions are maintained under 4 pounds/hour and particulates to 0.05 grains per standard cubic foot.

Economic Summary - Wet Air Oxidation System Modifications

1) Modified System (essential)

a. Estimated Construction Cost	\$230,000
b. Design Cost at 6%	13,800
c. SIOH at 5%	11,500
d. Additional Costs - Studies, field verification, etc. at 10%	<u>23,000</u>
TOTAL COST	\$278,300

D. Evaluate Fluidized Bed Incineration Systems and Ancillary Equipment
Develop Modifications to Fluidized Bed Incineration System and Ancillary Equipment (if any)

General. This section covers the Fluidized Bed Incinerator (FBI) which was designed and installed (partially) as part of Increment II.

Summary. ~~It is not recommended that the Fluidized Bed be placed in operation for the disposal of PEP materials.~~ A cursory hardware review revealed significant problems such as bed carryover and maintenance complications. The calculation review confirmed the Navy's calculations that indicate error in the contractor's design. Of greater significance, however is the technology gap that would require extensive testing before meaningful recommendations could be made for the system to function properly. It is also believed that copying existing operating incinerators such as the Army's EWI described in Section X would be much more economical than the expenditure required to bring the FBI facility into productive operation. Therefore, this section of the report has been abbreviated to include a broad overview that describes the reasons for this conclusion, cursory hardware evaluations completed prior to reaching this conclusion and an examination of Navy design calculations conflicting with the original.

Overview of FBI Technology

The fluidized bed incinerator has been in use since 1942. The application of this technology to PEP materials does present significant and new technology problems, however.

An excerpt from Dan Hill's paper entitled "Comparison of Fluidized Bed Incinerators and APE 1236 Deactivation Furnace for Disposal of Explosive Munitions and Explosive Wastes" is provided below as an introduction to this application for an FBI.

Technical Discussion on Fluidized Bed Incinerators

Description.

1. The fluid bed principle was first developed for catalytic cracking in the oil industry in 1942. Since that time interest in this unique principle has resulted in the development of the technique for a wide variety of industrial applications.
2. A fluid bed burner is a large, refractory lined vessel with an air distribution member or plate in the

bottom, a hot gas outlet in or near the top and some provisions for introducing fuel. The actual fluidized bed is formed by blowing air up through a layer of inert particles at a rate that causes the particles to go into suspension and continuous motion--analogous to a boiling liquid but with solid particles; therefore, the term "Fluid Bed". It should be noted that the media used in the burner remains as a granular solid. The material to be used as a fuel is introduced into the preheated bed, either from the top or by pneumatic injection into the fluidized bed. Material may also be fed into the bed as a slurry.

3. The primary functions of the air-fluidized inert bed material are to promote dispersion of incoming solid-fuel particles, heat them rapidly to ignition temperature, prevent surface ash buildup, and promote sufficient residence time for their complete combustion within the combustor. Secondary functions include the uniform heating of air and the generation of favorable conditions for residue removal.
4. The fluidized bed combustor greatly increases the burning rate of the solid fuel for three basic reasons:
 - a. The rate of pyrolysis of the solid material is increased by direct contact with the hot inert bed material.
 - b. The charred surface of the burning solid material is continuously abraded by the bed material, enhancing the rate of new char formation and the rate of char oxidation.
 - c. Gases in the bed are continuously mixed by the bed material, thus improving the flow of gases to and from the burning solid surface and enhancing the completeness and rate of gas-phase combustion reactions.

Capabilities.

1. Fluid bed burners provide the most benefits when deriving energy from problem fuels. These fuels are typically characterized by high moisture levels, slow burning rates (such as char), large material size or high inert levels. Successful testing has been conducted on such diverse fuels as high sulfur coal, petroleum coke, wood waste, municipal solid waste sewage sludge and chemical waste utilizing fluid beds of sand limestone.

2. In certain cases, the fluid bed can be used to control the chemistry of the combustion process. One example of this is the use of a limestone or dolomite bed for controlling the SO₂ emissions during combustion of high sulfur fuels. The sulfur dioxide combines with the calcium oxide to form a solid, calcium sulfate, which is removed from the burner during operation.

Support Equipment.

1. Material to be consumed may either be fed in bulk to the fluidized bed by conveyor, or injected into the bed in the form of a sludge or slurry. Material fed in bulk needs little or no preparation. However, materials fed in sludge or slurry form require special preparation, handling and feed facilities. Equipment required would consist of a shredder and/or a mill facility, a mixing and injection system, and a control system. It should be noted that the slurry feed system is required to capitalize on the high efficiency and special design features that the fluidized bed incinerator has to offer.
2. Special preheaters are required to precondition the sand bed.
3. A secondary fuel system to support combustion is required. The size and complexity of this system would depend on the burning characteristics of the material to be burned and the moisture content of the slurry or sludge.

Characteristics.

1. The Fluidized Bed Incinerator, with its support equipment, is a versatile and effective facility which offers many advantages in burning waste materials:
 - a. Bulk material or sludges and slurries may be fed directly into the fluid bed.
 - b. The chemistry of the combustion process in some instances may be controlled by additives mixed in the slurry or added to bed material. These additives are used to control emission and residue products.
 - c. The high constant heat content of the sand and continual mixing of sand and combustible material result in combustion efficiencies.
 - d. The fluidized bed incineration system lends itself to steam generation for the production of electrical power.

2. Because of the complexities and support equipment associated with the fluid bed, there are also many disadvantages to the system:
 - a. The system does not lend itself to a 40-hour week. Down times of 16 hours (overnight) do not present serious problems. However, down times of 64 hours (weekend) require 2 to 3 hours of start-up time.
 - b. The system cannot sustain any detonation involving fragments or overpressures because of the refractory material.
 - c. The pressure drop across the fluid bed is usually 30 to 80 inches of water column. This requires a "high pressure" fan.
 - d. The efficiency of the fluid bed decreases when the bed reacts in the combustion process, or when a sticky residue results from the process.
 - e. Complexities and support equipment required to operate a fluid bed incinerator necessitate high capital costs.

This ends the material taken from the referenced paper.

History of Technology as Applied to Explosives and Propellant Disposal

An understanding of the history of the application of the FBI to explosives and propellant disposal is considered essential to understand current technical problems. The Navy borrowed the FBI application for PEP disposal from the Army's development programs at Picattiny Arsenal (ARRADCOM). The Army, however, has now essentially rejected the use of the FBI for this application.

ARRADCOM is designated as the technology center for the Army's loadline and ammunition plants. These plants were faced with PEP disposal problems similar to NOS. ARRADCOM's first effort was the development of what has become known as the Radford Rotary Kiln. This kiln incinerates PEP slurries and uses a refractory lined kiln. It is extremely energy inefficient because of the water that must be evaporated during the incineration process. ARRADCOM investigation of the FBI was an attempt to develop a more efficient system and to reduce NOX emissions.

After this investigation, the Army production group "became aware" that the technology for using a rotary kiln had been in long time use by the office responsible for design of equipment for demilitarization of ammunition and explosives, the Ammunition Equipment Office, AEO. None of this technology had been used in the Radford design.

The AEO kiln was an unlined kiln that could withstand detonation of up to 1/4 lb. TNT equivalent without equipment damage and could sustain up to 5 lb. detonation without risk to operators. Furthermore, this system could be readily adapted to loadline PEP waste and could handle the material in a dry form. This eliminated the major drawbacks from the Radford Kiln. Huntsville Corps of Engineers (COE) became responsible for providing PEP incinerators to the load plants. This adapted AEO kiln became known as an EWI and was adopted by Huntsville COE as the standard system and installed at a variety of installations.

Before the adoption of the EWI, ARRADCOM's work with FBI's was being widely proclaimed as it was only being compared to the Radford design. The Navy at NOS was under pressure to begin eliminating their open burning and elected to investigate the use of the FBI for the waste streams that the WAO could not handle. However, in 1976, the FBI was tapped not only to be a test facility but a production facility for disposal of all the locally generated PEP material.

A significant technology gap exists in applying this system to PEP material. The ARRADCOM testing was limited to short test runs and did not test a wide spectrum of PEP materials. Furthermore due to funding constraints, their system was a modification of other equipment. Therefore, it was unknown whether operational problems encountered in these tests were due to the application of the FBI or the fact that original design equipment was not used.

Some test data by EXXON did exist that indicated bed "lockup" problems could occur with some PEP materials. ARRADCOM did not have funding to test these materials, however.

To this date, no full-sized FBI system has ever been successfully utilized for production rate disposal of PEP. It must be emphatically stated that technology is not presently available to make the NOS FBI function as intended. A high level of development and test work is still required before modifications can be recommended to use this facility for production.

In support of this emphatic statement, the following supporting evidence is cited:

1. An FBI erected at Pine Bluff Arsenal six years ago for the disposal of PEP still is not operational despite ongoing modification programs. Total bed lockup was experienced early in start-up. Recently an explosion or rapid burn within the bed caused extensive damage to the system. The exact cause of the incident is still under investigation and the required repairs will further delay the operation of the FBI.
2. The Army entered into a contract in mid 1981 with MRC to prove or disprove this technology. The contract was approximately \$750,000. MRC was directed to test a selected variety of materials (6). The original contract time period is long over schedule but the final report is not yet available.

The Army has drawn conclusions, however, from test observations. Although further experimentation and testing will likely continue, the Army does not look at the FBI system for PEP disposal as proven technology and was very disappointed with the results of the MRC tests. They experienced extensive feed system problems, problems with flashing and chuffing or incomplete combustion as they changed feed material, and bed agglomeration with aluminized material. Attempts to resolving problems during the course of the study and tests were largely unsuccessful.

Aeroject Liquid Rocket Company has disposal problems with propellants very similar to NOS. The Aeroject Energy Conversion Company, a part of the Aeroject Liquid Rocket Company is considered one of the foremost developers of fluidized bed test facilities. Because of the in-house expertise they possess with their technology, they have undertaken a program to dispose of their wastes with an FBI. The Aeroject executive report was very positive on the initial program. Despite their expertise, after one year of development effort, they still recognize that further development work is required.

It is believed that the existing technology gap for application of the FBI to propellant wastes is far more serious than flaws with the current equipment design at NOS. It is therefore strongly recommended that hardware modifications not be performed until technology progresses to the point that NOS may be assured that a workable system may be provided by modifications.

Apparent choices for the facility are:

1. Let technology progress on its own and then borrow it and apply it at a later date.
2. Direct technology advancement by funding it, thus the end result could be reached sooner.
3. Abandon this technology in favor of another for PEP disposal, and develop an alternate use (if possible) for the FBI.

Many intangibles are involved in making this selection that cannot be fully appreciated during this study. A face value examination of considerations for these choices is provided.

The technology for PEP disposal using an FBI is being developed now at various locations. Pine Bluff Arsenal personnel are trying to make a full sized FBI work. MRC and Aerojet are both handling materials similar to NOS, but both are using small test type facilities of 12" diameter or less. As we have monitored the progress of both these programs, solution to technical problems have been slow. Typical developmental problems are as discussed below.

Aerojet found that some of their propellant swells as much as 3 times after slurring. They, therefore, believe a final regrind right at the time of feed may be necessary. Aerojet did find a way to recover aluminum from the PEP and has elected to continue in the direction of using an FBI. However, other problems must still be solved before they scale up. These include the formation of HCN and feed preparation and handling developments. MRC also had feeding problems. They elected to increase the water ratio during transfer and then dewater somewhat right at the feed station. Feeding problems still persisted, however.

A proprietary underbed feed method developed by ERCO of Cambridge, Massachusetts for use in a dry feed has potential for eliminating these feed problems, and also would eliminate the tremendous energy consumption for "burning water" in the slurry. This system is yet untried for propellants and the exact application would have to be thoroughly developed and tested.

MRC is doing their work as a government contract; thus, their final report will be available to the Navy. Aerojet is performing their work on in-house assignment,

thus much of their data is proprietary. However, as Aerojet has elected to use this technology, they will continue development efforts.

It may be that Aerojet will field a workable production system in the future and the Navy could purchase application of their technology development provided by their program at much less cost than directly funding the developments. The disadvantage, of course, is that no timetable can be accurately established.

With respect to funding further equipment development, it is expected that a relatively expensive test program would have to be conducted prior to recommending any modifications to the NOS FBI. MRC studies showed that results varied greatly from one feed stock to another and it must be remembered that these tests are on a much smaller scale. It would be strongly recommended that only a highly qualified contractor familiar with the current and past development work provide future testing so as not to repeat past mistakes and relearn new solutions. An example program would require a review of existing operating parameters of the NOS FBI design and then conduct testing on NOS material at their facility on a smaller diameter test FBI. All of the problems would have to be resolved on the smaller unit before any design modification could be recommended. For budgetary purposes, it would require \$200-500K to conduct these tests to reach a point that meaningful modification to the NOS facility could be recommended and this assumes optimistic test results.

The total costs to modify NOS FBI facility to make it a workable system cannot be determined without first performing this development testing. Also given as a concern with proceeding with the FBI is that the system is complex. Aerojet will have the luxury of a large qualified staff to provide continued support to their facility if fielded, a luxury the Navy does not enjoy.

For the above reasons, it would be our choice to select Option 3, that the technology be abandoned in favor of another. It is believed that with time and money, this system can be made to operate. However, with less time and less money, an EWI as currently operated by the Army at three installations could be installed to replace the FBI. This is discussed further in Section X. The unfortunate part of this choice is the seemingly wasted expense of bringing the facility to its present condition and then abandoning it. The Navy may not want to place themselves in this light. This could be alleviated if an alternative use could be found for this facility, as discussed in Section X.

The Navy position is defensible to a point, in that the fact that the Navy was working on alternatives helped convince the EPA to permit open burning. Also, many of the problems using the FBI on PEP materials were not known at the time the decision was made to install it and the EWI was not fielded at that time. Also, the success of the limited ARRADCOM testing was being very enthusiastically proclaimed by proponents of the FBI and the shortcomings of the scope and depth of the testing were being minimized.

System Components - Phase (or Increment II)

Despite the foregoing discussion, system components or fixtures were analyzed to a limited extent. Those systems or features include the following:

1. Bed Material Feed System
2. Fluid Bed Incinerator Feed System
3. Maintenance Accessibility
4. Calculations for FBI Entrainment

1) Bed Material Feed System

General. This is an independent system used to feed the alumina bed material into the FBI. It is located (not presently installed) outdoors, approximately 15 feet south of the FBI, and was supplied as a package unit by Whirl Air Flow Corporation, Minneapolis, Minnesota. There are three major components in the package: (a) dust collector, (b) bag breaker, and (c) transporter.

The transporter is essentially a 50 cubic foot hopper for holding the alumina material. When operating, compressed air is introduced into this unit, moving the alumina out of the bottom and into a pipe system which conveys the material to the FBI. The alumina enters the upper sidewall of the FBI, above the fluidized bed.

The bag breaker is located on top of the transporter, and is a hooded cabinet through which the alumina is fed into the transporter. Operators manually load paper bags of alumina into the bag breaker where they are opened, allowing the contents to gravity dump through a tipping valve into the transporter body. The operator station for the bag breaker is an open platform about 8 feet above the equipment pad.

The dust collector is mounted on top of the bag breaker and provides ventilation air to minimize

alumina dust release during the bag breaking operation. The remainder of the feed system consists of the piping and controls, most of which were supplied as part of the equipment package.

Summary. This feed system is of proven design and should not present any mechanical problems. However, the use of this system is questionable from a capacity standpoint, due to unresolved questions regarding bed carryover. These questions are described in the following section, and until they are resolved, it is impossible to judge the adequacy of the alumina feed system.

Evaluation. The alumina feed system is judged to be satisfactory from a standpoint of design, operation, control, maintenance, and overall useability for its intended use. Our evaluation has disclosed one possible flaw in the system, however, which could render the system unsatisfactory, and unfortunately, the facts required to resolve the problem will not become available until the FBI can be run and tested.

The A & E firm for the project, Day and Zimmerman, designed the FBI for a maximum bed material carryover rate of 500 lb. per hour. NOS engineering personnel, in checking the FBI, expected operating parameters, have calculated the bed carryover rate to be 2,000 lb. per hour. Both parties believe their calculations to be correct and the question is at an impasse. Actual bed carryover can probably only be determined by operation of the system, which is, at best, far in the future. The alumina feed system currently provided will have satisfactory capacity if bed carryover is 500 lb. per hour, and unsatisfactory capacity at 2,000/hr. as described below. Our calculations, summarized hereinafter and included in the Appendix agree substantially with NOS calculations.

The alumina storage capacity of the transporter is approximately 50 cubic feet. Using a bulk density of alumina of approximately 115 lb. per cubic foot, this equates to a capacity of about 5,800 lbs. This alumina quantity would be adequate for about 11-1/2 hours of FBI operation at a bed carryover of 500 lb. per hour, and about 3 hrs. of FBI operation if carryover is 2,000 lb. per hour.

The load station that operators must use to manually charge bagged alumina into the transporter is an exposed platform near the FBI which cannot be occupied during live operation of the FBI. Consequently, if bed carryover is 2,000 lb. per hour, requiring

refilling of the transporter every 3 hours, the system is unsatisfactory because operators cannot enter the load area every 3 hours. If carryover is only 500 lb. per hour, the system will be satisfactory as presently configured.

Potential Modifications. We recommend no modifications for the alumina feed system at this time. As detailed previously, the system is judged totally satisfactory except for capacity, and the capacity requirement cannot be finalized at this time. We judge that it would be spurious to modify the system for larger capacity until a deficiency has been demonstrated.

If deficiency is demonstrated at some later time, it will require a reasonably simple design modification to increase feed system capacity by adding another feed unit parallel, and/or replacing the existing unit with one of higher capacity. The largest transporter currently supplied by Whirl Air Flow has a capacity of 90 cubic feet, or almost double the present unit.

2) Fluid Bed Incinerator Feed System

Description, Evaluation, Potential Modifications. If the fluid bed incinerator proposed to destroy PEP wastes at NOS is to be used, the feed system could be improved. The incinerator was originally designed so that the slurry nozzles fed the slurry within the bed. This design was to prevent the nozzles from plugging. Experience has shown that the heat generated by the bed material will dry the slurry discharging from on the nozzles and plugging will occur anyway. Also, there is less chance for the slurry to get well mixed within the bed material to adequately insure that complete combustion has transpired. It is recommended that the nozzles be designed to discharge the PEP slurry near the grid where mixing air has been well established and the fluidized air will directly mix the wastes throughout the bed material before the effluent is discharged into the cyclone. A fluidizing feed system developed by ERCO is recommended based on the apparent success of this feed method on a wide range of dry feed systems. The feed system in this case is in itself, a miniature fluidized bed.

Also a means for providing the PEP wastes as a dry powder instead of a slurry would be beneficial. Ultimately, the PEP waste would be fed into the reaction chamber by an air conveyor or some means to prevent propagation back through the supply lines. Thus, the amount of energy required to vaporize the

water would not be required and problems involved with pumping slurry and maintaining a proper PEP to water ratio to prevent propagation would be eliminated.

3) Maintenance Accessibility

Description, Evaluation, Potential Modifications. The FBI is mounted on a structural steel framework some 5 feet above the incinerator pad adjacent to the incinerator building (P-947D). The windowbox is a cylindrical steel fabrication, about 5 feet in diameter by about 5 feet long with flanges to the bottom of the incinerator body, and hangs from it. The incoming main air stream enters the incinerator via this windowbox. The grid plate in which the bed nozzles are mounted, is supported, and mounted between, the flanged connection between the incinerator and windowbox.

Any operational problem encountered in the area of the fluidized bed or the nozzles that requires direct access to the bed for inspection or maintenance, will require removal of the windowbox. Very minimal access can be attained through the incinerator side port, or the blowout panels. In any event, we predict that following startup, it may be necessary to remove the windowbox for inspection at fairly regular intervals. This is based on the history of several other existing FBI systems of which we are aware, which encountered problems with bed lockup and agglomeration, as well as nozzle problems.

We recommend that the windowbox removal clearances be reviewed and increased as required to provide ease of maintenance. It is recommended further that the clearances be such that they will accommodate machine rollers/dollies, or similar devices which could be used easily to support and move the windowbox from beneath the incinerator.

4) Calculations for FBI Bed Entrainment

It was noted that NOS refuted the contractor's estimate of the quantity of alumina bed material entrainment for the fluid bed incinerator. NOS provided calculations verifying the statements made against the contractor. The calculations showed new requirements for the quality of Alumina bed material based on entrainment and bed height. In order to clarify any doubt, we have performed and checked calculations in these areas of discrepancy. Calculations were performed independently of NOS

calculations with the exception that we obtained the values required for the various properties of the FBI gas stream.

Later, it was observed that the results obtained were similar to NOS's because the procedures and figures used were identical. Therefore, the particulate size distribution plot from the NOS calculations were merely checked and reused in the verifying calculations.

From these calculations, we are in total agreement with NOS on all points being disputed. Calculations are included in the Appendix. The major results are summarized below:

Amount of Alumina Bed Material	29,876 lbs.
Material Lost by Entrainment	2,106 lbs./hr.
Total Disengaging Height (TDH)	23'
Disengaging Height (DH)	11'
Entraining Velocity (Ve)	7.5 ft./sec.
Maximum Entraining Particle Size (DP)	280 microns

Conclusion. In an overall view, the fluid bed incinerator has some very promising features. It has been used for a wide variety of applications, over a long period of time. There is not another incinerator available today that has as uniform a temperature gradient as the FBI. Unfortunately, the phenomenon involved with a FBI are not fully understood, especially with PEP wastes. Small scale FBI incineration testing has been very limited for PEP wastes. Thus, more data and research should be performed before using the FBI for PEP wastes.

Economic Summary - Fluidized Bed Incinerator Modifications

1) Modified System (essential)	
a) Engineering and Development of FBI Technology as applied to PEP materials	\$1,265,000
b) Construction Cost of Modified System	750,000
c) Testing	<u>100,000</u>
	Total Cost \$2,115,000

Notes: This figure is an extreme approximation. Testing includes only normal construction testing such as hydrostatic and valve function, not full commissioning and proveout.

E. Evaluation of Wastewater Treatment Equipment and Interfaces with WAO, FBI Potential Modification to Wastewater Treatment Facility

General. With few exceptions the wastewater treatment system for Phases I and II are separate. During design of Phase II piping was provided in most instances which would allow all fluids to be transferred to tankage and equipment supplied under Phase I. This was presumably to provide some redundancy and emergency backup for each phase. Since it is the intent to basically use Phase I equipment for the treatment of Phase I waste i.e., waste generated by operation of the WAO unit, and Phase II equipment for treatment of Phase II waste, i.e., waste generated by operation of the FBI unit, these two Phases will be analyzed separately unless otherwise necessary.

System Components - Phase (or Increment) I

- 1) Treatment Tanks T-1A, T-1B, T-1C
- 2) Circulation Pumps P-5A, P-5B
- 3) Treatment Tanks Cooler E-1
- 4) Anhydrous Ammonia Tank T-12
- 5) Neutralization Solution Makeup Tank T-2
- 6) Neutralize Pump P-3
- 7) Fe Cl₃ Makeup Tank T-3
- 8) Fe Cl₃ Solution Pump P-4
- 9) Treated Water Transfer Pumps P-2A, P-2B
- 10) Vacuum Filter H-2
- 11) Filter Separator Pot T-4
- 12) Vacuum Pump P-7
- 13) Filter Vacuum Tank T-5
- 14) Precoat Mix Tank T-6
- 15) Precoat Pumps P-14
- 16) Filter Pumps P-6
- 17) Evaporator Feed Heater E-3
- 18) Evaporator S-1
- 19) Evaporator Condenser E-2
- 20) Evaporator Overhead Receiver T-7
- 21) Process Water Transfer Pumps P-11A, P-11B
- 22) Slurry Overflow Tank T-105
- 23) Sludge Tank T-8
- 24) Sludge Transfer Pump P-9
- 25) Trickling Filter H-3
- 26) Trickle Bed Pumps P-8A, P-8B
- 27) Sand Filter H-1

Summary - Increment I

The equipment supplied for treatment of oxidized slurry appears to lack some critical items, but could be modified successfully if operation of the WAO unit required water treatment. The most serious shortcomings are in the area

of sludge removal and handling both at the vacuum filter and downstream of the wiped film evaporator. The trickling filter/sand filter system requires additional tankage, pumps, and piping for filter backwash. The trickling filter would not be able to support bacteria for biological treatment if use of the facility is as intermittent as it appears to be. At least one additional surge tank would be required (ahead of pump P-6, and an installed spare for pump P-6 would also be essential for dependability. Several tank fill lines for initial solution makeup are also necessary.

Description of Process

Oxidized slurry is pumped from the Reactor Building #1571 to the Equipment Building #1573 where the gas and liquid are separated. The liquid oxidized slurry is then pumped to the Water Treatment Building #1574 and placed in Treatment Tanks T-1A, B, and C. The waste is neutralized using a 5% aqueous ammonia solution which adjusts pH to 7. The waste is originally highly acidic with a pH of 1 or 2. Ferric chloride is also added as a flocculent. By neutralization and flocculation the majority of the lead precipitates out. While in the tanks the waste liquid is agitated and can also be recirculated by drawing liquid from the tank sides and pumping back to the top, passing on the way through the Treatment Tank Cooler E-1 for temperature reduction.

After sludge has settled to the bottom of the tanks it can be pumped to the Vacuum Filter H-2, where the majority of the lead can be removed as lead hydroxide. The filtrate evidently will contain approximately 1 percent ammonium nitrate and approximately 200 ppm lead salts which would remain in solution.

After liquid separation in the Filtrate Separator T-4, Filter Pump P-6 pumps the filtrate through Evaporator Feed Heater E-3 and to the Wiped Film Evaporator S-1. The evaporated gases are condensed in Evaporator Condenser E-2, flow to Evaporator Overhead Receiver T-7, and are pumped by Process Water Transfer Pumps P11A and B to Slurry Overflow Tank T-105 located in Building #1570. This completes the basic water treatment portion of the process. The evaporator bottoms are collected in Sludge Tank T-8, and pumped by Sludge Transfer Pump P-9 to Vacuum Filter H-2. Sludge separated from the vacuum filter is to be drummed for ultimate disposal.

Additional units for water treatment are the Trickling Filter H-3 and the Sand Filter H-1. These units process a number of miscellaneous wastes including sanitary waste from the control building, #1572 cooling tower blowdown

water, and water collected in a floor sump. As designed for Increment I water from the filter would be discharged to the river. Modifications for Increment II have already changed some of the above.

Other ancillary equipment for Increment I water treatment includes a Precoat Mix Tank T-6, and Precoat Pump P-14 for mixing and precoating the vacuum filter cloth.

Component Evaluation - Increment I

1) Treatment Tanks T-1A, T-1B, and T-1C

Description. These tanks are of 8'-6" nominal diameter and 11' high, with nominal capacity of 4660 gallons, of 316 stainless steel construction.

Each tank contains a 3 HP mixer. The tanks have dished bottoms and flat tops. Nozzle connections on the top include a 1-1/2" vent, 2" oxidized slurry inlet, 1-1/2" treated water inlet for recirculated water drawn from the tank side, 1" treated water inlet for recirculated water from the tank bottom, 1" ammonia solution inlet, and a 1/2" ferric chloride inlet. One 1-1/2" nozzle on the straight side serves as recirculated water draw off. A 1-1/2" nozzle at the bottom low point connects to the treated water transfer pumps, and the bottom also contains a 2" drain. The side also contains a 24" manway.

Instrumentation and controls include temperature indication, level indication and high level alarm, pH measurement and control signal to an automatic valve to control ammonia solution flow rate.

Evaluation. Oxidized slurry is pumped to these tanks at the nominal rate of 11 gpm. Thus the three tanks could hold approximately 21 hours worth of waste prior to beginning of treatment.

It had been previously estimated that approximately 2500 lb/day of single and double base propellant would require disposal. At a nominal disposal rate of 500 lb/hr only five hours of operation per day would be required. Since process startup, shutdown, and cleanup would make only five hours of operation per day very inefficient, it has always been planned that waste would be accumulated until the facility could be operated 24 hours per day 5 days per week.

Therefore, with a 21 hour surge capacity it would be necessary to operate the waste treatment facility on a continuous batch basis to make room for additional

waste. Although no operating procedures have been provided, it is assumed that waste would be collected in the first tank, and when full, treatment would be started and collection begun in a second tank. Since treatment rate is the same as propellant disposal rate, and thus wastewater generation rate, theoretically the process could be continued indefinitely. If treatment of waste in the first tank were completed while the second tank was being filled, except for time lost due to repositioning of valves, two tanks would always be available for receipt of additional waste. If a problem developed which caused water treatment to stop, a surge capacity of approximately 9300 gallons or nearly 16 operating hours would exist. The maximum stored and prepared slurry at any given time is 6000 gallons. The WAO reactor holds 300 gallons. The gas/liquid separator reactor holds 300 gallons. The gas/liquid separator holds (perhaps) 750 gallons. If the entire system of piping holds an additional 500 gallons it appears that adequate time and surge capacity exist to preclude any chance of discharge of untreated wastewater. In actuality, fluid in piping to Increment I tanks can be diverted to Increment II waste tanks. This option would also be available in an emergency situation. Therefore, tank sizing is adequate for anticipated operational procedures. Tank instrumentation appears to be minimal.

Potential Modification. Tank sizing, material, and piping appear adequate for intended function. Currently no low tank level pump shut off controls exist. This appears to be a worthwhile addition to tank liquid level control system. When liquid level reached minimum level transfer pumps P-402 A and B would shut off automatically thereby preventing damage due to running dry.

2) Circulation Pumps P-5A, P-5B

Description. Redundant pumps are provided for circulating wastewater, drawing from the side of the tank near the bottom and returning to the top. Circulation rate is 20 gpm with TDH of 28 ft. Pumps are Gould model 3196 size 1 x 1 1/2 x 6. The primary purpose of these pumps appears to be cooling of the oxidized slurry by circulation through cooler E-1. The pumps are constructed of 316 S.S. and are driven at 1750 RPM by a 1 HP motor. Pumps are controlled by manual start/stop only.

Evaluation. Pumps are satisfactory for intended use.

Potential Modification. None recommended at this time.

3) Treatment Tank Cooler E-1

Description. The Treatment Tank Cooler is a shell in tube heat exchanger used for lowering the temperature of the oxidized slurry during the treatment process. The exchanger is rated at 60,000 Btu/hr with 10,000 lb/hr of slurry entering at 126°F and leaving at 120°F. Cooling water enters at the rate of 3000 lb/hr and 85°F, and leaves at 105°F to return to the treatment tanks. Heat exchanger tubes which contain the oxidized slurry are 316 stainless steel.

Evaluation. Since the system is not operational no measurement of performance has been made. However, heat balance and material balance calculations are consistent with unit specified. Instrumentation shown includes only slurry outlet temperature and cooling water outlet temperature measurements. Since slurry temperature in the treatment tank is measured, a temperature differential is measured which will verify heat exchanger performance. No temperature controls have been provided so it is assumed temperature is not critical.

Potential Modification. Without benefit of systems testing evaluation of any one component is difficult. If close control of temperature of slurry is important, additional temperature controls may be desirable.

4) Anhydrous Ammonia Tank T-12

Description. This is an above ground tank 6 feet in diameter by 16 feet long located outside the wastewater treatment building. It is used to prepare a solution used for pH adjustment of the oxidized slurry. The tank, instrumentation, piping and controls appear to be standard features of a tank of this type. They include level and pressure measurement, pressure relief, and both pressure regulation and flow indication between the storage tank and the solution makeup tank.

Evaluation. Since this unit is a commonly used item and has performed satisfactory many times previously there is not reason to suggest that it will not perform satisfactorily in this service.

Potential Modification. No modifications will be recommended.

5) Neutralization Solution Makeup Tank T-2

Description. This tank is used to mix anhydrous ammonia with water to prepare neutralization solution which is used for oxidized slurry pH adjustment. The tank measures 4 feet in diameter by 6 feet tangent to tangent. The tank is a closed vessel rated at 20 psig @ 130°F and is constructed of 304 stainless steel. The tank contains a cooling coil through which cooling water is circulated. The coil capacity is 262,000 Bth/hr. The tank holds a neutralization solution batch of 4367 lbs. Under Increment I design treated water makeup to the tank was supplied by filtrate from the vacuum filter.

Evaluation. As there is nothing unusual about preparation of this solution it would appear to be satisfactory. A possible problem, however, involves the lack of an outside makeup water source for the tank. As designed for Increment I the only water source is treated water from vacuum water filtrate. Since this water would only exist after treatment has begun, initial neutralization could not be performed until a portion of the oxidized slurry had passed through the vacuum slurry controlled. A study of the Increment II plans does not indicate that this problem was corrected. Valves at tank top are not very accessible. There is some question as to why anhydrous ammonia was selected as the neutralizing agent. It has been suggested that it was once hoped that the resultant sludge could be used as fertilizer, which is unlikely since it will contain lead. The effectiveness of ammonia as the neutralizing agent is questionable. Since it is a complexing agent it may inhibit removal of lead from the wastewater. Perhaps lime would have been a better choice, but change over would be expensive at this time.

Potential Modification. If a separate source of tank makeup water was not provided by modification (which is likely) it is recommended that one be provided. This will be field verified during the final field visit. Since aqueous ammonia solution is in place no change to lime is recommended at this time. Tests on wastewater would reveal if change to lime was warranted.

6) Neutralizer Pump P-3

Description. This pump transfers ammonia solution from the neutralization tank to the treatment tanks at the rate of 10 gpm. The pump is a Gould model 3196 size 1 x 1 1/2 x 8. The pump is constructed of stainless steel. The solution flow rate to the treatment tanks is controlled by AV-100 which receives its signal from tank solution pH measurement. AV-100 is an air operated control valve. A return line is provided to Tank T-2 to return a portion of the ammonia solution when AV-100 is partially closed.

Evaluation. Pump should perform satisfactorily for this application. Since three pH sensors exist (one for each tank) and only one flow control valve, depending on which tank is being neutralized input pH signal must be switched. Apparently this is a manual operation.

Potential Modification. None at this time.

7) Fe Cl₃ Makeup Tank T-3

Description. This is a small (2 feet diameter by 2 feet high) polyethylene tank with agitation for mixing ferric chloride solution which is used for flocculation in the treatment tanks. The tank holds a 22 pound batch.

Evaluation. This piece of equipment is a common one and appears well suited for the application. The only source of water for tank filling is filtrate from the vacuum filter. Therefore, a problem exists identical to that discussed previously with regard to the neutralization solution tank. The top of the tank is not very accessible for addition of ferric chloride.

Potential Modifications. A second source of tank makeup water is desirable.

8) Ferric Chloride Transfer Pump P-4

Description. This transfer pump supplies ferric chloride solution to the treatment tanks from the ferric chloride solution tank. The pump is a positive displacement metering type rated at 0.1 gpm and 12 psi TDH. Pump construction includes an acrylic resin casing with Hastelloy valves. A relief valve is provided to return fluid to pump suction in the event

of a closed valve in the discharge piping. No instrumentation or other controls are provided except manual start/stop. A 1/2" line ties into the ferric chloride discharge line which is evidently for connection of a hose for line flushing.

Evaluation. For this strictly manual operation pump should perform adequately. Running time and total quantity of ferric chloride to be added to each treatment tank would be determined based on operating experience and sludge quality to determine optimum addition rates for each type of wastewater.

Potential Modification. No discharge pressure or flowrate instrumentation has been provided to give an indication of pump performance. This would be desirable.

9) Treated Water Transfer Pumps P-2A, P-2B

Description. These are redundant centrifugal pumps for transfer of treated wastewater (and/or settled sludge) to the vacuum filter for solids separation. Nominal pump capacity is 14 gpm at 62 ft. TDH. The pumps are of 316 stainless steel construction, Gould model 3196 size 1 x 1 1/2 x 8. A flow control valve LV 105 regulates the rate of flow to the vacuum filter, using a liquid level signal from the vacuum filter/basin. A portion of the flow is recycled to a treatment tank if the flow control valve closes.

Additional instrumentation/controls include manual start/stop for the pumps and pump discharge pressure indication (local only).

Evaluation. The pumping and control schemes, while simple, appear adequate for the application. Currently all supernatant as well as sludge must pass through vacuum filter which is energy wasteful and would use much precoat solution unnecessarily.

Potential Modification. None anticipated at this time.

10) Vacuum Filter H-2

Description. The vacuum filter is a horizontal drum type used for separating solids precipitated during neutralization and flocculation from the filtrate which is further treated. No manufacturer's name appears on the unit. The sludge is scraped from the drum exterior and is evidently supposed to be transferred to storage drums.

Evaluation. Equipment for sludge collection and loading into drums or other containers has not been provided.

Potential Modifications. Complete systems for sludge handling and removal after separation by drum filter.

- 11) Filter Separator Pot T-4
- 12) Vacuum Pump P-7
- 13) Filter Vacuum Tank T-5

Description. The above three items will be described as a unit as they serve to produce the vacuum and separate the filtrate from the gas stream. Filtrate is sucked from the filter to pot T-4, where due to velocity and direction change, water is separated from the air stream. Vacuum from the top of T-4 passes through vacuum pump P-7 and tank T-5. Additional moisture collects in T-5 and drains by gravity to a floor trench. Tank T-5 is vented to the atmosphere. A 3" line from the bottom of T-4 feeds filtrate transfer pumps. The vacuum pump is a Bingham model 3G-M. The capacity is 500 SCFM at 22 inches of Hg vacuum. It is driven by a 30 HD motor. Vacuum tank T-5 is 10" diameter by 4' long. The system is virtually devoid of instrumentation.

Evaluation. If capacity of vacuum and filtrate separation system is properly matched to the vacuum filter H-2 it should perform the job of sludge separation and filtrate accumulation satisfactorily. However, the system appears to be devoid of any instrumentation or controls. For example, the Filter Separator Pot T-4 has no liquid level measurement. The volume of T-4 is small, so very little surge capacity exists. If flow to the vacuum filter were interrupted for any reason, and the Filter Pump P-6 continues to run it could run dry. Feed to the wiped film evaporator would also cease which may have serious effects.

Potential Modifications. Instrumentation which would shut off the wiped film evaporator feed pump upon low water level would be desirable. A surge tank to ensure a supply of water to the film evaporator may be required. This will be discussed further in subsequent paragraphs.

- 14) Precoat Tank T-16
- 15) Precoat Pump P-14

Description. These two items makeup the system for precoating the vacuum filtration unit drum surface

with diatomaceous earth prior to operation of the unit for separation of treated water solids. Tank T-6 has a capacity of 1500 gallons and is constructed of 316 stainless steel. The precoat pump is a Durco size 3 x 1 1/2 x 6, single speed and is driven by a 3 HP motor. As with several other tanks, the only water fill line appears to be filtrate from the vacuum filter. If this is in fact the only source the precoating could not take place until after operation of the vacuum filter. The precoat solution is pumped to the vacuum filter sump. Tank instrumentation consists of a level controller. There is a flow control valve in the delivery line to the vacuum filter and an orifice plate in the line running from pump discharge to the main tank.

Evaluation. Lack of a secondary water makeup line to the precoat tank is a serious deficiency and should be corrected. The operation of the control system and the logic are unclear. Why and how is level controlled in the premix tank by a flow control valve in the delivery line to the vacuum filter? A better question is why should tank level be controlled? Why not just fill the tank and pump the contents to the vacuum filter? No access has been provided for emptying diatomaceous earth precoat into mix tank. The mixer provided is too small. The shaft extends into the tank several feet only.

- 16) Potential Modification. Access platform, bag breaker, dust control needed for adding ingredients. A raw water makeup line should be provided.

Filter Pump P-6

Description. This pump is a single pump (without spare) whose principal use is to deliver filtrate from the vacuum filter to the wiped film evaporator. It is also used during filter precoating to remove liquid pumped from the precoat mix tank to the vacuum filter.

According to the drawings the pump has two ratings: (1) 226 gpm at 5.8 psi DP during precoat and (2) 11 gpm at 20.4 psi during normal operation. The pump actually appears to be a single speed Durco unit. Capacity is not shown on the nameplate. The pump is constructed of stainless steel. The only instrumentation consists of a pressure indicator on the pump discharge. The pump takes suction from Filtrate Separator Tank T-4. Flowrate is throttled to maintain a preset flow by FV 104.

Evaluation. Tank T-4 has very little capacity and is essentially just a wide spot in the line. No controls are evident which would match liquid level in tank T-4 and pump P-6 pumping rate. Thus, it appears very likely that many problems could be envisioned which could cause pump P-6 to run dry. Why pump P-6, which is one of the most critical of all regarding overall system operation, does not have a backup is not understood.

Potential Modification. A surge tank for pump P-6 to draw from would be beneficial and help protect the pump and systems downstream of the pump such as the evaporator. Because of importance of this pump an installed spare is recommended.

17) Evaporator Feed Heater E-3

Description. This unit is a shell and tube heat exchanger used for heating the filtrate prior to entry to the film evaporator. The unit has a heating capacity of 700,000 Btu/hr. The unit contains 316 stainless steel tubes through which the filtrate passes. The unit is designed to heat filtrate at the rate of 5163 lb/hr to 240°F at 2 psig using 100 psig steam entering the exchanger at 340°F. Fluid temperature is controlled by throttling steam, sensing fluid temperature and modulating TV 107.

Evaluation. The feed heater is a common device with simple controls so no unusual operating problems are expected. However the heat exchanger leaving conditions indicated on the drawings (240°F, 2 psig) indicates that the filtrate would evaporate in the heat exchanger and in the piping between the heat exchanger and the evaporator. Thus, the solids would plate out within the heat exchanger and piping.

There is a question regarding this data from the Increment I drawing. A heat exchanger with a capacity of 0.7 MM Btu/hr can raise the temperature of 5163 lb/hr of water by 135°F. Therefore the minimum entering water temperature to produce 240°F leaving would be 105°F. Temperature leaving the treatment tanks is indicated as 120°F so 105°F may be a reasonable temperature for entering the feed heater. At 2 psig, or 16.7 psia the saturation temperature is approximately 218°F so 240°F would definitely be a problem.

Specifications and drawings for Increment II indicate an entering temperature of 221°F which is more reasonable, so perhaps 240°F is incorrect.

Proposed Modifications. Filtrate temperature within the feed heater should be lowered to prevent evaporation prior to entering the wiped film evaporator. Replace or reset unit temperature control system.

film evaporator. Replace or reset unit temperature control system.

18) Wiped Film Evaporator S-1

Description. The evaporator is designed to evaporate and concentrate the filtrate feed solution to produce an overhead vapor containing less than 0.1 percent entrained liquid and a concentrated bottom sludge containing no more than 50 percent water. The unit installed was manufactured by Turba-Film. The unit contains a rotor driven by an overhead motor through a center column. Steam is supplied to the unit at a rate to maintain vapor leaving temperature. Steam flow is modulated by throttling valve TV 108. As mentioned in the previous section, a question exists regarding the desired operating temperature of the unit. Sludge is removed from the evaporator bottom and drains by gravity to sludge holding tank T-8.

Evaluation. The unit is more or less standard and the technology is well established. Therefore, except for normal startup problems it should perform adequately. The unit has no means of access to the top for maintenance. The unit is capable of surviving a temporary interruption in feed stream according to the specifications. One potential problem, however, appears to be transfer of bottom sludge to holding tank T-8. The sludge (by specification) must contain no greater than 50 percent water. Therefore, solids must be 50 percent or greater. Since a sludge of 30 percent solids is considered dry, it is very doubtful that a 50 percent solids sludge can be transferred by gravity through a 1" line to the collection tank.

NOTE: Further field checking revealed that this line had been changed to 4" by modification.

Potential Modification. Coordinate specified 240°F operating temperatures with manufacturer to see if this is excessive. Provide access ladder for maintenance.

- 19) Evaporator Condenser E-2
- 20) Evaporator Overhead Receiver T-7
- 21) Process Water Transfer Pumps P-11A, P-11B
- 22) Slurry Overflow Tank T-105

Description. These units will be discussed together as they represent final condensing and transfer of treated water for reuse.

The evaporator condenser is a shell in tube heat exchanger of 530,000 Btu/hr capacity. Both shell and tubes are constructed of 316 stainless steel. Cooling water flows on the shell side. No controls are indicated, although a temperature indicator is used on the cooling water discharge and a pressure safety valve is provided in the cooling water discharge line. Design circulation rates for cooling water are 360 gpm entering at 85°F and leaving at 115°F. Vapor enters at 240°F and leaves at 120°F.

Receiver T-7 is an 80 gallon tank constructed of 304 stainless steel. The tank contains a pressure control valve which limits tank pressure by venting to a building vent header. Level controls within the tank operate LV 110 in the discharge piping from transfer pumps P-11A and B to modulate flow, keeping tank T-7 full and preventing pump cavitation. Pumps P-11A and B are redundant process water transfer pumps which transfer fully treated wastewater to tank T 105 in building #1570 for slurry makeup. The pumps are Gould model 3196 size 1 x 1 x 8. These pumps are rated at 11 gpm at 9.6 psi. Tank T 105 is a stainless steel tank of nominal 2000 gallon capacity.

Evaluation. This subsystem, for condensing and transferring water for recycle, is straightforward and has adequate controls within the wastewater treatment building. It is not clear from the drawings how pumps P-11A and B are controlled. Tank T-105 which they serve has level transmission instrumentation. However, it does not appear to prevent P-11A and B from running if the tank is full. Since the capacity of T-105 is only 2000 gallons, and considerably more water than this could be produced in one treatment cycle, tank T-105 would overflow if additional slurring is not being done at that particular time.

Potential Modification. Add additional tankage to accept water from P-11A and B if T-105 is full. This need will be verified during final field visit. (see further discussion, Increment II)

- 23) Sludge Tank T-8
- 24) Sludge Transfer Pump P-9

Description. This tank and transfer pump constitute the final collection and transfer system for wet solids gathered from the wet film evaporator. Tank T-8 is a vertical tank with conical bottom, 2' diameter by 2' straight side, constructed of 316 stainless steel. The tank is agitated with a 1/4 HP 350 RPM stainless steel agitator. A cooling coil within the tank utilizes cooling water to reduce sludge temperature. Pump P-9 is a positive displacement pump of 5 gpm capacity which transfers sludge to an unspecified sludge receiver near vacuum filter H-2. Pump P-9 is started and stopped by level controls in Tank T-8.

Evaluation. Although simple in concept a question remains whether sludge of 50 percent solids can be agitated by a 1/4 HP agitator, and whether the 1" diameter pump suction line feeding P-9 is large enough to prevent plugging. The 1" pump discharge line is also extremely small. If P-9 is a positive displacement pump, very high pressures could be developed in this discharge line. Pressure indication is shown, but pressure relief provisions are unclear.

Potential Modification. Sludge transfer system from film evaporator through remaining components to final collection needs redesign and modification to provide workable system.

- 25) Trickling Filter H-3
- 26) Trickle Bed Pumps P-8A, P-8B
- 27) Sand Filter H-1

Description. The trickling filter is used for primary treatment of sanitary waste from the Control Building plumbing system, cooling tower blowdown water, and water from sumps in the wastewater treatment building floor. The filter is designed to process 120 gallons per day of sanitary sewage with 200 mg/liter solids and a BOD of 0.35 lbs per day. Recycle rate is one to one, loading is 0.4 gpm per ft². The unit utilizes 300 cubic feet of polypropylene packing. The distribution piping is 304 stainless steel. The unit will also process 5 gpm of industrial waste according to specification.

Pumps P-8A and P-8B transfer water from the trickling filter to a 4" diameter by 5' high holding tank between the trickling filter and Sand Filter H-1 or recycle water back to the trickling filter. This

holding tank appears to drain by gravity to a concrete sump. A sump pump (Weil 1 1/2") apparently feeds the sand filter. Currently the piping has been partially disassembled and the pumps removed so it is difficult to determine the exact process flow as significant deviations were made from the drawings. Flow to the sand filter is apparently modulated by LV 112 which in conjunction with LC 112 maintains water level in the trickling filter. The transfer pumps are rated at 22 gpm at 14.8 psi.

The Sand Filter H-1 is a multimedia type with a capacity of 10 gpm. The media includes a top layer of anthracite, a second layer of sand, and a bottom layer of garnet.

As designed for Increment I, discharge from the sand filter goes to the river.

Evaluation. This treatment/filtration system appears to have some serious shortcomings. No provisions have been made for filter backwashing. No discharge quality is specified for the water leaving the sand filter. Increment I drawings show discharge to the river. On Increment II lagoons were added to contain the wastewater. No chemical addition or chlorination is shown on Increment I. This is an item for field verification. Due to the extremely low and intermittent loading for the trickling filter, it is questionable if sufficient bacterial growth can be sustained for effective biological treatment.

Proposed Modification

Provide tankage for storage of clean filtered water which can be used for backwashing of sand filter and appropriate pumps and piping. Provide tank for use as a collector for backwash water. Backwash water would have to be disposed of. Settled solids could be sent to vacuum filter for disposal. Water after clarification and settling could be returned through trickling filter. Since bacteria could not be maintained in trickling filter, sanitary waste should be pumped to NOS central sewage collection system.

This completes evaluation of equipment supplied under Increment I.

System Components Phase (or Increment) II

- 1) Treatment Tanks T-401A, T-401B, T-401C
- 2) Circulation Pumps P-405A, P-405B
- 3) Treatment Circulation Filters H401A, H401B

- 4) Treatment Tank Cooler E-401
- 5) Soda Ash Tank T-413
- 6) Soda Ash Pump P-413
- 7) Treated Water Transfer Pumps P-402A, P-402B
- 8) Evaporator Feed Heater E-403
- 9) Wiped Film Evaporator S-401
- 10) Evaporator Condenser E-402
- 11) Evaporator Overhead Receiver T-407
- 12) Process Water Transfer Pumps P-411A, P-411B
- 13) Distilled Water Storage T-410
- 14) Distilled Water Transfer Pump P-412A, P-412B
- 15) Sludge Tank T-408
- 16) Sludge Transfer Pump P-409
- 17) Lagoon
- 18) Lagoon Pumps P-451A, P-451B

Summary - Increment II

Many of the problems identified during the evaluation of the Increment I systems were avoided during the Increment II design. Although the precise operating methods for treating the scrubber water are unclear, the chemistry is straightforward.

The entire plant is largely manually operated, which is desirable because the maximum versatility in operating methods can be utilized. As with any wastewater treatment plant exact operational methods will have to be developed from experience. The system provided should be functional with a minimum of additional modifications.

Description of Process

The primary waste generated during Increment II which must be treated is spent recirculated scrubber water from the Fluidized Bed Incinerator Gas Scrubber. Sodium carbonate solution is used in the scrubber to react with hydrogen chloride and sulfur dioxide gas to remove them from the exhaust stream. As the scrubber solution becomes depleted (reaches a concentration of 7% sodium chloride) it is ready for treatment.

The presumed operating mode is to prepare scrubber solution in one or two of tanks T-401A, B and C. Sodium carbonate (soda ash) is mixed in Tank T-413 and transferred to the Treatment Tanks T-401A, B or C by pump P-413. As scrubber solution is circulated through the gas scrubber and becomes contaminated it can be collected in the empty tank and treated. While being contained in Treatment Tanks T-401A, B, or C scrubber solution is circulated using Pumps P-405 A or B through Filters H-40 A or B and Cooler E-401 and may be returned to the Treatment Tanks or, if FBI is operating, pumped to the scrubber in Building 1651.

Treatment consists of transferring solution using pumps P-402 A or B to the vacuum filter unit H-2 previously discussed as part of Increment I. The vacuum filter (and accessories) is virtually the only unit not dedicated to either Increment I or Increment II waste treatment, but instead is used for both wastes. Perhaps this is because sludges generated by this process are expected to be minimal. Here sludge (if any) is drummed and filtrate is pumped from H-2 through Evaporator Feed Heater E-403 to Wiped Film Evaporator S-401 using Increment I pump P-6. Vapor from S-401 is condensed in Evaporator Condenser E-402, collected in Evaporator Overhead Receiver T-407, and pumped to Distilled Water Storage Tank T-410 using Process Water Transfer Pumps P-411 A or B. From Tank T-410 water may be transferred using Pump 412 A or B to Increment I or Increment II Slurry Building.

It further appears that during the design of the Increment II process, many cross connections between the Increment I and Increment II processes were added so that great redundancy and duplication of treatment capacity exists.

A lagoon was also added. Piping is provided to transfer water from building sumps to the lagoon or from the sand filter H-1. Lagoon pumps 451 A or B enable transfer from the lagoon to either Increment I or Increment II treatment tanks.

Component Evaluation - Increment II

1. Treatment Tank T-401A, T-401B, T-401C

Description. These tanks are dished bottom vertical tanks of nominal 3800 gallon capacity each. Tanks and tank covers are made of fiberglass reinforced plastic. The tanks are 8' diameter and 13'-3" deep. The tanks are used to collect, treat, and recycle scrubber solution used in the exhaust gas scrubber for the Fluidized Bed Incinerator (FBI). Piping entering the tank top consists of a 3" scrubber discharge water, a 1-1/2" recirculation line originating on the tank side through pumps P-405 A and B, a 1" recirculation line from the tank bottom through pumps P-402 A and B, a 1" line carrying soda ash solutions, and 1/2" line carrying ferric chloride from a system provided in the Increment I design. Tank instrumentation includes local temperature indication, level sensing and high level alarm, and pH sensing and transmitting to AV 401.

Evaluation. The precise operating method for the scrubber water treatment system is unclear from the contract plans and specifications. There is no well

water or river water supply to the treatment tanks. The only way to prepare the scrubber solution initially appears to be to mix 100 gallon batches of soda ash/water solutions and transfer the solution to the treatment tanks. Once a treatment tank is filled, the solution could be pumped to the scrubber and returned to the tank after passing through the scrubber. The scrubber water is to be used until concentration of sodium chloride reaches 7%. Presumably this would be determined by relating concentration to pH of the spent liquid. At any rate that is the only parameter measured other than temperature and pressure. One of the documents supplied to us for study was a letter dated 3 January 1980 which suggested certain design modifications for the soda ash system including removal of the pH control valve AV 401. The valve was retained to control adjustment of pH.

This system will be further investigated during the next field visit.

Potential Modification. None, pending further study.

2) Circulation Pumps P-405A, P-405B

Description. These pumps are used to supply recirculated scrubber solution to the gas scrubber. The pumps are Sethco size 1 1/2 x 2 x 6, rated at 102 gpm at 46.9 psi TDH. The pumps are driven at 3600 rpm by a 15 HP motor. Valving is provided so that solution can also be returned to the treatment tanks. Tank instrumentation consists of a local pressure indicator on each pump discharge. The pumps are operated from a local push button station. Pump casings are constructed of CPVC or polypropylene. The impeller is CPVC. Pump shafts are 316 stainless steel. Pumps have mechanical seals.

Evaluation. Pump appears to have proper capacity for gas scrubber feed.

Potential Modification. None anticipated at this time.

3) Treatment Circulation Filters H-401A, H-401B

Description. Each filter is rated at 100 gpm with maximum pressure loss of 50 psi. They are of the removable basket strainer type consisting of a floor mounted cylindrical housing with strainer removable

through a hinged top. Filters are Ronningen Petter model E2. The filters are for parallel operation with either capable of handling the entire design flow. The purpose of the filters is to remove solids from the recirculated scrubber water larger than 0.15" in diameter. The expected solids concentration is 0.10 percent by weight.

Evaluation. The materials of construction of the filter housing and basket are not specified, except that they must be suitable for service in solutions of sodium carbonate, ferric chloride, dilute hydrochloric acid and sodium chloride. If this is the case, the filter should perform satisfactorily providing the estimate of solids concentrated (0.10 percent) is accurate.

Pressure is measured at both filter inlet and outlet so the proper time for filter change over and basket cleaning should be easily determined.

Potential Modification. None anticipated.

4) Treatment Tank Cooler E-401

Description. This unit is a shell and tube heat exchanger for cooling recirculated scrubber water (evidently only when being recirculated back to the treatment tank prior to treatment. The capacity indicated on the drawings is 60,000 Btu/hr. It is not specified further, but is shown as future equipment. The cooler does not currently exist.

Evaluation. If the cooler were to be supplied as specified it would be virtually useless. The 102 gpm pumping rate through the cooler would produce approximately a 1.1°F temperature drop which seems unlikely to be the objective.

Potential Modifications. None recommended pending further investigation.

5) Soda Ash Tank T-413

6) Soda Ash Pump P-413

Description. As designed, the tank and pump make up the system for preparation and transfer of sodium carbonate solution to the treatment tanks for scrubber water preparation and treatment. The tank is a 100 gallon FRP tank. The pump is a 10 gpm FRP pump rated at 22 psi TDH with 1 HP 1800 RPM motor. The tank contains level control instrumentation and a level

transmitter which operates valve LV 402 to keep the tank full. The tank can be filled using well water or water from treatment tanks 410 A, B and C via P-405 A and B. Sodium carbonate is evidently to be added by hand from bags unless the intent was to use concentrate liquids. The tank contains no dust control or vent.

Evaluation. No design calculations were provided to indicate how many batches of soda ash solution are required for treatment during one operating cycle. Originally rate of addition to the treatment tanks was controlled by AV 401 which was operated by a signal from the tank pH instrumentation. Correspondence supplied to us indicated that this operational requirement has been abandoned and certain modifications made to this system. Nevertheless, the tank and pump seem to be suitable for mixing soda ash with water and transferring it to the treatment tanks regardless of exact operating methods. As currently constructed, the tank and pump as well as associated piping, do not exist.

Potential Modifications. A tank with dust control and pump would have to be provided to operate the plant.

7) Treated Water Transfer Pumps P-402A, P-402B

Description. These pumps are used to transfer water from Treatment Tanks T-401 A, B, and C to the vacuum filtration unit H-2 after neutralization and settling. The pump casings are of CPVC or high strength polypropylene. The impellers are of CPVC (semi-open type). Pump shafts are stainless steel with CPVC shaft sleeves. The pumps have single mechanical seals with flushing connections. The design pumping rate is 14 gpm at 25.8 psig. The pumps are Flater model C7P834000SV. Motor is 1 1/2 HP at 3460 RPM. The pumps are manually operated. The only instrumentation is pump discharge pressure.

Evaluation. Although the procedure requires the attention of an operator to start the pumps and stop them before the tanks run dry, the system appears to be adequate for the function intended.

Potential Modification. As with Increment I tanks, low level pump shut off controls would be desirable, but not mandatory.

8) Evaporator Feed Heater E-403

Description. The evaporator feed heater has a capacity of 700,000 Btu/hr and is designed to heat 5346 pounds of water leaving the vacuum filter (filtrate) from 120°F to 221°F. Steam supplied at 150 psig but reduced to 75 psig and 320°F is the heating medium. The water contains up to 7 percent NaCl and traces of HCl. The unit is of shell and tube construction with carbon steel shell and all wetted parts of impervious graphite. The unit is constructed to ASME standards. Temperature is controlled by modulating TV 404.

Evaluation. The heat exchanger has adequate capacity to heat the filtrate to the indicated temperature. The temperature of 221°F is below the saturation pressure at feed pump discharge pressure so (unlike the Increment I heat exchanger) boiling will not occur within the heat exchanger. Temperature control is simple and proven. The carbon and graphic construction should protect the unit from deterioration from chlorides. The evaporator feed heater should function adequately.

Proposed Modifications. None anticipated.

9) Wiped Film Evaporator S-401

Description. The evaporator (manufactured by Turba Film) is designed to concentrate impurities in the filtrate feed stream to enable recondensation of evaporated water for reuse and concentration of impurities in a bottom sludge for disposal. The Increment II evaporator was designed for two separate waste streams; (1) a 93 percent water, 7 percent sodium chloride solution, and (2) a solution approximately 98 percent water, 2 percent ammonium nitrate, and trace amounts of ammonium acetate, aluminum hydroxide, lead hydroxide and ash. Operating pressure for the unit is 2 psig. Evaporation heat is supplied by saturated steam at 75 psig. The unit operating temperature is 221°F. The resulting bottom sludge is a maximum of 50 percent water. The bottom sludge is drained by gravity to tank T-408 through a 2" diameter line.

Evaluation. The design of the Increment II evaporator appears to have several improvements over the Increment I unit. The operating temperature is lower for the feed stream, thereby reducing the possibility of flashing to steam prior to evaporator entry. Also, the sludge drawoff line has been increased in

diameter, thereby improving the possibility of being able to accomplish gravity removal. The unit has no access ladder to enable maintenance at or near the top. To summarize, the unit seems to be properly suited to the task.

Potential Modifications. Add access ladder or platforms.

10) Evaporator Condenser E-402

Description. This unit is a shell and tube heat exchanger designed to condense vapor leaving the evaporator at the rate of 4654 lb/hr. The condensate leaves the condenser at 120°F.

Cooling water at 340 gpm (85°F in, 115°F out) is the cooling medium. The rated capacity of the unit is 5 million Btu/hr. The heat exchanger is an ASME vessel, 8" inlet, 2" outlet on shell (vapor) side and 4" inlet, 4" outlet on cooling water side.

The shell is of 316 stainless steel as are all parts wetted by the process (which contains traces of HCl).

Evaluation. The unit is of conventional design with a minimum of controls. The design capacity of the unit is sufficient to condense the stated water mass flow. It appears adequate for its intended function.

Potential Modification. None anticipated.

11) Evaporator Overhead Receiver

Description. As the name implies, this unit serves to receive and hold the condensed treated water from the evaporator condenser. The tank is constructed of 316 stainless steel. It is horizontal with dished heads of 50 gallon nominal capacity.

Evaluation. The tank is suitable for intended function.

Potential Modifications. None anticipated.

- 12) Process Water Transfer Pumps P-411A, P-411B
- 13) Distilled Water Storage Tank T-410
- 14) Distilled Water Transfer Pump P-412A, P-412B

Description. These units cover transfer and storage of reclaimed water for reuse.

Pumps P-411 A and B are centrifugal pumps of nominal capacity 11 gpm and 20.4 psig discharge pressure manufactured by Durco, model D4 size 1 1/2 x 8 x 1. The pumps are driven by 1 HP motors at 1750 RPM. Pump casings are of 316 stainless steel. Impellers are closed, single suction type of 316 stainless steel. Pumps have single mechanical seals with flushing connection. These pumps take suction from the overhead condensate receiver T-407 and deliver water to storage tank T-410. Pumping rate to tank T-410 is controlled by LV-403. The LV-403 signal comes from level instrumentation in tank T-407. Water can also be directed to the trickling filter if desired.

Tank T-410 is a 4000 gallon fiberglass reinforced plastic tank. Instrumentation includes level sensing, indication and high level alarm.

Pumps P-412 A and B also Durco 1 x 1 1/2 x 8) pump from tank T-410 at the rate of 20 gpm and 22.5 psig. Pump discharge piping connects to existing Increment I piping to slurry tankage. An orifice plate FO-404 in a line which returns water to tank T-410 from P-412 discharge limits flow to 10 gpm and prevents pump from running dry. Pumps P-412 A and B are of identical construction to P-411 A and B, except the former are driven by 2 HP motors.

Evaluation. Pumps and tank materials and capacities are adequate. Instrumentation and controls have been provided to adequately regulate pumping rates to prevent pumps from running dry.

Potential Modifications. None anticipated at this time.

- 15) Sludge Tank T-408
- 16) Sludge Transfer Pump P-409

Description. This tank collects sludge from the evaporator for ultimate disposal. The tank is constructed of Hastelloy C-276 and has a nominal capacity of 40 gallons. The tank contains a cooling coil of 15,000 Btu/hr cooling capacity using cooling water as the medium. The cooling coil is also of Hastelloy C-276. Tank instrumentation consists of level transmitter which modulates LV-405 in the discharge of pump P-409 to maintain an acceptable sludge level in T-408 by returning a portion of the flow. Pump P-409 is a centrifugal pump for transferring a 50 percent solution of sodium chloride (sludge) to a sludge receiver near vacuum filter H-2. The pump casing material is Hastelloy C as is the

impeller. The pump is started and stopped manually. Pump capacity is 15 gpm at 12.6 psi TDH. The pump is a Durco model 1 1/2 x 1 x 6 driven at 1760 rpm by a 1 HP motor.

Evaluation. The tank and pump appear to be adequately sized and constructed to perform the intended function. Controls are basically manual and require a operator, as does most of the wastewater plant. The ability of a centrifugal pump to transfer sludge which is 50 percent solids is somewhat doubtful.

Potential Modification. Replace centrifugal pump with positive displacement type if sludge really contains 50 percent solids.

- 17) Lagoon
- 18) Lagoon Pumps P-451A, P-451B

Description. The lagoon was constructed during Increment II to provide a receptical for wastewater from various sources in lieu of dumping water into the river. Source of water for lagoon include cooling tower blowdown, water which has been treated by the trickling filter and sand filter. Provisions had been made on the plans to transfer lagoon water to the river, but this line was evidently deleted. Two separate lines have been run to the lagoon, one for sanitary waste and one for industrial waste with provisions for sampling each.

Pumps P-451 A and B are rated at 50 gpm and 45 psi and are provided for returning lagoon water to the water treatment tanks. They are Durco pumps of the self priming variety, driven at 1760 rpm by a 15 HP motor.

Evaluation. The lagoon system provides surge capacity and a safety factor in the event that wastewater cannot be treated immediately, or in the event of a failure or process upset. Since water stored in the lagoon over a period a time could become biologically active; some impact on treatment equipment due to biological material could result.

Potential Modification. None anticipated. However, operating and maintenance procedures should be developed to prevent clogging or other adverse results from transfer of biological material from lagoons to treatment plant.

Economic Summary - Wastewater Treatment System
Modifications

1) Modified System (essential) Increment I

a. Construction Cost	\$ 83,900
b. Design Cost at 6%	5,034
c. SIOH at 5%	4,195
d. Additional Costs - Studies, Field Verification, etc. at 10%	<u>8,390</u>

Total Cost \$101,519

Modified System (essential) Increment II

a. Construction Cost	\$ 20,200
b. Design Cost at 6%	1,200
c. SIOH at 5%	1,010
d. Additional Costs - Studies, Field Verification, etc. at 10%	<u>2,020</u>

Total Cost \$ 24,430

2) Recommended System (desirable) Increment I

a. Construction Cost	\$ 96,500
b. Design Cost at 6%	5,790
c. SIOH at 5%	4,825
d. Additional Costs - Studies, Field Verification, etc. at 10%	<u>9,650</u>

Total Cost \$116,765

4) Recommended System (desirable) Increment II

a. Construction Cost	\$ 39,100
b. Design Cost at 6%	2,346
c. SIOH at 5%	1,955
d. Additional Costs - Studies, Field Verification, etc. at 10%	<u>3,910</u>

Total Cost \$ 47,311

VII. Analysis For Energy Recovery From The Facility

VII. ANALYSIS FOR ENERGY RECOVERY FROM FACILITY

Purpose

In this study we examine several modifications to the Propellant Disposal Facility for their energy conservation potential. The modifications studied are modifications to major process equipment in order to recover energy that would otherwise be wasted.

Introduction

The processes of the Propellant Disposal Facility were studied and examined for areas where energy was being wasted. Where it was found that energy was being wasted, alternatives for energy recovery were studied. This report contains the results of those studies.

The water treatment process involves evaporation of large quantities of water and is a large energy consumer. In this section, means for recovering this energy are addressed. In Section VIII, alternate treatment methods which would be less energy intensive are discussed briefly.

Summary and Conclusions

Our analysis shows that it would be worthwhile to add the following energy recovery equipment:

1. Preheater for fluidized bed incinerator to recover heat from hot exhaust gases.
2. An air preheater for boiler B-700-1 with B-1 used as a spare.

These projects are worthwhile only if the system is used for at least five years with the frequency assumed in this report.

General

ThQ Propellant Disposal Facility (PDF) was constructed in two Increments. Increment I as it concerns this report features a Wet Air Oxidation system, a water treatment system and boiler. The second Increment features a Fluidized Bed Incinerator (FBI), water treatment system and boiler. Both Increments, although different in operating principle, perform basically the same function, thermal destruction of propellant and treatment of resulting wastes. A basic difference in the functions of the two increments is the types of propellant they will treat. Both increments will oxidize single and double based propellants, the second increment will also oxidize composite based propellants.

There are three basic types of propellant oxidized at the PDF, single-based, double-based, and composite. For energy recovery analysis, the only properties of concern are the heat of combustion and the products of combustion. For the purpose of this study, the heat of combustion was assumed to be an average of 4450 BTU/LBM of propellant. The source of this approximation is given in the Appendix calculations.

The process flow rates and temperatures for Increments I and II are as given in Figures E-1 and E-2 respectively. In both increments the propellant is slurried (not shown) before entering the actual process. Figures E-3 and E-4 show the waste water treatment system for Increments I and II respectively.

All energy to operate the process except electricity used for lighting and for motor driven equipment, etc., comes from No. 2 fuel oil burned on the site. This energy is used either indirectly as steam from one of the boilers or directly such as to fire the fluidized bed incinerator. The cost of fuel oil used in our analysis is \$.96/gallon and the cost of electricity used is \$.06/kwh.

Process Description

The following is a brief description of the operation of the PDF process. It describes the energy flow in the propellant disposal process. It does not go into detail about aspects of the process that are not related to energy use and possible energy recovery.

Wet Air Oxidation Unit

The propellant enters the WAO process, Increment I (Figure E-1) as a slurry. This slurry is pumped to a high pressure by two slurry feed pumps. High pressure air is injected into the slurry. The slurry and air mixture then enter a series of heat exchangers where it is heated to a temperature at which oxidation will take place inside the reactor. The first heat exchanger is heated by hot slurry leaving the reactor, the second exchanger is heated by high pressure steam. After being oxidized in the reactor and then passed through the heat exchanger where incoming slurry is heated, the liquid/vapor is cooled further in a cooler where about 1.3 million BTU/Hour (MMBTUH) are removed. The liquid and vapor then pass through a pressure reducing station. From there, the fluid is transferred to the vapor separator where the vapor is separated from the liquid. The liquid then goes to a storage tank where it awaits treatment in the water treatment system.

The WAO process, except for the afterburner, requires no process heat once the reactor is operating at design

temperature and pressure. At that time, the exothermic reaction occurring inside the reactor will release enough heat to heat the incoming slurry and air mixture.

The steam used to heat the reactor to a temperature where the reaction becomes exothermic comes from a small high pressure boiler. This boiler will be on standby once the reaction becomes exothermic.

The water (or oxidized slurry as it is called) from the vapor/liquid separator goes to the water treatment system (Figure E-3) where it is treated and returned to the system. Initially, the water enters the water treatment building and is stored for treatment in one of the storage tanks. In the storage tank, neutralization and settling take place. From the storage tank, the water goes to a vacuum filter where solids are removed. The water then goes to the wiped film evaporator system from which it is returned to the process or discharged.

The wiped film evaporator is the biggest energy user in the water treatment system because it must evaporate all the treated water. Before entering the evaporator, the water is preheated in a steam to water heat exchanger to 240°F, requiring 0.69 MMBTUH. In the evaporator, the water is converted to steam requiring 4.7 MMBTUH. The solids are then collected as sludge and the steam is condensed in a cooler before the water is returned to the process.

Fluidized Bed Incinerator

The FBI unit oxidizes the propellant in a 25% by weight propellant/water slurry. This slurry will be injected into the fluidized bed where it will be oxidized at a rate of 1,000 pounds per hour.

The incinerator contains a 8 foot deep bed of aluminum oxide (alumina). The bed is fluidized by 1100°F air blown from a distribution grid at the base of the bed. The propellant slurry and fuel oil are injected into the fluidized bed through nozzles above the base of the bed and around the perimeter of the incinerator. The incinerator requires 30 gph of fuel oil.

The exhaust from the incinerator goes through a cleaning system to bring emissions into compliance with air pollution regulations. After leaving the incinerator, the gasses pass through the cyclone separator where particles above 50 microns in size are removed. The gas then continues on, through the venturi gas quencher, the gas scrubbers and finally through the catalytic oxidation unit. In the gas quencher, the gases are cooled to a temperature of 140°F. The scrubber removes any hydrogen chloride vapor. In the catalytic oxidation unit, fuel oil heat the gases before they pass through the catalyst, this unit consumes 13.5 gallons per hour of fuel oil.

The water treatment system for Increment II is very similar to that for Increment I. The capacity of the wiped film evaporator and associated equipment is slightly different. In this system, the water preheater uses 0.74 MMBTUH and the wiped film evaporator uses 5.0 MMBTUH.

Steam Generating Units

There are three boilers in the PDF, all are fired with No. 2 fuel oil. There is a 7,000 lb/hr. boiler in Increment I and a 10,000 lb/hr. boiler in Increment II. Both of these boilers are used to produce 100 psig steam for process and space heat. These boilers are both fire tube type. The third boiler is the small package boiler in the first increment used to start up the WAO process. At peak firing rate fuel consumption is approximately 53 gph for the 7000 lb/hr. boiler in Increment I and 87 gph for the 10,000 lb/hr. boiler in Increment II.

The two main boilers were sized to provide steam for space heating and process loads. The space heating loads are small in comparison to the process steam load. The largest process loads are the two wiped film evaporators. Neither boiler is large enough to supply steam for both evaporators, but with the schedule of one week in eight being devoted to actual operation of each wiped film evaporator, it is obvious that with proper scheduling, only one boiler is required. Therefore, the application of heat recovery to just one boiler was considered as a possibility. This boiler could be used for all process and space heater loads and the other boiler could be kept as a spare.

Energy Conservation Opportunities

In the PDF systems, both Increments offer several possibilities for heat recovery which would lead to energy and cost reductions. These possibilities are discussed in the following paragraphs. The actual calculations for energy savings were done as shown in the Appendix.

The durations listed were calculated assuming each disposal system actually handled propellant for 8 weeks per year - 120 hours per week.

Possible sources and uses of waste heat as listed in Tables E-1 and E-2. Table E-1 lists sources of waste heat. This table lists the heat lost and the temperature ranges over which it is lost. Table E-2 lists heat users and, where possible, the amount of heat required.

In order to match up a specific heat source with a heat user, two basic requirements must be met. First, the energy must be available at the proper temperature for the heat requirement. Secondly, because energy storage is uneconomical, energy must be available at the same time it is needed.

To insure that the timing requirements are met, the processes shown in Tables E-1 and E-2 are broken down into three time frames:

1. Oxidation of Propellant
2. Water Treatment
3. Other

In general, any heat source in one time frame and increment is available only for use by a user in that time frame and increment.

It was decided that process heating as opposed to space heating was the only valid application of waste heat. The reason for this has to do with the operating schedule. Available data indicates that the propellant disposal system is only required to operate for one week in eight. When operating, either increment will be disposing of propellant 24 hours per day for 5 days. This means that for only a relatively short amount of time will there be any useful heat generated. Thus, process heat cannot be relied on for space heating.

The fluidized bed incinerator produces large quantities of hot gas. In the present system the heat present in these gases is wasted. In the original design process the installation of a heat exchanger to preheat incoming gases with this heat was considered. At that time it was felt that hydrogen chloride gas released in the incineration of composite propellant and high temperatures would require a graphite heat exchanger. This would have been very costly resulting in a payback period of 94 years for disposal rate of 480,000 pounds per year. However, if temperatures above 240°F can be maintained condensation can be prevented and the heat exchanger can be constructed of carbon steel thus reducing costs.

The catalytic oxidation unit in the second increment is also a good source of high quality heat. This heat can be used to preheat gas entering the unit and thus reduce the amount of fuel used to heat the gas. This has the extra beneficial effect of lowering the amount of air that needs to be added to the burner, which means less air must be heated.

The water treatment systems for both increments are very similar. In both of these systems, the wiped film evaporator and preheater are the only candidates for heat recovery. Heat can be recovered from the steam that leaves the evaporator and is condensed into water at 120°F in the cooler. It could be used to preheat the slurry before it enters the preheaters. The proposed heat exchanger would be a shell and tube type with 316 stainless steel tubes.

The two large process boilers in the PDF are good candidates for energy recovery systems. It was decided that the small high pressure startup boiler in Increment I is not used for sufficient lengths of time nor is it large enough to warrant any heat recovery system. The two large boilers as stated previously, will be used for both process heat during propellant disposal and for space heating during winter.

There are several methods of heat recovery from boilers. The two investigated were feedwater preheat and air preheat. Because makeup water is not required in large amounts, feedwater preheat was not deemed feasible. Air preheat, however, is feasible. In such a system, air entering the boiler would be preheated by the flue gases leaving at a temperature of 350°F.

The 9.1 MMBTU rejected by the cooling tower is of no particular use because the water is not of a high enough temperature.

In summary, the projects selected as worthy of detailed analysis are:

1. Use of a heat exchanger to transfer heat from the hot gases leaving the FBI to the incoming air stream.
2. Use of heat exchanger to transfer heat from the hot gases leaving the catalytic oxidizer (FBI System) to preheat the entering air.
3. Transfer of heat from the vapor condensing sides of the wiped film evaporator (FBI System) to preheat the entering water.
4. Use of air preheaters on one of the boilers.
5. Use of a heat exchanger to transfer heat from the afterburner gas discharge (WAO System) to heat incoming air.

TABLE E-1: WASTE ENERGY SOURCES

<u>SOURCE DESCRIPTION</u>	<u>HEAT REJECTED (MMBTUH)</u>	<u>TEMPERATURE RANGE (°F)</u>	<u>DURATION (HRS/YR)</u>	<u>OPERATION*</u>
<u>INCREMENT I</u>				
Afterburner Stack	.36	850-80	720	1
High Pressure Slurry Cooler	1.3	380-120	720	1
Evaporator Cooler	5.4	240	630	2
Cooling Tower Y-1	9.1	107-81	1350	1&2
Boiler B-1 Exhaust	1.3	350-80	630	2
<u>INCREMENT II</u>				
Fluidized Bed Exhaust	6.48	1650-190	720	1
Evaporator Cooler	5.0	221	720	2
Catalytic Oxidation Unit	4.0	850-80	720	1
Cooler E-620	3.81	190-120	720	1
Cooling Tower Y-704	15.0	115-85	-	1&2
Boiler B-700-1	2.2	350-80	720	2
Gas Quencher	6.0	190	720	1

*Operation 1. Oxidation of Propellant; 2. Water Treatment;

TABLE E-2: WASTE ENERGY USES

<u>SOURCE DESCRIPTION</u>	<u>HEAT REQUIRED (MMBTUH)</u>	<u>TEMPERATURE REQUIRED (°F)</u>	<u>POSSIBLE FUEL SAVINGS (GAL/YR)</u>	<u>OPERATION*</u>
<u>INCREMENT I</u>				
Preheat Afterburner Air	--	--	--	1
Preheat Water Entering Evaporator	.7	337	3800	2
Preheat Boiler (B-1) Air	.13	210	735	2
Heat Evaporator	4.7	320	25600	2
Start Up Heat Exchanger	.75	450	233	1
<u>INCREMENT II</u>				
PreHeat Air Entering Fluid Bed	2.2	1100	11660	1
Preheat Air Entering Catalytic Oxidation Unit	--	--	--	1
Evaporator Preheater	.64	320	3980	2
Heat Evaporator	5.0	320	31000	2
Preheat Boiler Air (B-700-1)	.19	210	1200	2

*Operation 1. Oxidation of Propellant; 2. Water Treatment.

Results

Each of the five projects listed at the end of the last section was analyzed to determine the payback period for each project. The results of these analyses are shown in Table E-3.

Table E-3

Application	Manufacturer of Unit	Initial Inst Cost	Annual Energy Savings	Payback Period (Years)
FBI Unit	Smith-Engrg.	75,700	13,800	7.8
Catalytic Oxidizer	Smith Engrg.	77,000	12,000	10
Wiped Film Evaporator	Taco	17,100	2,500	10+
Boiler Air Prehater	Condensing Heat Exchgr.	23,000	4,300	7.5
After Burner	Q-Dot	16,200	760	10+

The detailed economic analysis calculations are given in the Appendix. These calculations were done in accordance with NAFVAC P-442, "Economic Analysis Handbook". The cost of each modification project was roughly estimated. This estimate required input from heat exchanger manufacturers for recommended sizing and pricing of the heat exchanger. A rough layout of the new equipment was done to determine the approximate amount of new piping and piping modifications required for the installation. All this information was used to produce an order of magnitude estimate of installation costs. The energy savings are calculated from the information as given in the Appendix and from information supplied by heat exchanger manufacturers.

With the costs and savings figures calculated, it was possible to calculate payback periods, using the methods in P-442. The present value of the savings was calculated for a 10 year project life. The present value of savings was then divided by the investment cost to get the savings investment ratio (SIR). The savings investment ratio was then used to determine payback period in years.

Projects with payback periods in excess of 10 years are not economically justifiable and are not recommended. The reason for this is the 10 year project life used in our analysis.

Recommendations

In Table E-3, only two projects offer payback periods of less than 10 years. We recommend that if the propellant disposal facility is going to be used, these projects be constructed. These projects are the addition of a preheater for the fluidized bed incinerator and addition of an air preheater for the boiler B-700-1. The Boiler B-700-1 will then be the main boiler and B-1 will only be operated as a spare.

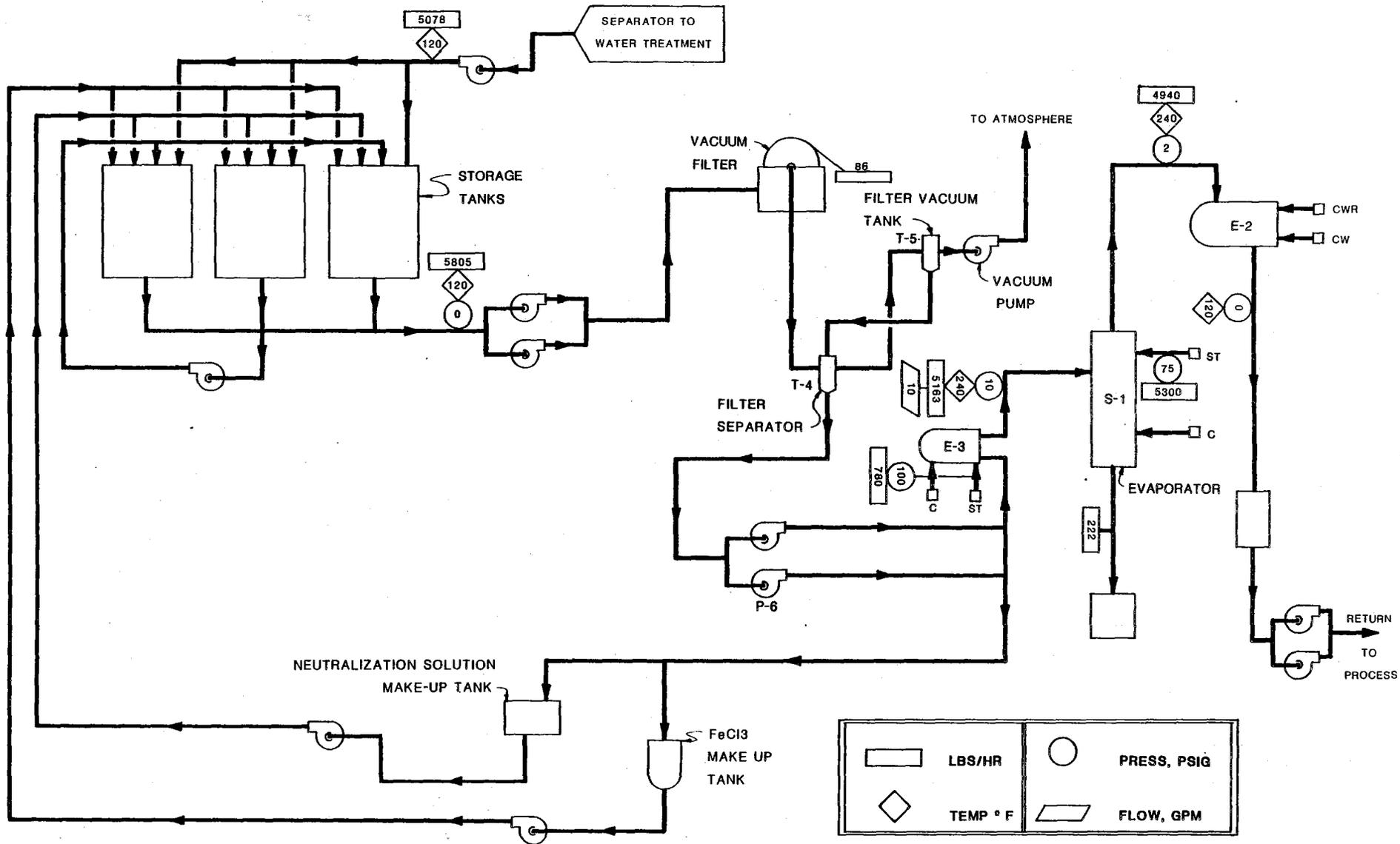


FIGURE E2 - WATER TREATMENT SYSTEM FOR WET AIR OXIDATION SYSTEM (Increment 1)

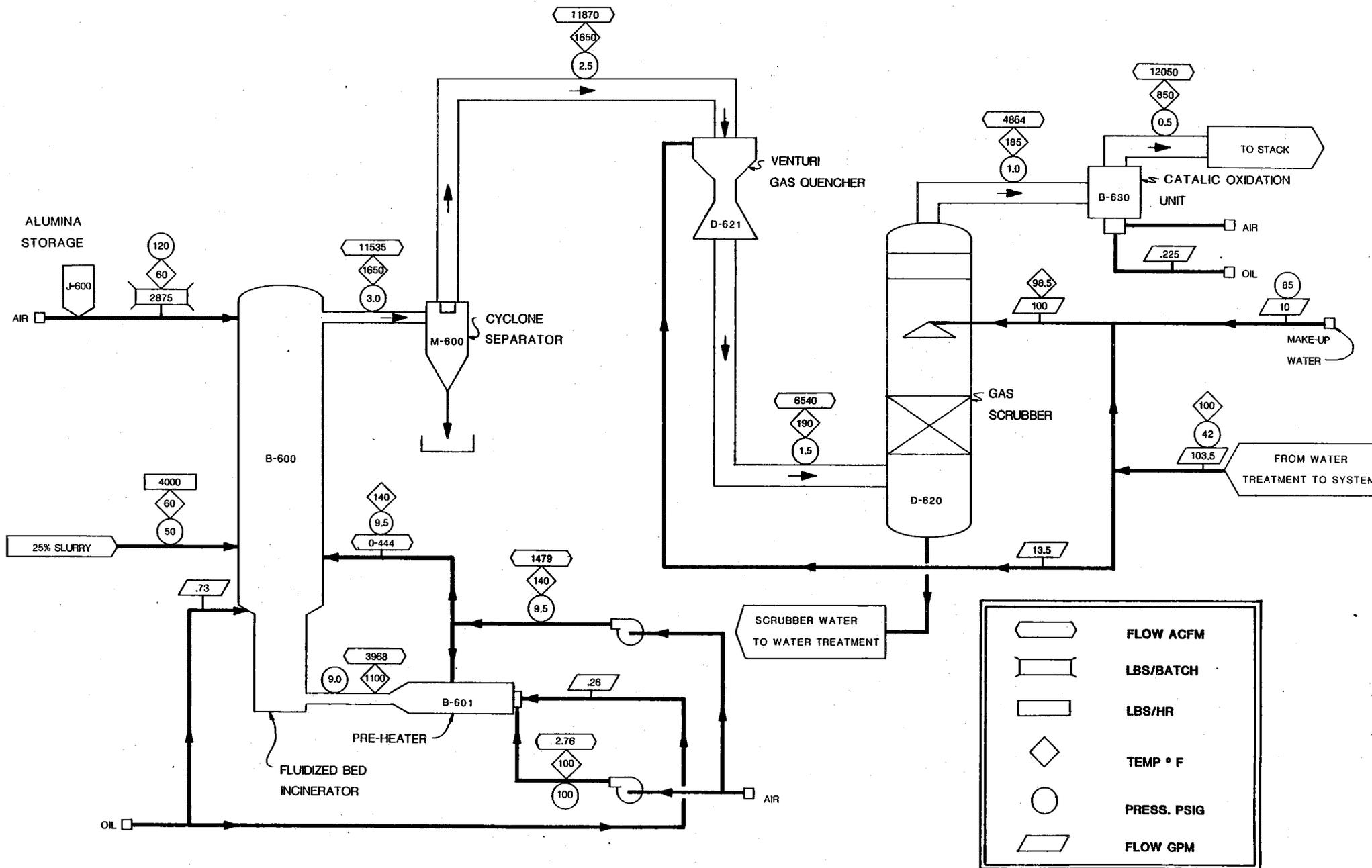


FIGURE E3 - FLUIDIZED BED INCINERATOR SYSTEM SCHEMATIC (Increment 2)

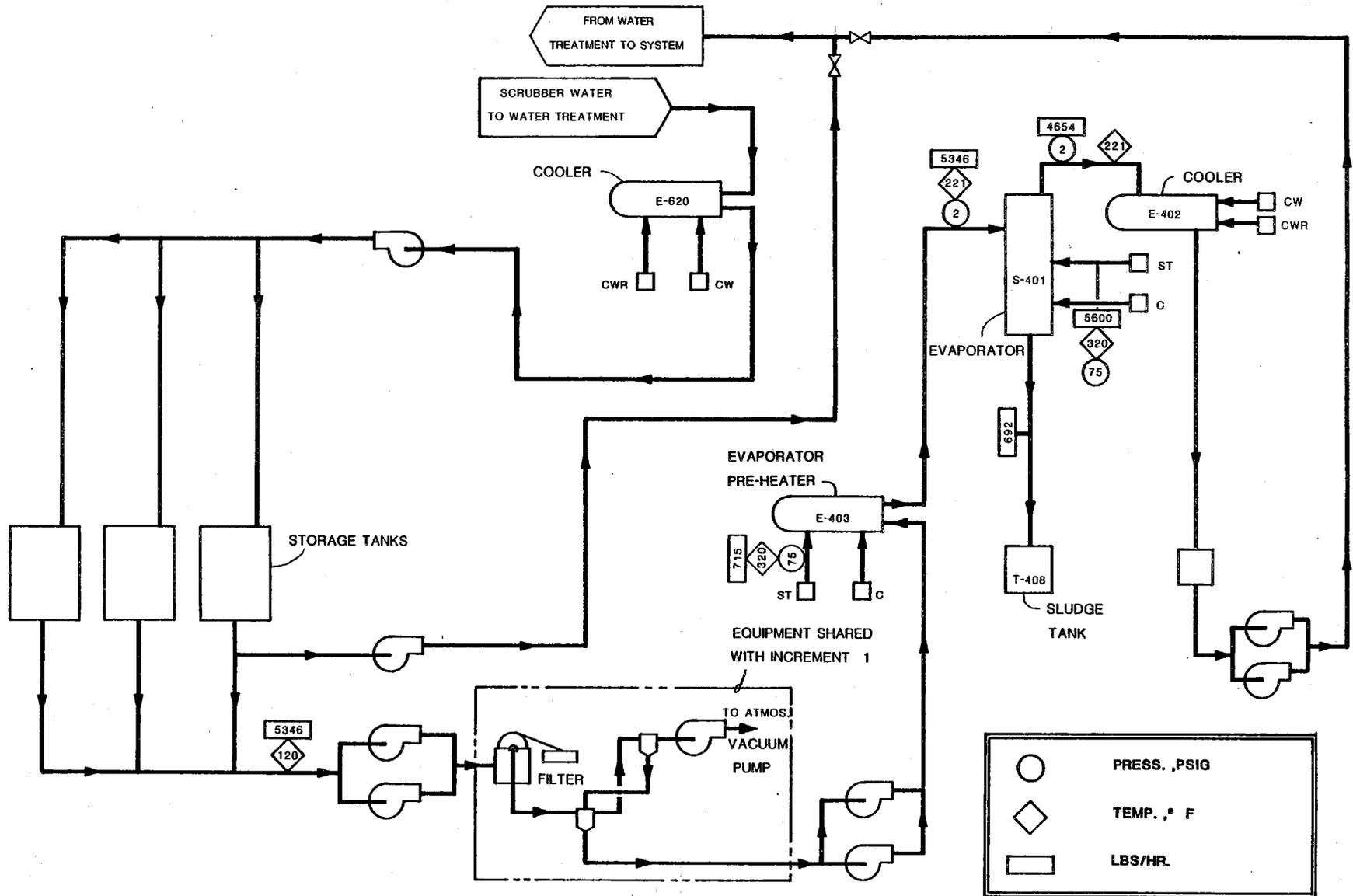


FIGURE E4 - WATER TREATMENT SYSTEM FOR FLUIDIZED BED INCINERATOR

VIII. Water Balance Analysis For Wastewater
Treatment Facility

VIII WATER BALANCE ANALYSIS
FOR WASTEWATER TREATMENT FACILITY

General. The purpose of this section is to examine the handling of water throughout the facility and especially in the wastewater treatment facility to determine if it is being handled in a conservative manner. Since all treated water now is evaporated within the treatment process, the system is very energy intensive. A secondary purpose of this section is to evaluate the possibility for an alternate treatment process which would use less energy and still allow for recycling process water.

Introduction. Water crosses the boundary of the Wastewater Treatment Building (Number 1574) in a number of forms and conditions. These include well water and river water into the building for initial tank filling and makeup, oxidized slurry and scrubber water for treatment, treated effluent water for discharge or recycling, and steam, vapor, and condensate. Not included in this analysis are cooling waters and steam and condensate which are part of energy transfer systems and are essentially closed loops with no net gain or loss of fluid within the building.

A. Increment I - Water Balance

Figure VIII-1 indicates all water crossing the building boundary for both increments. Increment I flows are indicated by a solid line. The following tables summarize these lines and indicate source, destination, and nominal rate. Only those lines affecting the water balances are included.

INCREMENT I

<u>Lines Entering</u>	<u>Destination and/or Source</u>	<u>Nominal Rate</u>
TW-067 8"	From Film Evaporator to Evaporator Condenser	4940 lb/hr @ 240°F, 2 psig
TW-062 1"	From Wet Film Evaporator to Sludge Tank	222 lb/hr @ 240°F
OS-100 2"	Oxidized Slurry from Bldg. #1573 to Tanks T1A, B, C	5078 lb/hr @ 120°F
WW-100 4"	From Wells to Various Destinations for Filling or Makeup	Uncertain and Intermittent

<u>Lines Entering</u>	<u>Destination and/or Source</u>	<u>Nominal Rate</u>
TW-061 1-1/2"	From Evaporator Feed Heater to Evaporator	11 gpm (5163 lb/hr)
SW-075 1-1/2"	From Evaporator Overhead Receiver to Sand Fill	11 gpm
SW-072 1-1/2"	From Evaporator Overhead Receiver to Building 1570 for Reuse	11 gpm
WW-103 2"	To Cooling Tower Basin for Makeup from WW Line @ NE Corner of Building	As Required
WW-100 3"	To Other Building from Well Water Pumps (No Effect on Water Balance)	As Required
V-122 4"	To Gas/Liquid Separator Tank from T1A, B, C	Unknown

Description of Water Usage

The following is a recapitulation of inflow and outflows affecting wastewater treatment water balance for Increment I.

For Increment I, all are directly or indirectly related to operation of the WAO unit.

Oxidized slurry enters the water treatment building from Building D at the rate of 5078 lb/hr @ 120°F (density of slurry is unknown). Slurry is pumped to treatment tanks T1A, T1B, or T1C. Transfer line is OS-100 2". Tank capacities are 4660 gal each. If filled at the rate of 11 gpm, OS could be pumped to tanks for approximately 21 hours prior to beginning treatment.

While in the tanks, ammonia solution and ferric chloride are added for treatment. Ammonia comes from neutralization makeup tank at transfer rate of 10 gpm, 4367 lb of ammonia solution per batch, 22 lb of ferric chloride per batch. Treated water is added to Tank T-2 but comes from within treatment building. Ferric chloride comes from Tank T-3. Makeup water to T-2 is also treated water from within plant loop via T-4 filtrate separator and pump D-6. Origin of water is H-2 Vacuum Filter.

Pumps 2A, B (transfer pumps) pump treated slurry water (now called TW) to vacuum filtration unit @ 5805 lb/hr, 120°F. Pump P6 transfers filtrate to E-3 evaporator feed heater @ 5163 lb/hr; therefore, sludge removed should be $5805 - 5163 = 642$ lb/hr. A discrepancy exists at this point because project flow sheets predict 86 lb/hr of sludge production. Reference 1 (at end of section) predicts 105 lb of sludge per 1000 lb of propellant or 52.5 lb of sludge per hour at a 500 lb/hr propellant destruction rate.

From evaporator feed heater (E-3) TW flows to (S-1) wiped film evaporator (line TW 061 1-1/2") leaving building at 5163 lb/hr. Vapor leaves S-1 at 4940 lb/hr to E-2 evaporator condenser and T-7 evaporator overhead receiver (5000 gal). Water transferred to Building #1570 at 4940 lb/hr (line SW 072 1-1/2") leaving building by pumps P11A, and P11B. Sludge from the bottom of S-1 at 222 lb/hr, reenters building to tank T-8 (sludge tank) via TW 062 1". Sludge is pumped at 222 lb/hr to sludge collector near vacuum filter. Slurry water goes to T-105 (2000 gal), Building #1570 for reuse (2000 gal = 16,684 lb.)

Conclusion - Everything balances except vapor lost to atmosphere when operating vacuum filter. This could be represented by the difference in computed sludge removal versus flow sheet indicated removal of 642 lb/hr - 86 lb/hr = 556 lb/hr. This seems extremely high so there may be an error on the flow sheets.

If there is no demand for slurry water at other buildings, water can be pumped to trickling filter (T-6) and sand filter (H-1) and ultimately to river. This could affect water balance greatly. Since tank T-105 holds only 16,684 lb of water, water could be transferred for only 3.4 hours prior to completely filling Tank T-105 if no demand for slurry makeup water exists at the time.

Total batch treated from Tanks 1A, B, C could be approximately $4660 \times 3 = 13,980$ gallons. Recovery percentage is $\frac{4940}{5805} \times 100 = 85\%$. Therefore, 11,883 gallons per batch could be transferred to Building 1570. Since tank capacity is only 2000 gallons, 9883 gallons of usable water could be wasted.

When operating continuously, however, the 85 percent water recovery for the Increment I process is quite good.

The only other line entering wastewater treatment building is WW-100 4". At the entry point, it splits, reduces and fills tank T-11, boiler feed water tank and leaves building in two places: (WW-103 2") to cooling tower basin, and (WW-100 3") to other buildings. These normal requirements for makeup water are unavoidable and usages are relatively small and intermittent and do not greatly affect the water balance. Waters which are ultimately discharged may, however, have an impact due to water quality rather than quantity.

Discussion and Potential Modifications

While continuously operating, the treatment system is reasonably efficient from a water balance standpoint. While operating, treated water is available for makeup water addition to ammonia solution tank and ferric chloride tank. Likewise, if propellant is still being slurried for eventual disposal at the same time waste is being treated, there is a need for recycled water.

Summary of water lost during continuous operation includes:

1. Lost in sludge at vacuum filter (approximately 10% by weight or 11 lb. per 1000 lb. propellant).

Total fluid into plant = 5078 lb/hr of 90% water, or 507.8 lb/hr propellant. Water lost = $\frac{507.8 \times 11}{1000} = 5.58$ lb/hr.

Sludge, including water = $\frac{507.8 \times 105}{1000} = 53.3$ lb/hr.

This does not agree with flow sheets which indicate either 642 lb/hr sludge removal or 86 lb/hr sludge removal. Also, 10% moisture content for sludge is highly questionable. Reference 2 indicates typical ranges of solids content for various types of sludges dewatered by vacuum filtration. Solids content of greater than 38 percent by weight is generally not achievable. At any rate, loss of water at vacuum filter is minor.

2. Water lost in sludge at wiped film evaporator is 222 lb/hr of 50% water (flow diagram) or 119 lb/1000 lb propellant per reference 1. Therefore, water lost is 111 lb/hr by flow diagram, or 60 lb/hr per referenced letter. Either way, water loss is minimal. Published solids concentration in sludges is somewhat suspect. If greater water percentages exist in sludges than stated, disposal problems will be greater and more costly.
3. Cooling tower blowdown (which can be reused for slurring) is of undetermined amount although blowdown rate shown on drawings is 10 gpm. Per Reference 1 it is 3 gpm with the following characteristics: pH 7-8, temperature 85°F, Total alkalinity as Calcium Carbonate 8786 ppm, sulfate 36 ppm, chloride 78 ppm.

To summarize, water lost during continuous operation is minimal although exact amount is uncertain due to disagreements among sources.

The overwhelming water requirement is for initial slurring of propellant, which is not strictly related to water treatment plant. Once treated water begins to return to Building 1570 to Tank T-105, little additional water is required. If, however, water cannot be used in Building 1570 as it is available and it has to be dumped, it would be wasted.

All of the above discussion on Increment I is somewhat irrelevant, however, since changes made during Increment II add tankage for temporary storage and lagoons to contain water from the plant not immediately returned for reslurring.

B. Increment II - Water Balance

The dashed lines on Figure VIII-1 indicate those lines carrying water in some form across the building boundary which were installed during Increment II. The following table summarizes these lines.

<u>Lines Entering</u>	<u>Destination and/or Source</u>	<u>Nominal Rate</u>
V-027 3"	Ammonia Tank Thru Building to Equip Building	N/A
TW-458 8"	From Wiped Film Evaporator to Evaporator Condenser	4654 lb/hr
TW-475 2"	From Wiped Film Evaporator to Sludge Holding Tank T408	692 lb/hr
EW-433 4"	From Lagoon to T1A, B, C or T401A, B, C	50 gpm
SDW-686 3"	To T401A, B, C from Scrubber	
EW-799 1-1/2"	From P706 to EW 424 (see below)	N/A
EW-706 1-1/2"	Drain CW Downstream of Pumps to Building Floor Sump	
EW-796 1-1/2"	Drain from CW Line Downstream of Cooling Tower Y-1	N/A
RW	From Yard Fire Main	As Required

<u>Line Entering</u>	<u>Destination and/or Source</u>	<u>Nominal Rate</u>
EW-424 1-1/2"	From Floor Sump or Sewage Sump to Lagoon via Pumps P16 or P706	15 gpm
TW-406 3"	To Gas Scrubber D-620 from Treat Tank Pumps	103.5 gpm
WW-758 2"	To Composite Slurry Building	gas needed
CF-713 1/2"	Chemical Feed to Cooling Tower	unknown-minimal
CF-714 1/2"	Chemical Feed to Cooling Tower	unknown-minimal
RW-701 2"	River Water to Cooling Tower Basin	unknown
CF-7001 1/2"	Chemical Feed to P706 Sump	unknown
TW-456 1"	From E-403 Preheater to Evaporator	5346 lb/hr
SW-466 1-1/2"	To Sand Filter or Trickling Filter	

The following is a recapitulation of inflows and outflows which affect water balance for Increment II.

Increment II differs entirely from Increment I in that all of the water used to make up the propellant slurry is evaporated in the Fluidized Bed Incinerator and does not constitute a wastewater to be treated. Although the quantity is the significant amount of water used in the facility, it has no meaning with regard to the water treatment plant water balance, and is not available for reclamation. The water treatment for Increment II consists of treatment for recycling of the water used in the FBI Scrubber.

Scrubber discharge water is pumped to Tanks T401A, B, C from the incinerator building. Some conflict exists between flow sheets regarding flow rate, but 109 gpm seems correct for average flow. Treated water from tanks is returned to incinerator building to scrubber by pumps P405A/B. Again some conflict regarding rates. Flow rate says 103.5 gpm, pumps are 102 gpm (use 103.5) 13.5 gpm goes to gas quench and ultimately to scrubber. Makeup is 10 gpm water out is 109 gpm. Therefore, water lost due to evaporation should be 4.5 gpm. Water lost at tanks should be $109 - 103.5 = 5.5$ gpm. This must be compared with sludge removal rates.

While in treatment tanks, only ferric chloride is added from existing system.

3. From bottoms of tanks T401A, B, C, TW is pumped by P402A, B to tie in ahead of existing vacuum filtration unit H-2. Transfer rate is 5346 lb/hr. Material balance sheet shows transfer to wiped film evaporator of 5346 lb/hr also. this can't be exact as this allows for no sludge removal. Sludge produced per Reference 1 is 392 pounds per 1000 pounds of composite propellant and only 6.3 pounds per 1000 pounds of double base propellant. Vapor leaves evaporator at 4654 lb/hr. Vapor is condensed in T407. Sludge leaves evaporator at rate of 692 lb/hr (50% H₂O). Condensed slurry water can be transferred to trickling filter for disposal or to storage tank T410 (5000 gal.). Sludge goes to Tank T408 and to sludge tank near vacuum filter unit.

Summary. Not including water lost as evaporated slurry and as a vehicle for chemical addition, the only water consumed or lost by the water treatment process consists of that added as makeup at the scrubber which is evaporated and not returned to the treatment tanks (approximately 4.5 gpm), water in the sludge or vapor at the vacuum filter (0.08 gpm maximum) and water contained in the wiped film evaporator sludge (0.7 gpm). This total of 5.3 gpm is suspect, as sludge as dry as that assumed in the various referenced documents, especially the 10% moisture at the vacuum filtration unit is suspect. Normally, sludge containing only 30% solids is suitable for landfilling. Nevertheless, this amount is small considering the amount of water handled.

Conclusion. Although the PDF is a significant water consumer due to the large amounts required for propellant slurring and tank filling, water is in general reclaimed wherever possible. Wastewater treatment is efficient and appears to render an acceptable percentage of reusable water. Especially after the redundancy in storage and transfer incorporated as part of Increment II, very few events would occur which would result in loss of otherwise recycleable water. Therefore, no obvious opportunities for water conservation exist in the treatment systems as designed.

The significant water consumer (the FBI) is one of the basic elements of this facility. Modification and/or elimination of this device is being studied as part of other tasks within this report.

References.

1. Propellant Disposal Facility Techno/Economic Study - date unknown
2. U.S. Environmental Protection Technology Transfer (EPA 625/1-74-006) Process Design Manual for Sludge Treatment and Disposal. October, 1974.

C. Alternate Wastewater Treatment Methods

Present Treatment Process

The treatment process as designed has been evaluated and described elsewhere. As previously discussed, the fact that wiped film evaporators are used in both increments for sludge concentration and water purification makes the wastewater treatment process very energy intensive.

It is far beyond the scope of this report to design an alternate treatment plant. Nevertheless, it seems appropriate to evaluate the possibility that the treatment process could be changed to save considerable energy, while continuing to recycle water. The following is devoted to treatment of Increment I wastes. The same process could not be adapted or modified for Increment II. If the FBI were shown to be economically feasible (which is unlikely judging by the many uncertainties still existing) still another alternate or use of the original treatment system would be required for Increment II wastewater.

Influent Characteristics

An examination of documents supplied indicates that the range of influent parameters expected in the oxidized slurry is as follows:

<u>Item</u>	<u>Concentration of Range</u>
O ₂ (residual)	1 to 2%
H ₂ O	>95%
Pb (inorganic)	1800 mg per l or 2% by weight
Cu) may be present	<2%
Ni) may be present	<2%
Al (may be present)	<2%
Ash	<1%
pH	1.0 to 2.0

Effluent Requirements

The exact limitations on contaminant levels permitted to be discharged from the wastewater treatment plant to the river depends upon the NPDES permit for NOS. If pretreatment only were considered, the required contaminant levels would depend upon the allowable levels acceptable at the NOS treatment plant. The following tabulation lists the presumed levels to

which the water leaving the plant would have to be treated.

Item	Concentration or Range	
	Discharge to Fresh Water	Discharge to Treatment Plant
Pb	0.02 to 0.05 mg/l	0.1 mg/l
Cu	0.01 to 0.05 mg/l	0.1 mg/l
Ni	0.02 to 0.10 mg/l	0.1 mg/l
Al	0.10 to 1.5 mg/l	---
pH	6.5 to 8.5	5.0 to 9.0
BOD	30 mg/l (typical)	300 mg/l
TSS	30 mg/l (typical)	350 mg/l

Treatment Methods and Options

The contaminant present in the largest concentration, and upon which the basic treatment system would have to be based, is lead. The stated maximum concentration of 1800 mg/l is far higher than any published treatment data found. However, in general, removal efficiencies increase with increased concentration of the contaminants. The following summarizes the treatment steps available and theoretical results.

1. Lime addition followed by sedimentation: 98.5% lead removal
Theoretical reduction: 1800 mg/l to 27 mg/l
2. Lime and Ferric Sulfate addition followed by sedimentation: 99% lead removal
Theoretical reduction: 1800 mg/l to 18 mg/l
3. Lime and Ferric Sulfate addition followed by sedimentation and filtration: 99.4% lead removal
Theoretical reduction: 1800 mg/l to 10.8 mg/l
4. Ion exchange: strong acid cation exchange resin: 99.9% lead removal
Theoretical reduction: 1800 mg/l to 1.8 mg/l

Processes 1, 2, and 3 were based on tests performed on waters with lead concentrations ranging from 5 mg/l to 6.5 mg/l. Process 4 was based on testing of wastewaters containing 127 to 145 mg/l.

Based on the above, it appears that none of the processes would result in a dischargeable wastewater all by itself. Evidently, a series of steps would be necessary.

Results. For purposes of developing a cost estimate (order of magnitude) for a more energy efficient treatment method, we have postulated the following treatment process.

A 24 hour retention time sedimentation basin equipped with provisions for both lime and ferric sulfate addition could be provided with a flocculation mixing zone and scrapers for sludge removal. Coagulation and precipitation should be followed by sand filtration. Final effluent would be polished using an ion exchange unit with a strong acid cation exchange resin. Projecting percentages based on previously stated removals, it should be possible to reduce lead to approximately 0.01 mg/l. Of course, this is only theoretical, and implementation would depend upon testing.

A schematic has been developed and is included as Figure VIII-2. It would be possible to reuse a number of the items of equipment from the existing treatment plant. We estimate a cost of approximately \$428,000 to construct this plant. Since the probability that the WAO unit will be operated in relatively small (especially on a full time/fully operational basis), this subject has not been explored further.



IX. Economic Summary

IX. ECONOMIC SUMMARY - EXISTING PROPELLANT DISPOSAL FACILITY
AND ALL RECOMMENDED MODIFICATIONS

Increment I

<u>Subsystem or Item</u>	<u>Minimal Modifications</u>	<u>Desirable Modifications</u>
Propellant Feed, Conveying, and Grinding	*\$ 208,000	*\$ 332,000
Propellant Slurry Preparation	30,000	30,000
Wet Air Oxidation Systems	278,000	278,000
Wastewater Treatment Systems	102,000	117,000
Energy Recovery Implementation	-----	40,000
Test, Debug, Shake Down @ 25%	<u>155,000</u>	<u>204,000</u>
Totals (see Note 1)	\$ 773,000	\$ 996,000

Increment II

<u>Subsystem or Item</u>	<u>Minimal Modifications</u>	<u>Desirable Modifications</u>
Propellant Feed, Conveying, and Grinding	*\$ 208,000	*\$ 332,000
Propellant Slurry Preparation	18,000	18,000
Fluidized Bed Incinerator Systems (This is an extreme approximation)	2,100,000	2,100,000
Wastewater Treatment Systems	24,000	47,000
Energy Recovery Implementation	-----	60,000
Test, Debug, Shake Down @ 25%	<u>536,000</u>	<u>556,000</u>
Totals (see Note 1)	\$2,678,000	\$2,781,000

*These costs are applicable to both Increments, but are not included in Increment II totals.

ALTERNATE WASTEWATER TREATMENT FACILITY

a. Construction	\$427,800
b. Design Cost @ 6%	25,668
c. SIOH @ 5%	21,390
d. Additional Costs-Studies, Field Verification, etc. @ 10%	<u>42,780</u>
Total (see Note 2)	\$517,638

NOTES:

1. Totals do not include actual facility commissioning, labor, spare parts, supplies, equipment, etc. This was estimated @ \$2,712,000 per memorandum from 2031C: PRS to E dated 20 March 1978, Subject: Commissioning Estimate.
2. Total does not include actual facility commissioning, labor, spare parts, supplies, equipment, etc.

X. Additional Modifications For Disposal Of
100 Percent Of Ordnance-Related Waste

X. ADDITIONAL MODIFICATIONS FOR DISPOSAL OF 100 PERCENT OF ORDNANCE RELATED WASTE

A. Introduction

The ordnance related wastes at NOS include a wide variety of material in many different configurations. Additional new facilities will be required to accomplish 100% disposal of these wastes. Various options and combinations of equipment must be considered in relation to the specific requirements for disposal of each waste category.

In order to provide an orderly approach to this analysis, the wastes have been categorized according to particular properties that make their disposal unique. These categories, along with the estimated quantities and their percent of the total workload, are listed in the attached table.

This categorization allows the definition of both the type of disposal process and the pollution control requirements for each type of waste.

It is recommended that only thermal treatment processes be considered for these materials. Later sections describe the rationale for this decision. Based on this rationale, several thermal processes, along with the necessary pollution control methods and two basic options of process equipment combinations to handle 100 percent disposal on site have been recommended. Section XI of this study addresses off site transportation and disposal.

Each of the options is also subdivided into program increments and prioritized in anticipation of the likely event that funding constraints will dictate incremental funding of the program.

Option 1 (Ref. Figure X-1) would consist of a Size Reduction Facility (SRF), and Explosive Waste Incinerator (EWI) and a Contaminated Waste Processor (CWP). Type 1 and Type 2 wastes would proceed directly to the CWP for processing. Types 3, 4 and 8 would proceed directly to the EWI and Types 5 and 6 would proceed to the EWI after processing in the SRF. Type 7 waste could be processed in the CWP as a fuel supplement or sent to DLA as their responsibility if certified clean of explosives and propellants.

Option 2 (Ref. Figure X-2) would consist of SRF, EWI, CWP and WAO facilities. Types 1 and 2 waste would be processed in the CWP, as in Option 1. Types 3, 5 and 8 waste would be processed in the EWI, and Types 4 and 6 waste would be processed in the

WAO. As in option 1, both Types 5 and 6 waste would first be processed in the SRF and Type 7 waste could supplement fuel in the CWP or be sent to DLA.

The basic difference between these options is the handling of Types 4 and 6 waste, which contain AP. They require halogen removal for pollution control and create corrosion considerations. We are aware of no systems that commonly handle these propellants containing AP on a production basis. Therefore, some design modifications to existing systems are required. We have proposed two options: 1) modify the EWI air pollution control system to incorporate HCl control or 2) modify the WAO to handle these materials.

Noticeably absent from these two recommended options is the Fluid Bed Incinerator (FBI). A third option (Ref. Figure X-3) would be to use the WAO, FBI, Deactivation Furnace (DF), and CWP in combination with an SRF. Economic considerations preclude recommendation of this option.

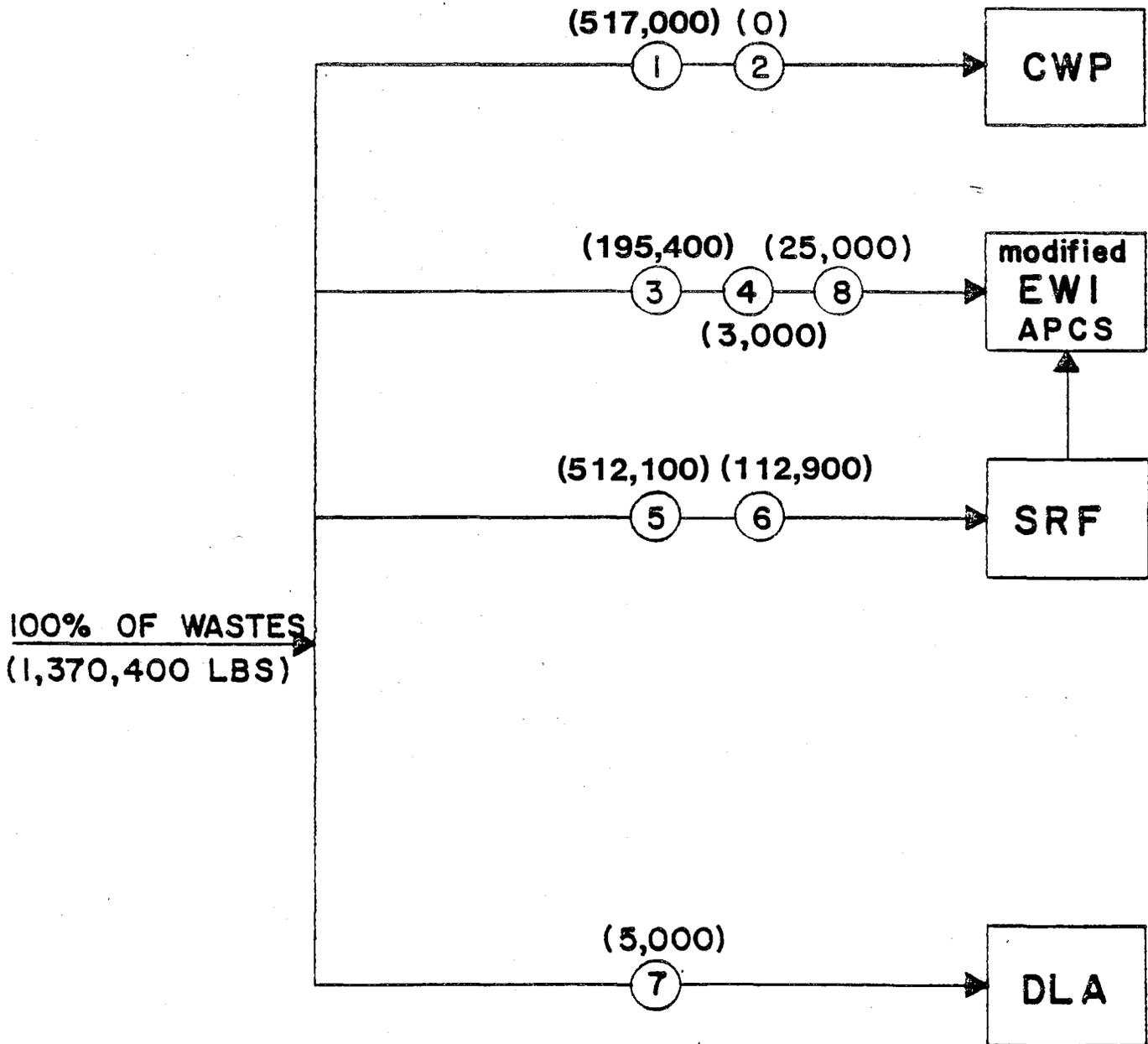
It should also be noted that the contaminated waste processor (CWP) is common to both recommended options. It is the clear cut choice for processing contaminated wastes. In harmony with existing open burning permits, it is recommended that this equipment be obtained as soon as feasible. The equipment is available with only little site specific design modifications and it can stand independent of other recommended equipment. The CWP by itself could eliminate 40% of all wastes that are now being open burned.

EPA regions 4 and 7 and also the state of Wisconsin have set precedence by ruling the wastes handled in the CWP are not Hazardous Wastes. The rationale behind this classification was that the contaminated waste did not contain enough explosive that the waste itself was reactive and no listed wastes were processed. This fact is significant in that permitting was not required for the CWP units in those areas. If this could be pursued in the state of Maryland and a similar ruling received, construction could begin when funds are available.

The following sections describe the considerations for development of the above options and a master plan outline for their implementation. Based on the developed data, Option 1 is the most highly recommended.

In the development of these options, a number of specific criteria were considered. These criteria are discussed hereinafter.

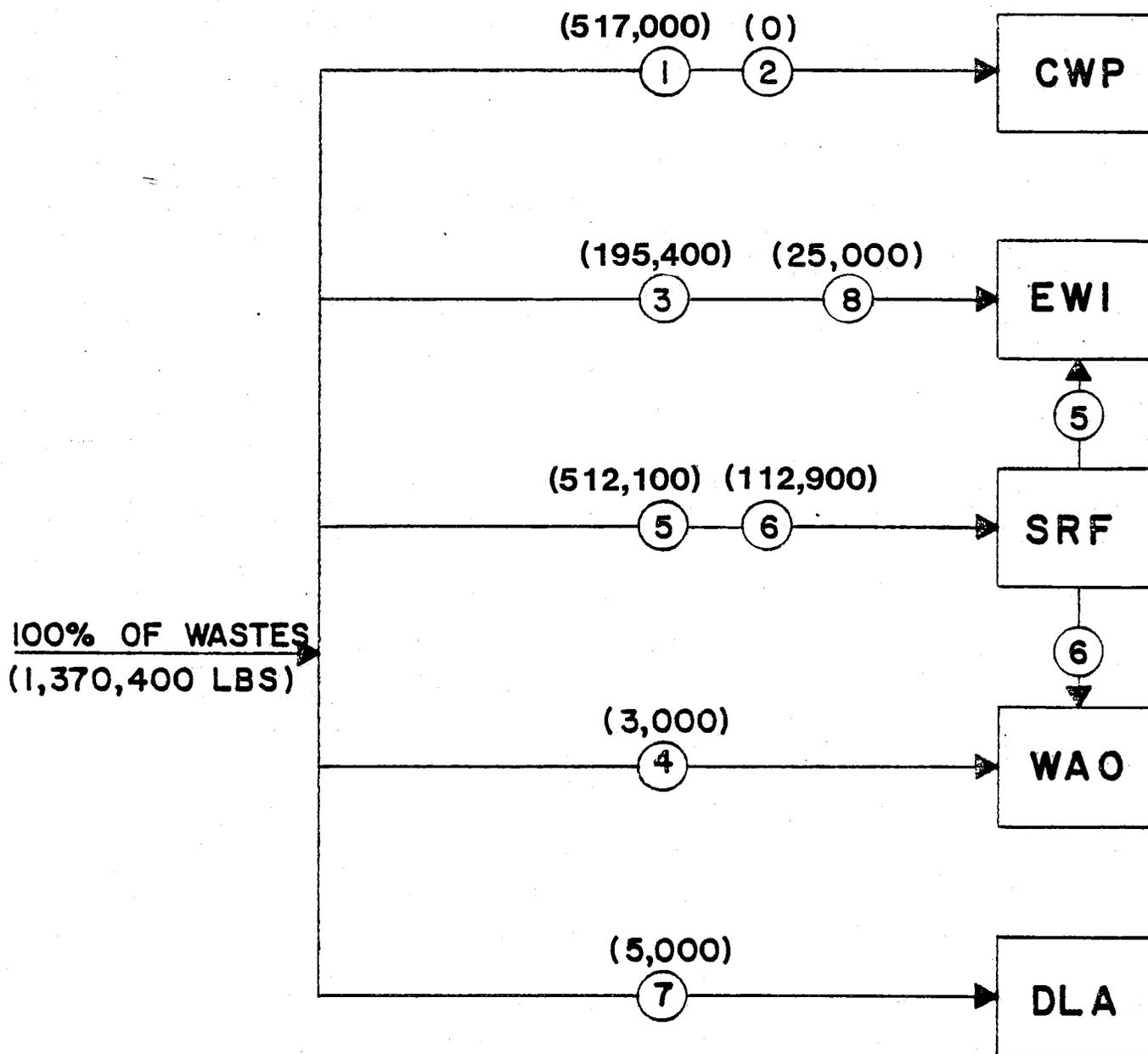
OPTION 1



CAPITAL COST - \$ 3,810,000

FIGURE X-1

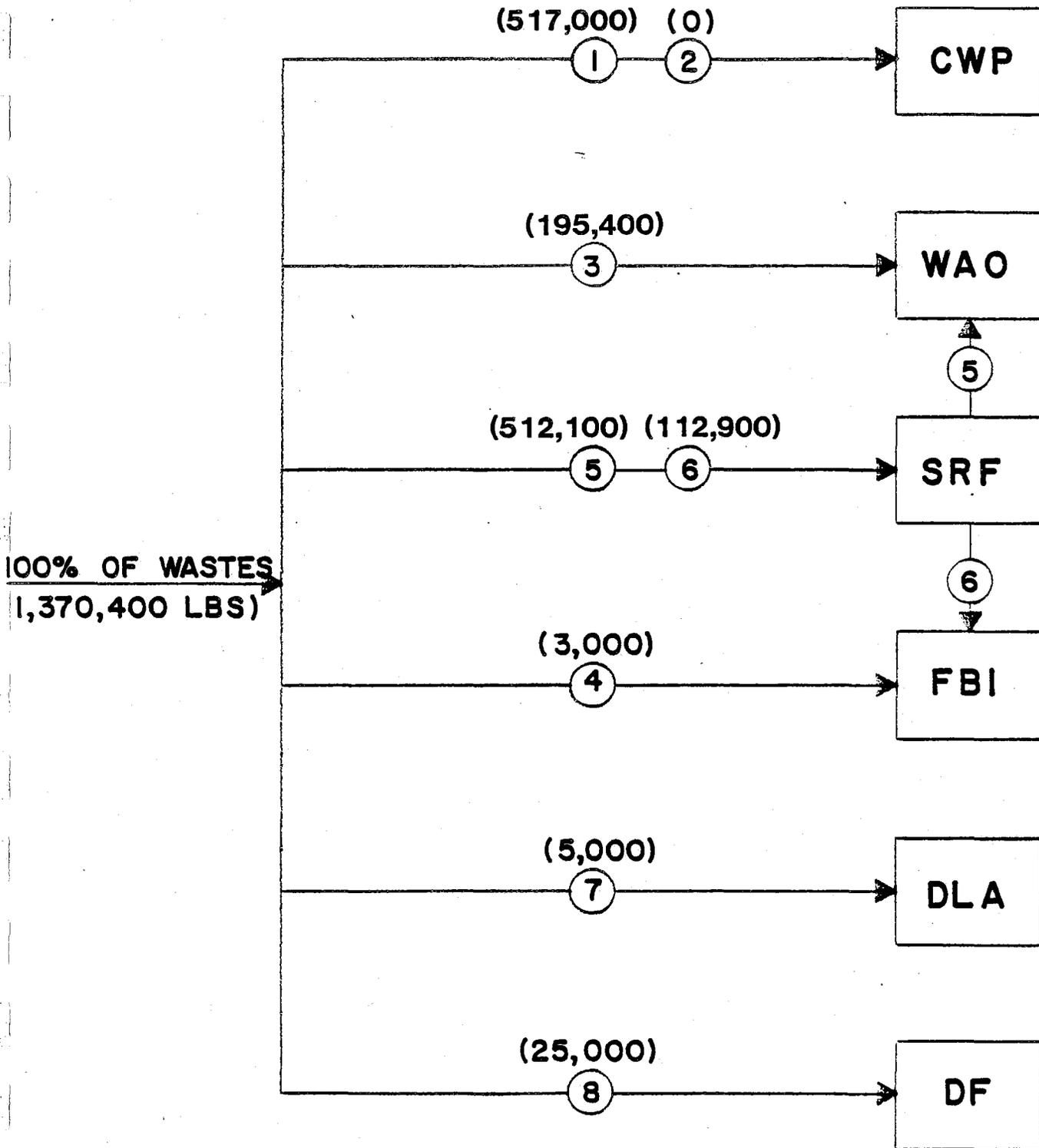
OPTION 2



CAPITAL COST - \$5,030,000

FIGURE X-2

OPTION 3



CAPITAL COST - \$6,659,000

FIGURE X-3

WASTE & WORKLOAD DEFINITIONS

CODE	DESCRIPTION	%	AMOUNT
1	CONTAMINATED WASTES W/O AP	37.7	517,000 (LBS.)
2	CONTAMINATED WASTES W/ AP	0	0
3	PROPELLANT & EXPLOSIVE WASTES W/O SR & W/O AP	14.3	195,400
4	PROPELLANT & EXPLOSIVE WASTES W/O SR & W/ AP	.2	3,000
5	PROPELLANT & EXPLOSIVE WASTES W/ SR & W/O AP	37.4	512,100
6	PROPELLANT & EXPLOSIVE WASTES W/ SR & W/ AP	8.2	112,900
7	LIQUID WASTES	.4	5,000
8	CONFIGURED ITEMS	1.8	25,000

TABLE X-1

B. Waste Stream Definition and Characteristics

The waste stream has been identified item by item in the following Table. They are broken down into 8 groupings or codes for disposal.

	<u>Material</u>	<u>Annual Prod. (Waste)</u>
1. Contaminated Wastes W/O AP	Gloves, rags, cotton wastebags, etc.	17,000 lbs.
	Equipment, Shipping Centers, Dunnage, drums, boxes, metals plastic parts.	500,000 lbs.
2. Contaminated Wastes W AP	Miscellaneous	Insignificant
3. Propellant & Explosive Wastes W/O SR & W/O AP	Nitrocellulose	1,000 lbs.
	Casting Powder	120,000 lbs.
	Shavings/Chips	2,000 lbs.
	Extrusion Flashings	300 lbs.
	PNC (Plastisol Nitrocellulose)	100 lbs.
	HMX & RDX	2,400 lbs.
	HBNQ	500 lbs.
	Powdered Al.(contaminated)	100 lbs.
	Slums	69,000 lbs.
	Nitroglycerin	
Metriol trinitrate		
Triethylene Glycol		
Dinitrate		
Otto Fuel		
4. Propellant & Explosive Wastes W/O SR & W/AP	Reject Composite Mix (uncured)	3,000 lbs.

	<u>Material</u>	<u>Annual Prod. (Waste)</u>
5. Propellant & Explosive Wastes W/SR & W/O AP	Talos Grain	20,000 lbs.
	Terrier Booster and Terrier Sustainer with inhibitor	272,200 lbs.
	ASROC Shell and ASROC Cruciform w/ethyl cellulose acetate inhibitor (uncased)	14,400 lbs.
	Zuni with Inhibitor	85,000 lbs.
	Sidewinder IA with Inhibitor	5,000 lbs.
	2.75 Motor (FY 85 Production)	54,000 lbs.
	Extrusion waxout Material	1,000 lbs.
	Rapac and MK51 with Inhibitor	3,000 lbs.
	Grain End Trim/Slabs	15,000 lbs.
	Carpet Rolls (excess or reject)	12,000 lbs.
	MK89 with inhibitor	15,500 lbs.
	LOVA/GAU Propellant (FY 85 Production)	15,000 lbs.
	6. Propellant & Explosive Wastes W/SR & W/AP	Zuni
CTBN		3,000 lbs.
Hogged-out Propellant		4,000 lbs.
Ammonium Perchlorate Scrap		9,700 lbs.
Standard Arm Sustainer and Booster Scrap (cured)		27,000 lbs.

	<u>Material</u>	<u>Annual Prod. (Waste)</u>
	Standard Arm Props Heels Uncured (could vary from cured hard to viscous liquid	43,000 lbs.
	Standard Arm Boosters (uncased)	14,400 lbs.
	2.2 Jato Scrap (CTBN) cured	1,000 lbs.
	2.2 Jato Scrap uncased	1,000 lbs.
	HTPB	100 lbs.
	2.2 Jato Heel uncured	8,400 lbs.
	BOMROC	300 lbs.
	RAP	
	SFU Igniter	
7. Liquid Wastes	Heptane Acetone Alcohols Hexane Agitine	5,000 lbs.
8. Configured Items	Pyrotechnics Squibs CAD PAD Igniters Caps Cartridges	25,000 lbs.

C. Pollution Control Requirements.

The pollution control requirements will be broken down into 3 categories: (1) Stack Emissions, (2) Ash Disposal and (3) Water Treatment.

Stack Emissions. In researching the Federal Stack Emission standards in Title 40 of the Code of Federal Regulations (40 CFR), it states in paragraphs 264.343 (b) and (c) that the maximum allowable hydrogen chloride (HCl) is four pounds per hour (or 99% removal efficiency, whichever is greater) and the particulate emissions shall not be more than 0.08 grains per dry standard cubic foot

dscf) when corrected for the amount of oxygen in the stack gas. The State of Maryland's standards were also researched and found that they do not have HCl requirements. However, COMAR 10.19.08.05A(3) currently allows up to 0.10 gr/dscf of particulates for incinerators. In order to comply with all applicable regulations, any new system will have to meet the 4 pounds per hour HCl standard and the 0.08 grains/scfd on particulates.

Ash Disposal. The waste ash generated in the processes must be disposed of in an environmentally approved manner. The major anticipated sources will be the residue from the furnaces themselves and from the cyclone and baghouse in the air pollution control system. At this time 3 options for the ash disposal should be examined.

Reclassify. If complete destruction can be guaranteed the waste ash may be certified and then can be disposed of in a common landfill. The ash from the contaminated waste processor may fit in this category.

Concrete Encapsulation. The ash could possibly be mixed with concrete to form a solid block. This block would contain the ash and prevent its dispersing. This block could then be disposed of in a landfill. It must be noted that this option is a possibility only. Its approval would depend on several factors and may not be feasible.

Hazardous Waste Landfill. The last option is to consider it still a hazardous waste and dispose of it in a hazardous waste landfill. This would essentially be a volume reduction process. This is the most direct approach. A cost estimate would have to be made to see if any of the other two options should be pursued.

Water Treatment. This area only addresses the water used for the wet scrubbers in the various options. The water is scheduled to go to the existing water treatment facilities. If it can not be cleaned adequately by chemical treatment or filtering, evaporation and then disposing of the salt residue is suggested.

D. Disposal/Destruction Options

Landfill. In the past, landfilling, surface impoundment, or underground injection have been acceptable methods for waste disposal. However, with the promulgation of the RCRA regulations, these methods have become very costly and difficult to use. In fact, legislation is currently in

process which could result in a total ban on using these methods for toxic waste disposal within the next four years unless there are absolutely no alternatives for the material in question. Landfill of reactive waste is already banned. Hence, this option is not viable at NOS.

Biodegradation. One method of providing waste detoxification is by biological action similar to that used in municipal sewage treatment plants or composting operations. The Army and Navy have tried several methods to speed up the rate of biological degradation on various types of explosives. However, there are formidable problems involved. The explosive materials tend to be refractory and toxic to micro-organisms and therefore do not support the biological action. Often times, the degradation proceeds only one or two molecular steps to a level where the products are both more refractory and more toxic than the original explosives were.

Open Burning/Detonation. Open burning is one of the oldest and most universal demilitarization techniques. It requires no elaborate equipment, negligible fuel and little labor costs. However, it is sometimes a very smoky operation, and it is no longer ecologically acceptable in some states. Open burning is presently allowed at NOS but it is anticipated that this won't be allowed in the future. High order detonation is also an old and universal disposal method. It is sometimes the only available method, especially when an item such as a large bomb or shell is so deteriorated that there is no safe way to disassemble it. Therefore, like open burning, detonation may be required to some degree. Depots with remote locations are all capable of providing high order detonation disposal. The method is low cost and requires no special equipment. However, as technology improves handling and disassembly capabilities, the need for open detonation is decreased. Also, as with open burning, it is anticipated that this will not be allowed in the future due to tougher environmental laws.

The major drawback to these options is the total lack of environmental and air pollution control.

Recycle/Recovery

General. Public Law No. 94-580, the Resource Conservation and Recovery Act, incorporates the Hazardous Waste regulations described in Title 40 of the Code of Federal Regulations. regulations were developed, in part, to foster recycling and recovery of materials as opposed to direct disposal. In conjunction with this philosophy, one must first be aware of the difference between recycling, recovery, and disposal, and second, how these definitions apply to individual "waste" streams and their ramifications on "waste" elimination.

To "recycle" waste means to process or otherwise treat the waste in such a way as to return it to its initial state, i.e., with the same characteristics the substance or material exhibited as a new product.

To "recover" means to reclaim, or "get again", a substance in a pure or usable form from refuse materials or from a waste product or by-product of manufacture.

To dispose, as quoted from 40 CFR 260.10, means "the discharge, deposit, injection, dumping, spilling, leaking or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters."

Many of the waste items of concern at NOS would be potential candidates for recycling or recovery operations, e.g., propellant and explosive scraps (recovery or recycling) and metal parts (recovery). Many of the waste materials do not lend themselves to recycling or recovery, such as contaminated production materials, shipping containers, drums, boxes, and plastic parts. This type of waste must be disposed of or destroyed. At the present time, incineration (with appropriate air pollution controls) is the most preferred method for destruction of these items.

The materials suitable for recycling or recovery and the methods used for such operations must be evaluated both economically and technologically. Since the economics of recycling or recovery processes is highly impacted by the technology applied, the technological evaluation must first be done.

The remainder of this discussion, therefore, will be concerned with the present technology in recycle/recovery processes related to the wastes at NOS.

Recovery/Recycling Processes For Explosives and Explosive Wastes

Washout Plant. Steam-out and wash-out facilities to recover both explosives and metal casings were in operation during World War II. Indications are that wash-out operations may have existed as far back as the 1920's. Other processes for recovery of explosives from outdated explosive munitions were developed in the 1960's as a side development of the Washout Plant used for removing explosive from bombs. This process resulted in pelletized explosives, which did not meet original specifications due to water contamination. However, the pelletized explosives were suitable for low grade industrial use (for mining operations, for example) and were sold at low prices for such use. Since this process resulted in a partial

utilization of waste material, it would be classified as a "recovery" process. Major disadvantages of the process included production of large quantities of contaminated water and high energy requirements for the process.

Microwave Meltout. During the period of 1978 to 1981, the use of microwave energy for melting explosives out of bombs and drying water contaminated explosives was investigated by the Ammunition Equipment Office, Tooele Army Depot, Tooele, Utah. The microwave meltout process was proposed as an alternative to the washout plant, with direct benefits including elimination of requirements for process water (and associated water treatment) and elimination of water contamination of the explosive, thus allowing the explosive to be directly recycled into new munitions. Due to the total elimination of water heating and treating requirements, the equivalent energy requirement per bomb was approximately 3% of the washout plant unit energy cost.

The microwave meltout process was tested for Minol II and Tritonal with good results, and with COMP B with less desirable results. The process has not been completely developed, however, and requires extensive work to become viable. In addition, the effect of microwave energy of different types of material varies greatly, and each individual propellant or explosive must be tested for acceptability and to determine procedures for energy application.

Microwave drying of explosives was also tried on several different types of explosives and tests showed good potentials. However, the application of this technology does not appear to be of use at NOS.

Explosive recovery by solvent extraction washout. Extensive research is currently being accomplished by the Navy and the Air Force, especially for PBX explosives, using explosive recovery by solvent extraction. Prominent solvent work on PBX explosives has been accomplished by Dr. Albert Tompa of the Naval Surface Weapons Center, attached to NOS. Dr. Tompa has authored many papers on this subject during the past ten years, and is probably the foremost expert currently working in the area. Naval Weapons Center has been investigating solvent extraction of the binders in AFX and PBX explosives for the past two years. That work consisted of using inert materials with the AFX and PBX binders. Those investigations have developed a basic understanding of the mechanism as to how solvents are taken into the matrix of the sample and quantitative methods for evaluating the physical strength of the simulants after exposure to the solvent. The efforts proposed in recent Air Force solicitations are follow-ons to the efforts sponsored by the Navy. Additionally, considerable work has been done, and is currently in progress at NOS, on degrading operations using a cavitating water jet. This work

is under the direction of Mr. Boyd Shaffer, and has processed over 1000 items to date, including Sparrow warheads, torpedo warheads, and rocket catapult motors.

Metal Parts Scrap Recovery. Both the Army and the Navy have been demilitarizing 11P account materials such as outdated or otherwise unserviceable small arms ammunition for some time. This work, primarily done with the Army's APE 1236 furnace and the Navy counterpart, results in recovery of brass for sale as scrap. Many of the existing facilities also recover lead for resale. More recent development includes the upgraded Explosive Waste Incinerator (EWI) which may be used for incineration of bulk powder with a Positive Feed System (PFS) (no scrap value). The EWI system includes air pollution control equipment which is 99% + efficient for particulate removal and with minor modifications, could control gaseous emissions also.

Another system which provides a high potential for metal parts recovery is the Contaminated Waste Processor (CWP) developed recently by the Army. This system may be used for bulk item flashing, allowing resale of the metal parts. The CWP may also be used for processing of contaminated waste by either batch loading or continuous feed (via shredder). Potential use includes waste oils, solvents, and other materials which normally present environmental problems when disposed of by other methods. In fact, the present design of the CWP would handle approximately 40% of all the wastes to be disposed of or processed at NOS.

Energy and Heat Recovery. The definition of "recovery" includes the reclamation of heating values from waste products. The BTU value of propellant and explosive waste is naturally quite high, and in some cases, may allow for self sustenance of the process which is being used to destroy the propellant or explosives. For example, tests performed at Tooele Army Depot, by the Ammunition Equipment Office, showed that once bulk explosive burning was initiated in the APE 1236 test furnace, the burner flame could be turned off entirely. Complete burner shutdown, of course, is not recommended, but fuel useage can certainly be reduced to a minimum.

The value of heat recovery from waste products, since the heat is difficult to store, is limited by the potential for immediate use; thus the primary value is in using the recovered heat for accomplishing portions of the process work or for supplemental building heat.

Energy recovery is a high possibility with explosive and propellant materials also. For example, many types of propellants and explosives may be mixed with fuel oil and used for process heating. Waste solvents may be used for supplemental fuel input. For example, Army tests have shown

potential for using a mixture of TNT and toluene as fuel for a turbine driven generator. This technology may be especially viable if developments in solvent extraction are successful, where the contaminated solvent may be used for fuel.

Recent developments in private industry in the area of specialized burners using pulverized coal for fuel may be potential for burning raw explosive or propellants; however, extensive research would have to be done in order to apply this technology at NOS.

Recycle/Recovery Problem Areas and Technical Uncertainties.

The Hazardous Waste Regulations are relatively new. As previously discussed, the philosophy of these regulations was to foster recycling or recovery operations as opposed to disposal. This was done by making it more difficult to "dispose" of wastes. However, prior to promulgation of these regulations, it was much easier to dispose of wastes. As a result, on an economical basis, recycle/recovery technology development was not begun until the HW regulations went into effect, and is still in the "infancy" stage except for the simpler "metal" recovery operations.

Most of the development in the area of explosive/ propellant recycle/recovery has been with explosives. Although most of the processes discussed would appear to be applicable (in fact, easier) with propellants, this needs to be verified by research.

Another problem exists in the area of explosive/propellant recycling. Because of the limited test work done in this area, users are not comfortable with the quality of the recycled materials for use in production of new items. Many are reluctant to chance the possibility of their products failing due to substandard explosive or propellant fill, regardless of test data showing that the recycled material to be as good or better than new material.

Summary. The primary potentials for recycling or recovery operations at NOS are in the areas of metal parts salvage and heat recovery. The former, however, appears to be limited by the quantities of metal wastes listed.

Other applicable recycle/recovery technologies do not appear to be developed to a useable level at this point in time. In addition, the reluctance of manufacturers to utilize recycled explosive or propellants reduces the sale potential of the material. Although many of these processes have future potential, they would not be recommended at this time for use at NOS.

Heat recovery and metal parts recovery would be the highest potential if an EWI and/or a CWP were installed. An added

benefit to these systems is that, if both were installed, the majority of the NOS wastes could be processed by these two systems alone.

Thermal Processing. Thermal processing includes the use of several process types and several equipment configurations. The acceptable thermal processes must include control of emissions to the environment. Several of these processes are discussed briefly below.

Wet Air Oxidation Systems. A wet air oxidation system (WAO) is presently installed and nearly operational at NOS. Wet air oxidation is an adaptation of a commercial process for the "under-water combustion" of concentrated aqueous organic wastes. In a WAO process, waste is injected into a water filled pressure vessel reactor at 150 to 2000 psi and about 200°C along with sufficient high pressure air to effect the oxidation of waste. The oxidation rate in the reactor is enough to sustain the temperature in the vessel. The oxidation products, consisting of gaseous and liquid materials, nitrogen from the compressed air and a minor quantity of ash, are cooled by the feed stream (and the feed stream is preheated) in a heat exchanger. The gaseous products are treated by an afterburner to destroy CO and residue hydrocarbons. A wet scrubber is used to remove NO_x. The liquid products are further processed to remove acidity and metallic salts and the purified water recycled to the slurry-preparator stage. WAO operations have been proven for many organic wastes, such as sewage sludge; however, applications on explosives are not proven, although units have been tested at low rates (70 to 200 lbs/hr of propellant) by both Zimpro and Barber-Coleman with some success. A detailed description of the WAO system is included elsewhere.

Fluid Bed Incinerators. The fluid bed principle was first devoted for catalytic cracking in the oil industry in 1942. Since that time interest in this unique principle has resulted in the development of the technique for a wide variety of industrial applications.

A fluid bed incinerator (FBI) utilizes granular materials, sometimes with catalysts added, to maximize the oxidation of materials passed through the bed. A fluidized bed system is currently planned for NOS but is not fully installed.

An FBI consists of a large, refractory lined vessel with an air distribution member or plate in the bottom, a hot gas outlet in or near the top and some provisions for introducing fuel. The actual fluidized bed is formed by blowing air up through a layer of inert particles at rate that causes the particles to go into suspension and continuous motion - analogous to a boiling liquid but with solid particles; therefore, the term "fluid bed". It should be noted that the media used in the

burner remains as a granular solid. The material to be used as a fuel is introduced into the preheated bed, either from the top or by pneumatic injection into the fluidized bed. Material may also be fed into the bed as a slurry.

The primary function of the air-fluidized inert bed materials are to promote dispersion of incoming solid-fuel particles, heat them rapidly to ignition temperature, prevent surface ash buildup, and promote sufficient residence time for their complete combustion within the combustor. Secondary functions include the uniform heating of air and the generation of favorable conditions for residue removal.

Some advantages of FBI systems are as follows:

1. The rate of pyrolysis of the solid material is increased by direct contact with the hot inert bed material.
2. The charred surface of the burning solid material is continuously abraded by the bed material, enhancing the rate of new char formation and the rate of char oxidation.
3. Gases in the bed are continuously mixed by the bed material, thus improving the flow of gases to and from the burning solid surface and enhancing the completeness and rate of gas-phase combustion reactions.

One of the main selling features for the FBI is that NO_x emissions are low due to the use of an NO_x decomposition catalyst (nickel oxide) and stage combustion. The bed is fluidized with less than the stoichiometric amount of air so that the burns are in under-oxidized conditions and yield a fuel-rich combustion gas with a high amount of NO_x . Under such reducing conditions and in the presence of the catalyst, NO_x is reduced to elemental nitrogen. Additional air is injected high up in the bed, above the NO_x reduction zone, where the remaining fuel value of the effluent or gases is burned at a temperature low enough that little new NO_x is found.

The FBI system, when used with explosives, also has a number of disadvantages. One major problem is in the generation of "bed lockup," or immobilization of the bed materials due to formation and conglomeration of salts or other materials. A detailed description of fluidized bed incinerators is included elsewhere.

Contaminated Wastes Processor. The contaminated waste processor (CWP) is a car bottom type furnace that is used to incinerate or flash a variety of contaminated wastes. These wastes, which are contaminated with either explosive or toxic residues consist of items such as rags, gloves, pallets, storage containers, piping, machinery, etc. Large items are loaded directly onto the car bottom and inserted into the furnace. Other materials are fed into a shredder and then into the furnace through an overhead feed hopper.

The CWP can be operated in either batch or continuous mode. In batch mode, waste materials are placed in baskets, which are then placed on the car bottom for loading. An overhead trolley system rotates the baskets into cooling and loading positions. Continuous operation is provided by using the shredder and overhead hopper discussed above.

The air pollution control system on the CWP consists of a gas to gas heat exchanger, cyclone fabric baghouse and controllable exhaust fan for maintaining a negative pressure in the system.

Explosive Waste Incinerator (EWI). The EWI is an APE 1236 Rotary Kiln deactivation furnace (DF) with a modified air pollution control and a modified feed system. The furnace is a steel rotary kiln approximately 30 feet long and four feet in diameter. The main body is composed of four 60" sections bolted end to end. The two inner section are 3-1/4 inches thick and the outer sections are 2-1/4 inches thick. The sections are cast with integral spiral flights that act like a screw conveyor in moving materials through the unit as the kiln rotates. An oil or gas fired burner in the discharge end of the tube provides a flame and hot flue gases which seep through the tube and eventually through the APCS equipment. The temperature near the burner is about 1200 F, about 600-900 F in the middle section and about 400-500 F in the stack prior to the afterburner.

As the items being processed are carried through the tube by the spiral flight, the explosives they contain deflagrate or detonate as they reach their initiation temperatures. After the items have been incinerated the ashes and residue are discharged onto another conveyor which carries the now inert metal parts to a scrap collection bin.

The quantity of detonation explosive allowed to be fed was normally limited to 600 grains per item. However, the furnace is capable of burning 5 pound chunks of TNT and has burned up to 10 pound chunks of rocket propellant in bags.

The fuel consumption of the APE 1236 is estimated to be around 9 to 21 gallons per hour, depending upon the work rate. Attached to the 1236 Deact furnace is an afterburner, cyclone gas cooler and baghouse which cleans all the effluent and

composes the complete EWI system. Several of these systems are installed and working at the present time. Also, the APE 1236 rotary kiln, which is the basis of the EWI, has been in operation (without the Positive Feed System or Afterburner included in the EWI) for many years at over 20 locations. A detailed description of the EWI System is included in the Appendix.

Miscellaneous Thermal Processes. The following thermal processes are included for informational and background purposes.

Closed Pit Incinerator. The closed pit incinerator is essentially open burning within a closed room. Several hundred pounds of waste bulk PEP are stacked on the floor inside a modified explosives storage igloo and ignited. An air blower provides more than enough air for the stoichiometric combustion and the combustion gases and excess air exit through the modified roof of the igloo. The modified roof vent is a sand bed supported on a truss and screen.

The disadvantages involved are the cleanup of the ash residue required and the sand filter will have to be changed.

Batch Box Incinerator. A batch box incinerator is basically an oil-fired trash incinerator with overfire air. It has been adapted for handling small PEP contaminated dunnage. The dunnage is charged batch wise through side doors and small PEP items are fed into the flame via a steep entry chute. Exhaust effluent travels through an afterburner and a marble bed wet scrubber prior to venting to the atmosphere.

Air Curtain Incinerators. An air curtain incinerator is an open pit incinerator. A "curtain" of air is blown over the top of the pit and down into the far side of it from an air blower on the ground above. The excess air is used to complete combustion of the carbon in the smoke and to reduce emissions.

Preprocessing Requirements.

General. All of the viable thermal processes discussed above require pre-process preparation of some of the waste materials. The two major categories of pre-process preparation of waste items are size reduction and slurry preparation, with slurry preparation basically being an extension of size reduction operations.

The EWI and CWP require limited size reduction only. The CWP facility incorporates a shredder which performs the necessary size reduction as part of the system. Size reduction requirements for these systems are necessary only to allow materials to enter the system, or, in the case of the EWI

applications, to limit the destructive potential heat release/volume, and emissions generated by the explosive or propellant items.

The WAO and FBI systems both require slurry preparation, which significantly increases the preparatory work and also limits their capabilities in providing destruction of many types of wastes.

Size Reduction

General. The waste stream feeding the disposal facility is composed of many materials of various shapes and sizes, as shown in Table X-3 of this study. This materials list, including annual quantities generated, was received recently from the NOS, with a latest revision date of 8-23-83; consequently it should represent the most current data available.

The maximum size to which material must be reduced by the SRF is dependent upon which disposal option is selected. If an option is selected which requires slurry preparation, the existing PDF slurry preparation system will be used. This system can receive material with a maximum dimension of 13"; consequently all incoming material exceeding this size must first be processed through the SRF, and reduced to this size. Based upon the waste generation table, this amounts to about 534,000 lb. of propellant materials, annually, which must be size reduced.

If a disposal option is selected which utilizes an EWI, the EWI feed materials must be reduced in physical size not to exceed 5" x 5" x 10". Again, from the waste generation table, this amounts to about 624,000 lb. of propellant materials, annually, which must be size reduced.

Based upon the above, it is obvious that the EWI requires smaller size feed materials than is required to feed the slurry production process. In option 1, no slurry production is required, and all large materials must be reduced to the 5" x 5" x 10" size. In options 2 and 3, utilizing both the EWI and the slurry-feed systems, part of the feed material must be size-reduced to the 13" dimension and part must be reduced to 5" x 5" x 10". In options 2 and 3, it is impossible to predict with any accuracy, the expected split of material flow through the various systems. We believe, however, that for options 2 and 3, there could be periods of processing time wherein all disposal materials are handled by the EWI. Further, with these options, it is unlikely that periods of processing time will occur in which all materials are handled in slurry form.

Based on the above rationale, we believe that SRF should be designed with an identical throughput, regardless of the option

with which it is to be used, and further, that it should be designed to meet the EWI size requirement of 5" x 5" x 10", which is the worst case, i.e., smallest size.

Consistent with the above discussion, the SRF details which follow are based upon the following assumptions:

1. The SRF proposed is applicable to all options.
2. All material processed will be reduced to 5" x 5" x 10" dimensions.
3. The total annual quantity of materials to be size reduced is approximately 624,000 lb.

It should be explicitly understood that the size reduction facility described in the following section is a very preliminary concept which utilizes what we believe to be feasible approaches, and is provided as required by the definition of this task, namely, modifications to achieve 100% disposal.

Other approaches doubtlessly exist which may or may not be superior to those proposed, but it is beyond the scope of this analysis to perform any detailed comparisons. Due to the relatively large scope of a SRF project, we believe that design should be preceded by a thorough study phase which will define the type of equipment to be used, and the costs. This study phase should include bench testing and piloting work.

Size Reduction

Chunk Materials. The materials requiring size reduction are further tabulated earlier in this section under "Waste Stream Definition," as items 5, 6, 7, and 8. This listing contains some 22 line items which are denoted "W/SR".

These 22 line items can be divided into two categories, namely those items in chunk form and those items which are grains. The chunk materials comprise some 9 items and annual production is about 126,000 pounds.

Since these items are irregular in shape and non-uniform in size, making them difficult to grip, we propose to size reduce these items in a knife grinder. This type of grinder has been successfully used in a number of propellant size reduction applications at NOS, Radford AAP, and at the Western Demil Facility, Hawthorne, Nevada.

The grinder proposed will have a capacity of about 1,000 lb./hr. and will receive the chunk materials from a storage hopper in sizes for which the maximum dimension would be around

30", although most of the feed will be in much smaller chunks. The grinder will reduce the feed material to approximately 5" cubes.

This will be a wet operation, with just enough water supplied by spray, to prevent initiation of the energetic material. A tank beneath the grinder will be used to capture the spray water and recirculate it. The water will be monitored for dissolved propellant constituents, and periodically will be discharged to the water treatment facility, and fresh spray water added. The water treatment facility will be either the existing facility (modified to treat this material) or a new smaller facility dedicated to handle this material.

The sized materials will be collected from beneath the grinder on an appropriate inclined conveyor, such as a chain mesh belt, and discharged into convenient-size storage/handling receptacle. The receptacle will be used to transfer the prepared materials to either storage or to the next process step (EWI or slurry preparation). An option available at this step is to consider transfer by conveyor rather than by receptacle.

A practical production rate for this operation will be about 6,000 lb. per shift. If this material is considered Class I, Division I material with a QD weight limitation of about 4,000 lb., and the 6,000 lb. would be run in two batches of 3,000 lb. each which is practical for a one shift operation. Based on the quantity of this type of material generated, the processing time required annually would be about 21 days.

Small Grains. Of the propellant wastes in grain form, 7 of these are 5" in diameter or less. We propose to size reduce these items by use of a wire cutter type, automatically-fed machine. Annual waste production in this category is about 163,000 lb.

The machine proposed will sever the grain normal to its axis by drawing a wire through it. This concept has been successfully used in other propellant cutting applications on large grains; however, considerable investigation and testing will be required to prove its applicability to the specific materials to be processed.

We proposed a machine with a manually-loaded magazine with a capacity of about 1,500 lb. Using two identical machines, and two runs per shift, production will be 6,000 lb per day. Size reduced materials will be collected in receptacles similar to those proposed for the chunk materials above, and will be delivered to the subsequent operation. Based upon the 163,000 lbs. in this category, annual production time will be about 28 days, using two machines.

Medium Grains. We propose to place grains in the 10" to 12" diameter range in this category and propose to size-reduce these items by using a wire-cutter type machine, similar to that described for the small grains. We believe that a machine dedicated to this size of grain is indicated, and so propose. This machine will use a manually filled magazine feed, and the severing operation will be automatic. The grains will be cut normal to their axis into 5" long sections. These sections will be conveyed to the grinder described for the chunk materials, above, for further size reduction down to the required 5" cube size.

This category contains 3 line items totalling about 30,000 lb. Based upon an estimated cutting production rate of 6,000 lb/shift using 1 machine, annual time required to size reduce this material (including both cutting and grinding) will be about 10 days.

Large Grains. Grains in this category are 14" to 18" in diameter, and we propose to sever these by use of a machine similar to that described above for the medium and small grains, but sized for the longer items.

Items will be cut into 5" long sections and conveyed to the grinder for further size reduction down to the required 5" cube dimensions.

The cutting machine will be automatic, magazine-fed equipment. The magazine will be manually loaded prior to each un-manned operational run.

Based upon the 284,000 lb. of propellant in this category (2 line items) two identical machines will be required to achieve a daily production rate of 4,000 lb. assuming a single shift operation. We believe that 4,000 lb. is a practical daily workload since these grains are fairly large and more difficult to handle than most of the other grains.

Time required for size reduction (using two machines) for this waste category will be about 71 days, not including the grinding operation. The grinding operation, using a daily production rate of 6,000 lb/day, will require an additional 47 days, yielding at total production time requirement for this category of 118 days, annually.

Talos Grains. These are the largest diameter grains to be size reduced, and annual production is 20,000 lb.

We propose to sever this item using a single wire-cutter machine of the type previously described for the other grains. The item will be severed normal to its axis into 5" long sections, and these pieces will be conveyed to the grinder for further size reduction to the required dimension. Only 1 item

will be sectioned per set-up, with a daily production rate of 2 items. Based upon the total quantity of 20,000 lb in this category, production time will be about 3 days, annually, exclusive of grinding time. Grinding time will add an additional 3 days, based on the grinder production rate of 6,000 lb. per day, yielding a total annual processing time of 6 days, for the Talos wastes.

Summary

A size-reduction facility is proposed which used either (a) a grinder, (b) wire-cutter machines, or (c) a combination of (a) and (b), to section the total annual production of 624,000 lb. to the 5" cube size. This facility features un-manned remotely operated equipment (during hazardous operation such as cutting and grinding) which will provide good personnel safety. Maximum use is made of wire-cutter type equipment for sectioning propellant grains, which significantly reduces the generation of propellant chips/fines.

The following tabulation summarizes processing of the various wastes at the SRF:

<u>Category</u>	<u>Wt.-Lb. Annual</u>	<u>Process Description</u>	<u>Days Required Annually</u>
Chunk Material	126,000	Grinder	21
Small Grains (< 5" diam.)	163,600	Wire Cutter (2)	28
Medium Grains (10"-12" diam.)	29,000	Wire Cutter (1) Plus Grinder	10
Large Grains (14"-18" diam.)	284,200	Wire Cutter (2) Plus Grinder	118
Talos	20,000	Wire Cutter (1) Plus Grinder	6
TOTALS			183/yr.

The above tabulation shows that the proposed SRF facility can easily accomplish the required annual workload using single shift operation with a cushion of about 80 workdays per year, that can be used for maintenance and other downtime.

It should be pointed out that although the SRF is designed to be a part of the on-station disposal plan, it can be used with equal effectiveness to size-reduce items for packaging and off-site disposal. Off-site disposal details are discussed in a subsequent section of this study.

Slurry Preparation

The existing slurry system, with modifications recommended elsewhere in this evaluation, will be used for slurry preparation.

E. Comparison of Thermal Destruction vs. Other Candidates

Thermal destruction has been used reliably for the destruction of hazardous explosive wastes. As technology for incineration of these material improve, a ban on open burning of explosive wastes looks more likely. Thermal treatment, in many cases, can accomplish safe destruction of hazardous explosive propellant wastes, permanently reducing large volumes of waste materials to non-toxic gaseous emissions and small amounts of ash and other residues, such as scrap metal. Incineration can provide a permanent solution to hazardous wastes with minimal long-term ecological burden.

The CFR 40 regulations specifically ban landfill of explosive wastes. The most viable candidate option other than thermal destruction is therefore to recycle and recover the wastes. Unfortunately, the present methods for recycling and recovery are not entirely proven and developed.

In conclusion, thermal destruction is the preferred method for disposal of PEP wastes.

Comparison of Thermal Processes.

General. In addressing the task of formulating plans for disposal of 100% of the NOS PEP wastes, we have compiled a listing of candidate processes as discussed earlier in this section. The various processes have been defined and their operational characteristics described in some detail. The purpose of this part is to compare the thermal processes listed to each other and to highlight their advantages and disadvantages. The processes compared herein are:

- (1) WAO
- (2) FBI
- (3) EWI
- (4) CWP

Table X-2 is a tabulated summary comparing the four candidates. Open burning, although technically a thermal process is not discussed in this section but is covered elsewhere in this evaluation.

Wet Air Oxidation. The existing NOS WAO system was evaluated under Section VI of this report and modifications were proposed. The summary of these tasks showed that the system is currently marginally operational, with fairly extensive modifications recommended prior to putting it on line using live PEP materials.

The fact that this system is mostly installed and is fairly close to being operational, is probably the most important advantage of the NOS WAO facility, when compared to the other three candidates, since there is not an EWI or CWP presently on station and since the FBI would require considerable additional work to become operational. As shown in Section VI, we believe the current status of the FBI is such that we are recommending against completion of the system, as least for the present.

Consequently, a consideration of all candidates shows the WAO it be the most nearly operable system. This analysis applies only to the Zimpro-supplied portion of the WAO system. The use of the system, however, is dependent upon proper support from several other portions of the PDF which are currently fraught with design problems. Prominent among these are the slurry preparation process and water treatment facility. These support systems are evaluated elsewhere within this study and their current status and impact must be considered when making the overall appraisal of each thermal process candidate. Present best judgment is that the water treatment facility will probably be made operational but the slurry preparation system is questionable for a reasonable cost. We believe that the highly questionable status of the slurry preparation system (upon which the WAO depends) strongly tempers any advantage that the WAO proces may enjoy due to its "nearly operational" condition.

The WAO can rate only average in regard to whether or not the process is proven technology for PEP disposal. To date, only pilot test work has been done with live materials, and although these have shown good feasibility, no production work has ever been accomplished.

In a related area, we believe that development of the full-scale WAO system at the NOS is very desirable from from the viewpoint that it will serve to advance the state-of-the-art in PEP disposal. It will provide important information on a new technology, and since this was one of the original objectives of the project at its inception in the early 70's, this is judged to be a good reason for favoring completion of the NOS WAO unit.

The WAO process is judged to be comparable to the other thermal processes in regard to air/water pollution aspects. All candidate systems will meet Federal, State and local standards.

Based on information available to us regarding types and quantities of PEP wastes generated on station, the WAO will be able to handle roughly 2% of the total wastes, without an additional size reduction facility (SRF), and 25% of this workload with the additional SRF. Performance of each of the other three thermal processes will exceed the WAO percentages with and without an SRF, as described later. This indicates that the other processes are all more well suited to the specific NOS wastes than the WAO unit.

A comparison of the four thermal disposal systems based on cost per pound of waste processed would be a valuable evaluation tool; however, accurate data is difficult to obtain, due to either a lack of information or the existence of conflicting information. Also, cost data based on actual production operations on PEP materials is non-existent for the WAO and FBI processes since they have never been run on a production basis.

The only theoretical cost comparison for a PEP WAO system found by us, is contained in the NOS Report #IHMR72-185 dated 15 June, 1972, entitled "Propellant Disposal Facility Phase I Summary Report," and which compiles system costs which include all capital equipment and operating expenditures. This document estimates WAO processing costs at about \$41/ton compared to incineration costs of about \$22/ton.

Based upon this published cost data, it can be concluded that the WAO system does not compare favorably with the other thermal systems, using an expenditure per unit of throughput as a baseline. Similar comparisons of the other thermal processes are detailed in later paragraphs of this section.

The NOS WAO system is not a versatile process for PEP disposal. There are other uses for the WAO process such as film destruction and sludge processing. These are discussed under Section XIII of this evaluation; however, the versatility rating discussed herein applied only to PEP wastes. It is intended for use in processing single and double base propellants, almost exclusively, and cannot be used for most composite propellants or propellants containing fluorocarbon materials, due to excessive corrosion rates. A few of the composite

propellants can be run in the WAO system by special operating procedures but even these do cause accelerated corrosion rates.

In regard to maintenance considerations, we judge the WAO system to rate considerably better than the FBI, slightly better than the CWP, and about equal to the EWI.

The operation of the WAO will require highly skilled chemical plant personnel for both operation and maintenance, and should be about equal to the FBI in this regard. The other thermal systems considered do not require highly qualified (or specialized) personnel, but rather can be run by munitions handlers supplemented with other labor type workers. The WAO process will require close attention to process controllers and monitoring, and malfunctions/process upsets can develop into hazardous and costly problems, these being among the major reasons for the need of high level operator skills. Both the FBI and WAO systems are relatively unforgiving of mistakes, whereas the EWI and CWP systems can hardly be made to malfunction in a manner that is costly or hazardous, as proved by much operating experience.

The energy efficiency of the WAO process is judged to be considerably better than the fluidized bed and slightly better than the EWI. No energy efficiency comparison was made for the CWP. The above conclusions are based in part upon a report published by the Ammunition Equipment Office Tooele Army Depot, Utah, dated 24 May 1978 and entitled "Comparison of Fluidized Bed Incinerators and APE 1236 Deactivation Furnace for Disposal of Explosive Munitions and Explosive Wastes." This document shows energy consumption for an FBI to be in the range of 3¢ to 5¢ per pound of processed material and to be about 1-1/2¢ per pound for the EWI. The WAO process is self-sustaining, from a fuel standpoint, after it has been brought up to temperature by use of steam heat, and consequently uses no fuel except for the afterburner. The remainder of the energy required to operate the system is electrical power, estimated at around 225 KWH, which equates to slightly under 1-1/2¢ per pound of processed material, using the same power costs as used in the Army paper.

Advocates of the WAO process feel that it has definite safety advantages over other disposal systems. One such argument advanced is that disposal is accomplished at much lower temperatures than that required for other conventional thermal processes.

WAO processing temperatures for PEP materials is expected to be approximately 650°F maximum, which is considerably lower than that reached in conventional thermal processes

which typically operate around 1200°F with peaks in the 1800°F range. Although the lower WAO operating temperatures do represent some safety advantages, it is attained at the sacrifice of safe operating pressures. The WAO pressures are in the 800 psig to 2400 psig range as compared to nearly atmospheric pressure for the other processes. In our judgment, from a safety viewpoint, the pressure/ temperature considerations of the processes result in tradeoffs which nearly balance their evaluation, and in fact we favor the lower pressure processes used in conventional thermal demil.

Advocates of the WAO also claim better safety because the feed stream is in slurry form and the slurry is prepared such that it is considered non-detonable. This is presented as an advantage over other thermal processes in which PEP solids are fed directly to the processor/incinerator.

The overall safety benefit claimed due to the use of a slurry feed stream is also questionable in our judgment. It is not in question that a properly prepared slurry is safer than solid PEP materials; however, it is difficult to ensure maintenance of that safety throughout a piping/pumping system where plating may be caused by constrictions and/or low velocity cross sections. Slurry systems have been known to accumulate solids at localized points to the extent that these areas become potential bombs awaiting accidental initiation. There have been a number of incidents of this type in slurry systems. One such instance occurred in a WAO pilot test by the Barber-Coleman Company and caused over \$10,000 damage to pumps and equipment. Perhaps the major safety problem with the slurry systems is that they are closed and inspection is difficult. Solids accumulation can occur over a long period of time and no one is aware of the growing hazard.

Another problem associated with PEP slurry handling systems is that of maintaining the flowing slurry at the proper liquid-to-solids ratio. This problem is related to the previously noted hazards of solids accumulation. Documented tests have proved PEP slurries to be non-detonable and non-propagating when properly prepared and maintained. However, in extensive slurry systems it is difficult to assure that all the slurry is properly maintained. It is common practice to monitor slurry condition using density meters installed at various points in the system, and these do work satisfactorily; however, the probability is high that some areas escapes detection and at times, contain improperly proportioned materials.

The overall visibility of the WAO process is low during operations, since it is a remotely run system, and since remote monitoring is considered minimal, as described in Section VI of this evaluation.

Operator contact with the operation is better in the EWI and CWP thermal processes. For this reason, and those reasons discussed above, relating to PEP slurry, we view overall safety of the WAO process to be about equal to the FBI systems, and to be inferior when compared to the EWI and CWP.

Fluidized Bed Incinerator. The existing NOS FBI system was briefly evaluated under Section VI of this report. Our analysis was curtailed by our initial findings which showed that there is low confidence that the system can be made operational, based on the state-of-the-art of similar systems. These findings are reported elsewhere in this evaluation, with the recommendation that the system not be completed until technology catches up, which could be far into the future. In view of the above, the comparison of the FBI to other thermal systems has been abbreviated as reported herein. We have included an FBI rating for comparison purposes for the various categories as tabulated in Figure 1, but the written rationale for the ratings has not been made since the findings are rendered moot by the recommendation against using the FBI in any 100% disposal plan.

Explosive Waste Incinerator. The EWI system is described in detail earlier in this section and in the Appendix, and is highly recommended in the proposed options for 100% disposal of NOS wastes. The various areas of comparison with the other thermal processes are detailed herein.

The EWI is a standard system used by the Army and is part of the Ammunition Peculiar Equipment (APE) inventory. As such, it is currently available in regard to design, and the time required to field an operational system is that time required for purchase, installation, startup and shakedown.

An EWI installation consists of two major parts: the brick and mortar portion, and the equipment. An EWI fielded through the Corps of Engineers (usual Army practice) would require 1-1/2 to 2 year to become operational. If handled by the private sector using Army drawings and specifications, and EWI could be completed in an estimated time of 8 to 10 months.

The EWI is essentially a self-contained system with minimal external dependency. As it would be used at the NOS, the EWI would depend upon support from the Size

Reduction Facility (SRF) to produce PEP materials in physical sizes that are compatible to the furnace retort and feed system. The EWI would require externally supplied utilities, as would all of the other proposed thermal systems.

A slurry preparation system would not be required for the EWI. This is considered to be a major advantage for the EWI over the WAO and FBI. Another advantage enjoyed by the EWI when compared to the WAO and FBI is that the estimated water treatment capacity requirement is less.

The EWI uses currently available technology and in fact, some 3 or 4 systems are presently installed and operational. Although some portions of the EWI use recently developed technology, the overall process is judged not to demonstrate a new PEP disposal process.

In regard to pollution control, the EWI will meet all applicable regulatory standards and therefore is judged to be at least equal to the other three candidate thermal processes under consideration. This system fits the NOS disposal requirements very well. The EWI has a demonstrated track record of destruction of these types of PEP wastes, and would be able to handle all wastes which could be handled by the WAO and FBI, plus the explosives and end items, such as squibs, caps, CADS, PADS, etc.

The brick and mortar portion of an EWI installation currently costs about \$550,000. The equipment (installed) would cost an additional \$500,000.

Comparison costs for the EWI versus FBI systems were taken from a widely published Army document written by the Ammunition Equipment Office, Tooele, Army Depot, entitled "Comparison of Fluidized Bed Incinerators and APE 1236 Deactivation Furnace for Disposal of Explosive Munitions and Explosive Wastes," dated 24 May, 1978. This reference shows EWI disposal costs to be \$.28/lb. compared to \$1.40/lb. for a full-size FBI (such as the NOS unit). Cost data for a Picatinny Arsenal "low-cost fluidized bed incinerator" is also reported in this paper at \$.23/lb. This low cost unit has an initial installed cost of about \$600,000 which is considerably lower than the NOS unit. Also, to our knowledge, no such "low-cost" unit has ever gone into operation. Consequently, for cost comparison purposes we judge that the proper analysis will be based on the \$.28/lb. versus \$1.40/lb. costs, which shows the EWI to be slightly the more attractive of the two systems (considering equipment in place, noted on the following page).

Since most the NOS FBI is on hand and much of it is installed, the cost figures used in Figure 1 have been adjusted to consider this factor, and also to include remaining work required to field an operational FBI system. Cost rating factors in parenthesis in Table X-2 are included for reference to compare the several processes using a common baseline that assumes no expenditures as having already been made.

No cost is currently available for comparing the FBI to the CWP. Such a comparison would have minimal importance, since the processes handle a totally different product and their capabilities have very little overlap.

The EWI is a very versatile process as has been proven by many years of operation. Hundreds of different end item munitions and PEP materials have been processed through this equipment. Prior to the requirements for air pollution control, the system was known as the APE 1236 deactivation furnace and there was some thirty of these installations around the world. The 1236 furnace became the EWI when pollution controls and modified feed systems were added. The EWI can handle cased items ranging from small-arms up to large boosted artillery fuzes, as well as explosives and propellants in bulk form. It has a reasonable capacity relative to physical size, having handled cubes of up to around 6" and cylindrical items (under 5" diameter) of up to around 16" in length.

Although the EWI has not been used to process all specific NOS wastes proposed for it, past history indicates that there is good confidence that it can be used for most, if not all of these wastes. We recommend that a pre-design test program be conducted at an existing EWI using NOS materials to determine applicability.

The EWI retort can handle detonations of explosive quantities of under 0.1 lb. with ease and can tolerate occasional detonations of up to about 1/4 lb. of HE, without damage.

From a maintenance standpoint, the EWI rates as the best of the four thermal systems considered. The design is simple and rugged and uses very low complexity commercial components. Improvements and refinement of the hardware over the years has resulted in a low maintenance system considering both repairs and normal periodic maintenance.

The EWI can be operated by a 3 or 4 man crew, depending upon the rate of feed required and the item unpackaging task, if any, at the feed station. The system does not require highly skilled operators. A normal crew consists of two ammo handlers and two laborers. The EWI is very

tolerant of operator error and does not require any frequent adjustments nor does it require close attention to operating parameters, since normal operating ranges of feeds, speeds, temperature and pressures are large. The important operational parameters are controlled automatically in the EWI which minimizes operator dependence.

In regard to efficiency, the EWI rates considerably better than the FBI, and not quite as good as the WAO. Details of how this comparison was made were discussed previously.

The EWI rates about the same as the CWP in regard to safety, and considerably better than both the WAO and FBI, in our judgment. The safety of the EWI has been demonstrated by many years of operation representing thousands of tons of demilled material. This material has been in many different forms and has been run at a wide variety of locations by both government and private sector crews within CONUS and abroad. In our judgment, this past safety history is an important factor when rating the thermal processes, and particularly when comparing the EWI to the unproven (WAO and FBI) PEP disposal processes.

The EWI is very forgiving of operator error and does not require high skill level personnel, as described earlier. This is a definite safety advantage. The explosive limits and feed rates for the EWI have been set up to ensure operator safety, and to our knowledge no serious operator injuries have ever occurred using an EWI operated in accordance with the proper SOP.

Extensive testing has proven that detonating materials within the furnace barrel do not propagate between retort flights (the screw which moves material through the retort). Other live tests have shown that the retort provides operator safety for high order detonations of over 7 lbs. of H.E. (explosions of this size do, however, cause equipment damage). The operating SOP's are based upon the above tests and do assure a high degree of safety for the EWI in regard to accidental explosion hazards.

In our judgment, the simplicity of the EWI is another safety advantage. The system is visible and straight-forward such that the operators easily understand the system and would intuitively know what actions/operations are safe, even if SOP's were unavailable.

Automatic control and interlocks are built into the EWI to ensure safe operation in critical areas. These include automatic startup and shutdown, flame safety controls, high temperature shutdown and various other interlocks.

In summary, we rate the EWI very satisfactory, regarding safety.

Contaminated Waste Processor. The CWP is described in detail earlier in this section and in the Appendix. In our 100% disposal plan for NOS wastes, we have proposed using the CWP in all options. This is mainly due to the fact that the CWP will process wastes that cannot be handled by any of the other proposed processes.

Due to the above, it is difficult to compare the CWP quantitatively against the other thermal processes. We have, however, rated the system to the extent possible in Table X-2. The weakness area of rating for the CWP is in category #7, "cost", wherein we have the data to compare costs, but these are the costs for processing a different category of waste than is processed by the other systems.

Currently, there is no CWP at the NOS. To field an operational CWP through normal Government channels, to include advertisement, procurement, fabrication/construction, installation and shakedown/start-up would require an estimated 2 years. By handling this effort entirely through the private sector, an operational system could be fielded in about 1 year. Since the design is presently existing for the CWP, the entire technical data package and drawings would have to be obtained through appropriate Government channels to allow providing the system by private sector.

The CWP has very little dependency upon external support systems. Specifically, the only external process need is electric power, and the site will require normal utility services such as heating, lights, water and sewer connections. In this regard, the CWP compares slightly better than the EWI, and much better than the WAO and FBI.

The CWP uses current, proven demil/disposal technology and several systems are installed and operational. Although the system is of recent design, it cannot be considered as primarily serving to advance the state-of-the-art in PEP disposal. CWP's currently being installed will no doubt serve to some extent as a test arena for working out minor deficiencies and hardware refinements, but the basic technology is existing.

The CWP is judged to be comparable to the other thermal processes regarding air/water pollution aspects. All candidate systems will meet Federal, State and local standards.

Information made available to us shows that the NOS generates over 500,000 lb. of contaminated wastes annually. This quantity is composed mainly of contaminated equipment and includes a lesser amount of contaminated production materials. The total constitutes (by weight) almost half of the NOS wastes. This makes the CWP a very attractive system to implement, since, of the four candidates, it will handle a large percentage of the total wastes, ranking just behind the EWI in suitability to NOS requirements.

There are available two versions of the CWP designated the large unit (LU) and the small unit (SU). This equipment is detailed in the Appendix. All three disposal options proposed would use the LU version. Current estimated cost of the LU system is as follows:

- (a) Site - \$600,000
- (b) Equipment (installed) - \$770,000

As previously noted, it is difficult to compare costs of this system with those of the other systems since the materials processed are different and there is little overlap. However, we have provided a rating for the CWP in Table X-2

In regard to versatility, we judge the CWP to rate less than satisfactory, since it is only good for contaminated wastes. When compared to the other three systems, it rates approximately equal to the WAO and FBI, and inferior to the EWI. Despite its low versatility, the CWP is still highly recommended for use at the NOS, because it will process a large portion of the wastes generated, as previously detailed.

Currently CWP's have not been in operation long enough to generate a useful history regarding maintenance. Based on our knowledge of the system hardware and a review of the design, we judge that maintenance should rate at least satisfactory, and will be better than either the WAO or FBI, and slightly inferior to the EWI.

The operating crew for a CWP is identical to that previously described for the EWI. Consequently, the skill level analysis described for the EWI will likewise apply for the CWP.

In regard to energy usage, the CWP uses slightly more fuel than the EWI. Power consumption for the CWP is considerably more than the EWI. The overall energy efficiency of the CWP rates as considerably less than the WAO and EWI and about the same as the FBI.

The CWP is designed to ensure complete operator safety. Explosive quantities in process are quite small and are closely controlled by the SOP's which govern the materials to be processed. Accidental processing of a concentrated quantity of up to 1/2 lb. of H.E. and a resulting high order detonation can be safely tolerated by the CWP, regarding blast and fragmentation hazards. Areas occupied by operators are protected from explosion hazards, and SOP's control operator movement out of these areas.

Overall, the CWP rates as good as the EWI, from a safety standpoint.

F. System Plan Development for 100% Disposal

General

The purpose for discussing and analyzing the wastes stream and candidate processes in the above sections was to provide adequate data for selection of the equipment necessary to accomplish 100% disposal of the wastes at NOS. Based on the available information, three options for accomplishing 100% disposal have been developed. Each of these options will accomplish the required task; however, there is a significant economic difference between each option.

Criteria for Development of Options

The various options proposed for consideration must, as a minimum, conform to the following criteria:

100% Disposal. Each system option must handle (as nearly as practical) 100% of the items now being open burned, as categorized into the following criteria:

- (a) Bulk items and items requiring additional size reduction.
- (b) End items which must be fed whole.
- (c) Liquid wastes
- (d) Contaminated wastes such as rags, wood, pipe, equipment.

Environmental. Each system option must conform to all Federal and State of Maryland environmental emission standards. Since Maryland particulate allowables were relaxed from 0.05 grains 1 dscf to 0.10 grains/dscf the Federal Standard of 0.08 grains 1 dscf would now prevail along with the Federal standard of 4 pounds/hours of HCl in the exhaust stream.

TABLE X-2

THERMAL PROCESS RATING CHART

NO.	RATING CATEGORY	PROCESS				Rating Factors
		WAO	FBI	EWI	CWP	
1	Expected Time Required to Field Operational System	2	1	2	2	Recommend against completion of FBI
2	Dependence Upon External Support Systems	1	1	5	5	WAO & FBI depend upon slurry prep & water treatment
3	Current Technology Available	2	1	5	4	
4	Demonstrates New PEP Disposal Process	5	5	1	2	
5	Pollution Control	3	3	3	3	
6	Process Fits NAVORDSTA Wastes	1	2	4	4	CWP handles wastes that other procedures cannot
7	Cost (Capital and Operating)*	3 (1)	3 (2)	4	3	CWP handles wastes that other procedures cannot
8	Versatility of Process	1	1	4	2	CWP handles wastes that other procedures cannot
9	Maintenance	5	2	5	4	History of problems on FBI pilot work
10	Skill Level of Operation/Maintenance Personnel	2	2	4	4	
11	Energy Efficient	5	2	4	3	
12	Safety	2	2	4	3	

* Rating Factors in parentheses do not consider the influence of capital equipment already purchased and partially installed at the NOS.

Safety. Each system option must be sized so that the feed rates and capacities can be within safe operating limits on all subparts, while meeting the production requirements.

In addition to the above items, the following areas must be considered in developing and evaluating the options - economics of the system, maintenance, use of existing equipment, past performance in the similar areas, anticipated start-up time and problems and incorporation of future work load into the system.

100% Disposal Options.

Three options of major equipment items for satisfaction of the above criteria are as follows:

Option 1 - A Size Reduction Facility (SRF), an Explosive Waste Incinerator (EWI) and a Contaminated Waste Processor (CWP).

Option 2 - Same as Option 1 with the addition of the Wet Air Oxidation System (WAO).

Option 3 - A Fluidized Bed Incinerator (FBI), a CWP, a WAO, a SRF, and a Deactivation Furnace (DF).

Details on each of these options follows. These options are presented schematically in Figures X-1, X-2, and X-3.

Option 1

In order to process 100% of ordnance related wastes, Option 1 proposes the use of a size reduction facility (SRF), a standard contaminated waste processor (CWP) and an Explosive Waste Incinerator (EWI) with a modified pollution control system.

The purpose of the SRF is to reduce the waste items slated for disposal down to a size that can be handled by the EWI. This size is based not only on what the EWI's feed system can physically handle, but also from the standpoint of heat released per volume, emissions generated and the explosive content of each item.

The standard CWP, as described in the Appendix, will handle a minimum of 300-600 lb./hr. of waste depending on the method of feed. The waste slated for disposal in the CWP comprise approximately 40% of the annual rate for NOS, and represents a workload of approximately 5 to 10 months single shift per year.

In researching the Federal Stack Emission standards in Title 40 of the Code of Federal Regulations (40 CFR), it states in paragraphs 264.343 (b) and (c) that the maximum allowable hydrogen chloride (HCl) is four pounds per hour (or 99.9% removal efficiency, whichever is greater), and the particulate emissions shall not be more than 0.08 grains per dry standard cubic foot (dscf) when corrected for the amount of oxygen in the stack gas. The State of Maryland's standards were also researched and found that they do not have any HCl requirements at this time but their particulate emissions standard is 0.10 grans/dscf. In order to comply with all applicable regulations any new system will have to meet the 4 pounds per hour HCl standard and the 0.08 grains/dscf on particulates according to the Federal requirements.

The standards for HCl emissions are not anticipated to represent a problem with the standard CWP. The chlorinated contaminated wastes to be burned in it only comprise a small percentage of the total wastes and these will contain only residual amounts of the chlorinated compounds. The total possible HCl that can be formed should be maintained under the 4 pound limit without any removal devices.

The air pollution control system on the CWP has demonstrated that it can operate at less than 0.08 grains/dscf particulate emission. The CWP, by nature, operates very cleanly.

The EWI will handle the remainder of items for disposal. This workload would require the EWI to operate at one shift for approximately the whole year. It will use either the conveyor or positive feed system for introducing the items into the furnace. Each of these feed systems are explained in the Appendix, along with a detailed description of the EWI.

The standard EWI is designed to physically burn or destroy all of the specified wastes. Its air pollution control system (APCS) has demonstrated that it can meet the particulate emission standard of 0.08 grams/dscf when burning straight TNT. In order to ensure continual compliance to this level, a bag-house inspection program must be maintained to correct any leakage or by-passing of the bags.

The standard EWI does not have provisions for gaseous removal of HCl; therefore, it cannot meet the Federal emission standards for HCl. Although the halogen generating wastes comprise less than 15% of th workload, they do present a problem that must be addressed in order to be in compliance.

In order to operate at the anticipated feed rate of 400 pounds/hr. on the ammonium perchlorate wastes, it would require a HCl removal efficiency of 97%. The addition of a dry scrubber and a wet scrubber to the APCS was studied. Either of these systems can achieve the required efficiency of 97%.

The dry scrubber uses an absorbent which will react with the HCl to form a filterable salt. This absorbent can either be introduced into the hot gas stream prior to the gas cooler or at the baghouse where it is kept entrained in the airstream. This concept is fairly new but has been shown to work. Its prime advantage is that it is dry. No water treatment facilities are required for this system. Also, there is no major increase in pressure drop to the system.

The second system to be considered was the wet scrubber. The wet scrubber is a proven system on HCl removal with many years experience. The wet scrubber will transfer the gaseous and particulate pollution from the airstream to liquid where it can then be cleaned and treated by conventional methods. The advantages of the wet scrubber for this system are as follows:

1. There is an existing on-site wet scrubber, originally designed for the Fluidized Bed Incinerator, that could be used in this system; therefore, no new capital investment.
2. There are existing water treatment facilities to treat the liquid from the scrubber (although depending on the actions taken as a result of this study it may not continue to exist).
3. The wet scrubber is a proven concept.

In order to take advantage of the existing equipment, the wet scrubber is the recommended option. It will be located between the baghouse and the exhaust fan. In order to comply with both the Federal HCl standard and particulate standard, both the baghouse and wet scrubber will be required when burning the halogenated wastes.

Since the halogenated wastes comprise less than 15% of the total anticipated load, it is suggested that the wet scrubber be an option to the system. It should be by-passed when not needed, since the wet scrubber substantially increases the pressure drop to the system and it requires added maintenance to the water treatment system. This would essentially give a standard EWI system for the majority of the wastes.

The addition of the wet scrubber option to the EWI's standard APCS would require the following modifications:

1. Provisions made to allow for the increased pressure drop when the scrubber system is on-line.
2. Modification of the existing layout to accommodate the scrubber.
3. Design of the by-pass ducting system.

4. Integration of the wet scrubber controls into the EWI's control system.

The advantages of Option 1 are the following:

- a. It uses incineration systems that are proven capable of handling the type of wastes involved. No additional revisions or test programs will be required to make the systems operational, both of which can be very costly.
- b. Both systems are versatile and have excess capability to be able to handle future increases either in volume or additional items.

The major disadvantage to this option is that it does not utilize many of the existing systems originally designed for this function. It must be noted, however, that existing systems have not been proven feasible in handling these wastes on a production basis.

Incremental Implementation:

As noted previously, Option 1 consists of an SRF, an EWI, and an CWPLU. These systems could be incrementally implemented if desired. Based upon maximum production return relative to the expected funding requirements, we recommend that the CWP be the first unit to be implemented. This system will cost about 25% more than an EWI, but can process over 40% of current NOS wastes. Also, these particular wastes cannot be handled by any of the other proposed processes.

The second increment recommended is the EWI. Although an EWI (without an SRF) will not handle a large percentage of the NOS wastes, it will process most materials currently planned for the WAO and FBI, and has the additional capability (not available in any of the other systems) of handling both explosives and end items, such as CADS, PADS, Squibs and initiating devices.

The final increment recommended is the SRF. With this addition, all current NOS wastes can be processed. If it is possible to implement the SRF simultaneously with the EWI, making the incremental implementation a two-step process, this would be a more suitable approach, from a standpoint of time, but at the expense of higher monetary outlay earlier in the program. It would be advantageous to have both systems installed at the same time to avoid interface problems.

Option 2

This option also would enable NOS to process 100% of its ordnance related wastes. It is very similar to the first

option with the exception of how the chlorinated wastes are handled. This option consists of a Size Reduction Facility (SRF), a standard Explosives Waste Incinerator (EWI), a standard Contaminated Waste Processor (CWP), and the Wet Air Oxidation (WAO) modified to handle the HCl emissions.

The Size Reduction Facility reduces the items, when required, to a size that can be fed into the EWI as discussed in Option 1. These items primarily consist of the single and double based propellant grains. The EWI will also process end-item ordnance such as CAD/PADs, pyrotechnics, squibs, and igniters.

The standard EWI does not have a provision to control gaseous HCl emissions. For this option, the chlorine containing wastes such as ammonium perchlorate will not be processed in the EWI. Although the State of Maryland does not currently have a HCl standard, the Federal standard of 4 pounds per hour must be met. The particulate standard for Maryland of 0.05 grains/dscf can be maintained by the air pollution control system on the EWI.

Under this option, the EWI would be in use approximately 10 to 11 months per year single shift.

The standard CWP, as discussed in the Appendix, will process all contaminated wastes such as rags, gloves, pallets, drums, metal and plastic parts, etc. This comprises about 40% of NOS workload. Existing test data on similar wastes show that the CWP will meet the emission standards for both HCl and particulate. Depending on the type of wastes and feed systems used, the CWP would be run between 5 to 10 months per year single shift.

In order to utilize existing equipment at NOS, the Wet Air Oxidation (WAO) system could be brought on stream to process the chlorinated wastes. In order to do this, the wet scrubber would have to be replaced by a larger unit. The existing scrubber scheduled for the Fluidized Bed Incinerator could be used. The WAO would only be scheduled for approximately 6 weeks a year in order to handle all of the chlorinated wastes. Its workload could be increased by running some of the single and double based propellants slated for disposal in the EWI. Items that could not be processed in the WAO are end-item ordnance such as the CAD/PADs, pyrotechnic, squibs and igniters and items containing powdered materials such as aluminum, which settles out in the reactor.

The advantages to this option are:

1. It utilizes more of the existing equipment at NOS.
2. The WAO unit could process part of the EWI's workload if needed for maintenance reasons.

The anticipated disadvantages or problems with this option are:

1. Due to the large amount of HCl in the liquid of the WAO, the corrosion rate would reduce its life to an estimated one to two years. Cleanout would be required after each run.
2. Option 2 adds another entire system that must be maintained and kept operational year round.
3. Option 2 offers substantial amounts of excess capacity but each system is required in order to process all the wastes.
4. The very extensive grinding and slurrying facility must be made to operate to support the WAO.

Incremental Implementation:

As previously described, Option 2 uses the same systems as Option 1, with the addition of the WAO process. If incremental implementation is desired for this option, we recommend a program for this, as follows.

As in Option 1, we recommend implementation of the CWP as the first increment, using the same rationale previously described.

The second increment recommended is the WAO and is prescribed at this early point in the program mainly because it is nearly operational, and a relatively small expenditure will be required to complete it. As detailed previously under Section VI, some of the support systems (namely, slurry preparation and water treatment) for WAO are questionable as to whether they can be made operational. If these systems do in fact fail, then the WAO process must be deleted from all options.

The third increment will be the EWI, followed by an SRF, as was the recommended sequence for Option 1. Again, it would be more desirable from a time standpoint to implement a third increment composed of both an EWI and an SRF.

Option 3

Option 3 is designed to utilize the existing Wet Air Oxidation (WAO) system and Fluidized Bed Incinerator (FBI) that were originally designed for installation at NOS. This option also consists of a Size Reduction Facility (SRF), a Deactivation furnace (DF) and a Contaminated Waste Processor (CWP.)

The SRF in this system is similar to that in the other two options. It reduces the bulk items down to approximately 5 to 8 pounds, or smaller, so that they can be handled in the various components of the systems.

The WAO unit would be used to handle the PEP waste except for the aluminized casting powders and halogenated wastes. Both of these would be run into the FBI. It is anticipated that modifications would have to be made to the air pollution control system (APCS) on the FBI in order to meet the stringent particulate emission standards now imposed by the State of Maryland. At this time, the addition of a fabric baghouse is anticipated in order to accomplish this.

Both the WAO and the FBI would require additional size reduction of waste items so they could be in a feedable form.

The DF is similar to the Explosive Waste Incinerator (EWI) used in the other options with the exception that it has a downsized air pollution control system and does not have a gas cooler. Because of this, its feed rate on highly exothermic materials will be lower than the EWI. The DF is required to dispose of end-item ordnances such as CAD/PADS, pyrotechnics, squibs and igniters. These items cannot be disposed of in either the WAO or the FBI since they cannot be safely ground down to the feedable size for either system.

The total workload for these three systems combined (the WAO, FBI and DF) would be approximately 1 year single shift. Many of the items could be run in any one of these systems and the workload could shift, but no single system can handle all of the items as is.

The standard CWP, as discussed in the Appendix, would process all contaminated wastes such as rags, gloves, pallets, drums, metal and plastic parts, etc. This comprises about 40% of Indian Head workload. Existing test data on similar wastes show that the CWP will meet the emission standards for both HCl and particulate. Depending on the type of wastes and feed systems used, the CWP would be run between 5 to 10 months per year single shift.

The advantage to this system is that it utilizes the two systems originally slated to be installed at Indian Head. However, both would require extensive modification to bring into operation.

The disadvantages are as follows:

1. The WAO and FBI do not have a past history in disposing of the PEP type wastes. Normal start-up problems with a new system and the potential modifications are anticipated.

2. The WAO and FBI require controlled particle sizing to ensure that they will stay in suspension. Similar systems have had plugging problems which could create not only production problems but also a safety problem.
3. The 4 systems together have several hundred percent excess capacity; however, all systems are needed for 100% disposal. Each system must still be maintained year round and since each system is so different, they will require a variety of skills and training to service them. Spare parts and special tools required will have to be kept for each system.
4. Operators and crew will have to be trained for each system.

Since the expense of this option is so much greater than Option 1 or Option 2, it is not recommended.

Incremental Implementation

Option 3 consists of an SRF, a CWP, a FBI, a WAO unit and an APE 1236 rotary kiln or Deactivation Furnace (DF) previously detailed.

Incremental implementation of these would best be accomplished as follows:

- (a) Increment 1 - CWP
- (b) Increment 2 - WAO
- (c) Increment 3 - DF
- (d) Increment 4 - SRF
- (e) Increment 5 - FBI

The rationale for the order of Increments 1 and 2 is the same as previously described for Option 2.

We recommend that the DF be installed as the third increment of this option. It will provide end item processing capability not provided by any of the other processes, and can be obtained for a relatively small expenditure (current installed cost of this unit is about \$250,000). The system is quite versatile and can process many other PEP materials, being limited chiefly by physical sizes which can be fed.

The SRF is recommended for installation as the fourth increment of this option. Although it is a vital system for processing 100% of the NOS waste, it is relatively expensive, which is the primary reason it is recommended at the fourth of the five increments. The SRF will be a part of the preparation of the

feedstream for both the WAO and DF and it will size reduce items too large for either the DF or the slurry preparation system.

We recommend the FBI be installed as the final increment. The system is relegated to this position mainly because of the low potential of becoming operational, and partially because remaining costs will be quite high. Also, it does not have the capacity to process a significant percentage of station wastes without the SRF, which means it should follow (or be concurrent with) that facility.

As noted previously for the WAO, the FBI will require the support of the currently questionable slurry preparation system. If slurry preparation cannot be made operational, then both the FBI and WAO systems must be dropped from consideration in all options.

G. Site Layout

Based on the drawing obtained from NOS, site layouts for each option of 100% waste disposal have been proposed. Criteria for the proposed site location were to optimize the use of existing facilities, minimize the utility installation cost, and integrate the new facility with existing equipment.

We have located the new facilities considering convenience and safety. On both the EWI and CWP, the operations are manned and there is no danger from explosions within either of these processes. The DF of the EWI is barricaded to resist the allowed amount of explosive being introduced into the system. The CWP is designed specifically to handle only contaminated items with small amounts of explosive wastes. Therefore, there is no added danger from either of these facilities.

The size reduction facility (SRF) location is the same for each option. It is located southwest of the proposed EWI facility site, and has been shown at approximately the same distance from a manned operation as the existing shredder building (130 ft). The SRF operation proposed uses an allowable propellant quantity of 3000 lb, which is the same as for the existing shredder building. Travel on Coffee Road just west of the PDF will probably be restricted during hazardous operations at the SRF. A formal QD analysis will be a necessary part of any site layout which may be considered for this PDF revision. This site is selected to minimize the distance to the EWI. In the future, the wastes that are being trucked to the EWI from the SRF could be conveyed.

The following discussions describe the proposed site layouts for each option. Since the site layouts for Options 1 and 2 are similar, they have been combined. Figures X-4 and X-5 are provided to visually aid in locating the proposed site layout.

Options 1 and 2

To optimize the use of the existing incinerator buildings, we propose that the EWI use the FBI incinerator building as a feed room. Thus, the existing FBI equipment would have to be removed and the existing building would have to be modified to accommodate the CWP.

In order for PEP wastes, ash and scrap metal to be distributed to and from the site, roadway, it would have to be modified to allow access to the feed room (FBI incinerator building) and provide a truck turnout. Utilities and plant water can be easily provided from the water treatment building. The existing fuel oil storage tank that was installed for the FBI can be used for firing the DF. Slurried PEP wastes can be brought in through the existing tunnel network. However, it would be more beneficial to incinerate the wastes dry rather than in a slurry form. Also, Roadway J can be extended down to loop by the proposed size reduction building. This would provide very convenient and safe access to and from the EWI and SRF.

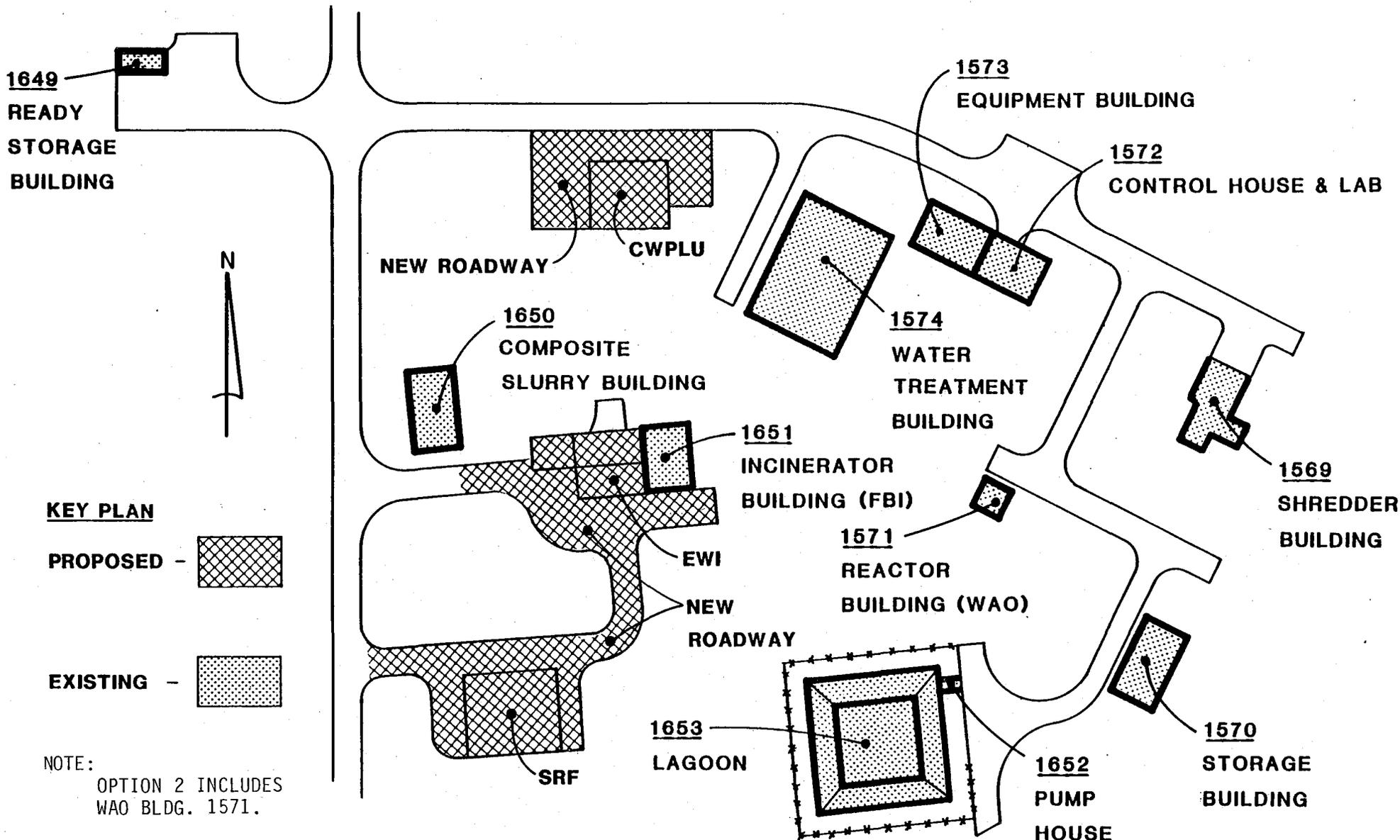
Depending on the amount and type of wastes being processed at the slurry preparation and size reduction building, some barricading may have to be provided to protect the EWI facility. This is the only anticipated problem that may alter this location for the EWI.

The CWP requires a large area in order to operate efficiently. Storage space for loading and unloading zones and basket cooling must be provided. The site selected for the CWP is between the Water Treatment Building and Caffee Road. This location has ample space and is easily accessible. Utilities can be provided from the Water Treatment Building.

For Option 2, the Wet Air Oxidation facility would be made operational. The site location for the EWI and CWP would not change. The EWI may be smaller since it will not have to handle ammonium perchlorate. No other changes are anticipated.

Option 3

In Option 3, the FBI and WAO would be made operational. The CWP would be installed in the same site as in Options 1 and 2. A deactivation furnace may have to be installed along with the CWP to dispose of end item ordnances such as cads, pads, pyrotechnics, squibs and igniters.



1649
READY
STORAGE
BUILDING



KEY PLAN

- PROPOSED - [cross-hatched box]
- EXISTING - [dotted box]

NOTE:
OPTION 2 INCLUDES
WAO BLDG. 1571.

SITE PLAN

OPTION 1 & 2
FIG. X-4



Conclusion

The proposed facilities have been laid out to meet their functional requirements. To minimize the amount of groundwork required to install each facility, sites with the flattest elevations were selected. Also these sites were laid out in a manner so that personnel would not have to travel through restricted or "hot" areas in order to reach either proposed or existing facilities.

H. Recommendations

Our recommendation for 100% disposal of NOS wastes is Option 1. Option 2 is our second choice, and Option 3 is not recommended, due mostly to the uncertainties of the FBI unit. Options 1 and 2 rate fairly equal, in our judgment; however, Option 1 appears to be the best, inasmuch as no slurry preparation system is required. The existing slurry preparation system is currently fraught with problems. Option 2 has one advantage over Option 1, in that it does utilize some existing equipment, namely the WAO unit. This advantage however, does not outweigh the slurry system disadvantage, in our judgment.

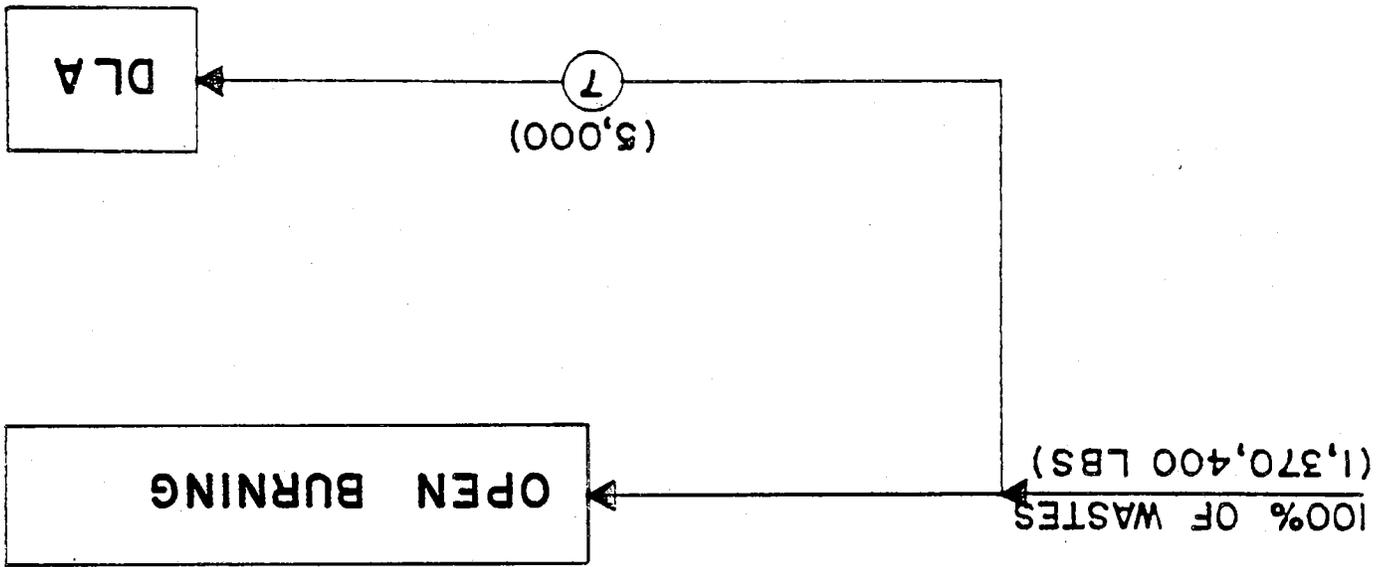
Since the contaminated waste processor (CWP) is common to both options, it is recommended that the Navy add a CWP at NOS as soon as possible. This will eliminate one entire open burning ground and dispose in an ecologically clean manner over 40% of the existing wastes that are now open burned. EPA regions 4 and 7 and the state of Wisconsin have classified the CWP as not a hazardous waste incinerator. Therefore, since precedence has been set, it is highly possible that the state of Maryland will concur and a Part B permit will not be required. Construction can proceed without the exhaustive permitting requirements of new hazardous waste incinerators. This facility requires no upstream preparation of the material prior to disposal. Therefore, it is not dependent on other facilities for its successful operation and could immediately be brought on line.

I. Additional Options

Additional options that utilize off-post shipping and/or on-site open burning are shown in the following figures. It should be noted that Option 7 is a very attractive option and fits incrementally with Option 1 as discussed previously.

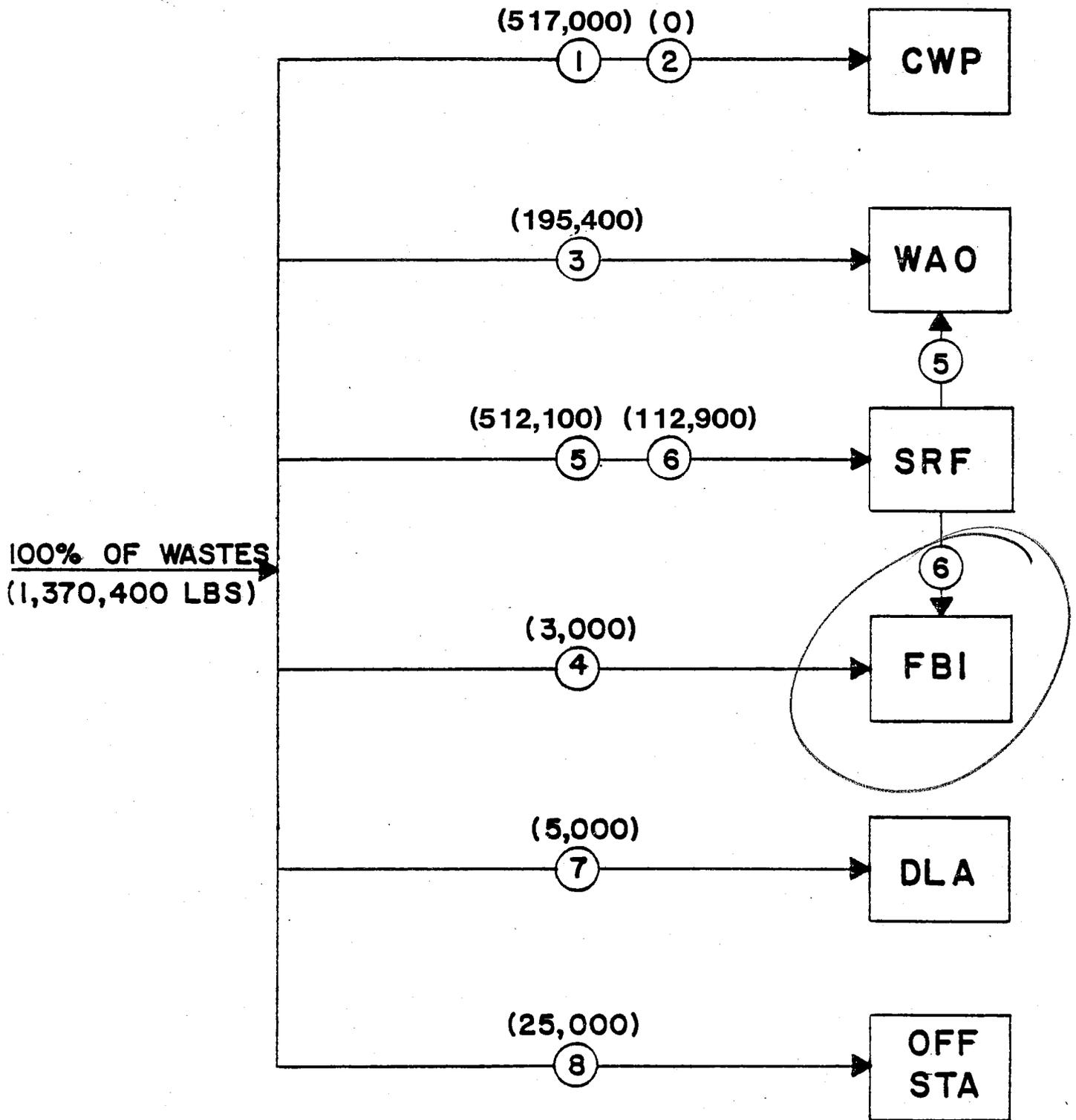
Off-station disposal requires significant considerations and these are described in detail in Section XI. Economic analyses of all eight options are presented in Section XIV.

CAPITAL COST - 0



OPTION 0

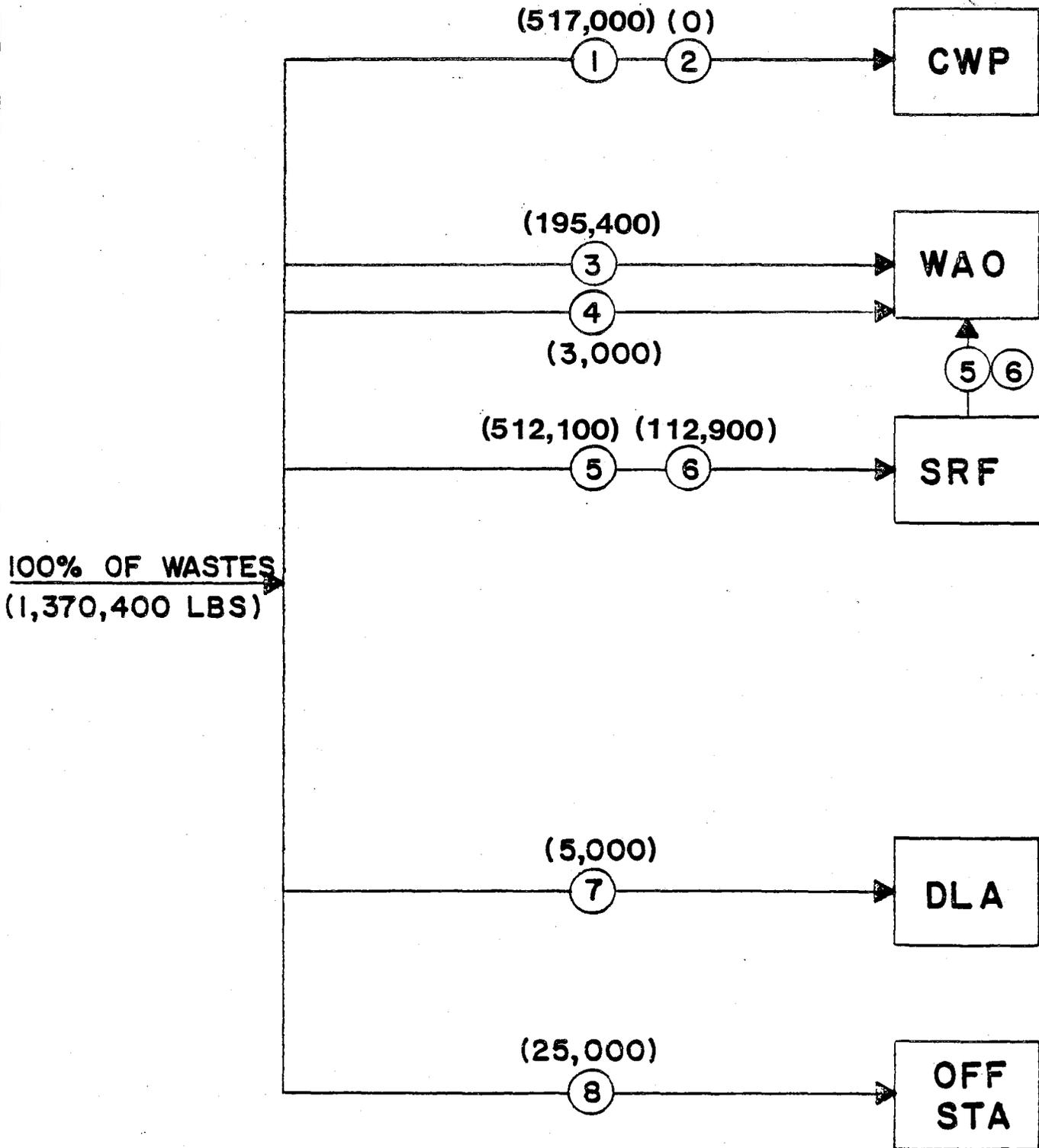
OPTION 4



CAPITAL COST - \$6,409,000

FIGURE X-7

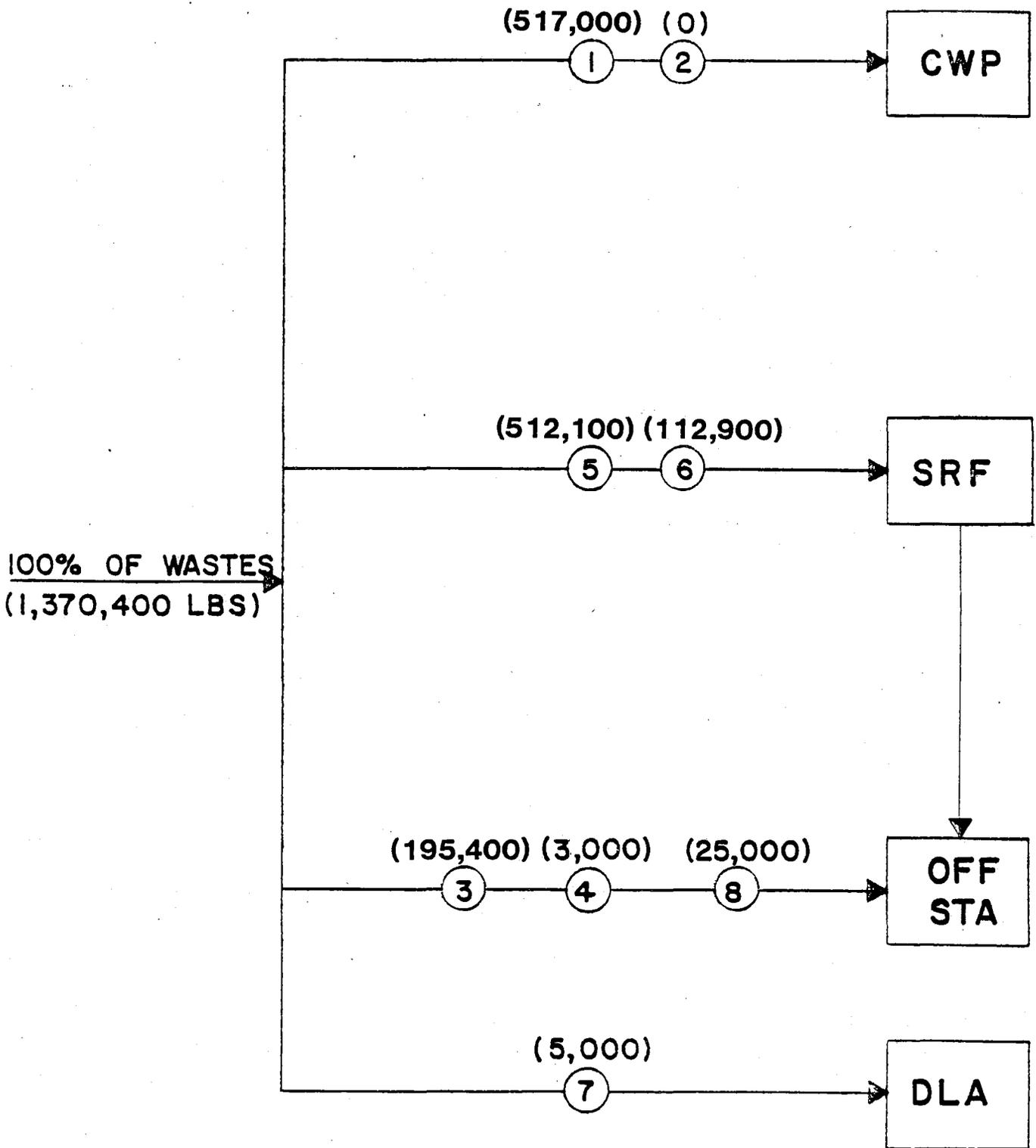
OPTION 5



CAPITAL COST - \$ 3,980,000

FIGURE X-8

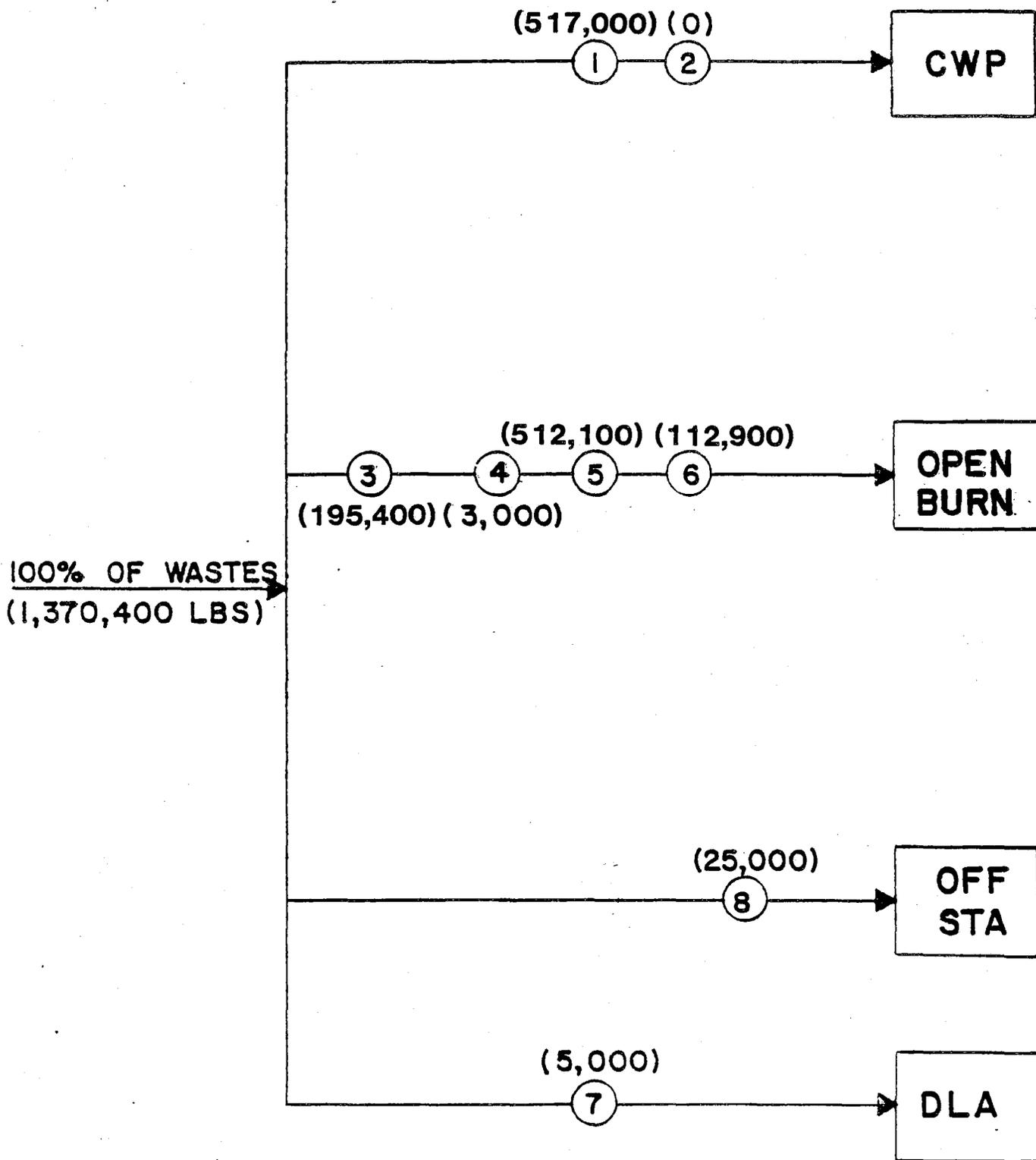
OPTION 6



CAPITAL COST - \$ 2,595,000

FIGURE X-9

OPTION 7



CAPITAL COST - \$ 1,370,000

FIGURE X-10

TABLE X-3

ORDNANCE RELATED WASTES - INDIANHEAD

I. SINGLE AND DOUBLE BASE PROPELLANTS/INGREDIENTS - 634,500 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Nitrocellulose	1,000 lbs.	Flakes	.002" to .080"	None	3
Casting Powder	120,000 lbs.	Powder granules	.040" to .080"	None	3
Grain End Trim/Slabs	15,000 lbs.	Chunks and slabs.	Fines up to 4" x 15"	Yes	5
Shavings/Chips	2,000 lbs.	-----	Fines to 1" x 1"	None	3
Carpet Rolls (excess or reject)	12,000 lbs.	Flat Prop. Rolled	12" wide x 16" dia. roll	Yes Shredder	5
Extrusion Flashings	300 lbs.	Pieces	.060 thick 3" x 5"	None	3
PNC (Plastisol Nitrocellulose)	100 lbs.	Flakes	Powder to .060" thick	None	3

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Talos Grain	20,000 lbs.	Solid Prop.	30" x 90" lg. has cellulose acetate inhibiter.	Yes	5
Terrier Booster and Terrier Sustainer with inhibitor	272,200 lbs.	Solid Prop.	18" dia. x 120" long 14" dia. x 50" long	Yes	5
ASROC Shell and ASROC Cruciform w/ethyl cellulose acetate inhibitor (uncased)	14,400 lbs.	Tube/cruciform grain	12" OD x 10" ID x 52" long 8" OD x 52" long	Yes	5
Zuni with Inhibitor	85,000 lbs.	Grain	5" dia. 60" lg.	Yes	5
Sidewinder IA with Inhibitor	5,000 lbs.	Grain	5" dia. 60" lg.	Yes	5
2.75 Motor (FY 85 Production)	54,000 lbs.	Grain	3" dia. x 31" lg.	Yes	5
Rapac and MK51	3,000 lbs.	Grain	3" dia. x 40" lg. 1" dia. x 12" lg.	Yes	5

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
MK89 with inhibitor	15,500 lbs.	Grain	5" dia. x 13" long	Yes	5
LOVA/GAU 8 Propellant (FY 85 Production)	15,000 lbs.	Granular and chunks	1/4" dia. x 4 to 6" long	Yes	5

II. COMPOSITE PROPELLANTS/INGREDIENTS - 118,600 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Std. Arm Sustainer and Booster Scrap (cured)	27,000 lb/yr	Shavings to long chunks	Shavings to max. chunk 10" to 70" long	Yes	6
Std. Arm Props Heels Uncured (could vary from cured hard to viscous liquid.	43,000 lb/yr	----	Up to 4" x 12"	Yes	6
Std. Arm Boosters (uncased)	14,400 lb/yr	Propellant grain	10" dia. x 70" long	Yes	6
2.2 Jato Scrap (CTBN) cured	1,000 lbs.	Shavings and chunks	Chunks to 2" x 10" dia.	Yes	6
2.2 Jato Grain uncased	1,000 lbs.	Grain	10" dia. x 43" lg.	Yes	6
2.2 Jato Heel uncured	8,400 lbs.	Chunks	1-3" x 10" dia.	Yes	6

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Hogged-out Propellant	4,000 lbs.	Dust to Chunks	To 4" x 6"	Yes	6
Ammonium Perchlorate scrap	9,700 lbs.	Powder to Chunks	Chunks to 10" x 15"	Yes	6
Zuni	1,000 lbs.	Solid Prop.	5" dia. x 62" long	Yes	6
CTBN	3,000 lbs.	Shavings to Chunks	Chunks to 3" x 10"	Yes	6
HMX & RDX	2,400 lbs.	fines/slurry	Collect in wet sawdust	None	3
HBNQ	500 lbs.	"	"	None	3
HTPB	100 lbs.	Powder to Grains	Grains 2-1/2" dia. x 20" long	Yes	6
Powdered Al	100 lbs.	Powder/Lumps	Lumps to 3" x 4"	None	3
Reject Composite Mix (uncured)	3,000 lbs.	Powder/Lumps fluid	Lumps to 3" x 4"	None	4

III. FLUOROCARBON PROPELLANTS - 300 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Bomroc RAP SFU Igniter	300 lbs.	Powder to Chunks.	Max. 4" x 8"	Yes	6

IV. END ITEM ORDNANCE - 25,000 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Pyrotechnics Squibs CAD PAD Igniters Caps Cartridges	25,000 lbs.	End items	Varies	None	8

V. FLAMMABLE LIQUIDS - 5,000 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Otto Fuel		Sawdust Slum 40 to 50% otto fuel.	----	N/A	7
Heptane Acetone Alcohols Hexane Agitine	5,000 lbs. (including Otto fuel above).	Liquid	----	N/A	7

VI. NITRATE ESTER SLUMS 69,000 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Slums Nitro glycerin Metriol trinitrate Triethylene Glycol Cinitrate	69,000 lbs.	Each slum contains	20-30% of the nitrate ester, 20% triacetin & the remainder in sawdust or shredded cloth.	N/A	3

VII. PLASTIC BONDED EXPLOSIVE - 1,100 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
PBX Cured in Case	1,100 lbs.	----	----	Yes	Unclassified
PBX Uncured	Unknown			No	3

VIII. CONTAMINATED WASTES - 518,000 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Reduction Required	Type Material
Gloves, rags, cotten wastebags etc.	17,000 lbs.	----	Cotton 1 lb. to 30 lb. bags - Bag sizes 4" x 4" to 36" x 48" 14" x 14" sheets	No	1
Equipment, Shipping Centers, Dunnage drums, boxes, metals, plastic parts.	500,000 lbs.	----	Equipment 5' x 5' x 18' Wood pallets up to 6' x 6' 20 & 55 Gallon drums metal bonding 1/2" to 2" x 40'.	Yes	1
Extrusion Wax - out material	1,000 lbs.	Sawdust shavings beeswax, oatmeal propellant.	1" to 15"	Yes	5

XI. Search For Alternate Off-Base Disposal Sites

XI. SEARCH FOR ALTERNATE OFF BASE DISPOSAL SITES

General

The purpose of this task was to determine if any of the ordnance related waste generated at NOS could be transported safely and economically off base and disposed of in an environmentally safe and cost effective manner at either another government disposal facility or one operated by private industry.

Procedure

In order to accomplish the above a study of the transportability of all portions of the NOS waste stream was performed. This included a comprehensive examination of federal and state regulations and guidelines pertaining to transportation of propellants and explosives. Packaging requirements were studied and economics of preparing the various materials for shipment and the shipping of materials was developed.

Various governmental and private waste disposal sites and organizations were selected for examination and questioned regarding interest in and capability for accepting all or part of that NOS waste deemed transportable. For any location currently capable of disposing of a portion of the waste stream, a five year forecast was developed predicting degree of continued disposal capability and the ability of each potential site to obtain a Phase B RCRA permit when required.

Finally, economics of off site disposal were developed and included as part of the evaluation of the various options.

A. List of Materials

Table XI-1 lists the materials presently forecasted as making up the workload for open burning at NOS. Ideally, an off base disposal site would be capable of handling all of these wastes. However, off base disposal of any of these would ease the open burning problem at NOS and/or reduce the number of types of new disposal equipment which would have to be constructed. The table lists two packing requirements for each item; (1) packing for on base disposal; and (2) packing for off base disposal.

If a decision were made to ship any of the wastes to off base disposal sites, DOT and RCRA packaging requirements for these materials would need to be precisely determined; however, it is beyond the scope of this study to make this determination.

ORDNANCE RELATED WASTES - INDIAN HEAD

TABLE XI-1

ORDNANCE RELATED WASTES - INDIAN HEAD

I. SINGLE AND DOUBLE BASE PROPELLANTS/INGREDIENTS - 634,500 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Nitrocellulose	1,000 lbs.	Flakes	.002" to .080"	Conductive Plastic bags in metal trash cans.	Pack in same Galvanized metal drum material is received.
Casting Powder	120,000 lbs.	Powder granules	.040" to .080"	"	Plastic bags in Lever Packs (18" dia. x 40" high fiber drum w/conductive strip).
Grain End Trim/Slabs	15,000 lbs.	Chunks and slabs	Fines up to 4" x 15"	"	"
Shavings/Chips	2,000 lbs.	-----	Fines to 1" x 1"	"	"
Carpet Rolls (excess or reject)	120,000 lbs.	Flat Propellant Rolled	12" wide x 16" dia. roll	Fiber drums	Fiber drums (same one in which material is received from Radford AAP.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Extrusion Flashings	300 lbs.	Pieces	.060 thick	Conductive Plastic bags in metal trash cans.	Plastic bags in Lever Packs.
PNC (Plastisol Nitrocellulose)		Flakes	Powder to .060" thick	"	"
Talos Grain	20,000 lbs.	Solid Prop.	30" x 90" lg. has cellulose acetate inhibitor.	Placed on truck mounted saddles for movement to open burning ground.	Cut into chunks for packing into plastic bags and lever packs OR uncut grain could be repacked in modified wooden or metal grain shipping container.
Terrier Booster and Terrier Sustainer with inhibitor	272,200 lbs.	Solid Prop.	18" dia. x 120" long 14" dia. x 50" long	"	"
ASROC Shell and ASROC Cruciform w/ethyl cellulose acetate inhibitor (uncased)	14,400 lbs.	Tube/cruciform grain	12" OD x 10" ID x 52" long 8" OD x 52" long	"	Cut into chunks for packing in plastic bags and lever drums.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Zuni with Inhibitor	85,000 lbs.	Grain	5" dia. 60" lg.	Placed on truck mounted saddles for movement to open burning ground.	Cut into chunks for packing in plastic bags and lever drum.
Sidewinder IA with Inhibitor	5,000 lbs.	Grain	5" dia. 60" lg.	"	"
2.75 Motor (FY 85 Production)	54,000 lbs.	Grain	3" dia. x 31" lg.	"	Pack in plastic bags and lever drum.
Rapac and MK51	3,000 lbs.	Grain	3" dia. x 40" lg. 1" dia. x 12" lg.	"	"
MK89 with inhibitor	15,500 lbs.	Grain	5" dia. x 13" long	Place in conductive plastic bag and metal trash can.	"
LOVA/GALI 8 Propellant (FY 85 Production)	15,000 lbs.	Granular and chunks	1/4" dia. x 4 to 6" long	"	"

II. COMPOSITE PROPELLANTS/INGREDIENTS - 119,500 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Std. Arm Sustainer and Booster Scrap (cured)	27,000 lb/yr	Shavings to long chunks	Shavings to max. chunk 10" to 70" long	Conductive plastic bag in metal trash can.	Cut as required, pack in plastic bag and Lever pack.
Std. Arm Props Heels Uncured (could vary from cured hard to viscous liquid.	43,000 lb/yr	----	Up to 4" x 12"	"	Pack in Conductive Plastic bats and Lever pack
Std. Arm Boosters (uncased)	14,400 lb/yr	Propellant grain	10" dia. x 70" long	Overpacked in plastic & placed in truck mounted saddles for movement to OB ground.	Cut-up package in plastic cntr. and fiber lever pack.
2.2 Jato Scrap (CTBN) cured	1,000 lbs.	Shavings and chunks	Chunks to 2" x 10" dia.	Conductive Plastic bag in metal trash can.	"
2.2 Jato Grain uncased	1,000 lbs.	Grain	10" dia. x 43" lg.	"	Cut-up package in plastic bag & lever pack.
1.1 Jato Heel uncured	8,400 lbs.	Chunks	1-3" x 10" dia.	Conductive plastic bag & metal trash can.	Pack in plastic bag & lever pack.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Hogged-out Propellant	4,000 lbs.	Dust to Chunks	To 4" x 6"	Conductive Plastic bag & metal trash can.	Pack in plastic bag & lever pack.
Ammonium Perchlorate scrap	9,7000 lbs.	Powder to Chunks	Chunks to 10" x 15"	"	Pack in plastic bags & special lined 55 Gal. Drums 250/lb. Drum.
Zuni	1,000 lbs.	Solid Prop.	5" dia. x 62" long	Unknown	Cut-up package in plastic bag & Lever pack.
CTBN	3,000 lbs.	Shavings to Chunks	Chunks to 3" x 10"	Conductive Plastic bag & metal trash can.	Package in plastic bag & Lever Pack.
HMX & RDX	2,4000 lbs.	finest/slurry	Collect in wet sawdust	"	Package with sawdust in plastic bags & Lever Packs.
HBNQ	500 lbs.	"	"	"	"
HTPB	100 lbs.	Powder to Grains	Grains 2-1/2" dia. x 20" long	"	Pack in plastic bag & lever pack

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Powdered Al	100 lbs.	Powder/Lumps	Lumps to 3" x 4"	"	Pack in plastic bag & 55 gal. drums.
Reject Composite Mix (uncured)	3,000 lbs.	Powder/Lumps fluid	Lumps to 3" x 4"	"	Pack in plastic bags w/sawdust overpack in lever packs or 55 gal. drum.

III. FLUOROCARBON PROPELLANTS - 300 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Bomroc RAP SFU Igniter	300 lbs.	Powder to Chunks.	Max. 4" x 8"	Packed dry in conductive plastic bags in metal cans.	To be determined

IV. END ITEM ORDNANCE - 25,000 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Pyrotechnics Squibs CAD PAD Igniters Caps Cartridges	25,000 lbs.	End items	Varies	Currently packaged in original packag- ing for shipment & disposal in a Deactivation Furnace at Earl, N.J.	Same as now used

V. FLAMMABLE LIQUIDS - 5,000 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Heptane Acetone Alcohols Hexane Agitine	5,000 lbs.	Liquid	----	Glass Cntrs. or metal drums.	Metal drums.

VI. NITRATE ESTER SLUMS - 69,000 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Slums Nitro glycerin Metriol trinitrate Triethylene Glycol Cinitrate Otto fuel	69,000 lbs.	Each slum contains 20-30% of the nitrate ester, 20% triacetin & the remainder in sawdust or shredded cloth, except the Otto fuel slum, is sawdust and 40 to 50% Otto fuel.		Conductive plastic bags in a metal trash can.	Packed with Sawdust in plastic bags in metal durms. This material may not be acceptable for shipment.

VII. PLASTIC BONDED EXPLOSIVE - 1,100 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
PBX Wastes	1,100 lbs.	----	----	----	----

VIII. CONTAMINATED WASTES - 518,000 LB./YR.

Material	Annual Production (Waste)	Material Form	Material Size	Packing for On Post Disposal	Packing for Off Post Shipment
Gloves, rags, cotton wastebags etc.	17,000 lbs.	----	Cotton 1 lb. to 30 lb. bags - Bag sizes 4" x 4" to 36" x 48" 14" x 14" sheets	Conductive plastic bags in metal trash can.	Baled with plastic wrap.
Equipment, Shipping Centers, Dunnage drums, boxes, metals, plastic parts.	500,000 lbs.	----	Equipment 5' x 5' x 18 Wood pallets up to 6' x 6' 20 & 55 Gallon drums metal bonding 1/2" to 2" x 40'.	Dumptruck	Unknown*
Extrusion Wax - out material	1,000 lbs.	Sawdust shavings beeswax, oatmeal propellant.	1" to 15"	Conductive Plastic bags in metal trash can.	Plastic bags in Lever packs.

* See discussion on page XI-16. These materials must be appraised on a case-by-case basis and packaged accordingly.

MEMO FOR RECORD

August 25, 1983

FROM: B. Crist

SUBJECT: Report of Visit to DOT

PURPOSE: Obtain information concerning the rules and regulations involved in the shipment of wastes developed at Indianhead, MD.

Jerry Clayson and I met with Wayne Goudie and discussed the feasibility of shipping Indianhead's wastes to other military installations. Mr. Goudie looked at our list and claimed he did not recognize most of the items listed. However, he did feel that almost all of the PEP wastes generated at Indianhead could be shipped by either interstate highway or railway according to 49 CFR 173.

The only waste he questioned was nitroglycerin. Mr. Goudie knew that nitroglycerin in a pure form was forbidden for shipment, but was not sure where it was mixed in sawdust and other materials. He said it would probably have to be tested and approved before it could be shipped. Otherwise, Mr. Goudie felt that we should treat the wastes as explosives with the exception of the flammable liquids which would be shipped as prescribed in 49 CFR 173.

Packaging for the wastes was described in 49 CFR 178. Mr. Goudie explained that we must determine the class rating and material description that closely relates to the class rating and material description in Table 172.101 and of 49 CFR 172.102 in order to determine what rules and regulations are required to ship the wastes. Mr. Goudie said that usually the manufacturer (Indianhead) is responsible for obtaining the wastes' class rating and for packaging the wastes.

Mr. Goudie also made us aware of a compatibility chart in 49 CFR 177.854 that would allow us to ship mixed wastes. We asked if there were any problems with shipping waste explosives that would not meet specifications. Mr. Goudie felt that they could be shipped and thought that if the CFR was followed and the wastes were approved for shipment, there would be no problems.

B. Survey of Department of Transportation Regulations and Transportability

The annual wastes generated at NOS have been categorized and are listed in Table XI-1. Where information was available, the current packing for on-post transportation has been listed and anticipated off-post packing is suggested. The governing regulations for the transportation of these wastes is 49 Code of Federal Regulations (CFR) Parts 171-179 and 40 CFR 263.11 and 263.31. These regulations were developed by EPA and DOT for the transporters of hazardous wastes as outlined in 40 CFR 263.10.

Mr. Wayne Goudie of DOT reviewed the list and stated that he felt most items were shippable. Minutes of this meeting are found in Attachment 1. Most items could be categorized into one of the listings in Tables 49 CFR 172.101 or 172.102. The testing for these listed items has already been performed and approved shipping containers and procedures are outlined. Those items which do not fall in the listed category of items that have been altered may fall under 49 CFR 173.86 "new explosives". This states that no person may offer a new explosive for transportation unless it has been examined and assigned a recommended shipping description and hazard classifications. Approval and testing agencies are outlined in 49 CFR 173.86(b).

Approved packaging is outlined in 49 CFR 178, subparts C to F. All containers must be DOT certified.

As stated previously, most items at NOS can be transported if properly packaged. Questionable items in each section as outlined in Table XI-1 will be discussed.

I. SINGLE AND DOUBLE BASE PROPELLANTS (634,500 lbs./year)

Nitrocellulose - This comprises only 1,000 pounds per year. In order to be shipped per 173.184, it must be 0-20 % by weight water and the gross weight per container under 490 pounds.

Grain End Trim/Slab; Shaving/Chips - These items are assumed to have the standard chemical composition. The ratio of surface area to volume will be greater than normal items. However, no problems are anticipated. Normal packing should satisfy and it is not felt that this will be classified as a new product.

II. COMPOSITE PROPELLANTS/INGREDIENTS (119,500 lbs./year)

Uncured Items - There are three listed items in this category: Standard Arm Propellant Heels (43,000 lbs./year), 1.1 Jato Heels (8,400 lbs./year) and Reject Composite Mix (3,000 lbs./year). Since the chemical composition of the uncured waste could be different from the standard, they conceivably will be classified as a "new product". This could require testing and approval of each batch prior to shipment off-post and would not be practical.

III. FLUOROCARBON PROPELLANTS (300 lbs./year)

No problems are anticipated if properly packaged. They may have to be shipped separately. 49 CFR 177.854 lists items that can be loaded on the same truck. The SFU Igniter may not be allowed with the propellant wastes.

IV. END ITEM ORDNANCE (25,000 lbs./year)

No problems are anticipated. Current packaging probably is adequate for off-base shipment. These items will probably be shipped separately from the other waste per compatibility as listed in 49 CFR 177.854.

V. FLAMMABLE LIQUIDS (5,000 lbs./year)

The sawdust slum with 40 to 50% otto fuel is not listed. Shipping details and approval must be obtained. This item may not be practical to transport off-base.

The other flammable liquids are covered in 49 CFR 173.118 and 173.119. Conformance will be for all shipping. These liquid wastes should be turned over to DLA as their responsibility for disposal.

VI. NITRATE ESTER SLUMS (69,000 lbs./year)

These slums are not listed and approval must be acquired prior to shipment. Due to the nitroglycerin, this approval may not be obtainable or the restrictions required may make it impractical. The wastes in this area are anticipated to be a problem in transporting off-post. Open air burning, if permitted, may be the only viable option for these wastes.

VII. PLASTIC BONDED EXPLOSIVES (1,100 lbs./year)

Minimal data is known. It is assumed that these will be classified as high explosives and conform with 49 CFR 173.61 and 173.87.

VIII. CONTAMINATED WASTES (518,000 lbs./year)

No problems are anticipated in being able to ship these items. Preparation of these items will be an important consideration from an economic and practical standpoint. If these items are considered a hazardous waste, a recommended packing method must be established. EPA Region 4 and 7 and the state of Wisconsin have ruled these wastes are not hazardous and that they can be treated as municipal wastes. If the same ruling could be obtained in Maryland, the disposal would be greatly simplified.

In summary, no major problems are anticipated in shipping the majority of wastes listed in Table XI-1. They can be legally and physically shipped; however, the economics in some areas may make them prohibitive.

The following items are anticipated to require testing and approval by the agencies listed in 49 CFR 173.86. Because the composition of many of these items could continually be changing, approval is very questionable.

Standard Arm Propellant Heels (uncured)	43,000 lbs./year
2.2 Jato Heels (uncured)	8,400 lbs./year
Reject Composite Mix (uncured)	3,000 lbs./year
Nitrate Ester Slums	69,000 lbs./year
Sawdust Slum (otto fuel)	>5,000 lbs./year

C. Discussion of Off Site Disposal Possibilities and Costs

It is evident that some of the NOS wastes will not be practical candidates for movement on public highways or railways. Disposal of NOS wastes at some off-post facility will necessitate considerable revision in the methods that are now used to accumulate and package wastes for on-post disposal. Safety requirements for accumulating and packing energetic materials for direct transfer to the on-post disposal area are miniscule compared to the precautions to be observed in packaging these same energetic wastes for long storage intervals and movement over public highways or railways. Estimates ranging from \$0.50 to \$1.20 per pound were given by experienced Army and Navy operating personnel for packaging propellant wastes that do not require size reduction. Navy operating personnel further estimated costs of \$1.50 per pound to cut large propellant grains into sizes that could be packaged in conductive plastic bags and the standard lever pack. This estimate is based on using equipment and facilities now available on NOS. It may be possible to reduce cutting costs if the large propellant grains to be cut can be accumulated until a quantity justifying a production run can be collected. Much more extensive details relative to NOS production operations would have to be obtained to enable a more comprehensive estimate of cutting and packaging costs.

For the purpose of this analysis, \$.85 per pound packaging costs and \$1.50 per pound cutting costs are being used to obtain an order-of-magnitude cost estimate for off-post disposal. The results are summarized in Figure XI-1.

Approximate cost per short ton to ship munitions from an east coast location to each of the DESCOM and ARRCOM Ammunition depots for disposal is as follows. These costs are based on our current understanding that shipping costs for PEP wastes are the same as munition or explosive shipping costs:

<u>Ammo Depot</u>	<u>Shipping Cost per Short Ton</u>
Anniston, AL	\$107.00
Crane, IN	87.00
Ft. Wingate, NM	222.00
Hawthorne, NV	268.00
Letterkenny, PA	48.00
Lexington, KY (Blue Grass)	102.00

OFF-POST SHIPPING

WASTE GROUP (exclusion items)	AMT. (LBS.)	COST * TO PACK	COST TO SHIP	TOTAL	APPLICABLE REGULATIONS
1. SINGLE & DOUBLE BASE PROP.	634,500	1,134 K	19-95 K	1,153 K- 1,229 K	49CFR 172.101/102 49CFR 173.79/92.178
2. COMPOSITE PROPELLANTS/INGR. (STD. ARM PROPS. HEELS-UNCURED) (2.2 NATO HEELS-UNCURED) (REJECT COMPOSITE-UNCURED)	119,500 (43,000) (8,400) (3,000)	102 K	4-18 K	106-120K	49CFR 172.101/102 49CFR 173.86 49CFR 173.86 49CFR 173.86
3. FLUROCARBON PROP.	300	.26 K		.26-30K	49CFR 172.101
4. END ITEM ORDNANCE	25,000	21.3 K	.7-3.7	22-25 K	49CFR 172.101/102. 173.79 49CFR 177.854
5. FLAMMABLE LIQUIDS	5,000				TRANSFER TO DLA
6.(NITRATE ESTER SLUMS)	(69,000)	NOT RECOMMENDED			49CFR 173.86
7. PLASTIC BONDED EXPLOSIVES	1,100			1-1.5K	49CFR 172.101/102 49CFR 177.854
8. CONTAMINATED WASTES	518,000	INSUFFICIENT DATA			

* ASSUMED COST TO PACK - .85/LB. PACKAGE, 1.50/LB. CUTTING

FIGURE XI-1

<u>Ammo Depot</u>	<u>Shipping Cost per Short Ton</u>
McAlester, OK	159.00
Navajo, AZ	250.00
Pine Bluff Ars., AR	140.00
Pueblo, CO	185.00
Red River, TX	108.00
Savanna, IL	119.00
Seneca, NY	61.00
Sierra, CA	299.00
Tooele, UT	245.00
Umatilla, OR	299.99

Disclaimer: The above information must be considered as approximate. It was not possible to obtain accurate shipping costs estimated by experienced government transportation personnel in time for inclusion with this submission. An Army report recently completed reported costs for shipping munitions from each of the depots to the Navy port of Earle, New Jersey. These costs provide a rough economic basis for selecting candidate disposal locations. Shipping costs to private sites should be comparable for the appropriate distances and geographic area.

Reducing the disposal mission at NOS would have some adverse impact on employees now engaged in this work. In that it appears to be impractical to ship all wastes generated, there will as a minimum continue to be a requirements for some post disposal capability.

The contaminated wastes (List VIII, Table XI-1) would be extremely difficult to package suitably for off-post movement if it is considered as "hazardous waste." A precedent established by EPA Region 4 may alleviate this problem. Region 4 determined that the small amount of energetic material contaminating the rags, paper, dunnage, metal parts, etc. did not warrant regulation of these wastes under RCRA. Region 7 EPA and the state of Wisconsin have since also accepted this precedent. The Army is currently pursuing a nationwide acceptance of these precedents. A favorable decision by EPA could make movement of the contaminated waste from NOS feasible. It is expected that the low density of this material will however increase its shipping costs above the other wastes.

Disposal at Other Military and Government Sites

As a first attempt to accomplish this task, letters of inquiry were sent to both Rock Island Arsenal and Huntsville Division of Corp of Engineers soliciting information regarding potential government disposal facilities. Copies of the letters are attached at the end of this Section. To date no replies have been received. Replies will be incorporated if received in time for the final report.

It is our understanding that prior to 1 October 1977, each service was responsible for management of its individual Conventional Ammunition requirements. On 1 October 1977 DOD assigned the Army as the Single Manager for Conventional Ammunition (SMCA). As the SMCA the Army assumed responsibility to procure, manufacture, and dispose of all ammunition, propellants and explosives for conventional weapons.

Approval for an Army installation to accomplish the work would have to be obtained from the Darcom Headquarters, Eisenhower Avenue, Washington, D.C. It is anticipated that Darcom, in addition to requiring funding to cover costs of the operation would solicit manpower spaces equivalent to the work to be performed.

Several Army Ammunition plants (load lines) and Army ammunition storage depots have the capability for either partial or total disposal of all the NOS wastes. Army Ammunition depots may be better candidates to accomplish the NOS work. Ammunition load lines report to the CG ARRCOM at Rock Island Arsenal. The load lines are manned by contract personnel and their numbers are very specifically tied to the mission workload of the installation. Demilitarization of munitions and/or energetic material, other than those generated as wastes or rejects from the production line, are not normally a mission of the load line. All except three of the Army Ammo depots report to the CG DESCOM located at Letterkenny Army Depot Chambersburg, PA. The depots are staffed with career civil servants and demilitarization/disposal of munitions and energetic materials is a regularly assigned mission of each depot. Three Army ammo depots, all formally Navy depots report to the CG ARRCOM. These depots have the assigned mission to manufacture munitions in addition to their ammo receipt, storage, issue and demilitarization mission. Two of these depots, McAllister and Crane, are staffed with civil servants and Hawthorne is operated by a contractor.

A point paper prepared by the Naval Audit Service has identified a number of facilities that would be capable of disposing of all or part of NOS ordnance waste. Among these facilities are:

Radford Arsenal - Virginia

Lone Star Arsenal - Texas
Pine Bluff Arsenal - Arkansas
Picittiny Arsenal - New Jersey
Western Area Demil Facility - Nevada
Louisiana Army Ammo Plant - Louisiana
Sunflower Army Ammo Plant - Kansas
Iowa Army Ammunition Plant - Iowa
Tooele Army Depot - Utah

Our review of available Army facilities for hazardous waste disposal disclosed that Savanna Army Depot, a sub-depot of Letterkenny Army Depot would be the best Army location to provide disposal services. Savanna has excellent material handling facilities, storage facilities and both the contaminated waste processor and explosive waste incinerator. We understand that these new facilities may not be fully workloaded and could accommodate the shippable NOS wastes. A wet scrubber would have to be added to the Savanna pollution control system to permit processing of the AP wastes. Shipping costs to move the entire 686 short tons of NOS wastes to Savanna would be \$81,658.

It is our understanding that NOS currently ships their end items ordnance generations to be demilitarized in the new deactivation furnace facility at Earle, NJ. It may be possible to either augment or modify the Earle facility to upgrade it to the "Explosive Waste Incinerator" standards. Additionally, wet scrubbing to permit handling of AP wastes must be added. This would permit disposal of a large portion of the NOS wastes in a relatively close Navy installation. Use of the Earle facility may also be enhanced if movement of the wastes would be accomplished using Navy barges. It is anticipated that the use of water transport would greatly minimize packaging requirements.

The following figures (XI-2 and XI-3) identify the Army ammunition plants (load lines), their geographic location and their EWI/CWP facilities for disposal of manufacturing wastes.

A small contaminated waste processor facility is under construction at Lexington/Blue Grass subdepot and should be available for operation in early 1984. A combination small CWP and EWI facility is also under construction at Savanna subdepot and is scheduled for completion in 1984.

Data sheets extracted from TM 0-1300-277 identify the location of the ARRCOM and DESCOM storage sites and their capability to demil/dispose of munitions and/or energetic material. This information has been included in the Appendix.

FACILITY INCINERATOR LOCATIONS

<u>INSTALLATION</u>	<u>LOCATION</u>	<u>CWP</u>	<u>EWI</u>
BADGER	BARABOO,WI	OPERABLE S.U.	—
IOWA	BURLINGTON, IA	OPERABLE L.U.	OPERABLE
KANSAS	PARSONS, KS	OPERABLE L.U.	OPERABLE
LEXINGTON BLUE GRASS	LEXINGTON, KY	S.U. UNDER CONST.	—
LOUISIANA	SHREVEPORT, LA	—	OPERABLE
MISSISSIPPI	PICAYUNE, MS	S.U. UNDER CONST.	—
SUNFLOWER	LAWRENCE, KS	L.U. UNDER CONST.	—
SAVANNA	SAVANNA, IL	S.U. UNDER CONST.	EWI UNDER CONST.

FIGURE XI-2

FACILITY INCINERATOR LOCATIONS

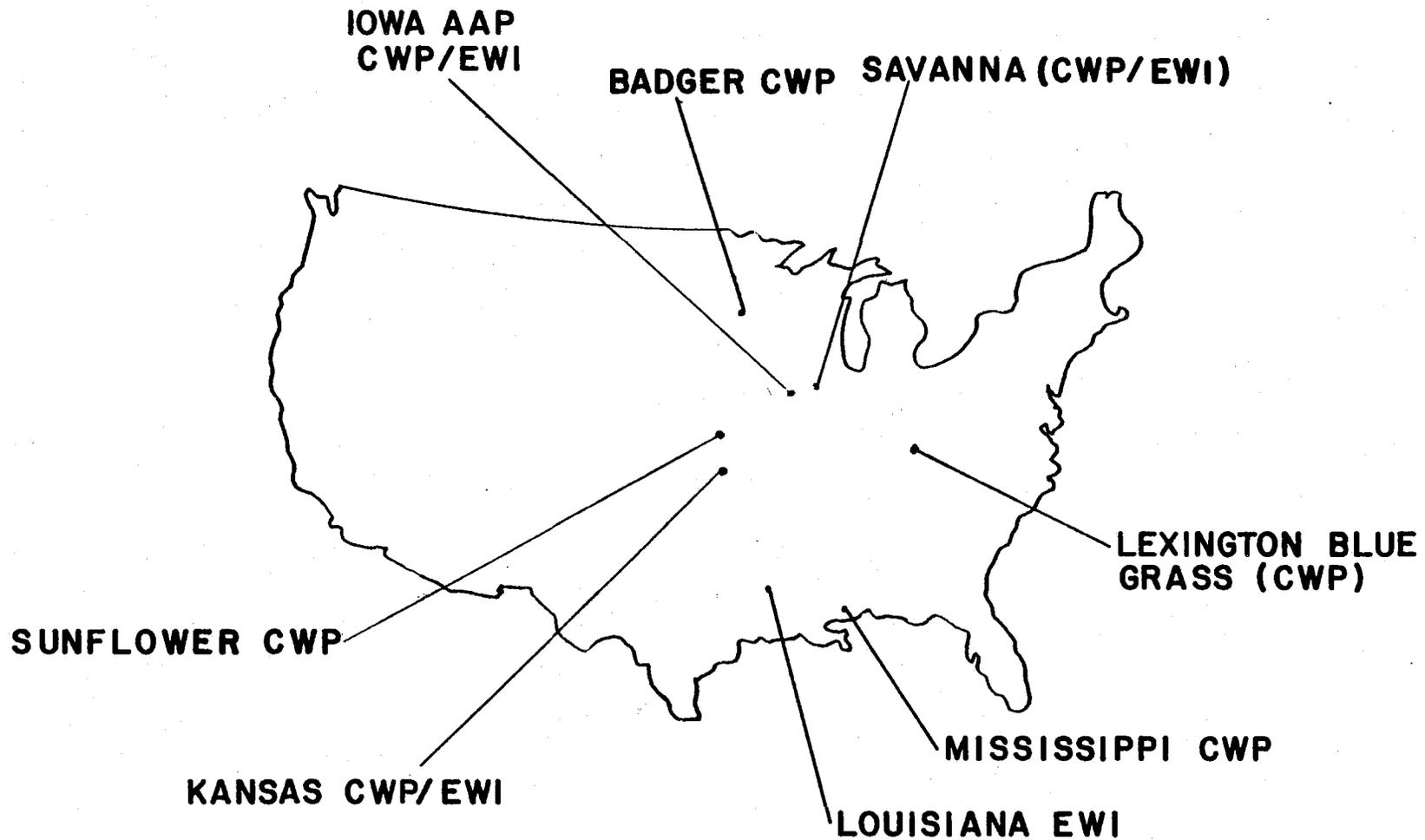


FIGURE XI-3

Conclusion Regarding Off-Site Disposal at Military or Government Sites

1. There are several Army installations with capability for disposing of most NOS wastes in an environmentally acceptable manner. None of the Army facilities have wet scrubbing equipment in their pollution control systems required for control of halogens when processing AP wastes.
2. Sorting, preparing and packaging of NOS wastes for off-post shipment would require additional operating personnel and result in higher operating costs.
3. All wastes could not be shipped off-post, therefore, some disposal capability would have to be maintained at NOS.
4. Use of Army disposal facilities would be expensive because of shipping costs and operating charges. Army personnel contacted also indicated the possibility that personnel spaces would have to be provided in order for the Army to provide this service.
5. The cardinal safety rule in handling energetic material is to use the least number of people with the least number of operations for the shortest possible time. Packing, storing, and shipping wastes is counter to this time-proven safety rule.

Private Industry Sites and/or Companies

In addition to government sites for disposal, private industry was searched for companies capable of handling a portion of the NOS waste. In the opinion of several companies contacted the technology exists for the disposal of waste propellant from the NOS. Based upon the attached telephone logs, it appears that at least three companies would be capable of off site disposal of some of the materials. These three possibilities are as follows:

- (1) SCA Chemical Waste Services of Boston, Massachusetts at their Chicago, Illinois incinerator;
- (2) Energy Systems Company (ENSCO) of Little Rock, Arkansas at their incinerator in El Dorado, Arkansas; and
- (3) Rollins Environmental Services, Inc. of Wilmington, Delaware at their incinerator in Baton Rouge, Louisiana; Houston, Texas; or Bridgeport, New Jersey.
- (4) Hercules, Inc. since they serve as operating contractor at several previously listed Army

ammunition plants this may be a duplication of previous government facilities.

While off site disposal by private industry is technically possible, it does not appear to be without significant obstacles. The minimum requirements which would have to be fulfilled, are as follows:

The companies indicated that they would first have to conduct trial burns at the Navy's expense, in order to obtain the necessary data for bidding on a yearly disposal charge. The waste propellant would have to be packaged in combustible containers that would be fed into the rotary kiln incinerator and shipped in accordance with D.O.T. regulations as discussed previously. The size of the combustible containers would have to be determined by the trial burn. The trial burn would have to be fully instrumented and witnessed by an independent inspection team (The independent inspection team would verify the results for EPA.) in order to gather necessary data for bidding and obtaining a permit. Even before bidding on the cost for trial burns, samples and an analysis of each type of propellant would have to be provided to the company. There is the possibility that some of the composite propellants might be incompatible with the refractory lining of the incinerator. A bunker at the site for storage prior to disposal would probably be required. Transportation and packaging costs would approximate these previously discussed for government sites.

From the government's standpoint the requirements would be as discussed below. The following guidelines apply to the Army and it is presumed the Navy would be required to follow similar procedures. The following guidelines were excerpted from a report prepared by a blue ribbon panel under the direction of DARCOM in September 1982.

Present guidelines stipulate that the Army pay the outloading and shipping cost to the contractor's plant at which point the contractor would assume responsibility for downloading. Final determination for transportation costs would be as agreed to by the government and the contractor and would be specified in the contract for sale.

Pre-award surveys would be required to evaluate the adequacy of the contractor's processes and demil equipment. A pre-award survey review board would be established to review and approve/disapprove pre-award survey reports. A pre-award survey monitor would be the designated person at the sales office who would administer the pre-award survey. A team coordinator would coordinate a pre-award survey, make arrangements for plant visits, and conduct team conferences.

As a minimum, one on-site inspector to certify that the ammunition had actually been demilitarized would be required at

each demil site. Depending on the specific operation, additional government inspectors may be required to provide adequate site or shift coverage.

One factor of great importance with regard to private contractors is that of liability. A memorandum from the ARRCOM General Counsel Office, dated 17 February 1982, concerns the legal implications of off-post demilitarization. The question addressed in the memorandum is, "What is the best contract format to be used in off-post demilitarization for ammunition in order to limit government liability arising from potential accidents?" In summary, the memorandum recognizes the infinite number of possibilities where the government might be held liable in an off-post demil situation and gives rise to the wide spectrum of the government liability problem. Cited as examples are instances where the contractor actually became a de facto agent of the government (making the government equally liable for negligent acts as the contractor), and where the contractor was found liable for injuries incurred during demil even with government supervision. The memorandum contends that there are three major options available to the government when contracting demil operations.

- a. All-in: The government provides demil procedures, supervisory and inspection personnel at the contractor's facility, and takes every safety measure to prevent an accident.
- b. All-out: The government avoids as much involvement in performing the contract as possible, with the exception of providing appropriate personnel to certify demil.
- c. In-between: The government consents to perform certain functions, i.e., pre-award surveys, providing some data concerning the ammunition items, etc.

The "All-out" option may appear to be the best for the government in that it limits avenues for government liability. In other words, the government's legal liability for accidents may be reduced due to the fact that the government essentially turns over the ammunition and allows the demil, using contractor developed methods with no government control.

It must be noted, however, that in reality the government is rarely in a position, with a contracted sale, of no liability and that it is virtually impossible to contract away all liability in advance.

D. Permits and Five Year Projection

As part of this task the ability of each potential disposal site (either government or private) to continue to operate in the foreseeable future (5 years) and obtain a Part B permit when required was to be evaluated.

Several potential government sites for disposal of the NOS wastes have been analyzed for their ability to be able to continue disposal over the next five-year period. This in essence is the site's ability to obtain a Part B permit (if requested) to operate their facility. Of the sites now disposing their own wastes, the incineration systems can be broken down into three basic types and likelihood of permitting in the future compared.

1. Air Curtain Incinerator - Radford is now operating an air curtain incinerator to dispose of the contaminated wastes. This method cannot meet air quality standard for a Part B permit and will be forced to shut down when the Part B is requested.
2. Contaminated Waste Processor (CWP) - Currently there are five CWP units either completed or under construction at the locations listed in the chart below. The CWP has been designed to comply with all requirements for the Part B permit. However, EPA's Region 4 and 7 and the state of Wisconsin have all ruled that the contaminated wastes to be disposed of in the CWP are not hazardous wastes. They have been defined as municipal wastes and therefore, the permits were not required in order to construct and operate. These 5 CWP sites will be able to dispose of contaminated wastes over the next 5 years.
3. Explosive Waste Incinerators (EWI) - There are operable EWI units at the three sites listed in the chart below. The EWI has been designed to comply with all areas required in order to get a Part B permit for the facility.

<u>Army Ammo Plant</u>	<u>Location</u>	<u>CWP</u>	<u>EWI</u>
Badger	Baraboo, WI	Operable, Small Unit	---
Iowa	Burlington, IA	Operable Large Unit	Operable
Kansas	Parson, KS	Operable Large Unit	Operable
Louisiana	Shreveport, LA	---	Operable

<u>Army Ammo Plant</u>	<u>Location</u>	<u>CWP</u>	<u>EWI</u>
Mississippi	Picayune, MS	Under Const. Small Unit	---
Sunflower	Lawrence, KS	Under Const. Large Unit	---

Conclusions and Recommendations

1. Transporting wastes off site for disposal with a few exceptions appears to be unfeasible from a preparation and transportation cost standpoint.
2. Potential liability when using private industry would also be a serious drawback.
3. A more cost effective approach would be to construct additional size reduction facilities and disposal facilities at NOS to dispose of many of the wastes, and dispose of the few off site which can be transported and disposed of economically. These new facility options are fully discussed in Section X.
4. The Navy should solicit EPA Region III approval of the Region IV precedent established on contaminated wastes.
5. The feasibility of upgrading the Earle deactivation furnace should be determined. The suitability of the wet scrubber available from the FBI for use on the Earle furnace should also be determined.
6. Barge movement of NOS wastes to Earle should be investigated.
7. The Navy should officially query the Army (DARCOM) about the availability of Army disposal facilities.
8. Non contaminated liquid wastes such as solvents should be transferred to the custody of the Defense Logistics Agency as disposal of these wastes are their responsibility. If, however, the liquid cannot be certified as being free of explosive or propellant ingredients, they can be disposed of through the DLA.

LETTERS OF INQUIRY

EL DORADO ENGINEERING INC.

HAZARDOUS WASTE SPECIALISTS

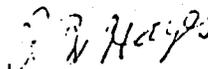
June 22, 1983

Mr. Herman Baren (DRSAR-MAD)
U.S. Army Armament Materiel Readiness Command
Rock Island Arsenal
Rock Island, Illinois 61201

Dear Mr. Baren:

El Dorado Engineering is currently performing as a subcontractor to Booker and Associates to provide a study to the Navy addressing their propellant and explosive disposal facilities. Part of this contract provides for our investigating off-site disposal services within other government agencies. Are you aware of any facilities which you believe could provide a disposal service for the propellant and explosive wastes currently generated at Indianhead? If there is significant interest, we would gladly provide details as to the type and quantities of material for which disposal services may be desired.

Sincerely,



RALPH W. HAYES
President

RWH/gh

EL DORADO ENGINEERING INC.

HAZARDOUS WASTE SPECIALISTS

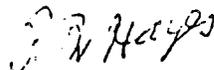
June 22, 1983

Mr. Jerry Gregg
Department of the Army
Huntsville Division Corps of Engineers
P.O. Box 1600 West Station
Huntsville, AL 35807

Dear Mr. Gregg:

El Dorado Engineering is currently performing as a subcontractor to Booker and Associates to provide a study to the Navy addressing their propellant and explosive disposal facilities. Part of this contract provides for our investigating off-site disposal services within other government agencies. Are you aware of any facilities which you believe could provide a disposal service for the propellant and explosive wastes currently generated at Indianhead? If there is significant interest, we would gladly provide details as to the type and quantities of material for which disposal services may be desired.

Sincerely,



RALPH W. HAYES
President

RWH/gh

TELEPHONE LOGS

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

TELEPHONE LOG

Project No: E-2278

Date: MAY 27, 1983

Project Name: ORDNANCE DISPOSAL STUDY

Time: 11:00 AM/PM

From/To Company: JOHN ZINC

City, State: TULSA, OKLAHOMA

Individual's Name: DR. JOHN CEGIELSKI

Phone No. (area code): (918)-777-1371

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:
DR. CEGIELSKI SAID THAT THE TECHNOLOGY PRESENTLY
EXISTS FOR THE INCINERATION OF WASTE PROPELLANTS
FROM INDIAN HEAD. HE POINTED OUT THAT THE ROTARY
KILN INCINERATOR WOULD BE THE BEST WAY TO
ACHIEVE THIS. HOWEVER, HE WENT ON TO POINT OUT THAT
HE FELT TRANSPORTATION PROBLEMS WOULD PRECLUDE
OFF BASE DISPOSAL. TRANSPORTATION IN ACCORDANCE WITH
D.O.T. REGULATIONS WOULD BE VERY EXPENSIVE. FURTHERMORE,
HE FELT THAT IT WOULD BE POLITICALLY UNTENABLE
TO TRANSPORT THE MATERIAL FOR OFF BASE DISPOSAL.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Kinell

Note: Please complete each item on this form.

TELEPHONE LOG

Project No: E-2278 Date: MAY 31, 1983

Project Name: ORDNANCE DISPOSAL STUDY Time: 2:15 ~~AM~~ PM

From/To Company: MITRE CORP

City, State: McLENN, VA.

Individual's Name: GREG VOGEL

Phone No. (area code): (703)-827-6000

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:
MR. VOGEL SAID THAT THE TECHNOLOGY EXISTS FOR THE
INCINERATION OF WASTE PROPELLANTS FROM INDIAN HEAD,
BUT HE FELT THAT IT WOULDN'T BE PRACTICAL TO
DISPOSE OF THEM OFF BASE. TRANSPORTATION FOR
OFF BASE DISPOSAL IN ACCORDANCE WITH D.O.T.
REGULATIONS WOULD BE VERY EXPENSIVE. IN ADDITION,
HE FELT THAT IT WOULD BE POLITICALLY UNTENABLE
TO TRANSPORT THE MATERIAL FOR OFF BASE DISPOSAL.
TRANSPORTATION OF THE MATERIAL WOULD BE MORE
HAZARDOUS THAN CONTINUING TO OPEN BURN IT.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Knapp

Note: Please complete each item on this form.



Distribution: _____

TELEPHONE LOG

Project No: E-2278 Date: JUNE 7, 1983

Project Name: ORDNANCE DISPOSAL STUDY Time: 10:30 AM/PM

From/To Company: U.S. DEPARTMENT OF TRANSPORTATION

City, State: JEFFERSON CITY, MO.

Individual's Name: BARBRA SPESSARD

Phone No. (area code): (314) 636-7107

Subject Discussed: D.O.T. REGULATIONS GOVERNING TRANSPORTATION

OF HAZARDOUS WASTES FROM INDIAN HEAD ORDNANCE

FOR OFF BASE DISPOSAL — 49 CFR

PARTS 100-199 GOVERN. THE NAVY SHOULD

IDENTIFY WHERE THE VARIOUS WASTES FALL

IN TABLE 172.101 OF SECTION 172 OF

49 CFR SINCE THEY ARE FAMILIAR WITH THE

VARIOUS CHEMICAL COMPOSITIONS. THIS WOULD THEN

GOVERN HOW THEY WOULD HAVE TO BE TRANSPORTED

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Kraft

Note: Please complete each item on this form.

TELEPHONE LOG

Project No: E-2278 Date: JUNE 15, 1983

Project Name: ORDNANCE DISPOSAL STUDY Time: 9:30 AM/~~PM~~

From/To Company: SCA SERVICES

City, State: BOSTON, MASS.

Individual's Name: MR. BOYLAND

Phone No. (area code): (617)-367-8300 EXT 605

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:

MR. BOYLAND SAID THAT THE TECHNOLOGY EXISTS AND THAT HIS COMPANY
AND TWO OTHERS (ENSCO LOCATED AT LITTLE ROCK, ARK AND ROLLINS
LOCATED IN DEL) POTENTIALLY COULD DISPOSE OF WASTES FROM INDIAN
HEAD. HOWEVER, ONE OF THE COMPANIES WOULD FIRST HAVE TO CONDUCT A
TRIAL BURN, AT THE NAVY'S EXPENSE, IN ORDER TO OBTAIN THE NECESSARY DATA
FOR BIDDING ON A YEARLY DISPOSAL CHARGE. THE WASTE PROPELLANT WOULD HAVE
TO BE PACKAGED IN COMBUSTIBLE CONTAINERS THAT WOULD BE FED INTO THE
INCINERATORS. TRIAL BURN WOULD HAVE TO BE FULLY INSTRUMENTED AND
WITNESSED BY AN INDEPENDENT INSPECTION TEAM. THE NAVY WOULD HAVE TO
PROVIDE SAMPLES AND AN ANALYSIS OF EACH TYPE OF PROPELLANT PRIOR TO THE TRIAL
BURN. PERMANENT DISPOSAL WOULD PROBABLY REQUIRE A BURNER AT THE SITE.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Knoff

Note: Please complete each item on this form.

TELEPHONE LOG

Project No: E-2278 Date: JULY 7, 1983

Project Name: ORDNANCE DISPOSAL STUDY Time: 1:30 AM/PM

From/To Company: ROLLINS ENVIRONMENTAL SERVICES, INC.

City, State: WILMINGTON, DEL.

Individual's Name: MR. BRYAN TRAYNOR

Phone No. (area code): (302)-729-2700

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:

MR. TRAYNOR SAID THAT HIS COMPANY COULD POSSIBLY
DISPOSE OF WASTES FROM INDIAN HEAD. THEY HAVE THREE
ROTARY KILN INCINERATORS LOCATED IN BATON ROUGE, LA.,
HOUSTON, TEXAS, AND BRIDGEPORT, N. J. BEFORE PRECEDING
ANY FURTHER, THEY WOULD REQUIRE A COMPLETE DESCRIPTION
AND CHEMICAL ANALYSIS OF ALL THE MATERIALS FROM THE
NAVY. HE SAID THAT HE WOULD SEND ME A COPY OF
THE QUESTIONNAIRE THAT WOULD HAVE TO BE FILLED OUT.
HE ACKNOWLEDGED THAT SCA SERVICES AT THEIR CHICAGO INCINERATOR
AND ENSCO AT THEIR LITTLE ROCK, ARK INCINERATOR COULD ALSO
POTENTIALLY HANDLE THE HAZARDOUS WASTE FROM INDIAN HEAD.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Knoff
RB

Note: Please complete each item on this form.

TELEPHONE LOG

Project No: E-2278

Date: JULY 12, 1983

Project Name: ORDNANCE DISPOSAL STUDY

Time: 10:30 AM/PM

From/To Company: SCA SERVICES

City, State: BOSTON, MASS.

Individual's Name: MR. BOYLAND

Phone No. (area code): (617)-367-8300 EXT 605

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:
MR. BOYLAND SAID THAT SCA SERVICES WOULD UTILIZE
ITS CHICAGO INCINERATOR FOR POSSIBLE DISPOSAL OF
WASTE PROPELLANTS FROM INDIAN HEAD. HE REITERATED
THAT SCA WOULD HAVE TO HAVE SAMPLES AND AN
ANALYSIS OF EACH TYPE OF PROPELLANT PRIOR TO THE TRIAL
BURN. THE POSSIBILITY EXISTS THAT SOME OF THE COMPOSITE
PROPELLANTS MIGHT DAMAGE THE REFRACTORY LINING OF THE
ROTARY KILN INCINERATOR. HE REITERATED THAT SCA SERVICES
WOULD BE VERY HAPPY TO MEET WITH BOOKER AND THE
NAVY AT INDIAN HEAD TO FURTHER DISCUSS THE MATTER AND INVITED
BOOKER AND THE NAVY TO INSPECT SCA SERVICES' CHICAGO INCINERATOR.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Unoff

Note: Please complete each item on this form.

XII. Open Burning Option

XII. OPEN BURNING OPTION

General. To this date, ordnance related waste at NOS continues to be disposed of by open burning. Three burning sites are used within the boundaries of NOS. Pyrotechnics are open burned at a site located west of Strauss Avenue, propellants at a site at the south of Strauss Avenue, and explosive contaminated waste material, such as shipping containers, are decontaminated by open burning at a site at the south end of Coffee Road. This is an extremely cost effective operation when compared to other methods of disposal. According to documents reviewed, the open burning grounds can be operated by two ordnance workers with part time supervision.

This has been permitted under current regulations of Maryland Department of Health and Mental Hygiene, Bureau of Air Quality and Noise Control, Regulation 10.03.35.010 which permits open burning of hazardous material where no other safe means of disposing of them exists. NOS currently operates under a facilities permit, Permit Number A 223, with an effective date of April 30, 1982 and an expiration date of April 29, 1985 issued by the State of Maryland Department of Health and Mental Hygiene. NOS has written and requested that the Charles County Health Department, serving as Public Officer, issue written permission to NOS to open burn waste munitions, but no replies have been received to date.

As defined in the Scope of Work for this project, this Task consists of examination of current air pollution regulations regarding open burning of propellant and explosives, a study of proposed draft regulations, and a judgment on how long open burning is likely to be permitted.

A. Current Air Pollution Regulations

Regarding open burning of hazardous material, Title 10 - Maryland Department of Health and Mental Hygiene, State Environmental Health Administration, Bureau of Air Quality and Noise Control (amended January 12, 1977) Regulation 10.18.07.01A, states: "'Hazardous Material' shall mean those substances (such as some types of explosives) which are dangerous and should be destroyed by open burning under controlled conditions when it has been established that disposal by land filling or burning in an incinerator perpetuates or increases the danger involved." The waste munitions generated at NOS fit the above described definition of a hazardous waste.

Maryland Air Pollution Regulation 10.18.01, governing the control of air pollution in state Area V (which includes Charles County where NOS is situated), gives the authority of granting permission to open burn to the Public Officer. Maryland Air Pollution Regulation 10.18.07.04B(3) states that the "Public Officer may authorize certain fires. Public Officers, in the performance of their official duties, may set an open fire or give permission for an open fire, with concurrence of the Control Officer, provided all reasonable means are employed to minimize smoke if the fire is necessary for one or more of the following reasons or purposes.

- (1) For the prevention of a fire hazard that cannot be abated by other means.
- (2) For the instruction of public fire fighters or industrial employees under the supervision of the appropriate fire control official.
- (3) For the protection of public health or safety when other means for disposing of hazardous materials are not available."

A letter dated August 4, 1977 from the Naval Facilities Engineering Command requested that the Charles County Health Department, serving as the Public Officer, provide NOS written permission to open burn waste munitions, specifically listed since burning this type of material complies with requirements listed in Maryland Air Pollution Regulation 10.18.07.04B(3). NOS has received no official reply to this letter.

The basis for this request was the opinion that disposal of explosives and explosive contaminated material by open burning is a necessary and acceptable practice at this time and that this open burning of propellants does not violate any air pollution laws or regulations. The Environmental Protection Agency (EPA) had previously stated that until such time as technology exists to dispose of waste munitions and explosive contaminated waste by an alternative method that "open burning is permissible without violating existing air pollution regulations." EPA recommended that NOS coordinate their open burning program with the local responsible agency (the Charles County Health Department).

NOS was subsequently issued Designated Hazardous Substances Facilities Permit A 223 to operate and maintain a thermal treatment and storage facility. This permit expires April 29, 1985. This permit was issued by the State of Maryland, Department of Health and Mental Hygiene.

New regulations (or amendments to existing regulations) have been in the preparation stage for some time and were expected to be published in June or July of 1983. It was suspected that these might have an effect on the NOS open burning grounds, especially in the area of tighter control on allowable ground water and adjacent surface water contamination or discharge. These regulations have not been released.

To determine their status, Mark Turgen of EPA was contacted by telephone. A copy of the telephone log is included in the Appendix. Mr. Turgen indicated that new requirements will be issued as Subpart X of 40CFR part 264. Subpart X will deal with one of a kind or special facilities which would probably be interpreted to include open burning of propellants and explosives. The actual requirements will be very general generic environmental goals. They may indicate only that no detrimental effects on groundwater or adjacent waters shall take place. The specific requirements would be up to negotiation with the individual States or EPA regions or their designated officials (such as Charles County). To summarize, these draft regulations do not appear to greatly affect the status quo at NOS.

B. Background and History

Historically, nearly all DOD PEP (Propellants, Explosives and Pyrotechnics) wastes, and obsolete munitions and PEP contaminated materials were open burned or open air detonated at military ordnance and ammunition facilities. Public sentiment emerged against the practice primarily from the blast wave produced during large scale detonations. This sentiment and the realization of the economics of recovery for some of the materials being lost by burning, prompted the development of early alternatives to this practice for selected items.

Alternatives developed included washout/steamout plants to recover explosive from bombs and large projectiles, deactivation or popping furnances to recover brass and other metals from small arms and other small items. These early alternatives more than paid for themselves and their operation by the sale of the recovered materials. This economic consideration for the development of alternatives prevailed from the time of these early developments in the 50's to the latter 60's and early 70's. At that time, environmental awareness grew, environmental protection became a popular theme and new regulations were developed, such as the Clean Air Act of 1970, water pollution and air pollution controls were required on the earlier developed alternatives and thus, they no longer were economical to build or operate.

These early alternatives to open burning only diverted a small portion of the waste streams being burned or detonated and the practice continued on a larger scale. With a new environmental awareness, there became calls for the elimination of open burning and open air detonation entirely.

Unfortunately, it was only assumed that this practice was a major air pollutor and no data was brought forth as evidence of the amount or the kind of pollution. In fact, two reports, "Pollution From Open Air Detonation" by Ralph Hayes in 1971, and "Open Air Detonation of TNT" by Hodges and Hayes in 1980, provide evidence that the actual pollution of air by open detonation is very minor. Both of these papers are attached in their entirety in the Appendix as they may be useful in providing arguments for the continuation of open burning and open air detonation. This glaring lack of evidence to support justification for stoppage of open burning and detonations for the most part still exists.

Anticipating regulatory requirements, many branches within the Department of Defense began to develop alternatives to open burning and open air detonation. These developments include:

1. Fluidized Bed Incineration
2. Wet Air Oxidation
3. Rotary Kiln (Wet Slurry)
4. Explosive Waste Incinerator (EWI) and Rotary Kiln Dry System
5. Air Curtain Destructors
6. Contaminated Waste Processors (modified car bottom incinerators)

The development of these technologies was a very formidable task when one considers the size reduction requirements and combustion control of such a broad range of energetic materials as they exist in a broad spectrum of configurations.

It was during this time period that Public Law 94-580k known as the Resource Recycle and Recovery Act was passed and became law. This instigated the promulgation of the Hazardous Waste Regulations. Initial drafts of these regulations banned all open burning.

This created a severe problem for DOD. In order to comply with this ban, there were tremendous technical, economic and time constraint problems that needed to be overcome. Each branch of the service began to attack these problems. Also, a joint services panel, JCAP (Joint Conventional Ammunition Panel) was tasked to review the EPA draft regulations and provide official DOD comment. A specific group was organized and so tasked.

In 1978, the EPA contracted with the American Defense Preparedness Association to prepare a publication in the Environmental Technology Series entitled "State of the Art Study - Demilitarization of Conventional Munitions". This became an EPA publication. The conclusions of this study are still valid today. Excerpts are given as follows:

"Detonation

This is a simple, safe and cost effective process for demilitarization of many munitions which are obsolete, or unsafe to handle otherwise. No additional energy consumption is involved. The quantities involved are small when compared with the commercial blasting industry (over one million tons/ year). Use of this process will always be required to a certain degree.

Until the same environmental criteria are applied to the use of explosives in the commercial blasting industry, there is no reasonable basis for criticism of demilitarization of obsolete or unsafe munitions by detonation. Principal products appear to be CO₂, H₂O and N₂, all of which are non-pollutants. Covering of the munitions by earth substantially reduces noise and particulates."

"Open Burning

This is also a simple, safe and cost effective process for demilitarization of munitions which are obsolete or unsafe to handle otherwise. Potentially adequate alternatives to open burning are under development, and their implementation will depend upon the relative balance among cost, energy implications, and environmental factors.

Alternatives to open burning are in various stages of development, and given sufficient funding, should provide adequate options for the elimination of the environmental problems associated with this process. These alternatives are reviewed in Section X of this report. Support of these development efforts by EPA funding is recommended, as well as more detailed evaluation of alternative processes."

In a thorough study of this problem, it became readily evident that the more imminent danger to life and property from this material was a result of its energetic properties, not air toxins from open burning. Technology to safely dispose of all of this material in other methods than open burning/detonation did not exist and prolonged storage would create unwarranted risk. The JCAP panel therefore recommended that EPA allow open burning of PEP materials where developed alternatives did not exist.

This recommendation became incorporated in the final regulations as 40 CFR 265.382, which states:

"Open burning of hazardous waste is prohibited except for the open burning and detonation of waste explosives. Waste explosives include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment. Detonation is an explosion in which chemical transformation passes through the material faster than the speed of sound (0.33 kilometers/ second at sea level). Owners or operators choosing to open burn or detonate waste explosives must do so in accordance with the following table and in a manner that does not threaten human health or the environment."

The State of Maryland similarly permits exemption of this PEP material. State of Maryland Air Regulation 10.18.07.03 states that the control officer may grant approval for open burning if the following conditions are met:

1. No practical alternative to open burning exists;
2. No hazardous, air pollution or nuisance condition will be created;
3. Fire control laws or regulations of other government agencies will not be violated;
4. Materials which produce dense smoke will not be burned; and
5. The material to be burned originates on the premises on which it is to be burned.

Responsible authorities at NOS have officially requested a concurrence by both EPA and the State of Maryland as to their interpretations of these regulations as they apply to Indian Head PEP materials. Both agencies agree with the Indian Head position that they are allowed to continue with open burning. NOS currently enjoys an Hazardous Waste Disposal permit through April 29, 1985.

C. Alternatives to Open Burning/Likelihood That It Will Be Banned

Only two possibilities exist, therefore, that could cause the banning of open burning at Indian Head. These are:

1. New laws are passed.
2. New technology development cause practical alternatives other than open burning to exist.

The possibility of new laws banning open burning of this material is considerably unlikely. Logic dictates that unless alternatives exist to safely accomplish an alternative, that risk of life and property far outweigh any advantages to elimination of open burning. As reported previously, the latest upcoming drafts do not seem to greatly affect the status quo.

New technology advancements and development will be realized for practical alternatives. It is considered highly unlikely, however, that a single universal system will ever be developed that can totally replace open burning. It may also be that open burning can never be totally replaced. Practical alternatives are, however, being developed for a significant portion of the open burning workload. It is our opinion that the quantities now being open burned at NOS can be reduced and will be required to be reduced over the next few years.

The open burning permit indicates that 517,000 lbs. of contaminated waste are burned each year. The Army Corps of Engineers at Huntsville has recently developed, fielded and tested a modified flashing furnace as a contaminated waste processor (CWP). Tests have demonstrated the ability of this unit to meet environmental standards. Fuel consumption is reasonable and only minimal preparation of feed stock is required. We would thus judge the unit to be practical. A more complete analysis of this unit as it applies to the NOS workload is described in Section X.

It is believed that in order to remain in compliance with the open burning permit, a program and plan should be underway for a CWP unit at NOS. This plan should be started by April 1985, the expiration date of the current open burning permit. Even more desirable would be to have a unit in operation if possible.

Alternatives for the disposal of bulk propellant and explosives include bringing into operation the wet air oxidation facility and fluidized bed facility partially completed at NOS or the use of an EWI (Explosive Waste Incinerator) or combination of these facilities. A comparison discussion of these units is described in Section X. All of these alternatives require some primary size reduction of the feed materials, however. Therefore, a practical alternative does not now exist for all items.

Life Expectancy for Open Burning

In order to help predict the life expectancy of open burning at NOS, we sent inquiries to knowledgeable officials to gain their insight. Copies of this letter are attached.

Copies were sent to:

1. Ivan Tominac of OESO who served on the open burning subcommittee of JCAP and has coordinated very closely with us in respect to this matter specifically at NOS.
2. John Byrd, Chairman of the JCAP panel charged with review of RCRA. His panel provided official DOD comments to EPA.
3. Mark Turgon of EPA, who has knowledge of the specific NOS operation and permit. (Mr. Turgon was also contacted by telephone regarding newest draft regulations.
4. Colonel Daly, Director of Environmental Policy.

To date, only one reply has been received and a copy of this letter is included. Additional replies will be enclosed as they are received.

To summarize, the general feeling of those questioned is that open burning of propellant waste will continue to be allowed for the foreseeable future (at least five years).

LETTERS OF INQUIRY

EL DORADO ENGINEERING INC.

DESIGNERS/CONSULTANTS

April 22, 1983

Mr. Ivan L. Tominac
Commander
Ordnance Environmental Support Office (OESO)
Naval Ordnance Station
Indian Head, MD 20640

Dear Mr. Tominac:

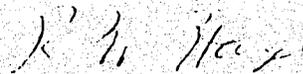
El Dorado Engineering, Inc. (EDE) has been awarded a contract by the Navy through Booker and Associates to evaluate the propellant disposal facility at Indian Head. A key issue that will affect our evaluation of proposed modifications to this facility is the length of time that the practice of open burning of propellant, explosive, and propellant and explosive contaminated materials will continue at Indian Head Naval Ordnance Station.

When the propellant disposal facility was designed, it appeared that EPA stoppage of all DOD open burning activity was imminent. However, as the JCAP panel and others in DOD worked with EPA, an exemption was granted for open burning of the subject material.

In order to estimate how long this open burning practice may continue, EDE is soliciting an opinion from yourself and others knowledgeable of the DOD/EPA relationship. Please provide us with your best opinion as to the future of open burning at Indian Head.

As we need this information early in our study, we respectfully request that you provide this opinion at your earliest convenience.

Sincerely,



RALPH W. HAYES
President

RWH/gh

EL DORADO ENGINEERING INC.

DESIGNERS/CONSULTANTS

April 22, 1983

Mr. John L. Byrd, Jr.
Defense Ammunition Center & School
SARAC-DO
Savanna, IL 61074

Dear Mr. Byrd:

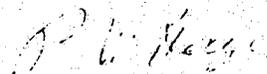
El Dorado Engineering, Inc. (EDE) has been awarded a contract by the Navy through Booker and Associates to evaluate the propellant disposal facility at Indian Head. A key issue that will affect our evaluation of proposed modifications to this facility is the length of time that the practice of open burning of propellant, explosive, and propellant and explosive contaminated materials will continue at Indian Head Naval Ordnance Station.

When the propellant disposal facility was designed, it appeared that EPA stoppage of all DOD open burning activity was imminent. However, as the JCAP panel and others in DOD worked with EPA, an exemption was granted for open burning of the subject material.

In order to estimate how long this open burning practice may continue, EDE is soliciting an opinion from yourself and others knowledgeable of the DOD/EPA relationship. Please provide us with your best opinion as to the future of open burning at Indian Head.

As we need this information early in our study, we respectfully request that you provide this opinion at your earliest convenience.

Sincerely,



RALPH W. HAYES
President

RWH/gh

EL DORADO ENGINEERING INC.

DESIGNERS/CONSULTANTS

April 22, 1983

Mr. Mark Turgon - EPA
WH-565A
401 M Street S.W.
Washington, D.C.

Dear Mr. Turgon:

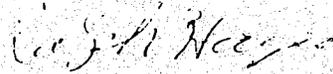
El Dorado Engineering, Inc. (EDI) has been awarded a contract by the Navy through Booker and Associates to evaluate the propellant disposal facility at Indian Head. A key issue that will affect our evaluation of proposed modifications to this facility is the length of time that the practice of open burning of propellant, explosive and propellant and explosive contaminated materials will continue at Indian Head Naval Ordnance Station.

When the propellant disposal facility was designed, it appeared that EPA stoppage of all DOD open burning activity was imminent. However, as the JCAP panel and others in DOD worked with EPA, an exemption was granted for open burning of the subject material.

In order to estimate how long this open burning practice may continue, EDE is soliciting an opinion from yourself and others knowledgeable of the DOD/EPA relationship. Please provide us with your best opinion as to the future of open burning at Indian Head.

As we need this information early in our study, we respectfully request that you provide this opinion at your earliest convenience.

Sincerely,


RALPH W. HAYES
President

RWH/gh

EL DORADO ENGINEERING INC.

DESIGNERS/CONSULTANTS

May 5, 1983

Colonel Daly
Director of Environmental Policy
OASD (MRA & L)
I/EP Rm. 3D 833
Pentagon
Washington, D.C. 20301

Dear Col. Daly:

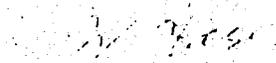
El Dorado Engineering, Inc. (EDE) has been awarded a contract by the Navy through Booker and Associates to evaluate the propellant disposal facility at Indian Head. A key issue that will affect our evaluation of proposed modifications to this facility is the length of time that the practice of open burning of propellant, explosive, and propellant and explosive contaminated materials will continue at Indian Head Naval Ordnance Station.

When the propellant disposal facility was designed, it appeared that EPA stoppage of all DOD open burning activity was imminent. However, as the JCAP panel and others in DOD worked with EPA, an exemption was granted for open burning of the subject material.

In order to estimate how long this open burning practice may continue, EDE is soliciting an opinion from yourself and others knowledgeable of the DOD/EPA relationship. Please provide us with your best opinion as to the future of open burning at Indian Head.

As we need this information early in our study, we respectfully request that you provide this opinion at your earliest convenience.

Sincerely,


RALPH W. HAYES
President

RWH/gh

REPLIES TO LETTERS OF INQUIRY

CODE (A)

PHONE NO (S)

Personnel:

- Crumpler (EPA)
- McTurgeon (EPA)
- Ivan Tominack (OES)
- Linda Lay, Pam Clements (OESO)

ORGANIZATION VISITED - ADDRESS

Environmental Protection Agency
Washington, D.C.

DATE (S) OF VISIT

3/23/81

PURPOSE (S)

- I. Open Burning Ordnance Waste
- II. Lithium Battery Incineration
- III. OESO Advice/Consultation to EPA

SUMMARY (Information obtained, evaluations made, conclusions reached, decisions made, commitments given, and/or action required.)

This OESO/EPA meeting was also designed to reestablish liaison developed during the open burning effort of some 18 months ago.

I. Background. The allowance for the open burning of ordnance waste under RCRA relieved some of the pressure for immediate installation of controlled incinerators. Some concern was expressed by Navy planners as to determining the expected life of the allowance.

Both EPA representatives indicated that the ordnance waste open burning issue had very low priority in EPA and unless some unexpected public outcry developed it would remain a low priority. Given the present administration posture very little new regulation is expected and then only after a thorough cost benefit analysis was conducted. Also, now that open burning is an approved method, it would be incumbent on the EPA to propose a proven alternate method. Given the present state-of-the-art available to both DoD and EPA, the development of a proven alternate method will be hard to come by.

Crumpler indicated that one of the major reasons for granting the allowance was the property damage likely to accrue the size reduction of large grains. (We toured them through the Building 720 saw bay that was severely damaged with the burning of a 110# grain and compared it to what might happen if a 4000 pound grain caught fire.)

Both Crumpler and Turgeon thought that similar contacts as OESO/EPA needed to be made at the state level.

In summary, the working level at EPA thinks that the open burning allowance is likely to continue for at least five years.

SIGNATURE (S) (Preparer's)
I. L. TOMINACK

DATE

APPROVAL (Division Head)

DATE

DISTRIBUTION

A/B, PM/TD, EN

NAVSEA (641, 04H(Holter))
NSWC/WO (Mueller, Fauth)

NEESA (Kneeling)

XIII. Alternate Uses For All Or Part Of The
PDF Facility

XIII. ALTERNATE USES FOR ALL OR PART OF THE PDF FACILITY

General

This Task involves an investigation of other possible end uses for the facility. This possibility would arise if it were determined that the facility could not be modified for use as intended. In order to approach this problem, a number of potential alternate uses were listed. This study was confined to non-mission or marginally related alternatives. It was not, for example, within the scope to examine the possibilities of manufacturing ordnance using these buildings with new equipment. The existing subsystems were evaluated for each alternate use. That is, whether or not they are usable as is, or whether they would require modification, or whether they would be needed. Also, a judgment was necessary as to whether there is a need for the proposed alternate use, and/or could the function be provided better by an existing facility. A table was prepared to evaluate each alternate which appeared to have any promise. For purposes of this study, the facility was divided into the following subsystems and the effect a proposed alternate use would have on each was examined.

1. Product Feed
2. Conveying and Grinding
3. Slurrying, Weighing, Pumping
4. Wet Air Oxidation System
5. Fluidized Bed Incinerator System
6. Water Treatment Systems
7. Utilities - Steam, Air, Water
8. Process Controls
9. Basic Building Configuration

Summary and Conclusions

Our results indicate that only one alternate use examined has a positive payback within an estimated 10 year equipment life. That use is silver recovery from x-ray and photographic plate and the fixer solution. The current estimated availability of film for recovery would occupy the WAO unit for only approximately one month per year. It would, therefore, be a good "fill in" use but could not be justified as the only use for the WAO unit.

Due to the high energy material and labor costs involved in operating the FBI and WAO units (which were taken from documents supplied to us by CHESDIV) all other uses studied in detail would result in higher disposal costs for the particular material (sludge, trash, etc) than current disposal costs.

It is possible that other uses would be worthwhile, such as destruction of hazardous chemicals, but these materials are not generated on NOS and would have to be solicited from elsewhere. Thus, the availability and cost were too uncertain to analyze in detail.

Survey of Potential Wastes for Disposal or Recovery

One of the reasons for originally selecting the WAO and FBI systems was that they appeared to be capable of being used for a number of different purposes.

The Propellant Disposal Facility Phase I Summary Report 1 HMR 72-185, 15 June 1972, suggests alternate uses for disposal equipment. These are listed in the following page.

Alternate Uses for Major Equipment

<u>WAO</u>	<u>FBI</u>
1. Sludge Disposal	1. Sludge Disposal
2. Silver Recovery	2. Metal Decarburization
3. Destruction of Classified Documents and Film	3. Destruction of Classified Documents and Film
4. Chemicals Disposal such as Lab Solvents, Tear Gas, Cyano Components	4. Chemicals Disposal such as Lab Solvents, Tear Gas, Cyano Components
	5. Destruction of Pesticides and Herbicides

Some of these wastes are likely to exist at NOS and others are not.

Potential alternate uses for parts or all of facility utilizing waste materials generated on site are:

1. Disposal of solid wastes not contaminated by propellants or explosives - boxes, boards, plastic containers, fiber drums, etc.
2. Recovery of silver from photographic or x-ray film.
3. Thermal destruction of sewage sludge or industrial sludge.
4. Steam generation to supplement other NOS generating capacity.
5. Wastewater treatment of other NOS waste streams.

Possible uses of the WAO and/or the FBI facility to handle materials obtained from commercial sources are (Ref. 1 - see page XIII-22).

1. Reduction of complex organic wastes to simpler compounds such as acetic acid, ethanol, methanol, and propionic acid, which are biologically treatable. Sulfur, chlorine and nitrogen contained in the feed waste is kept in the aqueous phase as sulfuric acid, nitric acid, hydrochloric acid, which are recoverable. These products may produce acid rain if produced during open burning.

Typical wastes are:

- a. Cyanide, chromate, and chlorinated compounds
 - b. Electroplating copper solution
 - c. Paint manufacturing wastes
 - d. PCB containing wastes
 - e. Metal grinding sludges
2. Recovery of valuable metals contained in inorganic compounds such as silver, tin and chrome.
 3. Purification of materials by oxidizing the impurities, regeneration of spent slurries of powdered activated carbon for waste water treatment.
 4. Destruction of toxic wastes listed by EPA as top priority for elimination (Ref. 2), such as benzidine, aldrin/dieldrin, DDT, endrine, toxaphene.

In general, the WAO facility is suitable for treatment of wastes having a concentration of oxidizables between 1.5 and 20 percent, depending on the COD. Concentrations in excess of 20 percent could generate sufficient heat to cause high rates of boil-off. The more concentrated wastes should be disposed of in the fluidized bed incinerator. Highly corrosive wastes should be disposed of in the fluidized bed incinerator since it is operated at pressures much lower than the WAO unit, making it more safe in case of component rupture.

Evaluation of Potential Uses

In order to preliminarily evaluate potential alternate uses, the following forms were filled out. From this initial evaluation, the more promising ones could be analyzed in further detail.

Ordnance Disposal Study
NOS Indian Head, Maryland

ALTERNATE USE Silver Recovery

- A. Brief Description: Would consist of using wet air oxidation unit for thermal destruction of x-ray and photographic film and fixer, and recovery of silver.
-
- B. Impact on Individual Subsystem:
1. Product Feed: Since quantity distance requirements would not apply, feed of film could be closer to WAO building. Therefore, existing loading hopper would not be used as is. If reused, would have to be moved.
 2. Conveying and Grinding: Grinding of film and transportation to slurring tanks would still be necessary. However, could more efficiently be carried out nearer to WAO. Perhaps all could be adjacent to current slurring building.
 3. Slurring, Weighing, Pumping: Pilot testing indicated ground film was extremely difficult to pump. Feed should be minimum of 10 gpm (which currently exists) and piped velocities no less than 3-4 feet per second.
 4. Wet Air Oxidation System: Existing system operates at 572°F and 2400 psi. Pilot testing was performed at 610°F and 3000 psi. Unit may be generally usable as is but additional testing would be required.
 5. Fluidized Bed Incinerator: N/A. Silver ash would be mixed with entrained bed material, complicating the silver recovery process.
 6. Water Treatment System: Oxidized slurry different from current design. Recovery of silver from oxidized slurry required.
 7. Utilities-Steam, Air, Water: Utilities would be essentially usable as is.
 8. Process Controls: Controls would be essentially usable as is. Additional controls for modified grinding, slurring, and feed would be necessary.
 9. Basic Building Configuration: If unloading, grinding, slurring and feed were simplified and located close to process, some building modifications would be required. A dryer to remove water from the silver sulfide sludge or residue should be installed.

C. Is there a need for the proposed alternate? Yes, depending on quantity of film produced.

D. Is there a source of input material? Yes, from x-ray film waste produced.

E. Can residue, if any, be disposed of? To be sent to silver refinery.

F. Could other parts or buildings be used for other purposes? Yes.

G. Summary of Advantages and Disadvantages and Remarks.

The amount of silver recoverable is estimated at 2 ounces per 100 sq. ft. of film, including the amount of fixer to develop 100 sq. ft. (Ref. 3). The cost of refining the silver sludge produced in the WAO unit is estimated at \$0.70 per 100 sq. ft. film and fixer with 97 percent of the silver returned to NAVORDSTA. Considering a silver value of \$10.00 per ounce, \$20.00 could be recovered for the cost of less than \$1.00. This refining cost, however, necessitates the use of a dryer to produce a dry residue. A component of the refining cost is based upon the weight of residue as received.

Ordinance Disposal Study
NOS Indian Head, Maryland

ALTERNATE USE Sludge Disposal

A. Brief Description: Process would be the thermal oxidation of sludge from the drying beds on base.

B. Impact on Individual Subsystem:

1. Product Feed: A loading hopper and slurring tank should be placed near the WAO unit if sludge from the drying bed were used. A loading hopper should be placed near the FBI facility.
2. Conveying and Grinding: N/A
3. Slurring, Weighing, Pumping: The sludge concentration would have to be reduced from the present drying bed level of 30 percent solids to a level enabling pumping into the WAO (6 to 8 percent). The FBI could handle the sludge as received by using a moyno pump.
4. Wet Air Oxidation System: The WAO system is ideally suited for sludge disposal since a great commercial usage of the Zimpro WAO unit has been for waste treatment, converting 99.9 percent of the contaminants to carbon dioxide, water, and inorganic ash.
5. Fluidized Bed Incinerator: The FBI is useful to dispose of heavy sewage sludge as directly obtained from the drying beds. FBI unit would have to be assembled and modified to eliminate problem areas discussed elsewhere.
6. Water Treatment System: Very little water treatment is required if the WAO is operated at 600°F to produce nearly complete oxidation.
7. Utilities-Steam, Air, Water: The utilities should be usable in present form.
8. Process Controls: The process controls should be usable in present form.
9. Basic Building Configuration: Building additions would be required: (a) loading hopper and slurring tank near WAO unit; (b) loading hopper near FBI unit.

- C. Is there a need for the proposed alternate? Yes, if economically justified. Presently the sludge is hauled away.
-
- D. Is there a source of input material? Yes, base generated sewage.
-
- E. Can residue, if any, be disposed of? Yes, the residue is sanitary.
-
- F. Could other parts or buildings be used for other purposes? Yes.
-
- G. Summary of Advantages and Disadvantages and Remarks.

Drying the sewage sludge to 30 percent solids and then slurrying back to value less than 10 percent for input to the WAO would be cost ineffective. The sewage settlement should be pumped to the WAO from a clarifier at the lower concentration.

The FBI is ideally suited for the sewage sludge of 30 percent solids or greater. However, the present condition of the unit is such that completion of assembly, modification of certain parts, prove out and addition of auxiliary equipment would result in significant expense.

Ordinance Disposal Study
NOS Indian Head, Maryland

ALTERNATE USE Sewage Disposal

A. Brief Description: Process would be the thermal oxidation of sewage generated on base.

B. Impact on Individual Subsystem:

1. Product Feed: A piping system would have to be provided between a sewage collection facility and the WAO unit.
2. Conveying and Grinding: N/A
3. Slurrying, Weighing, Pumping: The present 10 gpm WAO unit capacity would be adequate for batch processing.
4. Wet Air Oxidation System: This type of processing of untreated sewage is cost inefficient since the oxidizable concentration is small.
5. Fluidized Bed Incinerator: Cost inefficient.
6. Water Treatment System: Very little water treatment is required if the WAO is operated at 600°F.
7. Utilities-Steam, Air, Water: The utilities would be usable in present form.
8. Process Controls: The process controls would be usable in present form.
9. Basic Building Configuration: A system for densifying the untreated sewage to a solids concentration of greater than 1.5 percent would be required. An optimal concentration would be 6 to 8 percent.

C. Is there a need for the proposed alternate? Not if a sewage treatment facility is provided on base.

D. Is there a source of input material? Yes, base generated sewage.

E. Can residue, if any, be disposed of? The residue would be sanitary ash.

F. Could other parts or buildings be used for other purposes? Yes.

G. Summary of Advantages and Disadvantages and Remarks.

The WAO unit could be more cost effective for processing sewage if the oxidizable concentration were increased from less than 100 ppm to 6 percent. This could be done by pumping the settled residue at the correct sediment concentration from a clarifier into the WAO unit.

The most cost effective results would be the use of the WAO facility operated at a lower temperature and pressure in conjunction with a biological treatment system. A large sewage treatment plant in Newark, New Jersey, utilizes many Zimpro WAO units piped in parallel.

Ordnance Disposal Study
NOS Indian Head, Maryland

ALTERNATE USE Destruction of Pesticides and Herbicides

A. Brief Description: Process would assure the thermal conversion of pesticides and herbicides to simple compounds which can be neutralized and salts which can be disposed of.

B. Impact on Individual Subsystem:

1. Product Feed: A mixing or feed tank should be installed near the oxidation units.
2. Conveying and Grinding: N/A
3. Slurrying, Weighing, Pumping: These systems would be only partly usable in their present form.
4. Wet Air Oxidation System: Low concentrations of oxidizables would necessitate heat addition to the process to maintain reactor temperatures. Only those materials not containing halogens could be oxidized because of corrosivity of the effluent.
5. Fluidized Bed Incinerator: The FBI would be more costly to operate from an energy standpoint than the WAO. However, it would be effective.
6. Water Treatment System: Could be used as designed.
7. Utilities-Steam, Air, Water: Could be used as designed.
8. Process Controls: Could be used as designed.
9. Basic Building Configuration: Location of a feed tank near the oxidation units would require minor modifications.

C. Is there a need for the proposed alternate? Unknown

D. Is there a source of input material? That generated on base.

E. Can residue, if any, be disposed of? Yes.

F. Could other parts or buildings be used for other purposes? Yes.

G. Summary of Advantages and Disadvantages and Remarks.

The primary advantage of oxidizing pesticides and herbicides is the assurance of complete conversion to harmless substances. Sources of disposable material would generally come from off base. Profitability and practicability of NOS operating a facility which depended on off-base waste supplies is questionable.

Ordnance Disposal Study
NOS Indian Head Maryland

ALTERNATE USE Chemicals Disposal

A. **Brief Description:** The WAO process would convert hazardous organic material to their highest oxidation states in which form the chemical products can be neutralized and safely disposed of, or recovered.

B. **Impact on Individual Subsystem:**

1. **Product Feed:** A slurring or mixing tank should be installed near the WAO unit for non-corrosive materials, and near the FBI for dense and corrosive materials.
2. **Conveying and Grinding:** The grinding of solid chemical wastes and conveying to a slurring tank should take place near the WAO unit and the FBI unit for small quantity wastes that may otherwise merely wet the present transfer system.
3. **Slurring, Weighing, Pumping:** The slurry has to be pumpable by the centrifugal pumps which prime the WAO input high pressure positive displacement pump.
4. **Wet Air Oxidation System:** The unit would be useful for disposing of oxidizable materials not containing chlorides or fluorides. The WAO system could become hazardous if the combination of high pressure and corrosive materials were permitted to exist.
5. **Fluidized Bed Incinerator:** The FBI could be safely used to oxidize hazardous chemical wastes; however, chemical stress corrosion caused by chlorides and fluorides could necessitate costly replacement of 316 stainless steel tank, agitator and pump parts.
6. **Water Treatment System:** The water treatment facility would be operated as designed.
7. **Utilities-Steam, Air, Water:** Operated as designed.
8. **Process Controls:** Operated as designed.
9. **Basic Building Configuration:** Building modifications would be required if slurring, grinding and conveying equipment were located near the oxidation units.

- C. Is there a need for the proposed alternate? unknown.
- D. Is there a source of input material? unknown.
- E. Can residue, if any, be disposed of? The residue can be drummed and hauled.
- F. Could other parts or buildings be used for other purposes? Yes.
- G. Summary of Advantages and Disadvantages and Remarks.

Chlorides would destroy the stainless steel heat exchanger piping of the WAO unit; therefore, water from the separator tank cannot be passed through the heat exchanger. This would increase operating costs. Chlorides would cause a 50 mil per year erosion rate of the titanium jacket in the WAO reactor.

Also, titanium is not compatible with some fluorides.

The FBI could be safely used to destroy these hazardous organics at the risk of certain materials causing corrosion damage to stainless steel parts unless parts were rubber coated.

Ordinance Disposal Study
NOS Indian Head, Maryland

ALTERNATE USE Steam Generation

A. Brief Description: Boilers in wastewater treatment plant produce 7,000 pounds, 10,000 pounds of steam, respectively, (17,000 lb/hr total). If steam is needed elsewhere, distribution lines could be provided for steam supply and condensate return.

B. Impact on Individual Subsystem:

1. Product Feed: N/A
2. Conveying and Grinding: N/A
3. Slurrying, Weighing, Pumping: N/A
4. Wet Air Oxidation System: Use of steam elsewhere would preclude operation of WAO and film evaporator unless carefully scheduled.
5. Fluidized Bed Incinerator: Use of steam elsewhere would preclude operation of wet film evaporation of waste scrubber water.
6. Water Treatment System: See 4 and 5 above.
7. Utilities-Steam, Air, Water: Would limit steam availability for heating of buildings. Would require additional distribution piping on station.
8. Process Controls: N/A
9. Basic Building Configuration: N/A

C. Is there a need for the proposed alternate? According to NOS personnel, no.

D. Is there a source of input material? Yes.

E. Can residue, if any, be disposed of? Yes.

F. Could other parts or buildings be used for other purposes? Yes.

G. Summary of Advantages and Disadvantages and Remarks.

Boilers are in good condition and could produce usable steam. However, no steam distribution system exists to other areas of NOS and apparently, steam is not needed. Better choice would be to move boilers to another location or retain in present location to serve building complex which is being used for different mission.

Ordnance Disposal Study
NOS Indian Head, Maryland

ALTERNATE USE Solid, Non-Contaminated Waste Disposal

A. Brief Description: The WAO and FBI units would convert combustibile wastes to carbon dioxide, water and ash.

B. Impact on Individual Subsystem:

1. Product Feed: The solid wastes would have to be chopped or ground, slurried and then pumped into the WAO unit. The FBI would handle a more dense slurry than the WAO unit.
2. Conveying and Grinding: The conveying and grinding equipment could be located near the oxidation units.
3. Slurrying, Weighing, Pumping: A slurry capable of being handled by a centrifugal pump is required by the WAO unit. A slurry that can be handled by a screw conveyor is suitable for the FBI.
4. Wet Air Oxidation System: The WAO would be operated as designed.
5. Fluidized Bed Incinerator: The fluidized bed incinerator would be operated as designed.
6. Water Treatment System: Very little water treatment would be required since combustion should be complete.
7. Utilities-Steam, Air, Water: Usable as designed.
8. Process Controls: Usable as designed.
9. Basic Building Configuration: The building configuration would have to be modified to house the grinding and slurrying equipment.

C. Is there a need for the proposed alternate? Depends on the availability and suitability of the base incinerators.

D. Is there a source of input material? Yes, that generated on base.

E. Can residue, if any, be disposed of? Yes.

F. Could other parts of buildings be used for other purposes? Yes.

G. Summary of Advantages and Disadvantages and Remarks.

A more cost effective method of solid waste disposal would be the use of an incinerator, the operation of which would be contingent upon the availability of pollution control equipment.

Ordnance Disposal Study
NOS Indian Head, Maryland

ALTERNATE USE Destruction of Classified Documents and Film

A. Brief Description: The WAO and FBI units would be used to completely destroy classified materials.

B. Impact on Individual Subsystem:

1. Product Feed: The classified materials would be chopped or ground, slurried, and injected into the oxidation units, but would require new equipment or relocated equipment near units.
2. Conveying and Grinding: The conveying, chopping and grinding equipment could be located near the oxidation units.
3. Slurrying, Weighing, Pumping: A slurry capable of being handled by a centrifugal pump is required by the WAO unit, and capable of being handled by a screw conveyor or a Moyno pump is required by the FBI unit.
4. Wet Air Oxidation System: The WAO would be operated as designed.
5. Fluidized Bed Incinerator: The fluidized bed incinerator would be operated as designed.
6. Water Treatment System: Very little water treatment would be required unless silver were being recovered from the film.
7. Utilities-Steam, Air, Water: Usable as designed.
8. Process Controls: Usable as designed.
9. Basic Building Configuration: The building configuration would have to be modified to house the grinding and slurrying equipment.

C. Is there a need for the proposed alternate? No, due to the existence of an incinerator on base.

D. Is there a source of input material? Yes, base generated.

E. Can residue, if any, be disposed of? Yes.

F. Could other parts or buildings be used for other purposes?
Yes.

G. Summary of Advantages and Disadvantages and Remarks.

One incinerator is operational on base and a second is being built. The incinerator is more cheaply operated than the WAO or FBI and will, therefore, be used to destroy classified material.

Ordinance Disposal Study
NOS Indian Head, Maryland

ALTERNATE USE Wastewater Treatment

A. Brief Description: Industrial type wastewater generated on base would be treated at the facility.

B. Impact on Individual Subsystem:

1. Product Feed: The waste water would be piped to the treatment facility or transported by tank truck.
2. Conveying and Grinding: N/A
3. Slurrying, Weighing, Pumping: A pumping system would be required to transfer the base generated waste water to the treatment facility if not transported by truck.
4. Wet Air Oxidation System: N/A
5. Fluidized Bed Incinerator: N/A
6. Water Treatment System: Possibly usable as designed, although depending on characteristics of wastewater, other unit processes may be required.
7. Utilities—Steam, Air, Water: Usable as designed.
8. Process Controls: N/A
9. Basic Building Configuration: The building would remain the same.

C. Is there a need for the proposed alternate? Unknown.

D. Is there a source of input material? Unknown.

E. Can residue, if any, be disposed of? Unknown.

F. Could other parts or buildings be used for other purposes? Yes.

G. Summary of Advantages and Disadvantages and Remarks.

Source of wastewater for treatment is unknown so no evaluation is possible.

General Recommendations for WAO

Based on the preceding preliminary evaluations, the following uses are recommended for the Wet Air Oxidation Unit if justified economically:

1. Silver recovery from waste film (photographic and x-rays) and the spent fixer. Two ounces of silver could be refined from the silver sludge for the refiner's charge of less than one dollar.
2. Oxidation of sewage sludge of 6 to 8 percent solids concentration obtained from a settling facility.
3. Destruction of pesticides and herbicides. Heat addition will be required to sustain a 600°F oxidation temperature.
4. Disposal of non-corrosive organic chemicals if they can be slurried to 5 to 8 percent organics concentration by weight.

Uses not recommended for the Wet Air Oxidation Unit are:

1. Disposal of corrosive chemicals. Stress corrosion of the WAO components would impose a safety hazard as well as costly repairs.
2. Destruction of solid non-contaminated waste. The cost of preparing the waste for injection into the WAO and operating the facility would be greater than contracting to a commercial hauler or use of an incinerator on base having adequate capacity.

General Recommendations for FBI

The following uses are recommended for the Fluidized Bed Incinerator if justified economically:

1. Oxidation of dense sewage sludge as obtained from the drying beds on base. This material could be conveyed with a Moyno Pump or screw conveyor.
2. Destruction of pesticides and herbicides. The cost of incineration would decrease with increase in organics density since less water would have to be vaporized.
3. Destruction of dense slurries of organic non-corrosive chemical waste.

4. Destruction of hazardous organic compounds from the standpoint of operating personnel safety since the incineration occurs at relatively low pressure.

Uses not recommended for the Fluidized Bed Incinerator are:

1. Destruction of hazardous organic compounds from the standpoint of cost effectiveness since chloride and fluoride compounds could cause costly repairs to the stainless steel system components.
2. Destruction of solid non-contaminated waste. As for the WAO unit, the cost of material preparation and operating the facility would be greater than contracting to a commercial hauler. Material preparation would consist of sorting to eliminate non-organic materials, chopping or grinding, and slurring.

References

1. Canadian Chemical Processing, June, 1982.
2. Journal of Water and Pollution Control Federation, Volume 52, No. 8.
3. Silver Recovery for Hospitals, American Hospital Association, AHA Catalog No. 1300, 1980.

Alternate Use Evaluation

Based on the tentative conclusions, the economics of modifying the WAO process and the FBI process for disposal of a variety of materials were examined in greater detail.

In both cases, it was assumed that additions of certain pieces of equipment would enable processing of a variety of waste materials, not just the single most cost effective use. For example, if the appropriate building modifications and roadway modifications were made to enable receiving of waste at the point of disposal, and additional hoppers, grinders, slurring tanks, and feed pumps were provided, if equipment were selected wisely, the same equipment could be used (with proper cleaning between uses) to handle photographer plate as well as sludge.

It was further assumed that the FBI unit was complete and functioning prior to beginning to evaluate additional equipment required for disposal of alternate materials. This is, of course, not the case, but judgments regarding completion of the basic FBI unit are reserved for elsewhere in the report.

Based on these assumptions, one approach was as follows:

1. Schematics of the WAO and FBI processes were modified to indicate addition of waste handling equipment. See Figures XIII-1 and XIII-2.
2. Conceptual building floor plans were prepared showing new equipment and any building modifications and/or roadway modifications required. See Figures XIII-3 and XIII-4.
3. Construction cost estimates were prepared based upon these floor plans.
4. Savings investment ratios were developed based upon a hypothetical availability of the waste streams and payback analyses were performed.

Results of Economic Analysis

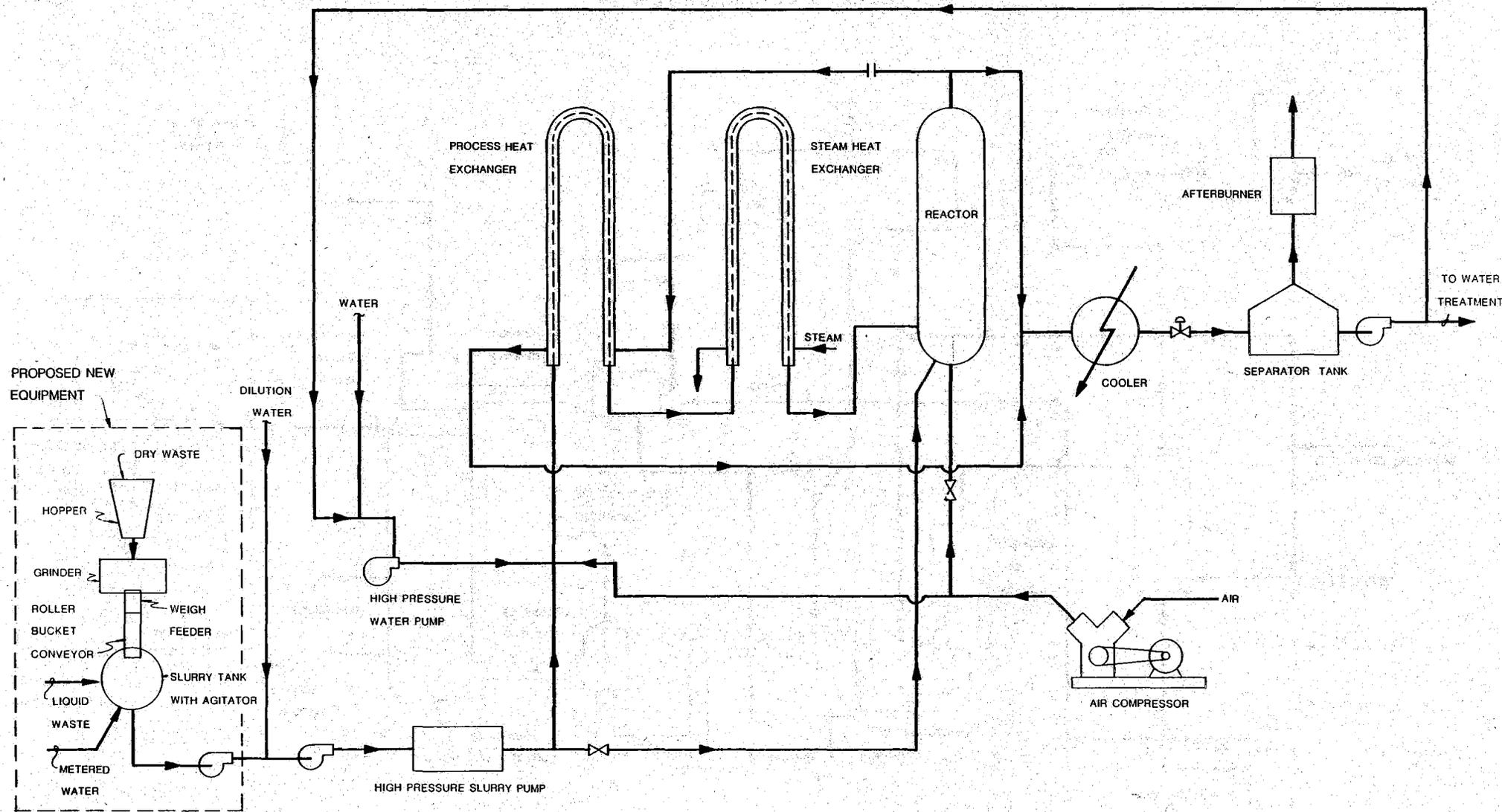
An economic evaluation was performed for the disposal of those non-ordnance related wasted materials having significant value or volume. Only one waste material had appreciable value, this being discarded photographic and x-ray film and the fixer solution. Two waste materials were found to exist in sizeable volume. These were non-hazardous base generated trash and sewage sludge.

The waste photographic and x-ray film and fixer, if processed through the WAO unit, showed a payback of 10 years considering the cost of new grinding, conveying, and slurrying equipment, cost of operating the facility, the present credit obtained from selling the waste film and spent fixer, and the sale price of refined silver. The cost estimate for the new equipment is given in the Appendix along with the savings investment ratio calculation.

The waste material existing in the largest volume category was the base generated non-hazardous trash. This was found to be most logically processed by the FBI facility since a much higher ratio of solids to slurry water is handled by the FBI unit than the WAO unit, reducing the operating time requirement and the fuel oil requirement for a given dry weight. The cost estimate for new equipment enabling the FBI to process trash and the economic evaluation are given in the Appendix. Relative to the present \$110,000 per year cost of commercial trash disposal, incineration of the trash in the FBI was found to be economically prohibitive.

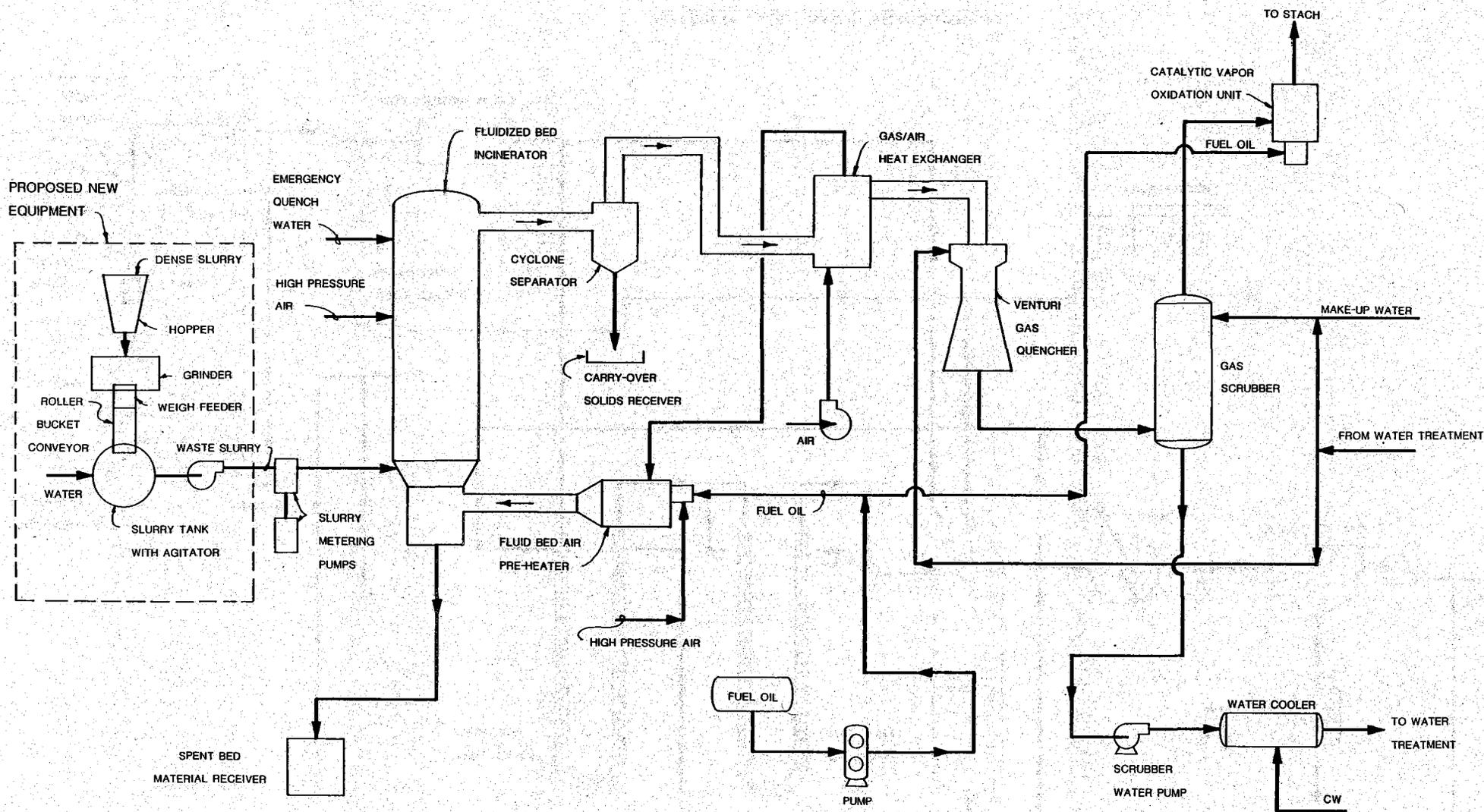
The next largest volume of waste produced was sewage sludge. This is obtained from drying beds on base at an oxidizable solids to water weight ratio of 30 percent. This could be slurried to 6 percent concentration and oxidized in the WAO unit or injected into the FBI unit in the present form. Regardless, the cost of disposing of the 150 cubic yards of sewage sludge per year generated on base would be in the range of \$35,000 to \$45,000 using the WAO or FBI units, whereas the sludge is presently hauled off base at a cost of \$5,000.00, this being part of a larger general ground maintenance contract.

The other base generated waste materials considered in the alternate usage evaluation section of this report were of small amount and did not warrant economic evaluation.



ALTERNATE USES - WAO SYSTEM SCHEMATIC

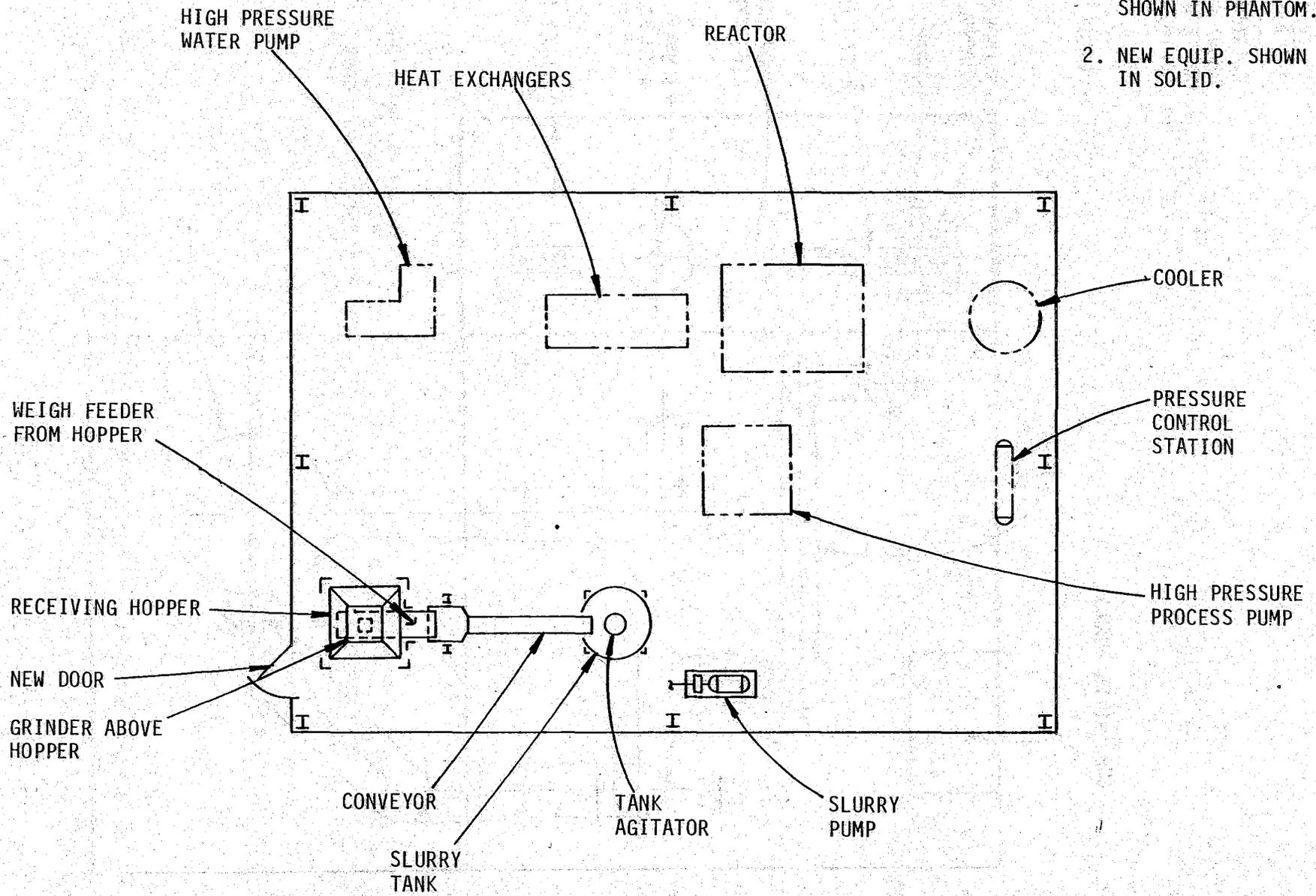
FIGURE XII-1



ALTERNATE USES - FBI SYSTEM SCHEMATIC

FIGURE X111-2

FIGURE X111-3



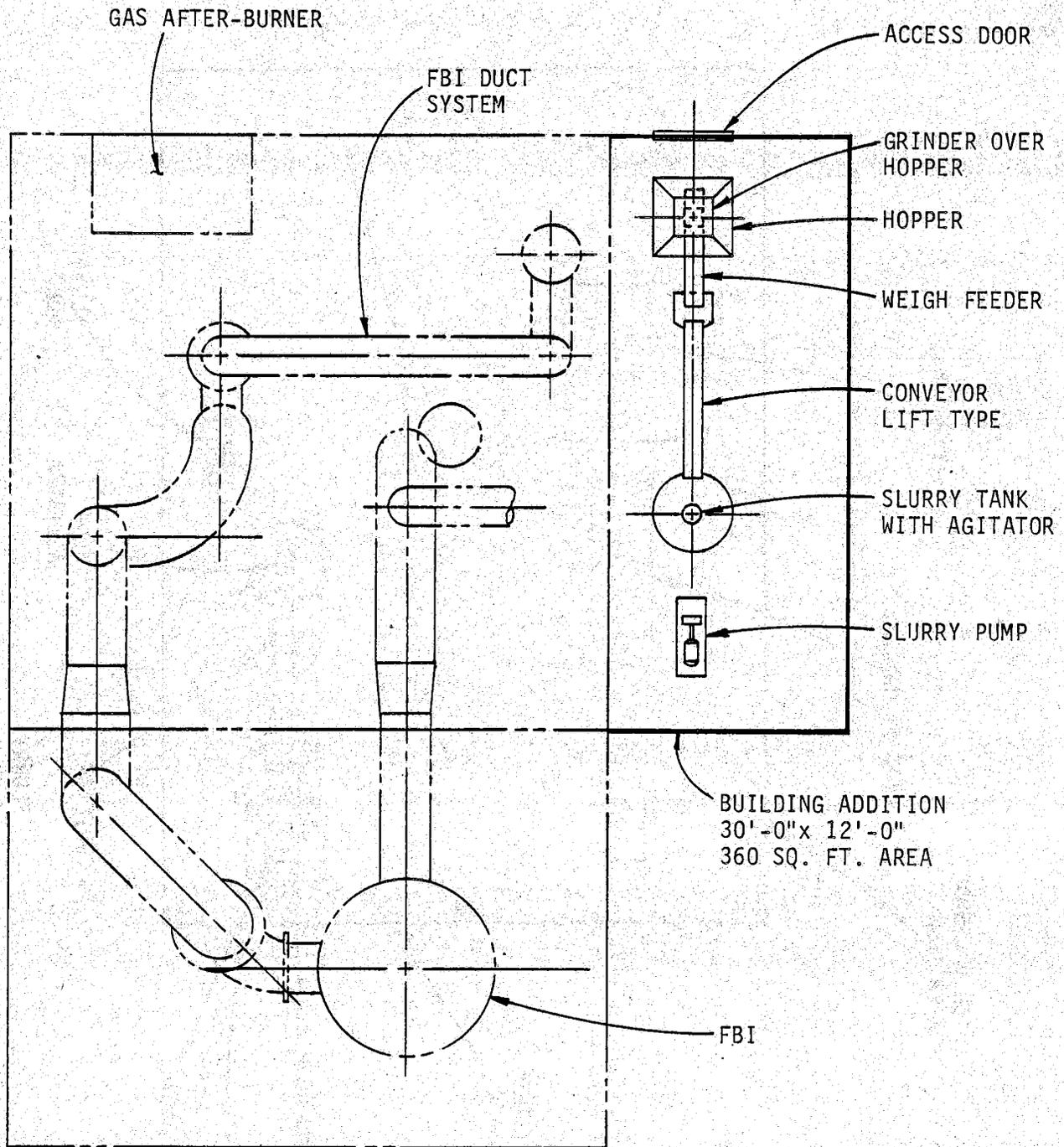
NOTES:

1. ALL EXISTING EQUIP. SHOWN IN PHANTOM.
2. NEW EQUIP. SHOWN IN SOLID.

WAO SYSTEM

NOTES:

EXISTING EQUIP.
SHOWN IN PHANTOM.
NEW EQUIP. SHOWN
SOLID.



FBI MODIFICATIONS

FIXTURE X111-4

XIV. Economic Summary –
Alternate Disposal Methods, Alternate Uses

XIV ECONOMIC SUMMARY
ALTERNATE DISPOSAL METHODS, ALTERNATE USES

General

This section consists of an economic comparison of the three options developed in Section X for 100 percent disposal using existing modified equipment within the PDF (WAO and FBI) and several newly proposed construction projects (CWP, EWI, SRF), and the five options discussed in Section X for 100 percent disposal using a combination of existing equipment, new equipment, continuation of open burning, and off site disposal. The options considered and waste workload are presented again in Figures XIV-1 through XIV-17. These options are compared on a Uniform Annual Cost Basis using formulas and tables presented in NAVFAC P442 Economic Analysis Handbook. A summary of costs associated with several possible alternate uses for portions of the PDF is also presented in this section.

Methodology

In order to make an economic comparison for the seven options it was necessary to estimate the capital cost of any hypothetical new equipment, and the operating cost per ton of material disposed to arrive at a yearly disposal cost. For materials disposed of on base the operating cost takes into account labor and energy costs. For material disposed of off base the operating cost includes estimates of on base handling and packaging, transportation costs, and off base handling costs. All of these estimated costs are presented and discussed elsewhere in this report. Backup estimating data are included in the Appendix.

Also required for comparison purposes were the life expectancy and salvage value for new construction. The Uniform Annual Cost (C) was then computed from the following formula:

$$C = NPV/b_n$$

Where:

C = Uniform Annual Cost
NPV = Net Present Value
 b_n = Present value of one dollar cumulative
uniform series over life of project

The NPV is computed using the capital cost plus the annual expenditures and salvage value multiplied by the appropriate discount factors from the referenced handbook.

Results of Disposal Option Analysis

The results of the economic analyses are summarized in the following table. All costs are in thousands of dollars.

OPTION	EQUIVALENT UNIFORM COSTS	CAPITAL COSTS	OPERATING COSTS/YEAR	NUMBER OF NEW CONSTRUCTION PROJECTS REQUIRED
0	55	0	55	0
1	1444	3810	865	3
2	1735	5030	970	4
3	2407	6659	1395	5
4	2385	6409	1411	4
5	2229	3980	1624	3
6	1613	2595	1212	2
7	597	1370	389	1

The most economically favorable option is, of course, Option 0, continuation of open burning. The next most favorable is Option 7 which includes construction of a CWP, but also relies on a large amount of continued open burning. The two most attractive options which require no open burning are Options 1 and 6. Option 1 involves construction of three new facilities (CWP, EWI, SRF). Option 6 involves two new construction projects (SRF, CWP) and off base disposal of a relatively large percentage of the waste. Options 2, 3, 4, and 5, all of which consider utilization of some portion of the PDF after suitable modification do not compare favorably. These options also involve from 3 to 5 new construction projects, or substantial modification to existing facilities. Because costs for construction and modification are at this point approximate estimates at best, the more separate projects involved the more uncertainty must be placed on the estimated costs. For this reason, we feel the fewer new projects or modifications considered, the better the data.

This economic analysis cannot take into account benefits as such. Although undoubtedly some of the options would have benefits over others such as fuel/energy savings, etc. the major benefit which would be realized by implementation of several of the options would be elimination of open burning which cannot be quantified.

In conclusion, we recommend a stepped implementation of Options 0, 7, 6, and 1 in that order. It may be desirable to design all new construction at the same time to facilitate coordination and interfacing. However, construction could be phased if necessary.

Results of Alternate Uses Study

The results of the alternate uses study are discussed in detail in Section XIII. The estimated construction costs of several potential alternate uses are listed below. The only alternate use having a positive payback within 10 years is silver recovery. However, using current estimates of photographic and x-ray film generation at NOS the WAO would be required to operate only one month per year.

Alternate Uses

Construction Costs

Silver, Sludge, Misc. Disposal/
Recovery Equipment

*1. Using WAO	\$ 200,000
2. Using FBI	250,000

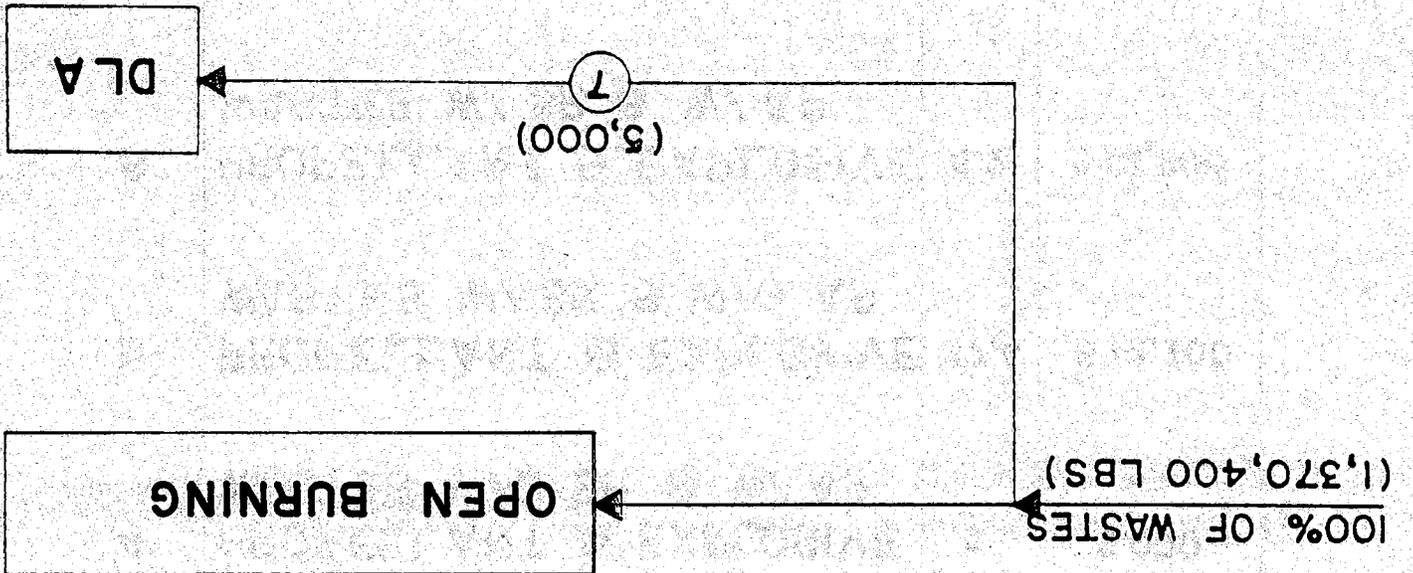
* Includes only new material handling and prep, no mods to WAO AND FBI.

WASTE & WORKLOAD DEFINITIONS

CODE	DESCRIPTION	%	AMOUNT
1	CONTAMINATED WASTES W/O AP	37.7	517,000 (LBS.)
2	CONTAMINATED WASTES W/ AP	0	0
3	PROPELLANT & EXPLOSIVE WASTES W/O SR & W/O AP	14.3	195,400
4	PROPELLANT & EXPLOSIVE WASTES W/O SR & W/ AP	.2	3,000
5	PROPELLANT & EXPLOSIVE WASTES W/ SR & W/O AP	37.4	512,100
6	PROPELLANT & EXPLOSIVE WASTES W/ SR & W/ AP	8.2	112,900
7	LIQUID WASTES	.4	5,000
8	CONFIGURED ITEMS	1.8	25,000

FIGURE XIV-1

CAPITAL COST - 0



OPTION 0

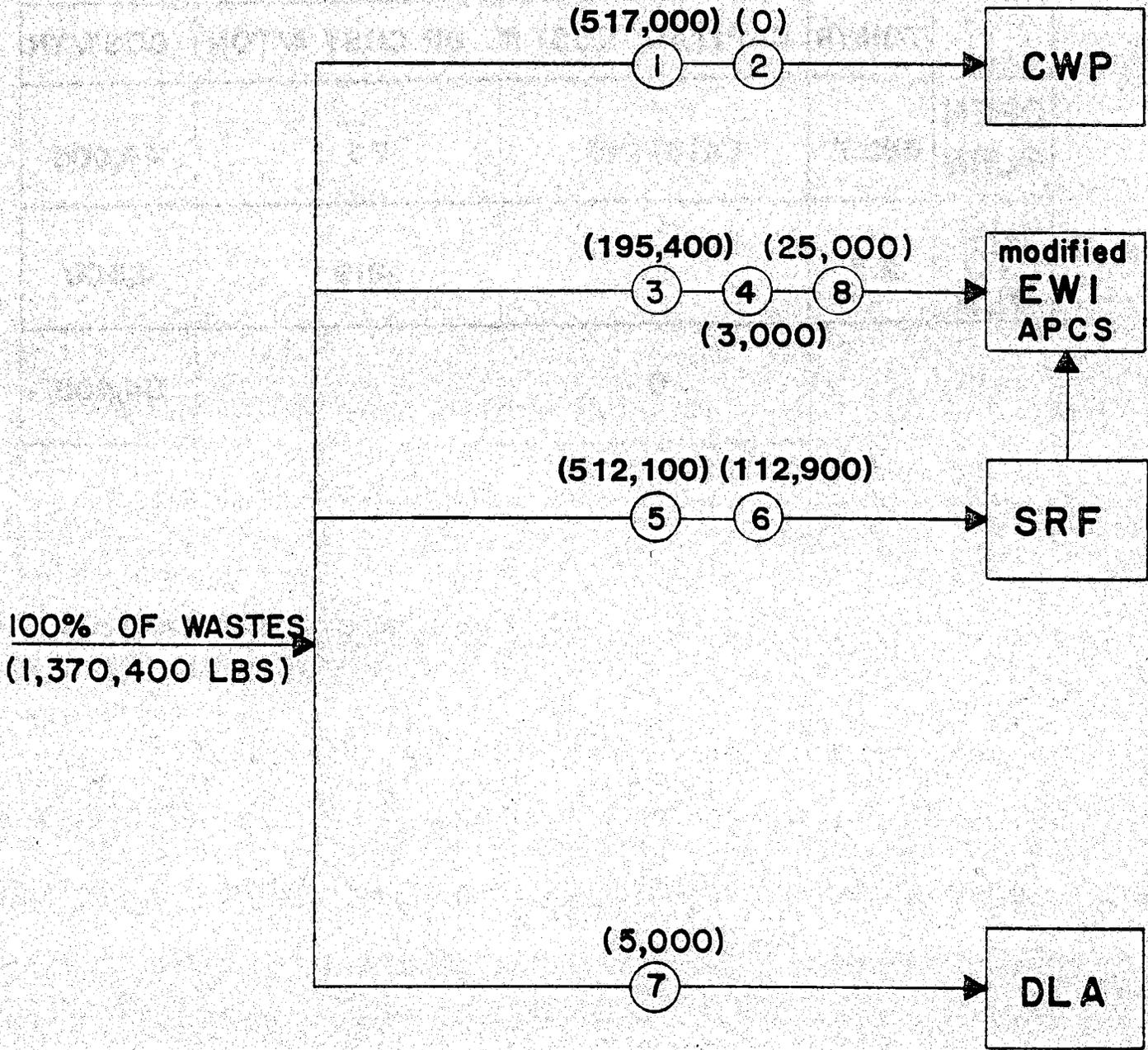
COST EST. - INDIAN HEAD

OPTION 0

	TON/YR	CAPITAL COST \$	OP. COST \$/TON	COST/YR
OPEN BURN	682.7	EXISTING	73	49,900
LIQ TO DLA	2.5		1819	4,500
		0		54,400

FIGURE XIV-3

OPTION 1



100% OF WASTES
(1,370,400 LBS)

CAPITAL COST - \$ 3,810,000

FIGURE XIV-4

COST EST. - INDIAN HEAD

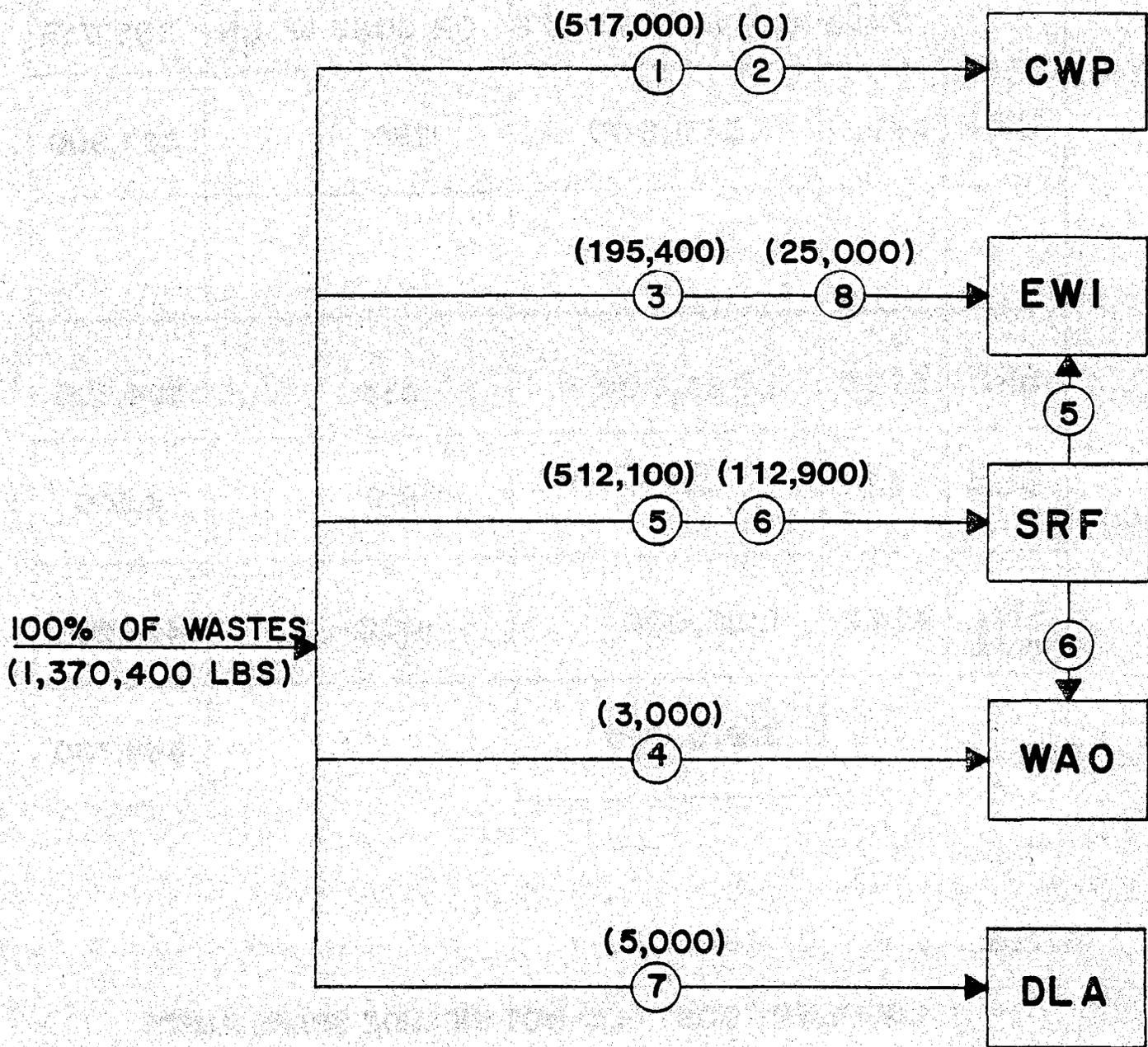
OPTION I

	TON/YR	CAPITAL COST \$	OP. COST \$/TON	COST/YR
CWP	258.5	1,370,000	1284	331,900
SRF	312.5	1,225,000	333	104,100
DLA	2.5	—	1819	4,500
EWI mod.	424.2	1,215,000	1000	424,200
		3,810,000		864,700

NOTES:

1. EQUIPMENT COSTS DO NOT INCLUDE SPARE PARTS

OPTION 2



CAPITAL COST - \$5,030,000

FIGURE XIV-6

COST EST. - INDIAN HEAD

OPTION 2

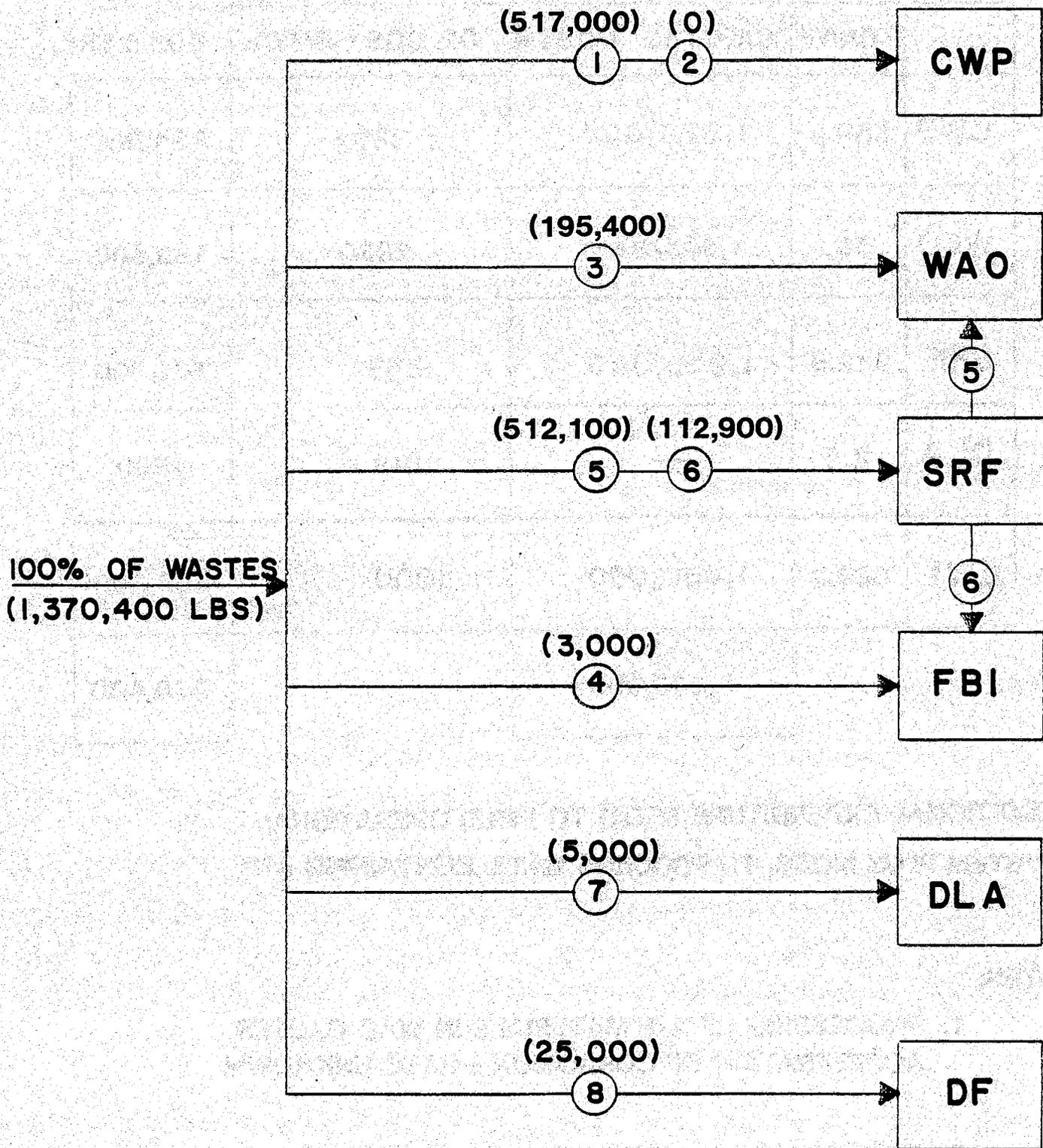
	TON/YR	CAPITAL COST #	OP. COST \$/TON	COST/YR
CWP	258.5	1,370,000	1284	331,900
WAO	58	1,385,000#	2820	163,600
SRF	312.5	1,225,000	333	104,100
DLA	2.5	—	1819	4500
EWI	366.3	1,050,000	1000	366,300
		5,030,000		970,400

ADDITIONAL EXPENDITURE REQ'D TO FIELD OPERATIONAL SYSTEM PLUS MODS. TO PROCESS MAT'L CONTAINING A/P

NOTES:

- 1. PROCESSING OF A/P MATERIALS IN WAO CAUSES ACCELERATION OF CORROSION - RATE UNKNOWN**
- 2. EQUIPMENT COSTS DO NOT INCLUDE SPARE PARTS**

OPTION 3



CAPITAL COST - \$6,659,000

FIGURE XIV-8

COST EST.- INDIAN HEAD

OPTION 3

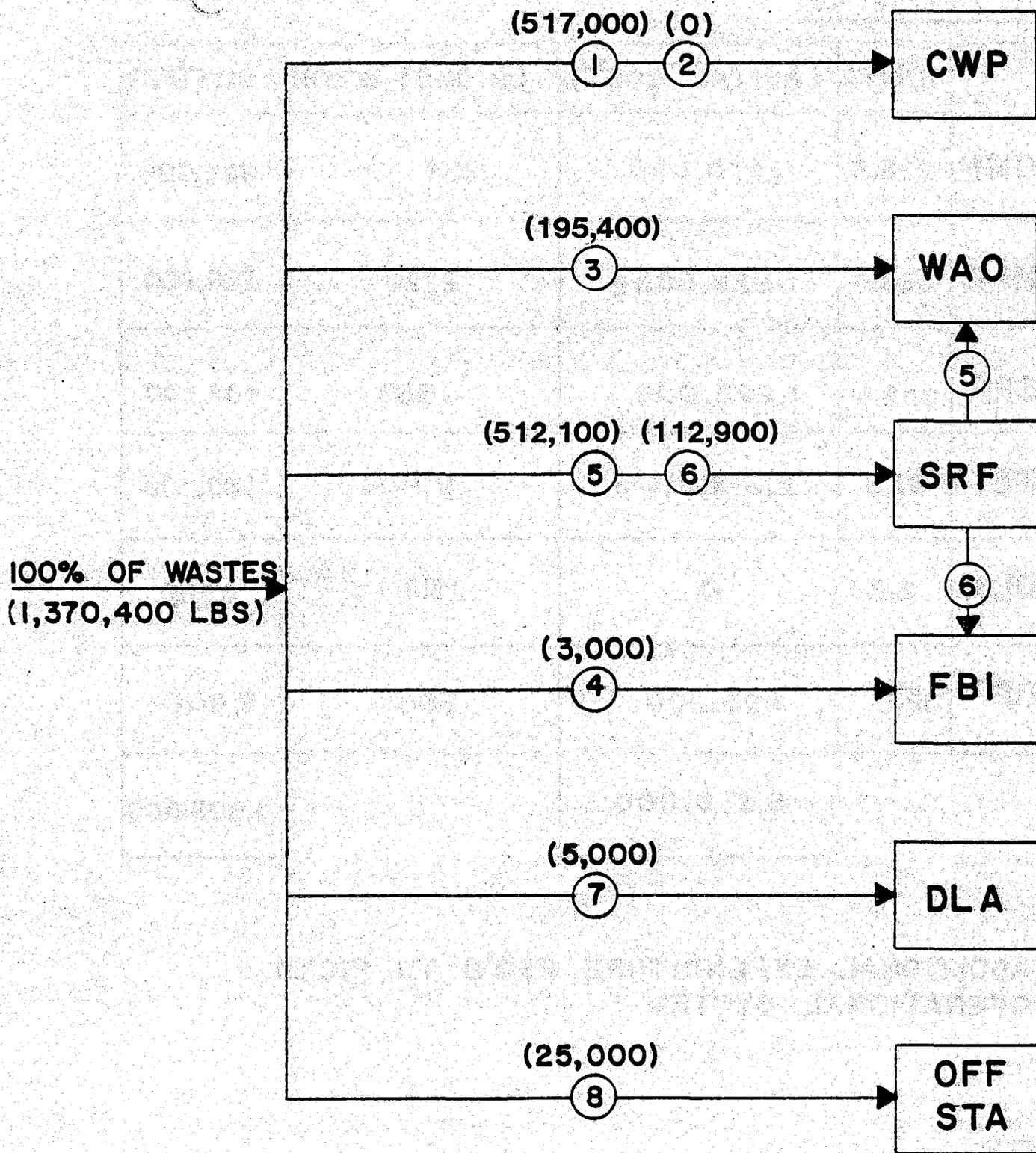
	TON/YR	CAPITAL COST #	OP. COST #/TON	COST/YR
CWP	258.5	1,370,000	1284	331,900
WAO	353.8	996,000*	2220	785,400
SRF	312.5	1,225,000	333	104,100
FBI	57.9	2,818,000*	2,800	162,100
DLA	2.5	0	1819	4,500
DF	12.5	250,000	560	7,000
		6,659,000		1,395,000

*** ADDITIONAL EXPENDITURE REQ'D TO FIELD OPERATIONAL SYSTEM**

NOTE

1. DOES NOT INCL. SPARE PARTS

OPTION 4



CAPITAL COST - \$6,409,000

FIGURE XIV-10

COST EST. - INDIAN HEAD

OPTION 4

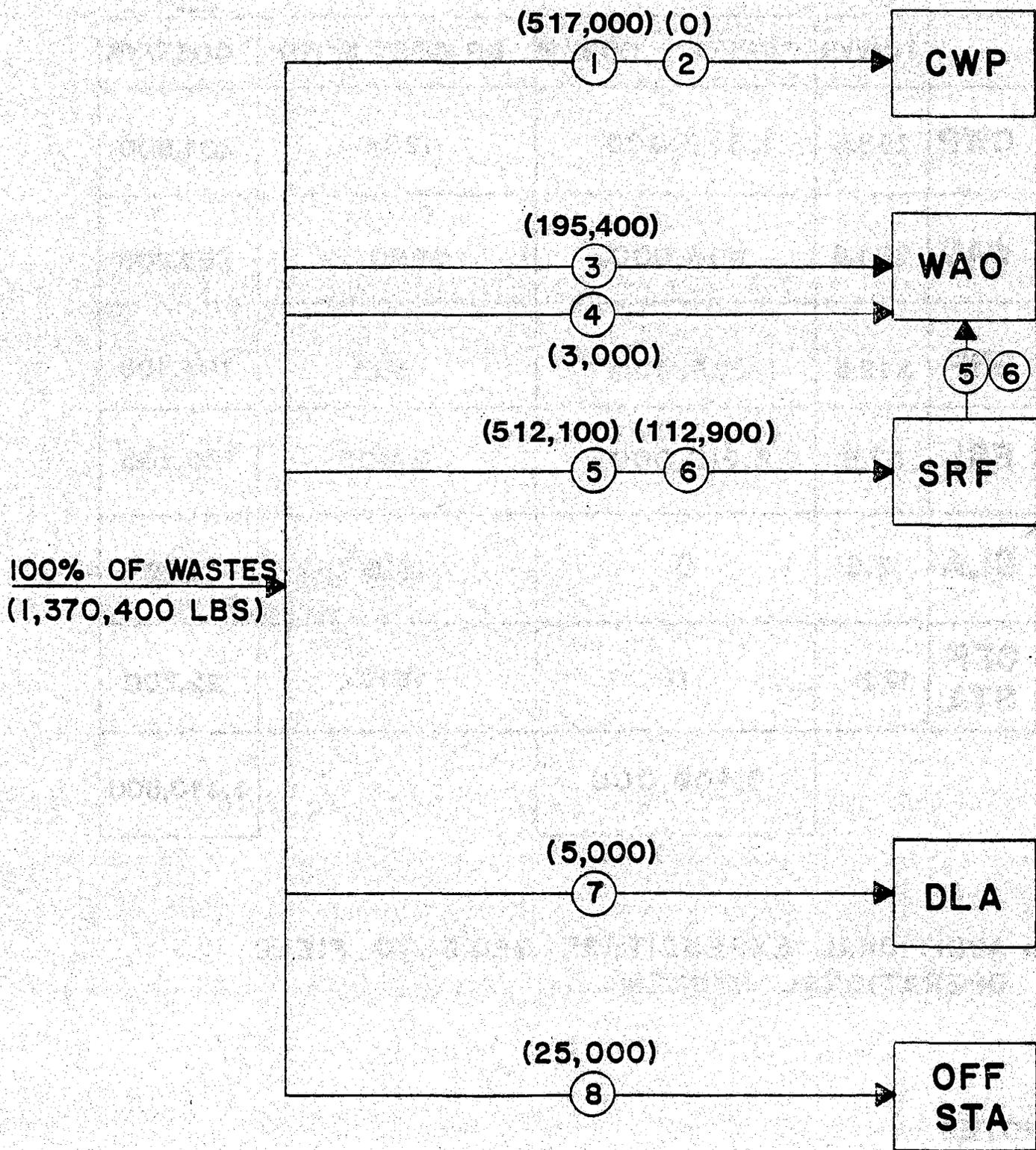
	TON/YR	CAPITAL COST #	OP. COST #/TON	COST/YR
CWP	258.5	1,370,000	1284	331,900
WAO	353.8	996,000*	2220	785,300
SRF	312.5	1,225,000	333	104,100
FBI	57.9	2,818,000*	2,800	162,100
DLA	2.5	0	1819	4,500
OFF STA.	12.5	0	1819	22,700
		6,409,000		1,410,600

* ADDITIONAL EXPENDITURE REQ'D TO FIELD OPERATIONAL SYSTEM

NOTES

I. DOES NOT INCL. SPARE PARTS

OPTION 5



CAPITAL COST - \$ 3,980,000

FIGURE XIV-12

COST EST.- INDIAN HEAD

OPTION 5

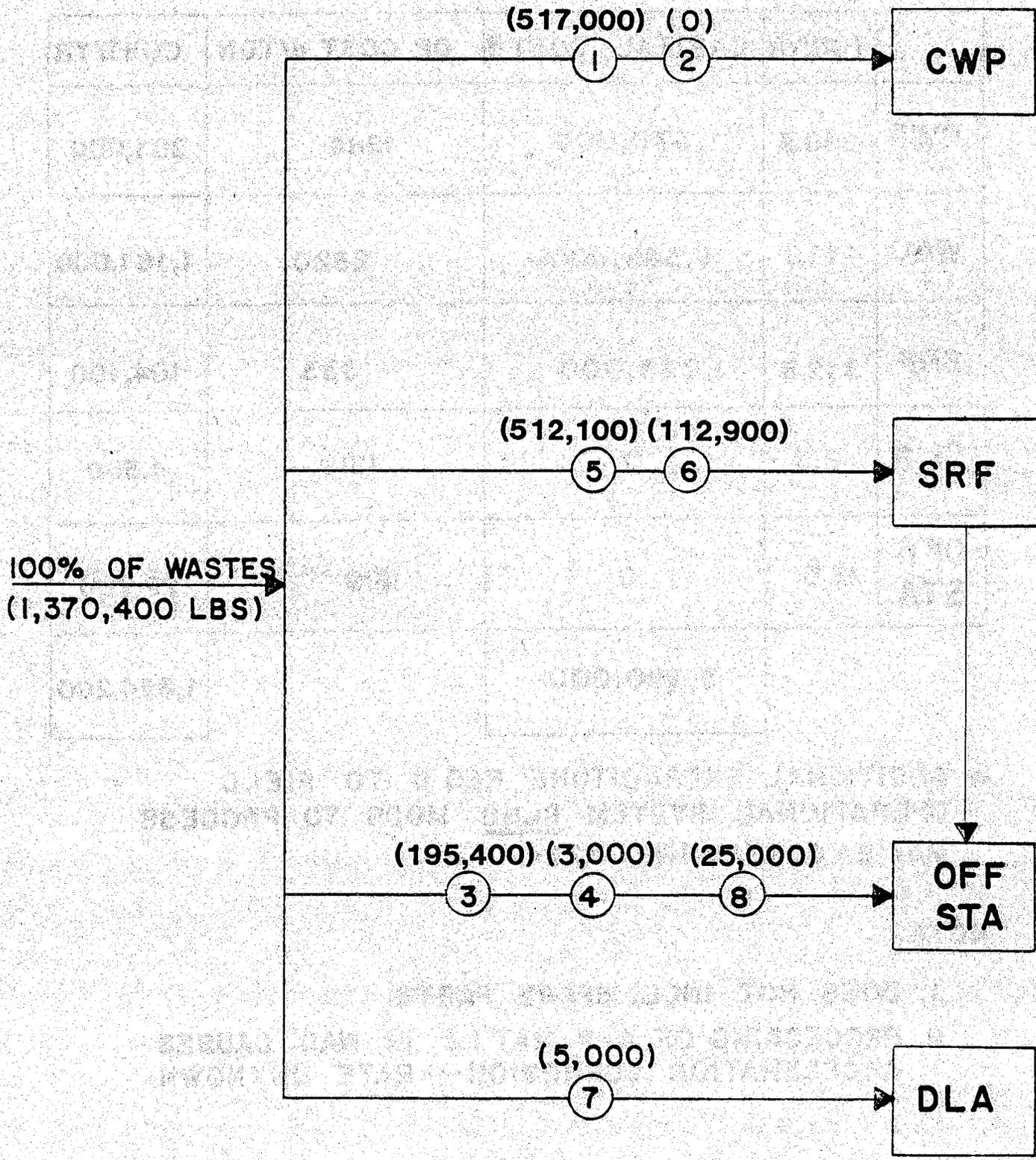
	TON/YR	CAPITAL COST #	OP. COST #/TON	COST/YR
CWP	258.5	1,370,000	1284	331,900
WAO	411.7	1,385,000*	2820	1,161,000
SRF	312.5	1,225,000	333	104,100
DLA	2.5	0	1819	4,500
OFF STA.	12.5	0	1819	22,700
		3,980,000		1,624,200

* ADDITIONAL EXPENDITURE REQ'D TO FIELD OPERATIONAL SYSTEM PLUS MODS TO PROCESS MAT'S CONTAINING A/P

NOTES

1. DOES NOT INCL. SPARE PARTS
2. PROCESSING OF A/P MAT'LS IN WAO CAUSES ACCELERATION CORROSION — RATE UNKNOWN

OPTION 6



100% OF WASTES
(1,370,400 LBS)

CAPITAL COST - \$ 2,595,000

FIGURE XIV-14

COST EST.- INDIAN HEAD

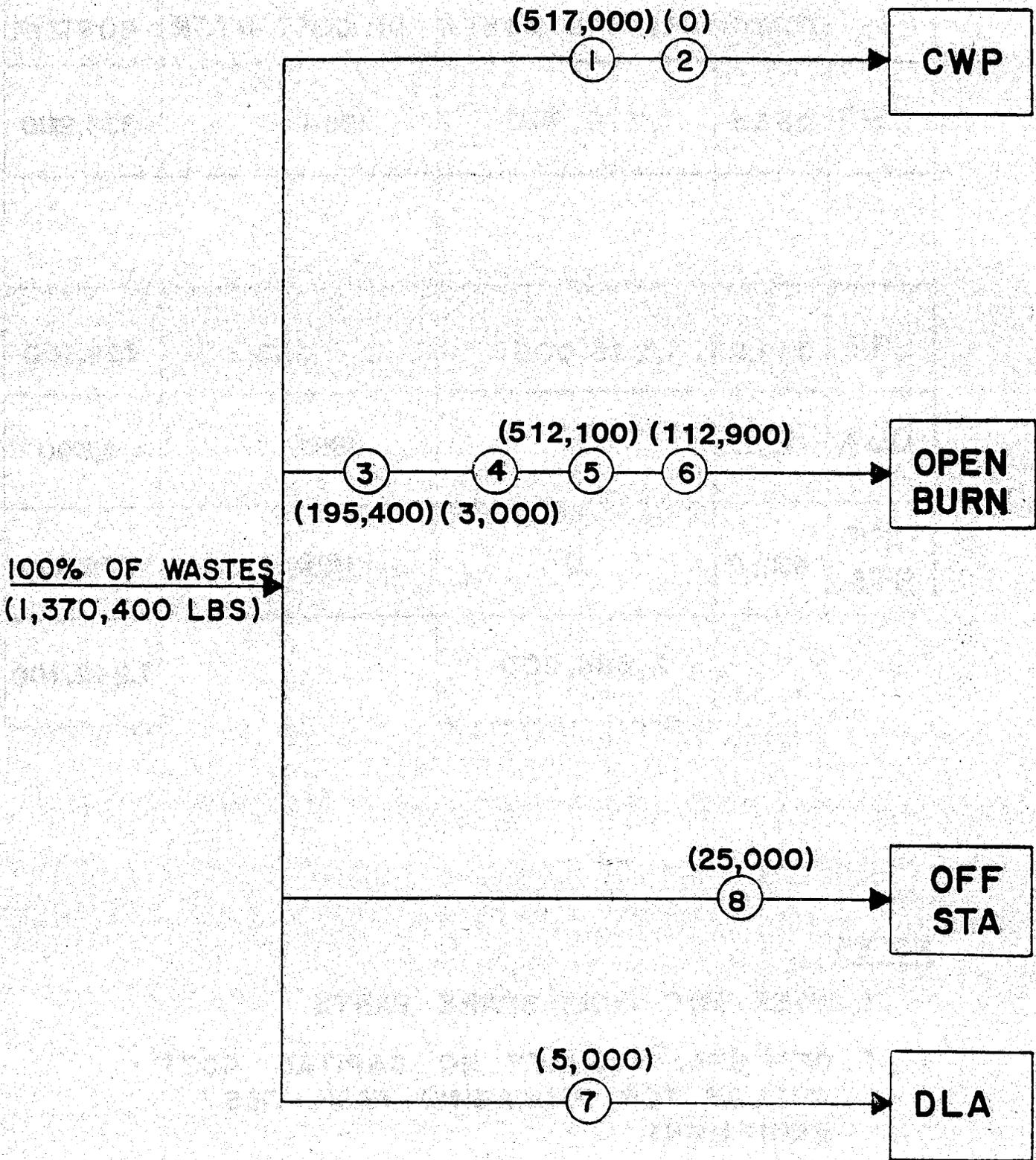
OPTION 6

	TON/YR	CAPITAL COST #	OP. COST #/TON	COST/YR
CWP	258.5	1,370,000	1284	331,900
SRF	312.5	1,225,000	333	104,100
DLA	2.5	0	1819	4,500
OFF STA.	424.2	0	1819	771,600
		2,595,000		1,212,100

NOTES

1. DOES NOT INCL. SPARE PARTS
2. OFF- STA. ASSUMES NO CAPITAL COST OUTLAY FOR PACKAGING FACILITIES / EQUIPMENT

OPTION 7



CAPITAL COST - \$ 1,370,000

FIGURE XIV-16

COST EST.- INDIAN HEAD

OPTION 7

	TON/YR	CAPITAL COST #	OP. COST #/TON	COST/YR
CWP	258.5	1,370,000	1284	331,900
OPEN BURN	411.7	EXISTING	73	30,100
DLA	2.5	0	1819	4,500
OFF STA.	12.5	0	1819	22,700
		1,370,000		389,200

FIGURE XIV-17

For Chesapeake Division
of the Navy

Project No. 82-5061-7

Washington Testing Inc.

TEST BORING LOG

Boring No. Site 1

Sheet of

Job Name and Location E. O. D. Site Testing - Range 6

Boring Location

Date Begin <u>10-14-83</u>	Casing Size, O.D. <u> </u> "	Spoon Size, O.D. <u> </u> "
Date Completed <u>10-14-83</u>	Hammer Weight <u> </u> #	Hammer Wt. <u> </u> #
Depth of Soil <u> </u>	Hammer Drop <u> </u> "	Hammer Drop <u> </u> "
Depth of Rock <u> </u>	Core Bit Size <u> </u> "	Rig No. <u> </u>
Total Boring Depth <u> </u>	Driller <u> </u>	Asst. Driller <u> </u>

Progress & Ground Water Data

Date	Depth Reached	Depth Water	Hour
10-14-83	18.0	15.5	

Ground Elev.
Datum Elev.
Depth Surf. Water
Weather

BORING LOG		SPOON SAMPLE & ROCK CORE DATA						REMARKS (water loss, cavities, etc.)	CASING BLOWS			
Depth From To	Material Description	Sample		Blows on Spoon 6" Intervals					Run No.	Depth of Run	Core Rec. (ft)	0-1
		No.	Depth	0-6	6-12	12-18	18-24	1-2				
0.0 2.0"	Clayey fine to coarse SAND trace fine gravel (SC)	B1	2"								2-3	
		B2	6"								3-4	
2" 3'	Clayey fine to coarse SAND some fine gravel (SC)	B3	1'								4-5	
		B4	2'								5-6	
3' 4'	Silty fine to medium SAND trace coarse sand (SM)	B5	3'								6-7	
		B6	4'								7-8	
4' 5'	Silty, clayey fine to coarse SAND trace fine gravel (SC-SM)	B7	5'								8-9	
		B8	6'								9-10	
5' 6'	Sandy CLAY trace fine gravel (CL)	B9	18'								10-11	
											11-12	
17' 18'	Silty Clayey fine to medium SAND with some fine gravel (SM-SC)										12-13	
											13-14	
											14-15	
											15-16	
											16-17	
											17-18	
											18-19	
											19-20	
											20-21	
											21-22	
											22-23	
											23-24	
											24-25	
											25-26	
											26-27	
											27-28	
											28-29	
											29-30	
											30-31	
											31-32	
											32-33	
											33-34	

Inspector Resident or Soils Engineer

For Chesapeake Division
of the Navy
 Project No. 82-5061-7

Washington Testing Inc.

TEST BORING LOG

Boring No. Site 2
 Sheet _____ of _____

Job Name and Location E. O. D. Site Testing - Range 6
 Boring Location _____

Date Begin 10-14-83 Casing Size, O.D. _____"
 Date Completed 10-14-83 Hammer Weight _____#
 Depth of Soil _____ Hammer Drop _____"
 Depth of Rock _____ Core Bit Size _____"
 Total Boring Depth _____ Driller _____ Asst. Driller _____

Progress & Ground Water Data

Date	Depth Reached	Depth Water	Hour
10-14-83	10.0	7.5	

Ground Elev. _____
 Datum Elev. _____
 Depth Surf. Water _____
 Weather _____

BORING LOG		SPOON SAMPLE & ROCK CORE DATA					REMARKS (water loss, cavities, etc.)	CASING BLOWS					
Depth From To	Material Description	Sample No.	Depth	Blows on Spoon 6" Intervals				Run No.	Depth of Run	Core Rec. (ft)	0-1		
0.0 6"	Clayey fine to coarse SAND, trace fine to medium gravel (SC)	B1	2"	0	6	12	18	24				2-3	
		B2	6"									3-4	
6" 1'	Clayey fine to medium SAND, little fine gravel (SC)	B3	1'									4-5	
		B4	2'									5-6	
1' 4'	Clayey fine to coarse SAND and fine gravel (SC-GC)	B5	3'									6-7	
		B6	4'									7-8	
4' 5'	Clayey, Silty fine to medium SAND trace fine gravel (SC-SM)	B7	5'									8-9	
		B8	6'									9-10	
5' 6'	Fine Sandy SILT with organics (OL)	B9	7'									10-11	
		B10	8'									11-12	
6' 8'	Silty fine to coarse SAND and Silty, Clayey fine to Medium Gravel (SC-GC)											12-13	
												13-14	
												14-15	
												15-16	
												16-17	
												17-18	
												18-19	
												19-20	
												20-21	
												21-22	
												22-23	
												23-24	
												24-25	
												25-26	
												26-27	
												27-28	
												28-29	
												29-30	
												30-31	
												31-32	
												32-33	
												33-34	

Inspector _____ Resident or Soils Engineer _____

For Chesapeake Division
of the Navy
 Project No. 82-5061-7

Washington Testing Inc.

TEST BORING LOG

Site 3

Boring No. _____

Sheet _____ of _____

Job Name and Location E. O. D. Site Testing - Range 6

Boring Location _____

Date Begin 10-14-83 Casing Size, O.D. _____"

Date Completed 10-14-83 Hammer Weight _____#

Depth of Soil _____ Hammer Drop _____"

Depth of Rock _____ Core Bit Size _____"

Total Boring Depth _____ Driller _____

Spoon Size, O.D. _____"

Hammer Wt. _____#

Hammer Drop _____"

Rig No. _____

Asst. Driller _____

Progress & Ground Water Data

Date	Depth Reached	Depth Water	Hour
10-14-83	20'	4.5'	

Ground Elev. _____

Datum Elev. _____

Depth Surf. Water _____

Weather _____

BORING LOG		SPOON SAMPLE & ROCK CORE DATA						REMARKS	CASING BLOWS			
Depth From To	Material Description	Sample		Blows on Spoon 6" Intervals				Run No.	Depth of Run	Core Rec. (ft)	(water loss, cavities, etc.)	
		No.	Depth	0-6"	6-12"	12-18"	18-24"					
0.0 2"	Clayey fine to Medium SAND trace fine gravel and organics (SC-OL)	B1	2"								Note* Top 3 1/2 feet is fill material	0-1
		B2	6"									1-2
2" 1'	Clayey fine to Medium SAND trace fine gravel (SC)	B3	1'									2-3
		B4	2'									3-4
1' 3'	Clayey fine to medium SAND trace to little fine gravel (SC)	B5	3'									4-5
		B6	4'									5-6
3' 4'	Silty-Clayey fine to medium SAND trace fine gravel (SC-SM)	B7	5'									6-7
		B8	6'									7-8
4' 5'	Silty fine to medium SAND trace to little fine to medium gravel (SM)											8-9
5' 6'	Silty fine to medium SAND trace clay and fine gravel (SM)											10-11
												12-13
												13-14
												14-15
												15-16
												16-17
												17-18
												18-19
												19-20
												20-21
												21-22
												22-23
												23-24
												24-25
												25-26
												26-27
												27-28
												28-29
												29-30
												30-31
												31-32
												32-33
												33-34

Inspector _____ Resident or Soils Engineer _____

For Chesapeake Division
of the Navy

Project No. 82-5061-7

Washington Testing Inc.

TEST BORING LOG

Boring No. Site 5

Sheet of

Job Name and Location E. O. D. Site Testing - Area 8

Boring Location:

Date Begin 10-14-83
Date Completed 10-14-83
Depth of Soil
Depth of Rock
Total Boring Depth

Casing Size, O.D. "
Hammer Weight #
Hammer Drop "
Core Bit Size "
Driller

Spoon Size, O.D. "
Hammer Wt. #
Hammer Drop "
Rig No.
Asst. Driller

Progress & Ground Water Data

Date	Depth Reached	Depth Water	Hour
10-14-83	4.0	--	

Ground Elev.
Datum Elev.
Depth Surf. Water
Weather

BORING LOG		SPOON SAMPLE & ROCK CORE DATA					REMARKS (water loss, cavities, etc.)	CASING BLOWS					
Depth From To	Material Description	Sample No.	Depth	Blows on Spoon 6" Intervals				Run No.	Depth of Run	Core Rec. (ft)	0-1		
				0	6	12	18	24				1-2	
0.0 2"	Silt and organic root mat (OL)	B1	2"									2-3	
		B2	6"									3-4	
2" 6"	SILT trace organics (ML-OL)	B3	1'									4-5	
		B4	2'									5-6	
6" 4'	SILT, trace to some fine sand, trace fine gravel	B5	3'									6-7	
		B6	4'									7-8	
												8-9	
												9-10	
												10-11	
												11-12	
												12-13	
												13-14	
												14-15	
												15-16	
												16-17	
												17-18	
												18-19	
												19-20	
												20-21	
												21-22	
												22-23	
												23-24	
												24-25	
												25-26	
												26-27	
												27-28	
												28-29	
												29-30	
												30-31	
												31-32	
												32-33	
												33-34	

Inspector Resident or Soils Engineer

For Chesapeake Division
of the Navy

Project No. 82-5061-7

Washington Testing Inc.

TEST BORING LOG

Boring No. Site 6

Sheet _____ of _____

Job Name and Location E. O. D. Site Testing - Area 8

Boring Location _____

Date Begin 10-14-83

Date Completed 10-14-83

Depth of Soil _____

Depth of Rock _____

Total Boring Depth _____

Casing Size, O.D. _____"

Hammer Weight _____ #

Hammer Drop _____"

Core Bit Size _____"

Driller _____

Spoon Size, O.D. _____"

Hammer Wt. _____ #

Hammer Drop _____"

Rig No. _____

Asst. Driller _____

Progress & Ground Water Data

Date	Depth Reached	Depth Water	Hour
10-14-83	4	3 1/2	

Ground Elev. _____

Datum Elev. _____

Depth Surf. Water _____

Weather _____

BORING LOG		SPOON SAMPLE & ROCK CORE DATA					REMARKS (water loss, cavities, etc.)	CASING BLOWS					
Depth From To	Material Description	Sample No.	Depth	Blows on Spoon 6" Intervals				Run No.	Depth of Run	Core Rec. (ft)	0-1		
				0	6	12	18	24				1-2	
0.0 6"	SILT and Root Mat (OL)	B1	2"									2-3	
		B2	6"									3-4	
6" 1'	Sandy SILT (ML)	B3	1'									4-5	
		B4	2'									5-6	
1' 2'	Silty fine to Coarse SAND with fine gravel (SM)	B5	3'									6-7	
		B6	4'									7-8	
2' 3'	Silty-Clayey Fine to Medium SAND (SM-SC)											8-9	
												9-10	
3' 4'	Silty fine SAND (SM)											10-11	
												11-12	
												12-13	
												13-14	
												14-15	
												15-16	
												16-17	
												17-18	
												18-19	
												19-20	
												20-21	
												21-22	
												22-23	
												23-24	
												24-25	
												25-26	
												26-27	
												27-28	
												28-29	
												29-30	
												30-31	
												31-32	
												32-33	
												33-34	

Inspector _____ Resident or Soils Engineer _____

APPENDIX

Ordnance Disposal Study Naval Ordnance Station Indian Head, Maryland

Prepared for

Department Of The Navy
Chesapeake Division
Naval Facilities Engineering Command
Washington, D.C.
November 1983



Booker Associates, Inc.
St. Louis, Missouri

Prime Consultant



El Dorado Engineering Inc.
Salt Lake City, Utah

Sub-Consultant

APPENDIX INDEX

DIVIDER NUMBER

SUBJECT

I	LIST OF REFERENCE DOCUMENTS PROVIDED BY NFEC CHESAPEAKE DIVISION
II	CONTAMINATED WASTE PROCESSOR - EQUIPMENT, PROCESS, CONTROLS
III	EXPLOSIVE WASTE INCINERATOR - DESIGN ANALYSIS
IV	TECHNICAL PAPER - POLLUTION FROM OPEN AIR DETONATION
V	TECHNICAL PAPER - OPEN AIR DETONATION OF TNT
VI	EXCERPTS FROM TM 9-1300-277 DESCOM AND ARRCOM DEMIL CAPABILITIES
VII	COST ESTIMATE BACKUP SHEETS
VIII	MISCELLANEOUS CALCULATIONS
IX	MISCELLANEOUS COMMUNICATIONS

I. List Of Reference Documents Provided By NFEC
Chesapeake Division

P-879 Propellant Disposal Fac. - 1st Increment
Incinerator Mfgs.
4 - May, 1971

Wet Air Oxidation of X-Ray Film For Silver Recovery
Preliminary Report
Zimpro, Inc.
5 - May, 1972

Laboratory Oxidation of "Orange" (2, 4, 5 - Trichlorophenoxy)
Acetic Acid and Otto Fuel
Zimpro, Inc.
11 May, 1972

P-879 Propellant Disposal Fac. - 1st Increment
Process Description
17 August 1971

Letter From: Barber - Colman Co.
To: Naval Facility Engineering Command
9 September, 1973

Letter From: U.S. Environmental Protection Agency
To: Environmental Engineering Branch, Maintenance/Utilities Divisions
1 June 1977

Letter From: Department of The Navy, Chesapeake Div.
To: Charles County Health Department
4 August, 1977

Letter From: Department of Defense Explosives Safety Board
To: Chief of Naval Operations
1 September, 1977

Material Disposal of by Open Burning
Naval Ordnance Station
11 October, 1978

Preliminary Commissioning Estimate For Second Increment,
Propellant Disposal Facility
20 March, 1979

FBI Entrainment Calcs.
Naval Ordnance Station
4 September, 79

Demonstration of Fluidized Bed Conveyor
Rexnord - Louisville, KY
4 December, 1979

Propellant Disposal Facility, Increment II
21 July, 1977
Memorandum

Memorandum
Fluidized Bed Incinerator
11 July, 1977

Proposed Plan for Zimpro Demonstration
30 June, 1977

Memorandum
Fluidized Bed Incinerator,
21 June, 1977

Memorandum
Design Review of Fluidized Bed Incineration
16 June, 1977

Memorandum
Propellant Disposal Facility
7 June, 1977

Design of a Propellant Facility/Reclamation Facility
25 October, 1972

Military Construction Project, P-947, Propellant Disposal Facility,
Second Increment
March 26, 1979

Memorandum
Propellant Disposal Facility, Second Increment
5 November, 1979

Memorandum
Propellant Disposal Facility, First Increment
28 November, 1979

Memorandum
Propellant Disposal Facility, Second Increment
18 September, 1979

Memorandum
Propellant Disposal Facility; checkout of
17 February, 1978

Memorandum
Propellant Disposal Facility, Second Increment
19 April, 1979

Memorandum
Propellant Disposal Facility, Second Increment
13 December, 1978

Undefinitized or Unfunded WPM Change Orders. 1st Increment
5 February, 1980

Review Comments on FBI Interlocks and Controls
2 April, 1980

Review Comments For Scope of Work For Modifications P-00013
2 May, 1980

Letter From: Department of Health and Mental Hygiene
To: Navordsta

Propellant Disposal Facility Techno/Economic Study

Cost Estimate to Mothball Propellant Disposal Facility

Proceedings to the American Defense Preparedness Assoc.
Symposium on Demilitarization of Conventional Munitions
18 May, 1977

1974 Jannaf Propulsion Meeting Vol. 1 part II
Johns Hopkins University

Industrial Preparedness Measure: Propellant Disposal/Reclamation
Facility Design
28 September, 1973

Propellant Disposal Demonstration by Wet Air Oxidation
Zimpro Inc.
Nov, '71

Economic Analysis Handbook
July, '80

Amendment of Solicitation/Modification of Contract
6 June, 1983

Operation and Maintenance Instructions For the 10 gpm Zimpro
Wet Air Oxidation Unit For the U.S. Navordsta.
Zimpro Inc.
6 June, 1983

Notice: Bids Wet Oxidation System

NAVSEA OP 5 Volume 1 Fourth Revision
Ammunition And Explosives Ashore

Contract No. N62477-72-C-0803 Drawing and Specifications -
for Propellant Disposal Facility at the U.S. Naval Ordnance
Station Indian Head, Maryland

Contract No. N62477-74-C-0333 Drawing and Specifications - Second
Increment Propellant Disposal Facility at the U.S. Naval Ordnance
Station Indian Head, Maryland

Memorandum
Propellant Disposal Facility
9 January, 1979

Memorandum
Propellant Disposal Facility, Second Increment
6 November, 1979

Memorandum
Propellant Disposal Facility
22 August, 1979

Memorandum
Propellant Disposal Facility
16 August, 1979

Memorandum
Propellant Disposal Facility, Second Increment
16 August, 1979

Naval Speedletter
Military Construction Project, P-947, Propellant Disposal
Facility, Second Increment
April 20, 1978

Military Construction Project P-879, Propellant Disposal
Facility, First Increment; submission of Facility study for
30 August, 1971

Military Construction Project P-879, Propellant Disposal
Facility, First Increment; Resubmission of facility study for
20 November, 1972

II. Contaminated Waste Processor —
Equipment, Process, Controls

DESCRIPTION OF SYSTEM

The Contaminated Waste Process (CWP) is designed to thermally destroy explosive or toxic contaminated wastes and to decontaminate metal parts by flashing. The wastes typically consist of rags, gloves, sludges, shipping containers, wood pallets, piping, pumps, motors, etc. The CWP is comprised of 3 major elements: the carbottom furnace, the air pollution control system and the feed systems. A description of each follows.

Carbottom Furnace

The CWP furnace is a single chamber, self-propelled carbottom type with a capacity for loading a 6 foot high by 8 foot wide by 21 foot long load of 10,000 pounds gross weight. The nominal interior dimensions of the furnace are 7 feet high from top of carbottom to ceiling of furnace by 8-1/2 feet wide by 21-1/2 feet long. The load door opens vertically so that there is 6-1/2 feet of clearance above the top of the carbottom. The furnace is designed to operate at a 1800⁰F maximum continuous working temperature with a capability of withstanding intermittent temperatures of 2200⁰F. The furnace is operated under a negative pressure of approximately 0.1 inch water to control fugitive emissions. Included with the furnace is an unfired vertical afterburner to provide a residence time of approximately 0.4 to 0.5 seconds for the exhaust gases at 1600⁰F.

The CWP furnace is insulated so that it can withstand a hot face temperature of 2200⁰F and will not be affected by thermal cycling. The nominal thickness of the insulation is 6 inches consisting of a base of 3-1/2 inches of mineral block insulation, maximum operating temperature of

1800°F, and an outer layer of 2-1/2 inches of aluminosilica ceramic fiber blanket, maximum operating temperature of 2300°F.

The carbottom has a structural steel frame and two layers of cast refractory insulation. It is designed to transport a load of 10,000 pounds at a peak speed of 36 feet per minute.

The CWP's burner system consists of two combination oil/gas burners that supply a total 7.3 million BTU/hour. They are modulated from high to low fire to maintain an internal temperature of 1600°F. The burners are each linked to air injection nozzles to provide combustion air for the waste. As the waste begins to burn and generate its own heat, the burners turn back to low fire. Under the same action, each air injection nozzle adds up to 1700 SCFM of air to ensure complete combustion of the waste.

Air Pollution Control System

The CWP air pollution control system (APCS) is designed to meet EPA's allowable particulate emissions of 0.08 grains/SCF corrected to the amount of oxygen in the stack. The APCS consists of a gas cooler cyclone, baghouse, exhaust fan, and exhaust stack. The furnace exhaust gas (4000 scfm) will be maintained at nominally 1600°F to assure combustion of the wastes. Dilution air will be added to the 1600°F exhaust gas to provide 900°F air at the gas cooler inlet. The gas cooler will cool the furnace diluted exhaust gas down to 250°F in order to provide gas temperature conditions within the operating limit of the baghouse. The gas cooler is used to minimize the exhaust fan power requirements as well as exhaust gas processing requirements. The exhaust gas will

then pass through the cyclone to remove particulates down to approximately the 30 micron size, followed by the baghouse for removal of particulates to 0.5 micron. It is expected that better than 99% of the emitted particulates will be removed by the cyclone/baghouse combination. The exhaust gases (250⁰F) will then pass through the fan, which provides a negative draft on the CWP system, and exist out the exhaust stack.

Feed Systems

Two types of feed systems are provided: 1) Batch loading onto the carbottom using an automated overhead trolley system; and 2) continuous furnace top dump conveyor system with front end preparation. The carbottom system allows the furnace to not only handle typical wastes that are generated, but will also give the furnace the added versatility of flashing metal objects such as bombs, projectiles and odd shaped wastes such as blowers, coolers, long pipes, etc., that are not conducive to conveyor feed.

a. Batch System

The batch loading uses a 6 foot wide by 12 foot long by 2 foot high loading basket with a holding tray below. The basket is placed on the standard carbottom with an overhead traveling trolley loading system. The loading basket is designed to allow for batch or continuous feeding of contaminated waste.

The basket is fabricated of steel with wire braided sides and enclosed pan to catch the ash and residue. Large metal scrap may be placed directly on the car, for batch processing. This can be accomplished by using the overhead trolley with a sling or a forklift (if carbottom is cold). The smaller scrap may be placed in the baskets with the contaminated wastes to be processed. These baskets will be loaded at some distance from the car in the

loading area. The baskets will then be picked up and transferred to the furnace by the overhead trolley. Remote controlled quick release hooks will be used to load and unload the baskets thus insuring the safety of the operator.

b. Continuous Feed

A top dump continuous conveyor feed system may be used to increase the processing capacity of the furnace as well as its flexibility. The smaller scrap will be loaded (pushed) onto a continuous feed conveyor, carried to the top of a shredder and then into the furnace. The industrial waste shredder is driven by a hydraulic motor. The shredder has the capacity of shredding 55 gallon drums, railroad ties, wire, cable, light gauge scrap metal, cloth, paper and cardboard. It has shredding rates to 120 pallets per hour and can process approximately 40-55 gallon drums per hour. The shredded waste will be carried from the shredder and dumped into the furnace using a cleated conveyor.

CWP Operation

Operation of the CWP will first require the start-up of the furnace and APCS. The start-up will be automatically controlled from the central control panel. Once a flame is established in the furnace, the waste materials can be fed to the furnace via the overhead trolley or continuous feed system.

During continuous feed system operation, the conveyor feed will be interlocked with the furnace temperature sensor to control the rate of waste input. In the event of a high temperature situation, the feed conveyor will automatically stop. Also, the hopper under the shredder will be interlocked with the shredder feed conveyor and when a pre-determined volume of shredded

material has collected in the hopper, the shredder feed conveyor will stop. Though the interlock system should prevent overloading the furnace, operator awareness and concern should help keep the system operating smoothly.

After the furnace/carbottom has cooled, probably at the beginning of the next day's operation, the carbottom will be cleaned by vacuuming up the fly ash.

If the batch loading system is to be utilized, the furnace/APCS will be started and a basket will be loaded with waste material for processing. With the flame established in the furnace, the basket will be loaded on the carbottom and the carbottom then advanced into the furnace. While one basket is in the furnace, another is loaded with material for processing. When the first batch is consumed, the carbottom is brought out of the furnace and the hot basket is unloaded from the car and placed in the cooling area. A loaded basket is then placed on the car and the cycle is repeated. When all the baskets are cool, probably at the beginning of the next day's operation, the cooling area and the carbottom tray will be cleaned by vacuuming up the fly ash and shoveling up the residue scrap metal.

The complete system is designed to operate from a main control panel. Individual control panels are provided at specific equipment for maintenance etc.

Large Item Flashing

When the need arises for flashing large or heavy items that exceed the capacity of the baskets, the items will be loaded directly on the carbottom with a forklift. Flashing operations for this type of item will be the first operation of the day when the carbottom is cool. Access will be provided through a door at the furnace end of the building for loading large or heavy items directly on the carbottom.

Problem Areas *

The CWP is a new system, it has been checked out and complies with all environmental regulations however, during startup, the following problems developed and must yet be resolved.

1. Baskets. Due to the weakening of the metal at 1600⁰F, the basket deformed under full load as it was picked up off the carbottom. The basket design must be re-engineered to correct this.
2. Overhead Trolley. Due to misalignment, and tolerances on the trolley's rail system, it had a tendency to bind up. The tolerances are being tightened up and a large motor specified which should eliminate this problem.
3. Shredder. The wastes from the shredder had a tendency to bind up in the double sliding valve prior to being fed into the furnace. The shredder has been sent back to the manufacturer for corrective action.

Although the above problems do exist in the system, each is being addressed and should be resolved in the near future.

Attached is a detailed step sequence on the CWP control philosophy that describes the workings of the system in detail.

*NOTE: The report from which this information was taken is several years old. At this time, with several operating facilities, most operational problems have been corrected.

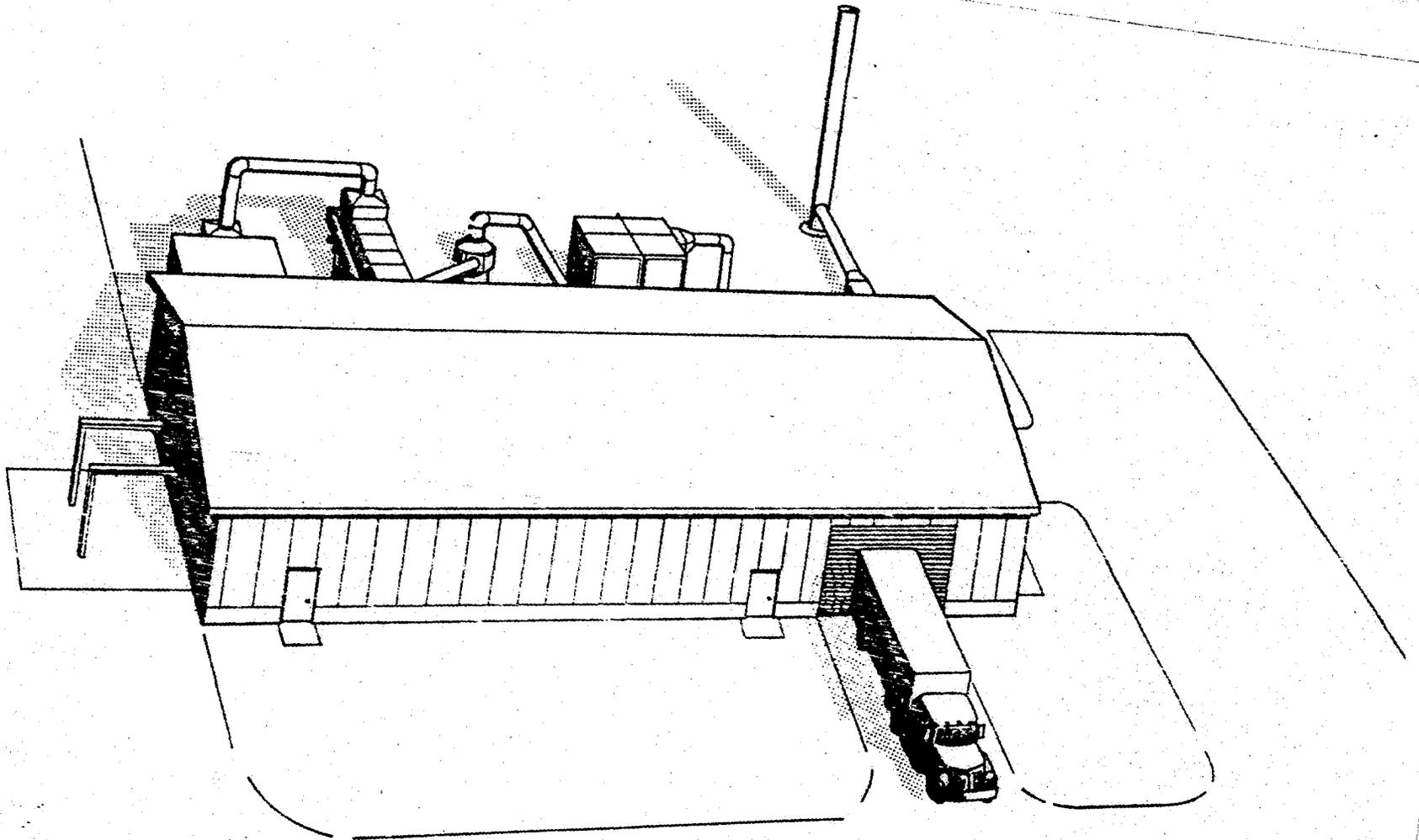
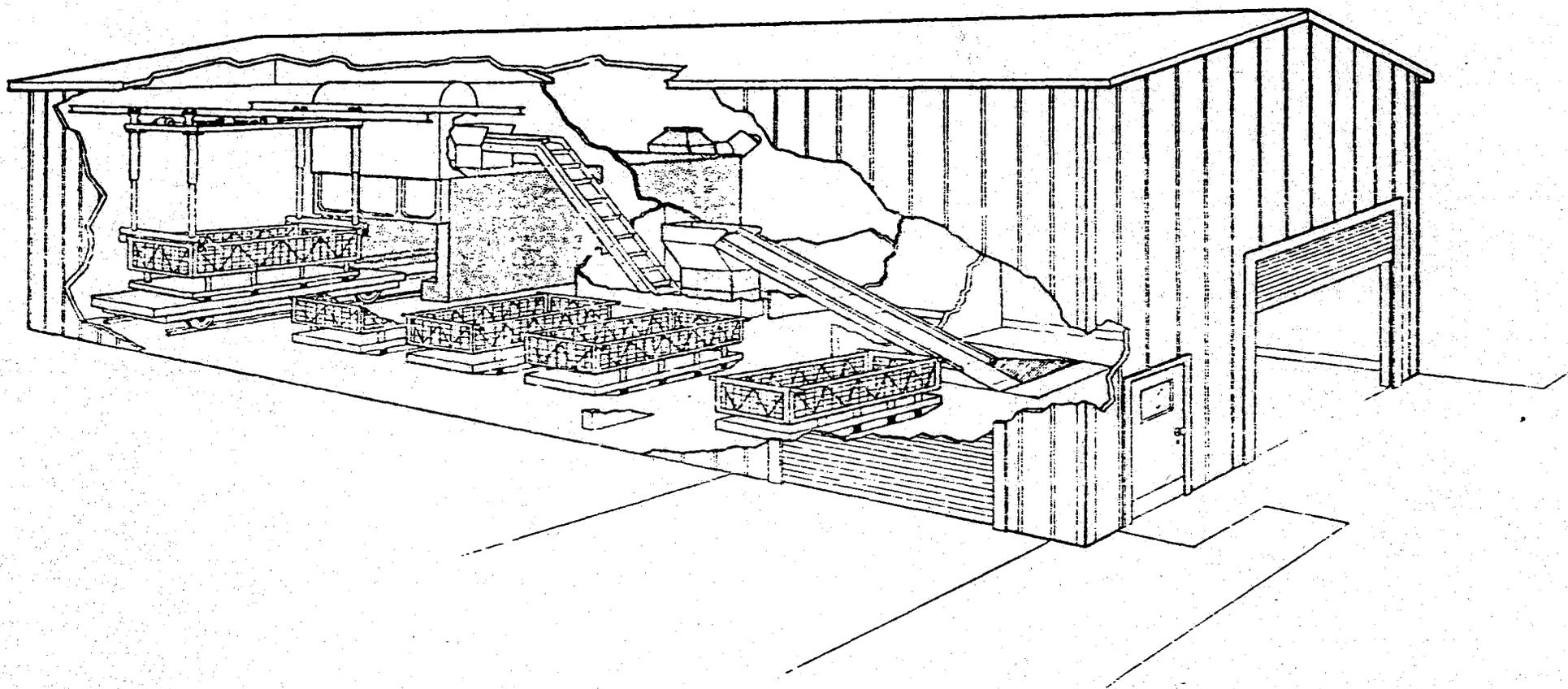


Figure 1 , Contaminated Water Processor Facility Layout



- 8 -

Figure 2, Contaminated Waste Processor Equipment Concept

CWP CONTROL PHILOSOPHY

Description of System.

The Contaminated Waste Processor System consists of the following subsystems:

A material handling system for loading and unloading waste containers into the furnace. The following equipment is included:

- (1) Furnace door.
- (2) Furnace Carbottom.
- (3) A two speed trolley/hoist system used to place waste handling baskets in the positions required for loading, unloading, and cooling of the waste material.
- (4) Basket type containers for holding wastes for processing.

A shredder system for supplying a continuous feed of shredded wastes into the furnace. This system includes the following equipment:

- (1) Shredder input conveyor.
- (2) Shredder.
- (3) Furnace feed conveyor.
- (4) Sliding gate mechanism for dropping the shredded wastes into the furnace.

A waste processing furnace which includes the following:

- (1) One large burner and one small burner for supplying heat input.
- (2) Combustion air blower.
- (3) Excess air blower.
- (4) Flame safeguard system.
- (5) Burner ignition system.

- (6) Combustion temperature control system.
- (7) Burn cycle control system for batch, continuous feed, and flashing operations.

A pollution control system with the following equipment:

- (1) Stack dump damper.
- (2) Inline shutoff damper.
- (3) Dilution air damper.
- (4) Draft control damper.
- (5) Gas cooler w/tipping valve.
- (6) Cyclone w/tipping valve.
- (7) Baghouse w/automatic cleaning system.
- (8) Draft fan.
- (9) Draft control system.
- (10) Temperature control system.

The operation and control of these subsystems is discussed in detail in the following sections.

Material Handling System Control

The material handling system equipment will be controlled via manual pushbuttons or a microprocessor based automatic control system. All control functions are operable in manual mode, including all safety interlocks. However, since it is anticipated that automatic operation will be used almost exclusively, the following discussion will pertain to the automatic control of the system.

The primary function of the automatic material handling system is to provide the correct placement of the waste containment baskets for loading, processing in the furnace, cooling, and unloading. To accomplish this, the seven available positions for the baskets have been defined as follows: (See figure 3)

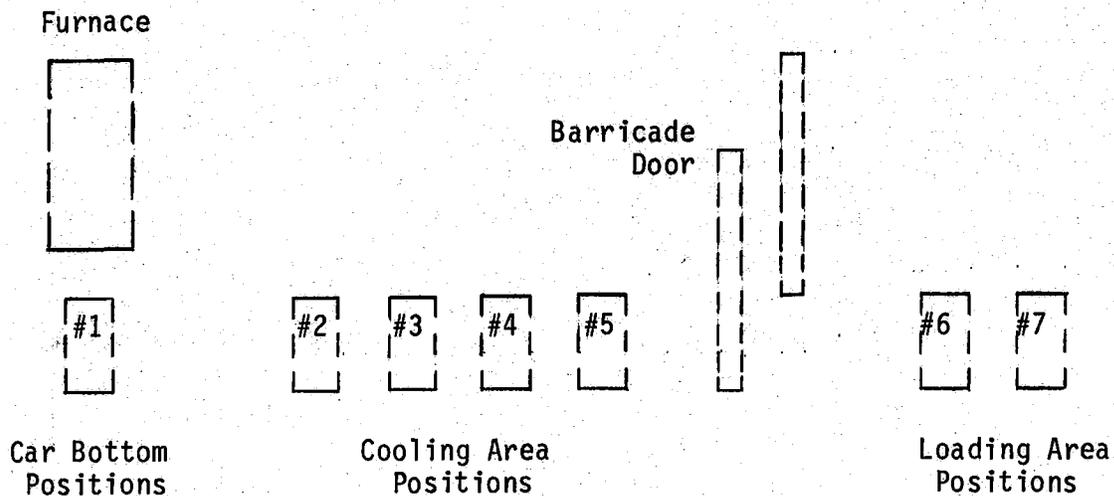


Figure 3

(1) Position 1 - Carbottom. From this position, the basket will be loaded into and unloaded from the furnace.

(2) Positions 2 thru 5- Cooling positions. Baskets will be placed in these positions for a cooling period after processing through the furnace.

(3) Positions 6 and 7 - Load/unload positions. Baskets in these positions will be cleaned and reloaded for processing into the furnace.

Prior to system startup, baskets will be manually placed such that an empty position exists in position 2, 3 or 4, and position 6 or 7. These empty positions will later be preloaded into the microprocessor memory as the first cooling position (position 2, 3 or 4) and the first return position (position 6 or 7). Based on this information, the microprocessor will control the placement of hot, unloaded, and loaded baskets in a rotating fashion during the daily operation.

The material handling functions have been separated into three independant cycles:

- (1) Unload furnace.
- (2) Basket transfer.
- (3) Load furnace.

These cycles are defined as follows:

Unload cycle - opens the furnace door, moves the carbottom (with basket) out of furnace, and opens the interior barricade door. This cycle is initiated by operator push button.

Basket transfer - Moves hot basket from the carbottom (position 1) to an empty cooling position, a cool basket to the loading area (position 6 or 7), a loaded basket to the carbottom, and checks and opens or closes the interior barricade door as necessary. This cycle is initiated by operator pushbutton or under program control.

Load cycle - Checks and opens the furnace door if necessary, moves carbottom into furnace, closes the furnace door and insures that the barricade door is closed. This cycle is initiated by operator pushbutton or under program control.

Automatic control is separated into two modes:

(1) Select cycle. In this mode, any of the three above cycles can be initiated by pushing the appropriate cycle start button. Only one cycle may be in operation at any one time. Cycles may be operated in any desired sequence, as long as all interlock requirements are met.

(2) Auto sequence. This mode will be used for most batch loading operations. Operation in this mode will cause the furnace unload, basket transfer, and load cycles to automatically sequence (under microprocessor control) in that order. Initiation of the total sequence is normally via the unload cycle start button. Completion of the unload cycle will be automatically followed by the transfer and load cycles. The auto sequence will automatically stop after completion of the load cycle. Auto sequence may be initiated by any of the cycle start buttons; however, the sequence will start with the cycle initiated and will stop after the unload cycle, as in normal operations.

Furnace door operation. Provision is made for manual operations of the furnace door if no automatic cycle is processing. This allows the operator to monitor the status of the burn without switching to manual control.

Based on the above discussions, a typical startup and operation procedure of the material handling system will be as follows:

- (1) Step 1 - Turn on power.
- (2) Step 2 - Turn mode select switch to "preload"
- (3) Step 3 - Turn preload select switch to "cool position" and hold.
- (4) Step 4 - Push position button 2, 3, or 4 to select first cooling position. "Ready" light will turn on for 3 seconds, and turn off.
- (5) Step 5 - Turn preload select switch to "first return" and hold.
- (6) Step 6 - Push position button 6 or 7 to select the location of the first loaded basket. "Ready" light will turn on.
- (7) Step 7 - Turn mode select switch to "Auto Cycle"
- (8) Step 8 - To load first basket into furnace, push "Crane Cycle Start." The system will respond by unloading the carbottom, picking up the new basket, placing it on the carbottom, and loading it into the furnace. After completion of the burning process, push "Unload Cycle Start" to initiate the automatic sequence.

For a more detailed description of the system operation, reference Appendix A of the microprocessor specification.

Shredder Control.

The shredder system consists of a commercial 75 HP shredder, a shredder feed conveyor, a furnace feed conveyor, and a sliding gate valve system. Control of this system is totally automatic and includes the following provisions:

- (1) Shredder jam detection.
- (2) Furnace overtemperature shutdown.

(3) Shredder hopper full detection.

(4) Fire detection/deluge system.

Shredder control is initiated from the main control panel. The shredder will be used during continuous feed operation only.

The furnace feed conveyor will incorporate a variable speed drive system to allow adjustment of furnace feed rates. The sliding gate system will be cycled when a load of material is dumped from the conveyor into the hopper.

If the furnace temperatures exceed 1800⁰F, the shredder system will shut down. Restart will automatically occur after the furnace temperature drops below approximately 1700⁰F.

Automatic cycling of the sliding gate system will occur on a furnace overtemp. This will discharge any residual material from the gate valve mechanism.

Furnace Controls.

The primary control functions required for the furnace pertain to regulating the furnace temperature at specified levels to provide total destruction of the contaminated wastes while simultaneously allowing for system safety and energy conservation. To accomplish this task, a combustion control circuit board has been designed which will control the fuel and air input levels in such a way that an operating temperature of 1600⁰F will be achieved using minimum fuel. This is based on the fact that fuel input is needed only to initiate the combustion of the waste material. Once this combustion is initiated, the fuel input is decreased and the required heat input for maintaining, the 1600⁰F temperature is supplied by the burning waste material. After the burning process has subsided, fuel input is increased only as necessary to maintain operating temperature.

A second important requirement for furnace control is a method of ensuring that a flame is present. This is accomplished via a flame safeguard unit which monitors the presence of a flame on both burners, and shuts off the fuel input on loss of flame. This unit will initiate other appropriate shutdown processes and sound an alarm if the flame is lost from either burner.

The burning process has been separated into three modes:

- (1) Batch operation.
- (2) Flashing operation.
- (3) Continuous feed.

The batch and flashing modes both utilize the basket input processes (load, unload, and basket transfer cycles). The batch mode is used for processing combustion wastes, and the time duration of the burn is primarily determined by the burning rate of the material, plus a fixed time period to guarantee total destruction. The flashing mode is used for non-combustible materials, and the time duration of the burn is preset by the operator. In both of these modes, the burn cycle is initiated by the operator, and the cycles are automatically stopped on completion of the burn.

The continuous feed mode utilizes the shredder system to supply waste input into the furnace. The burning process in this mode is started after the furnace is at operating temperature and the shredder system is started. In this mode, the cooling cycle (automatically initiated in batch and flashing modes) is initiated by operator pushbutton, following shutdown of the shredder system.

A typical operating procedure for batch operation is as follows:

- (1) Step 1 (Preparation) Ignite burners and operate load, unload, and basket transfer cycles as necessary to load furnace. Select batch mode operation.

(2) Step 2 Push burn cycle start button. The "Burn Cycle On" light will turn on and automatic burner controls will cycle. Upon completion of the burn, the "Cool Cycle On" light will turn on. When the furnace temperature has cooled to 800⁰F, the "Burn Cycle Complete" light will turn on.

For flashing operation, the above procedure will include selecting flashing mode and setting the required time interval prior to pushing "Burn Cycle Start"

For continuous feed operations, the carbottom with a loaded basket will be moved into the furnace, the furnace door will be closed and the burn cycle initiated. The shredder system will operate as required to maintain temperature. Upon completion of continuous feed operation the operator will push the "Cool Cycle Start" pushbutton. When the temperature drops to 800⁰F, the "Burn Cycle Complete" light will turn on.

Air Pollution Control.

As discussed in section 1, the pollution control equipment consists of a gas cooler, cyclone, baghouse, and draft fan, with appropriate control dampers. The following is a more detailed description of the above equipment.

Gases leaving the furnace enter a vertical stack. The top of this stack contains a "dump" damper, which, when open, allows the gases to dump to the atmosphere. Under normal operating conditions, the dump damper is closed, and the gases are pulled through a horizontal duct leading from the furnace stack to the gas cooler. Between the vertical stack and the gas cooler is a "dilution air" damper which allows outside air to mix with the furnace exhaust for temperature control. The temperature of the mixed air is monitored prior to the gas cooler and the dilution air damper is modulated to maintain the gas temperature at 900⁰F. An additional controller will shut down the system, dumping the exhaust gases to the atmosphere, if the temperature exceeds 1000⁰F at the entrance to the gas cooler.

The gas cooler is a commercial system consisting of four banks of cooling area. This system will cool 900°F air to approximately 250°F at the discharge. Any particles dropping out in the cooler will be discharged through a double tipping valve.

Following the gas cooler, the gases will enter a cyclone separator which is designed to separate particles of 30 microns in diameter or larger. These particles will be discharged from the cyclone via a double tipping valve system.

The cyclone will discharge the gases into a baghouse filter system. Prior to the baghouse is an in-line shutoff damper which will close if the gas temperatures exceeds 280°F. This temperature is monitored at the entry and exit of the baghouse.

The baghouse consists of a 196 bag self cleaning system. The dust collected in the baghouse will be discharged through a sliding gate mechanism (manually opened and closed). Continuous cleaning of the bags is obtained via a pulsed air system. Particles larger than approximately 0.5 microns will be removed from the air stream.

The gases leaving the baghouse will go through an in-line draft control damper into a 60 HP blower system which discharges the air into a vertical stack and to the atmosphere. The draft control damper is modulated to control furnace draft at 0.1" H₂O as measured in the furnace chamber.

The air pollution control system is started by turning on the gas cooler and the draft fan. The system is automatically shut/down in the event of baghouse or gas cooler overtemperature, or overtemperature in the furnace. Shutdown of the APCS will in turn initiate an emergency shutdown of the furnace system.

Miscellaneous Controls.

An optional loading system for the furnace provides loading of baskets on the carbottom from an open area beyond the furnace. This option utilizes the trolley/hoist system and is operated under manual control only.

Remote control panels are provided for manually operating 1) MHE equipment and 2) Burner ignition.

The gas cooler and shredder equipment have self contained control panels. These controls are enabled from the main control panel.

The above descriptions are general in nature and do not attempt to provide detailed operational or control logic functions.

References: 1. This material was assembled using material taken from the Contaminated Waste Processor design specifications authored by the Ammunition Equipment Office, Tooele Army Depot. Approximate Date 1980.

III. Explosive Waste Incinerator — Design Analysis

SUMMARY

There are several ammunition plants within the U.S. Army Armament Materiel Readiness Command (ARRCOM) with missions to manufacture propellants, explosives and pyrotechnics (PEP); and to load or assemble munition end-items. Throughout the processes of manufacture and assembly, PEP wastes are generated that have traditionally been disposed of by open-air burning or detonation.

These disposal techniques are no longer environmentally acceptable. ARRCOM's Environmental Quality Office, within the Installation and Services Directorate; requested the Ammunition Equipment Office, at Tooele Army Depot, Utah, test the feasibility of burning PEP wastes in the APE 1236 Deactivation Furnace.

The APE 1236 Deactivation Furnace is an incinerator developed specifically for demilitarization of conventional end-item munitions. The furnace has been in use for approximately 25 years at the Army's ammunition storage depots.

Tests proved the feasibility of burning various bulk explosive and propellant wastes in the furnace at rates up to 600 pounds per hour for some types of PEP. Burning PEP wastes in the furnace provides a containment system wherein exhaust emissions from the burning process can be captured and cleaned.

The Ammunition Equipment Office has been funded by the Corps of Engineers to provide an APE 1236 Deactivation Furnace with such ancillary equipment as air pollution controls and special feed mechanisms to several Army Ammunition Plants.

This document is intended to provide such information as to permit familiarization with and evaluation of the several equipment components that comprise the Explosive Waste Incinerator.

TABLE OF CONTENTS

	PAGE
INTRODUCTION-----	1
BACKGROUND-----	2
DESCRIPTION OF SYSTEM-----	7
Furnace-----	7
Positive Feed System-----	13
Air Pollution Control System-----	17
Container Retrieval System-----	19
Equipment Control Panel-----	20
OPERATIONAL SEQUENCE-----	22
SIGNIFICANT EFFORTS/EVENTS-----	27
Burn Tests-----	27
Explosive Limits Tests-----	28
Container Study-----	28
Composition A-5 Incidents/Tests-----	29
Environmental Loads-----	29
Waste Survey-----	29
Hazard and Safety Analysis-----	29
REFERENCES-----	30
APPENDIX A - Letters	
APPENDIX B - Photographs of Typical Explosive Wastes	
APPENDIX C - Environmental Loads or Equipment	
APPENDIX D - Utilities Requirements	
APPENDIX E - Preliminary Report on Composition A-5 Incidents	

LIST OF TABLES

	PAGE
TABLE	
1 Waste Generation Rates-----	3
2 Summary of Explosive Wastes Burned-----	6
3 Particulate Emission Data-----	6
4 Conveyor Feed Rates-----	12
5 Number of Items Between Spiral Flights-----	13
6 Residence Times-----	13

LIST OF FIGURES

	PAGE
FIGURE	
1 Artist's Concept of Explosive Waste Incinerator-----	7
2 Equipment Layout-----	8
3 Deactivation Furnace-----	9
4 Positive Feed System-----	14
5 Flow Diagram-----	18
6 Purge System for EWI Control Console-----	20
7 Equipment Control Panel-----	26

INTRODUCTION

Disposal of explosive wastes that are generated daily during the processes of manufacturing explosives and munitions at ARRCOM's Army Ammunition Plants (AAP) is a problem of major proportions because of restrictions on open-air burning, the long-practiced method of incineration of explosive wastes.

A meeting was held at HQ ARRCOM on 29 September 1976 for the purpose of standardizing criteria for an acceptable alternative to open burning; specifically an explosive waste incinerator. A decision was made at that meeting to specify the APE 1236 Deactivation Furnace as the presently available technology for explosives incineration and, therefore, the acceptable incinerator for installation at the various AAP.¹

An Explosive Waste Incinerator (EWI) is a system designed to dispose of PEP and PEP-filled wastes that result from manufacture of propellants, explosives and pyrotechnics; and loading of munitions at the Army's Ammunition Plants.

The EWI will be used to burn a large variety of high explosives (Composition B, TNT, Teteryl, Octol, Black Powder, etc.); single and double base propellants and composites; and pyrotechnics (signal flares, illuminating candles). In addition to these bulk wastes, various assembled end-item munitions may be burned.

Waste PEP is generated from a number of sources, including off-specification and scrap materials resulting from research and development, primary production, loading, rework, demilitarization, and resource recovery operations.

¹Letter DRSAR-ISC-A to DRXTE-AEO; Letter of Confirmation, 19 Oct 76.

During R&D, wastes such as residue from lathe turning, mixing operations scrap, obsolete or unstable samples, and bulk materials that become overage are created. Production operations produce waste PEP from filling plant processing, cleanings from catch basins and sumps, materials from production jobs considered unsafe for storage or handling, and unserviceable, off-specification and excess materials. Testing also produces waste PEP such as excess items from tests, misfires, and partially consumed test items. Table 1 illustrates the scope of the waste PEP problem, showing quantities of wastes generated currently at each AAP and the quantities expected to be generated under mobilization (MOB) conditions.

The PEP wastes are in many configurations that include flake, granular, powder, chunks (riser, funnel scrap), cubes and pellets. The wastes may be dry or in slurry form. The wastes will also be in "end-item" configuration such as booster assemblies, small arms ammunition, rocket motors and warheads, and artillery primers, fuzes and projectiles. Photographs of many types of wastes are contained in Appendix B.

BACKGROUND

In August 1975, AEO was contacted by ARRCOM (DRSAR-ISE) concerning possible methods for disposal of bulk explosive wastes. ARRCOM had a concept in mind, called SITPA (Simplified Incineration Techniques for Pollution Abatement), that consisted of burning layered explosive on a pad covered with a canopy which could be ducted to some air pollution control device.

AEO suggested a couple of approaches and was subsequently funded to perform tests. The two methods became known as SITPA I and II and were tested in the September-November 1975 time frame.

TABLE 1

WASTE GENERATION RATES

TONS PER MONTH (Current/MOB)						
AAP	FY	HE	PROPEL- LANT	EXPL FILL END ITEMS	PYRO- TECHNICS	TOTALS
Louisiana	74	3/ND	0.1/ND	1/ND		4/ND
Holston	74	6/40	-	-		6/40
Indiana	78	51/ND	-	-		51/ND
Iowa	79	5/93	3/86	-		8/179
Kansas	79	0.5/10	0.1/0.1	0.1/1		1/11
Longhorn	79	0.5/ND	2/ND	12/ND	11/ND	26/ND
Milan	79	29/73	0.5/1	Neg		30/74
Crane	80	ND	ND	ND		ND
McAlester	80	ND	ND	ND		ND
Volunteer	80	82/274	-	-		82/274
Badger (I)	81	-	0/36	-		0/36
Cornhusker	81	0/41	Neg	-		0/41
Joliet (I)	81	0/53	0/1	0/27		0/81
Newport (I)	81	0/61	-	-		0/61
Ravenna (I)	81	0/83	-	0		0/83
Redstone Arsenal	79		25/ND	-		25/ND
TOTALS		177/728	31/124	13/28		232/880

(I) - Inactive

ND - No Data

These data obtained from waste survey questionnaires answered by the AAP in June 1978.

SITPA I which was a variation of the original ARRCOM concept, dealt with burning layered explosive wastes in a pit, or trench that was covered with steel plates, with a suction fan providing an air flow countercurrent to the direction of the flame front to permit control over the burn rate. The exhaust gases could then be ducted from the trench into an air pollution control device. SITPA I tests were conducted during October 1975.

AEO then conducted tests to determine the feasibility of burning bulk explosive wastes in the APE 1236 Deactivation Furnace (SITPA II). The furnace is a time-proven piece of equipment, used for approximately 25 years, at the Army's ammunition storage depots to destroy or demilitarize conventional end-item munitions.

In October and November, preliminary testing was done, burning reclaimed pelletized TNT in the furnace. The furnace used in these early tests had an APE 1276 Air Pollution Control System (APCS) installed, but the filter bags were removed as a precaution against burning; however, the furnace emissions were passed through a cyclone collector before final exhaust.

Data from these early tests showed that bulk explosive wastes could be burned in the furnace under controlled conditions with certain modifications.

1. A better method of feeding the explosive into the furnace was required.
2. An APCS capable of handling higher temperatures and larger volumes of gases than can be handled by the APE 1276 APCS appeared necessary.

During the period April through July 1976, additional tests were conducted burning various types of explosive wastes including propellants, octol, black powder and composition B. The tests were conducted to determine burning characteristics and to establish some preliminary feed rates.

All of this testing led to the ARRCOM decision in September 1976 to use the APE 1236 Deactivation Furnace as the basic component in the explosive waste incineration program.

Concurrently with these test efforts AEO had designs on the board for a positive feed system, funded through the ARRCOM's Ammunition Peculiar Equipment (APE) Program, to supplement the standard furnace feed conveyor for feeding certain conventional end-item munitions into the furnace. It now appeared the new feed system had application for feeding bulk explosive wastes.

AEO then received funding in June of 1977 to continue some testing, finalize designs for an APCS, and to provide EWI equipment for two installations (Holston & Louisiana AAP's). There were sixteen installations programmed through FY81 at the time of the writing of this document. They are shown in Table 1. Table 2 summarizes the burn-testing conducted to date, while Table 3 presents some particulate emission data.

AEO is tasked to provide, with funding from various Corps of Engineers districts, the equipment that makes up the Explosive Waste Incinerator. That equipment will be installed within facilities constructed by other Corps of Engineers contractors.

TABLE 2 - SUMMARY OF
EXPLOSIVE WASTES BURNED - 15 SEP 78

EXPLOSIVE WASTE	CONFIGURATION	FEED RATE LB/HR	TOTAL QUANTITY BURNED		No _x ppm Peak
			Lbs.	Ave	
Composition B	Chunks, riser scrap	300	2,600	1,000	1,500
Composition A-3	Thin flakes	200	650	-	-
Composition A-3	Cubes	200	2,040	-	-
Composition A-5	Fine granular		2,035	200	340
TNT	Pellets	340	5,500	3,000	4,000
TNT	Flakes		2,165	-	-
Nitroguanidine	Fine powder	200	800	30	60
Black Powder	Pellets	180	2,075	25	180
Octol	Chunks, riser scrap	450	800		
M1 Propellant	Small cylinders	240	400		
M9 Propellant	Flakes	200	<u>1,040</u>		
			20,105		

- (1) Maximum achieved with confidence
(2) By chemiluminescence

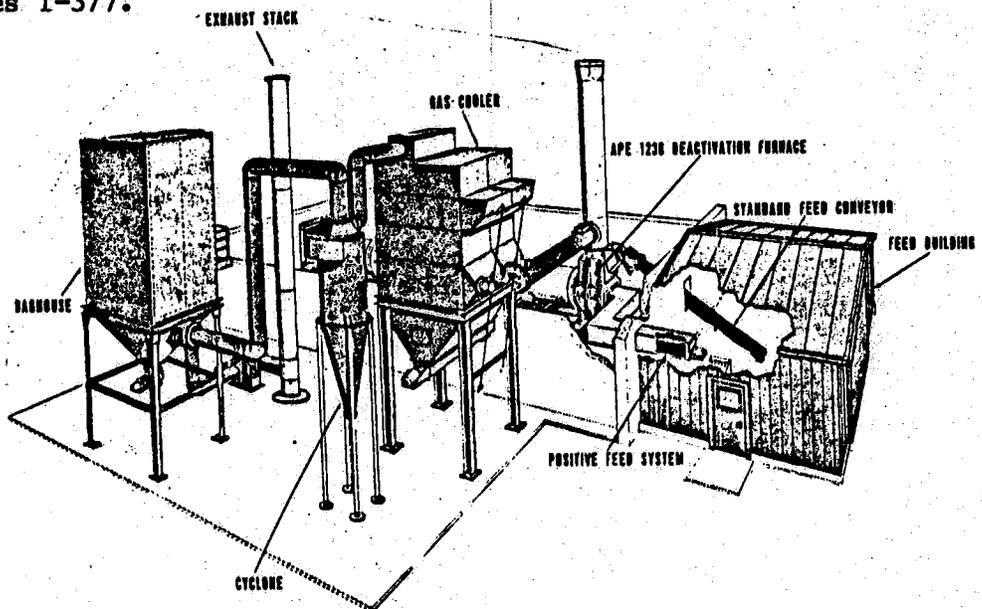
TABLE 3 - PARTICULATE EMISSION DATA

	TNT 1	TNT 2	Black Powder 1	Black Powder 2
Feed Rate				
Stack Velocity, fps	70.1	70.5	69.9	67.6
Stack Volume, scfm	2088	2211	2702	2589
Stack Temp, °F	617	553	388	396
H ₂ O Content, %	4	5	2	2
Particulate				
* Concentration, gr/scf	2.11	1.52	1.51	1.55
Particulate	37.75	28.80	34.97	34.38
* Mass Rate, lb/hr				

*EPA Method 5

DESCRIPTION OF SYSTEM

The standard EWI system is comprised of five major elements: Deactivation Furnace (DF); Positive Feed System (PFS); Air Pollution Control System (APCS); Container Retrieval System (CRS); and Equipment Control Panel (ECP). Figure 1 presents an artist's concept of the assembled EWI albeit slightly different from the final design configuration shown in Figure 2. Site-specific requirements may dictate some deviations from the standard design described herein. All equipment components are described on Ammunition Equipment Office Drawing Series T-377.

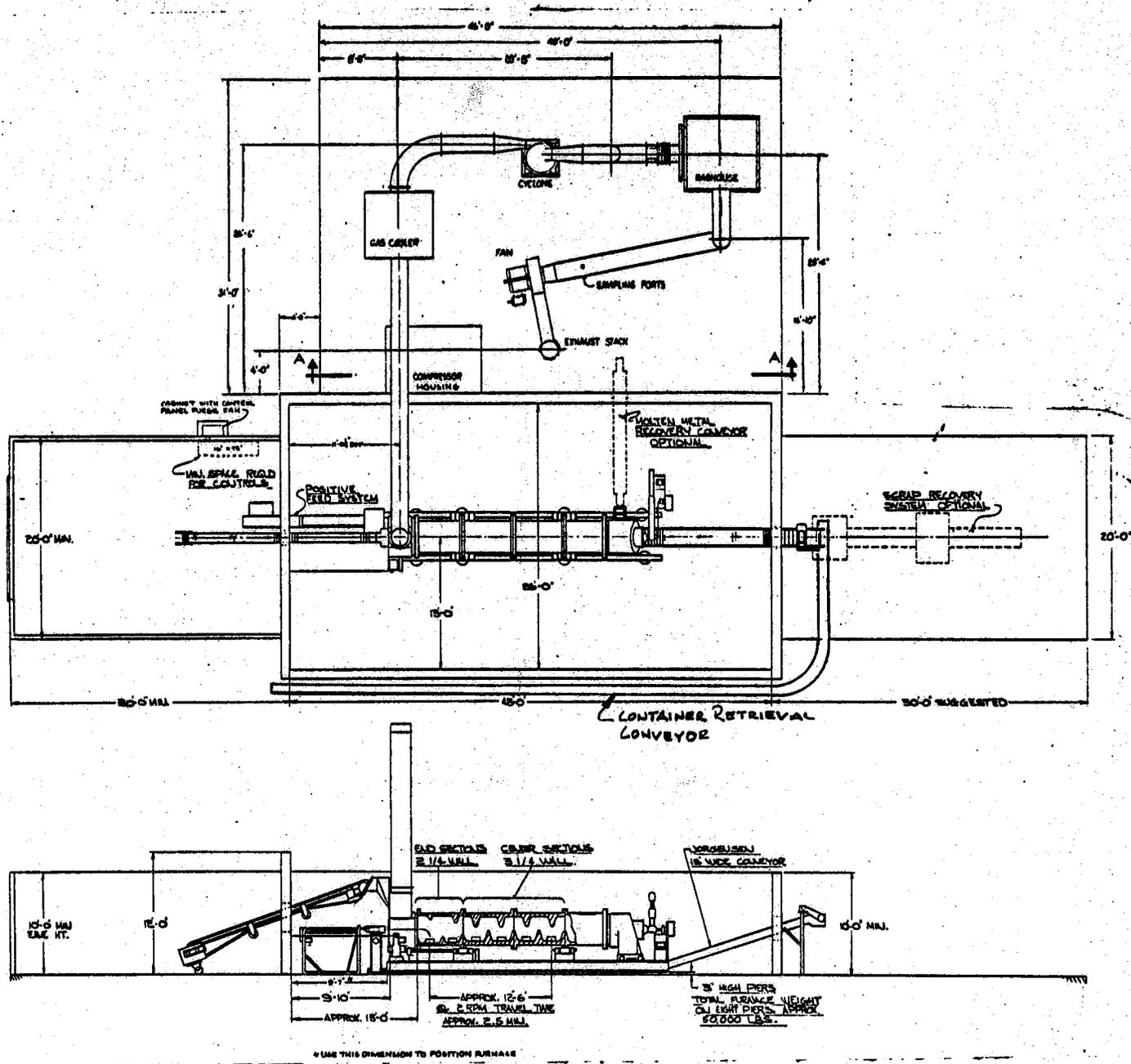


EXPLOSIVE WASTE INCINERATOR

Figure 1

Furnace

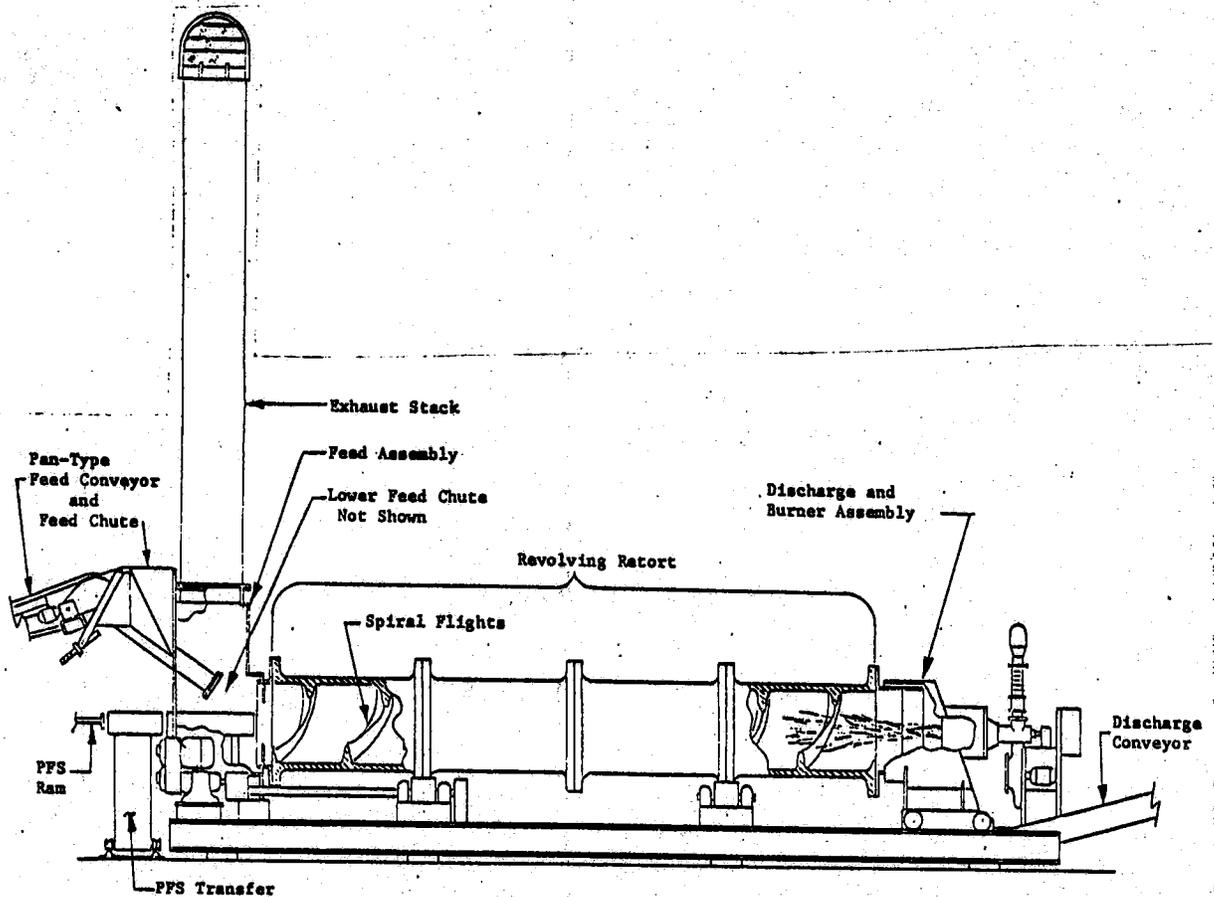
The major component of the EWI is the furnace. The furnace used is an APE 1236 Deactivation Furnace, a long-time standard item in



EQUIPMENT LAYOUT
FIGURE 2

ARRCOM's Ammunition Peculiar Equipment (APE) inventory. The DF was developed in the early 1950's to demilitarize conventional, explosive-filled end-item munitions at Army depots throughout the country and OCONUS. In recent years, use of the DF has been expanded greatly and there are approximately 25 furnaces currently in use in a variety of conventional and chemical munition demilitarization programs (exclusive of the Explosive Waste Incineration program discussed herein).

The furnace, Figure 3, consists of feed and discharge assemblies: a cast-steel revolving retort within which the heating and destruction of munitions or explosives occurs, and various ancillary equipment.



DEACTIVATION FURNACE

Figure 3

Bulk explosive wastes loaded into open-top containers, are injected into the furnace by a positive feed system (described later herein), while assembled or degraded end-item munitions are fed into the furnace on a pantype feed conveyor. Safety interlocks insure that both feed systems are not operational simultaneously. The explosive wastes or munitions are moved through the retort toward an oil-fired flame at the burner (discharge) end of the furnace by means of spiral flights which are an integral part of the retort casting. As the explosive/munitions approach the flame they detonate or burn freely, depending upon the munition configuration and characteristics. An abnormal detonation is contained by the thick retort wall (end sections are 2.25" thick; center sections are 3.25" thick). The spiral flights provide physical separation of quantities of explosives or munitions, discouraging sympathetic propagation of detonations and defeating fragments generated by detonations. Control over quantities of explosive in the furnace at any given time is a function of explosive feed rate, speed of rotation of the retort and temperatures within the retort. Normally, explosives begin burning in the first or second compartment of the retort and are consumed by the fourth or fifth compartment. The retort consists of four sections bolted together with two compartments per section, separated by spiral flights on 30" lead. Metal components of end-item munitions or the bulk explosive containers are discharged from the furnace and the containers are forced-air-cooled and conveyed back to the feed room for eventual reuse.

The furnace is normally operated with No. 2 fuel oil, consumed at rates of 6 gph at low-fire to 23 gph at high-fire. A predetermined reference temperature is established as the optimum operating

temperature for each type of PEP waste and this temperature is maintained by automatically modulating the oil burner from low to high-fire as the need is indicated by a temperature recorder/controller in the control panel. Typical average fuel consumptions for a given operation range from 9 to 21 gph, for a heat input of from 1.26 million to 2.9 million BTU/hr.

Two thermocouples continuously record temperatures: One thermocouple, inserted at the base of the exhaust stack, provides a reference temperature to the temperature recorder/controller which maintains the desired operating temperature at this preset reference point; the other thermocouple, inserted immediately above the flame provides a reference temperature of the burner end of the furnace. The controlling reference temperature is set in a range from 300°F to 400°F depending on the items to be burned.

Combustion air is provided by a low-pressure centrifugal blower and by air induced through the metal-parts discharge opening and an annular opening where the retort enters the discharge housing.

An ultra-violet flame sensor is used to detect presence of flame at the burner. Upon flame failure, the UV Sensor causes a flame-safeguard unit in the control panel to close the oil valve, shutting off oil flow to the burner, and activates visible and audible alarms at the control panel. A retort motion sensor is used to note rotation of the retort and activates alarms if a failure in the retort drive occurs.

The furnace is operated within a concrete enclosure designed to contain the effects (blast pressures and fragmentation) of a high-order detonation.

PEP and/or PEP-filled wastes will be delivered in their various containers to the furnace feed building and off-loaded by fork lift. The maximum quantity of explosives permitted in the feed room will be limited to a four-hour working supply.² Dry bulk wastes will be manually scooped by plastic or non-sparking scoops from their delivery containers in quantities predetermined by testing and specified in appropriate SOP's but not to exceed five pounds TNT equivalent, in any case. Wet or slurried explosives will also be loaded into the containers. Vacuum dewatering equipment will be installed, by others, at those plants where the manufacturing processes generate wastes with "standing" water. Assembled end-item munitions will generally be hand-placed on the standard pan-type feed conveyor which is inclined at approximately 20° and runs at about 44 ft/min. There are 19 sections separated by one inch high carrier flights. Table 4 gives feed rates for various quantities of items placed in each conveyor section.

TABLE 4 - CONVEYOR FEED RATES

NO ITEMS PER CONVEYOR SECTION	ITEMS/MIN	FEED RATE ITEMS/HR
1	20	1,180
5	98	5,900
10	197	11,800
20	393	23,600
30	590	35,400

The furnace retort revolves at speeds from 0.5 to 3.0 rpm. Table 5 shows the number of items that will be in each compartment of the retort at various feed rates and retort speeds.

² Letter, DRCSF to DDESB; Siting Criteria for Explosive Waste Incinerators and Contaminated Waste Incinerators; 31 Aug 77.

TABLE 5 - NUMBER OF ITEMS BETWEEN SPIRAL FLIGHTS

RETORT SPEED	NO. ITEMS BETWEEN SPIRAL FLIGHTS						
	FEED RATE, ITEMS/MIN						
RPM	1	2	3	10	100	300	600
0.5	2	4	6	20	200	600	1200
1.0	1	2	3	10	100	300	600
1.5			2	7	67	200	400
2.0		1		5	50	150	300
2.5				4	40	120	240
3.0			1	3	33	100	200

Residence times within the retort at various retort speeds are given in Table 6.

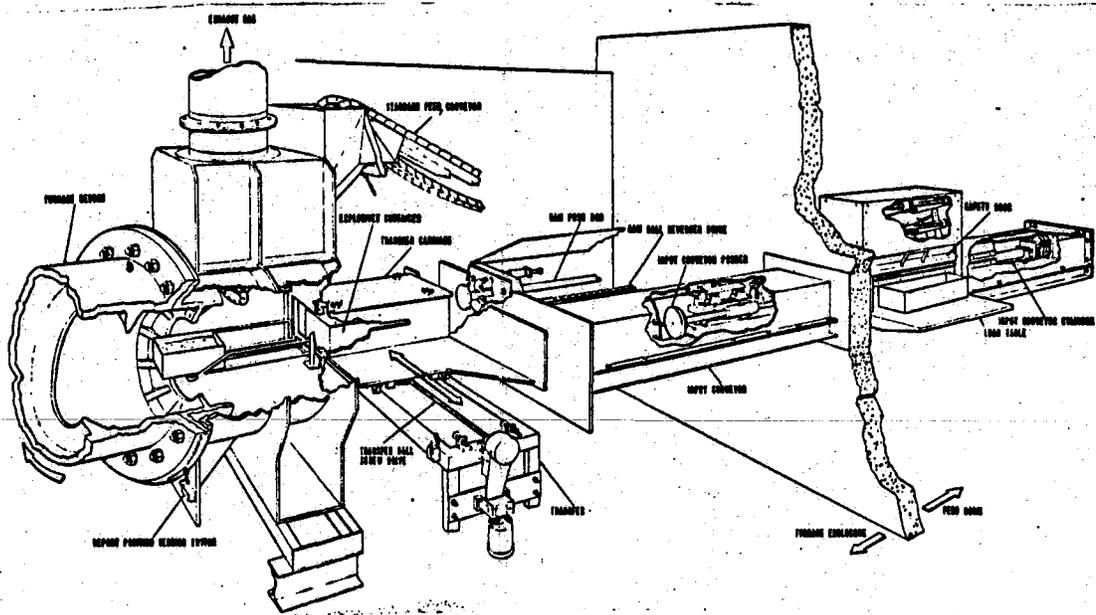
TABLE 6 - RESIDENCE TIMES

RETORT SPEED	TIME/SECTION	TOTAL TIME
	MIN	MIN
0.5	2	16
1.0	1	8
1.5	0.67	5.2
2.0	0.5	4
2.5	0.4	3.2
3.0	0.33	2.6

Positive Feed System

The Positive Feed System is a specially designed mechanism for injecting containers of explosive into the APE 1236 Deactivation Furnace. The positive feed system was designed as an accessory to the furnace to be used as an alternate to the standard feed system. For materials such as bulk explosives and propellants, it has the advantage of being a more rapid and positive furnace feed, eliminating the chance

of these very heat sensitive materials beginning to burn before they are entirely within the confines of the retort. The system eliminates direct line of sight from the point the containers are injected into the furnace to the point behind a concrete barricade where the containers are manually placed into the mechanism. Besides eliminating the chance of explosive propagation to the loading point, the mechanism also positively controls the feed rate to insure that only one container may be placed in the furnace at any one retort spiral flight spacing. The containers are open-top steel boxes, 5" wide X 5" deep X 12" long, made of 1/8" material.



POSITIVE FEED SYSTEM

Figure 4

The system can be operated in two modes, manual or automatic. The manual mode is for maintenance and troubleshooting only. The operation of the system can probably best be explained by referring to Figure 4. The mechanism consists of three separate submechanisms, the input conveyor, the transfer and the ram. The manual operation functions by

manually sequencing the push buttons on the control panel. Safety interlocks cannot be overridden by manual operation. When the system is in the automatic mode there are no buttons to push for operation. Indicating lights in the control panel signal the location of the container at all times. When the system is ready to feed, the lock on the safety door releases and the door springs open. A container is then placed in the opening and the door is manually closed. The action of closing the door automatically locks the door until the feeding operation has been accomplished and the mechanism is again in the ready position. Closing the door also trips the switch that conveys the container through the concrete barricade to the transfer mechanism. A gap of 3" is maintained between the input conveyor and the transfer to reduce the possibility of a fire propagating from the transfer to the input conveyor.

The transfer mechanism has several unique safety features. When the transfer is in the receive position, a steel plate is directly in front of the opening into the furnace, sealing this opening. When the container is placed in the transfer, a signal causes the transfer to begin to place the container in line with the furnace opening and the feed ram. The action of moving toward the furnace seals off the opening of the feed tube conveyor by means of a steel plate attached to the transfer. The transfer advances to a halfway position where it waits for a signal from a sensor located on the retort. (At this halfway location, both the feed tube opening and furnace opening are closed and the container is not exposed to excessive heat). The retort signal insures that one revolution has been completed, placing the previous container one spiral flight away from the receiving space in the retort opening.

Upon receipt of the retort signal, the transfer proceeds to line up the container with the furnace opening. The container is immediately accelerated by the feed ram and it slides through the

furnace opening along guide rails inside the door to alight within the retort sections. After the ram returns, the transfer returns to a receive position. The ram action is extremely fast with the explosive container injection taking about one second. The process is then ready to be repeated. Should a malfunction in the ram occur while the container is in line with the furnace opening, the transfer will automatically return to the halfway point within four seconds and an alarm will sound. This precludes any chance of exposing the containers to heat outside of the retort.

By use of controlled speed actuators (on input conveyor and ram) spillage of explosive will be reduced to a minimum or eliminated with the established explosive feed rates and container sizes.

By means of the retort position cam and limit switch, the PFS is limited to injecting only one container into the furnace per spiral flight of the retort (i.e. only one container can be injected into the furnace each revolution of the retort):

1. The minimum cycle time of the PFS is 22 seconds.
 - a. Input conveyor - 10 seconds to travel one way
 - b. Transfer conveyor - 4 seconds to travel one way
 - c. Ram conveyor - 1 second to travel one way
 - d. Load time approximately 2 seconds

Minimum PFS cycle time: 10 sec. + 4 sec + 1 sec + 1 sec + 4 sec + 2 sec = 22 seconds

(Input Conveyor takes container to transfer; transfer positions container in front of furnace opening; ram injects container into furnace; ram returns; transfer return; next container loaded.)

2. The position cam and limit switch only allow the PFS to inject a container into the retort for the time duration of 1/4 of one revolution.

3. Minimum retort speed = 0.75 RPM or one revolution takes 80 seconds.

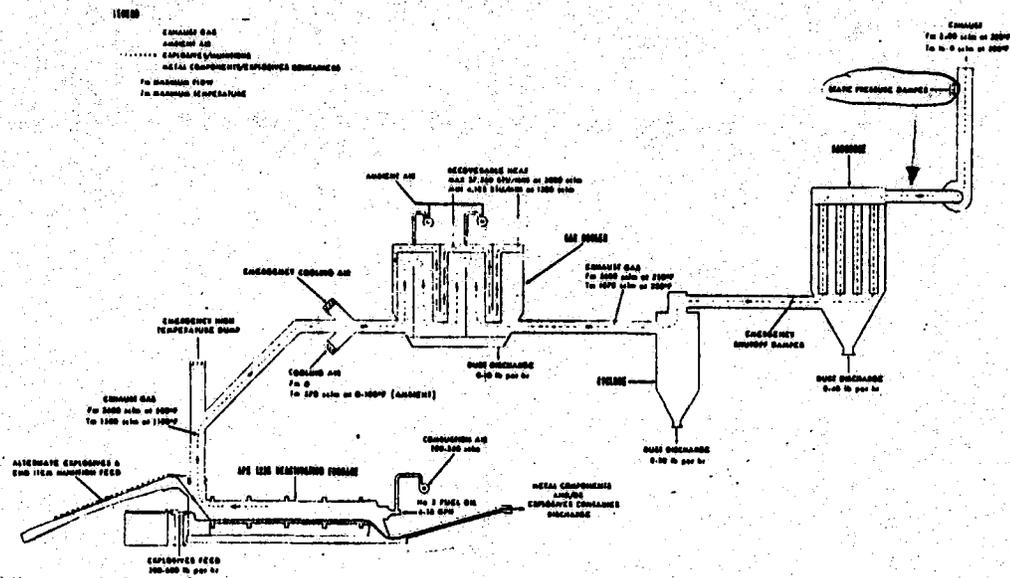
4. At this minimum speed (80 seconds/revolution) the position cam/limit switch enables the PFS for 20 seconds. This is the maximum PFS enabled time interval that will be seen with the PFS. As the retort speed increases the enabled time interval will decrease.

5. The enable interval occurs only once per retort revolution (i.e., only once per spiral flight).

6. As the maximum enable interval is less than the PFS cycle time, two containers cannot be injected into the retort during the same enable interval. Since there is only one enable interval per spiral flight, two containers cannot be injected into the same flight.

Air Pollution Control System

The air pollution control system (depicted in the flow diagram. Figure 5) consists of an indirect, forced-air cooler which will cool entering gases from a maximum of 1000°F down to 250°F; a centrifugal dust collector (cyclone) that achieves some particulate removal but is used primarily for spark arrest; a baghouse for final particulate cleansing; and a thirty foot exhaust stack.



FLOW DIAGRAM

Figure 5

Exhaust gases exit the furnace at a maximum rate of 3600 scfm @500°F or 1,500 scfm @ 1100°F and are cooled, if necessary, by mixing with ambient air introduced through an automatically modulated cooling air damper controlled by a thermocouple installed immediately preceding the cooler. The gases proceed through the cooler, passing over flattened heat-exchange tubes through which ambient cooling air is blown and then exhausted in the form of recoverable heated air. The furnace exhaust gases then leave the cooler at approximately 250°F. A thermocouple immediately preceding the baghouse insures that temperatures entering the baghouse do not exceed 250°F by signalling a temperature switch to close an in-line damper ahead of the baghouse, and shut off the induced draft fan if the temperatures start to exceed 250°F. Some particulate will be deposited on the heat-exchange tubes and is removed by chains scraping across the tubes. The particulate is

then moved via a screw conveyor to a double-dump discharge valve for collection.

The cooled exhaust gases then pass through a cyclone collector for some further particulate removal and for spark-arrest.

The gases (maximum 4800 acfm @250°F) are then directed through a baghouse for final particulate cleansing. The baghouse is a 144 bag unit (bags are 4.5" dia X 8'-0"; 1356 ft total filter area), providing a 3.5 air to cloth ratio. The bag material is nomex felt. Nomex is a relatively high temperature resistant nylon fiber (450°F maximum operating temperature) with reasonably good acid resistant characteristics. The bags are periodically cleaned by introducing a jet-pulse of air at the top of each bag causing a momentary reverse flow through the bag forcing the collected dusts into a hopper at the bottom of the baghouse. The collected dusts are continuously discharged through a double dump discharge valve.

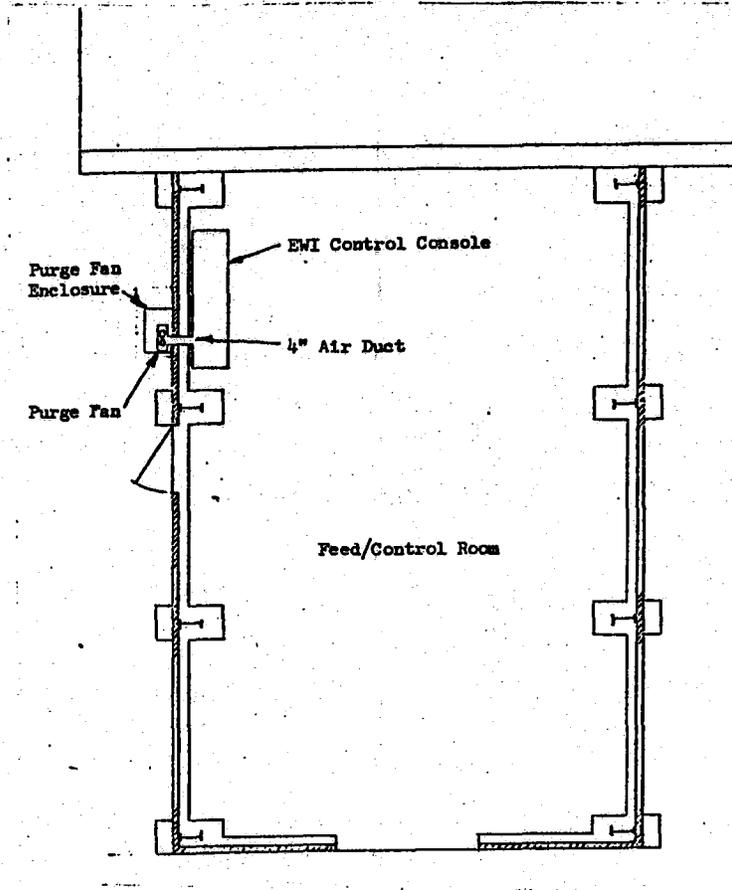
The cleaned gases are then drawn through the induced-draft fan and exhausted out the thirty foot exhaust stack. Sampling ports are provided in the horizontal duct (at ground level) between the baghouse and fan.

Container Retrieval System

A container retrieval system picks up the explosives containers from the discharge end of the furnace and returns them to a collection point outside the feed room. As the containers are conveyed toward the feed room, they pass through a shrouded section of conveyor where they are cooled by ambient air blown through the shroud.

Equipment Control Panel

The equipment components described herein are all controlled from and by the Equipment Control Panel (ECP) which conforms to a Class II, Group E, Division I hazardous location classification by being air-purged and pressurized.³



PURGE SYSTEM FOR
EWI CONTROL PANEL
Figure 6

³Letter, SDSTE-AEO to DRSAR-SF; Explosive Waste Incinerator Controls; 31 May 78; w/1st Ind DRSAR-SF to SDSTE-AEO; 20 Jun 78.

Located outside of the feed room is purge blower enclosure which contains a purge fan and associated interlocking circuitry (see Figure 6).

This circuitry begins with a stop-start switch located in the enclosure cover which is used to pick up and drop out the purge fan. The fan is rated at 250 CFM. In the discharge air stream of the fan is a flow switch which is rated to drop out at an air velocity of 630 ft/min. (The fan output velocity at 200 CFM is 2100 ft/min.) After the fan is switched on and the air velocity reaches 750 ft/min., the flow switch closes which in turn energizes a timer. A purging process continues until the time set on the timer, 120, seconds has passed. This time allows 10 case volume changes of air to be put into the enclosure before the timer closes. The timer closes and picks up a 3-phase power contactor which applies the power to the main control panel distribution center.

The main control enclosure (NEMA 12) is located inside the feed room, thru the wall from the purge fan enclosure. The two are connected via a 4-inch air duct. The main control enclosure contains the motor starters, push button stations, indicating lights and instrumentation necessary to operate the EWI facility.

The main panel also contains an internal air pressure indicating gauge to show the inside pressure, in inches of water, at all times. This feature allows the operator a quick visual check if needed.

If the main enclosure is opened for some reason, after the initial purge the fan will continue to run and the power contactor remains energized since it is a greater hazard to shut down than to lose purge pressure however, the system alarm will sound and a light will illuminate indicating the console door is not shut.

OPERATIONAL SEQUENCE

The following describes the start-up and operational procedures for the EWI equipment. Refer to Figure 7 for control panel layout.

1. Turn on main feed circuit breaker for EWI facilities.
2. Push Purge Fan Start push button located on Purge Fan Control Panel.
 - a. This provides a purge air flow and pressure into the Equipment Control Panel (ECP). The pressure is to be at least 0.5" H₂O and the flow will allow 10 air changes for initial purge.
 - b. The internal timer will time out after 2 minutes and pick up the power contactor, applying power to the distribution panel in the ECP.
 - c. When power is applied to the ECP an alarm will sound and the Retort Stopped alarm light will be on. The temperature indicators will be operational also.
3. Push Alarm Reset button
 - a. This will silence the audible alarm but the light will remain until the fault condition is removed.
4. Push Retort Blower Start push button
 - a. This will also apply power to the flame sensing circuitry and temperature recorder/controller.
 - b. The alarm will again come on along with the Flame Out indicating light.

5. Push Alarm Reset button

a. Alarm will silence but Flame Out light will remain illuminated.

6. Push Oil Pump Start push button.

7. Push Retort Start push button.

a. This will cause the Retort Stopped light to extinguish and the retort RPM readout will change from "00" to the speed set by the varidrive control.

8. Set the temperature control point to the lowest setting.

a. This will cause the flame control actuator to drive the oil-air valve of the burner to the low fire position and close the low fire limit switch.

b. Wait for the retort to purge and the Ready or Flame light to illuminate.

9. Push the Ign. Start button after the Ready or Flame light comes on.

a. A 15 sec. trial for ignition period is allowed before the purge cycle must be started again.

b. With the Ign. Start button held down, the oil valve allows oil in the furnace burner and supplies an ignition spark to ignite the atomized oil coming from the burner valve.

c. If the burner fails to ignite, the Ready or Flame light will extinguish and the purge cycle starts again. When the Ready or Flame light illuminates again, repeat Step #9 again.

d. If the flame is established the Ready or Flame light will stay on and the Flame Out light will go out.

10. Set the temperature control point on the temperature recorder/controller to the desired stack operating temperature.

a. This will cause the flame control to drive the burner mixture to high fire position until this set temperature is reached.

b. After the temperature recorder indicates that the stack temperature is above 300°F the Air Pollution Control System (APCS) may be turned on.

11. Push the Compressor start push button.

12. Push the Gas Cooler start push button.

a. This applies power to the gas cooler subsystem which is controlled by its local sensors.

13. Push the Draft Fan start pushbutton.

a. This also applies power to the baghouse bag pulser circuit, causes the stack damper to close and the in-line damper to open.

b. With the draft fan running the stack static draft will be indicated on the Draft Gauge in the ECP which is controlling the static draft damper.

c. When the above is completed and the stack temperature has reached operating temperature, the furnace is ready for incineration.

14. Push the Disch. Conv. start push button.

15. Turn the P.F. Power switch to "ON".

a. The P.F. Power light will come on along with the Ram Back light.

b. When the PFS transfer is in the receive (at end of input conveyor) position, the Trans. in Rec. light will illuminate.

c. The input conveyor door will be open and the system is ready for use.

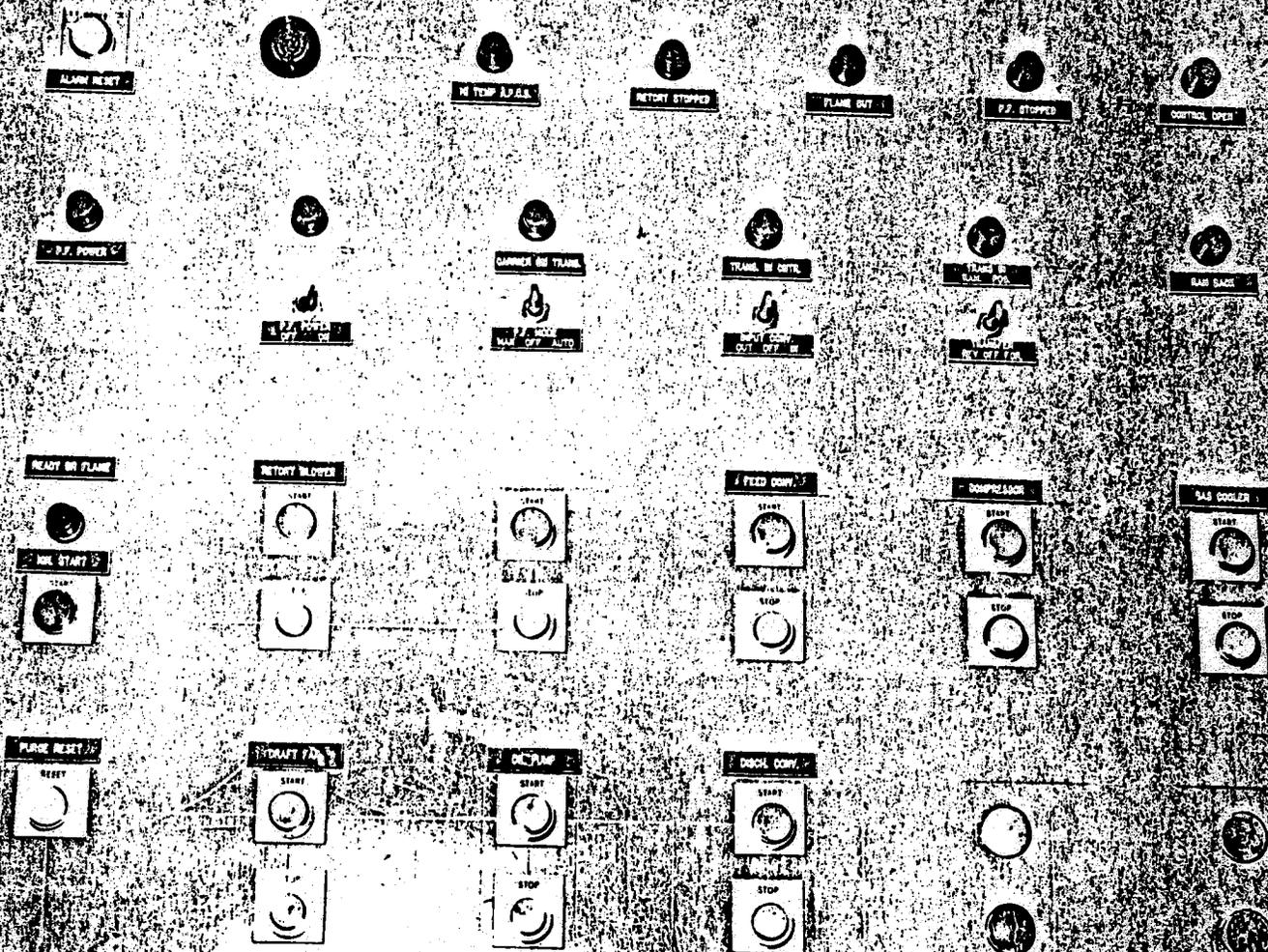
16. Place a loaded container in the PFS Input Conveyor.

17. Pull Input Conveyor Door down to close.

a. The door will lock shut and the input conveyor will push the container onto the transfer.

b. When the container reaches the correct position on the transfer, the Carrier on Trans. light will come on, the input conveyor pusher retracts and when clean, the transfer will move toward the ram position in front of the furnace and the Trans. in Rec. light will extinguish.

c. The transfer will wait in the midway position until the retort flight is in the correct position. While waiting here the Trans. in Cntr. light will be on.



EQUIPMENT CONTROL PANEL
Figure 7

WARNING
 WITHIN PRESSURE
 DE-ENERGIZE BEFORE OPENING

d. When the retort is in the correct position, the transfer will move into the ram position and the Trans. in Cntr light will go out.

e. When the transfer reaches the ram position the Trans. in Ram Pos light will come on and the ram will operate.

f. When the ram starts forward the Ram Back light extinguishes and when the container is pushed out of the transfer the Carrier on Trans. light will go out.

g. After the ram returns back, the transfer will return to the end of the input conveyor.

h. When the transfer reaches the receive position the input conveyor door will come open ready for the next container.

SIGNIFICANT EFFORTS/EVENTS

The following summarize various efforts or events of significance that have occurred during development of the Explosive Waste Incinerator.

a. Extensive testing consisting of burning several types of PEP wastes (in various configurations) in the furnace to obtain such operational data as feed rates, furnace temperatures, emission rates and furnace operating parameters. Table 2 presents a summary of the PEP wastes burned.

b. Concurrent with the burn-tests, other tests were being conducted to determine maximum quantities of explosive that if involved in an unanticipated detonation, would not constitute a safety hazard to operating personnel, either from blast overpressures or from fragments. The tests showed that a detonation of up to 7.23 pounds equivalent TNT would cause extensive damage to the equipment but would not create overpressures outside the furnace enclosure exceeding 2.3 psi peak positive incident pressure, the maximum allowable for operator exposure. Fragmentation outside the enclosure was not experienced.

Tests were also conducted to determine if propagation would occur between explosive charges placed in separate spiral flights within the furnace. The tests failed to produce any propagation even though charges in flights adjacent to the donor charge were displaced.

Huntsville Division, Corps of Engineers, used the data from these tests to design the furnace enclosure walls in accordance with TM 5-1300. AEO Report 31-78⁴ presents a detailed final report of these tests.

c. An extensive study was done evaluating materials and configuration for use in the design of the Positive Feed System containers. That study resulted in the selection of low-carbon steel from which to manufacture the containers. The study also addressed cool-down times for the containers to aid in design of a container retrieval system. The study is reported in AEO Report No. 17-78⁵.

⁴Miller, Determining Explosive Limits of the Present Design of The APE 1236 Deactivation Furnace and Enclosure; AEO Report NO. 31-78, July 1978.

⁵Seeglitz, Study of Positive Feed System Container Alternatives; AEO Report No. 17-78, 15 June 1978.

d. During test-burns of composition A-5, some detonations were experienced. No causes have yet been determined; however efforts are continuing to either establish cause(s) or to establish safe and satisfactory feed rates. Some efforts were made, subsequent to the detonations, to determine probable causes. Those efforts are described in a report of tests designed to duplicate the detonations⁶. A discussion of the incidents and some analyses of samples of the Composition A-5 done by Hercules, Inc. were submitted to ARRCOM and are contained in Appendix E.⁷

e. An analysis was made of the environmental loads (wind, live, seismic) on the various EWI equipment components, the calculations are presented in Appendix C.

f. A survey of expected PEP wastes at each AAP was conducted by questionnaire. The responses from that survey are summarized by quantity in Table 1.

g. A Hazard and Safety Analysis was performed by the Tooele Army Depot Safety Office in October 1976. That analysis primarily addressed the then newly-designed Positive Feed System. The analysis has been updated and expanded to cover the entire EWI system⁸.

⁶Walker, Composition A-5 Explosive Test; AEO Report No. 18-78, 23 June 1978.

⁷Letter, SDSTE-AEO to DRSAR-ISE; Preliminary Report on Composition A-5 Incidents.

⁸Hazard and Safety Analysis for Explosive Waste Incinerator, June 1979.

REFERENCES

1. Letter, DRSAR-ISC-A to DRXTE-AEO, 19 October 1976; Subject: Letter of Confirmation (Copy in Appendix A).
2. Letter, DRCSF to DDESB, 31 August 1977; Subject: Siting Criteria for Explosive Waste Incinerators and Contaminated Waste Incinerators. (Copy in Appendix A).
3. Letter, SDSTE-AEO to DRSAR-SF, 31 May 1978; Subject: Explosive Waste Incinerator Controls; w/ 1st Indorsement DRSAR-SF to SDSTE-AEO, 20 Jun 1978; subject: Explosive Waste Incinerator Controls (Copy in Appendix A).
4. J.R. Miller, Determining Explosive Limits of the Present Design of the APE 1236 Deactivation Furnace and Enclosure; AEO Report No. 31-78, July 1978.
5. W. Seeglitz, Study of Positive Feed System Container Alternatives; AEO Report No. 17-78, 15 June 1978.
6. M.P. Walker, Composition A-5 Explosive Test; AEO Report No. 18-78, 23 June 1978.
7. Letter, SDSTE-AEO to DRSAR-ISE; Subject: Preliminary Report on Composition A-5 Incidents; (Copy in Appendix E).
8. Hazard and Safety Analysis for Explosive Waste Incinerator; June 1979.

APPENDIX A
LETTERS



DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY ARMAMENT COMMAND
ROCK ISLAND, ILLINOIS 61201

CPT Hager/mka/
793-4785

REPLY TO
ATTENTION OF:

DRSAR-ISC-A

19 OCT 1976

SUBJECT: Letter of Confirmation

Commander
Tooele Army Depot
Ammunition Equipment Office
ATTN: DRXTE-AEO
Tooele, UT 84074

1. Reference is made to meeting, 29 Sep 76, subject: ARMCOM Explosive Waste Incineration Program.
2. It is the position of this headquarters, as developed in the referenced meeting, that the Ammunition Equipment Office (AEO), Tooele Army Depot, Tooele, Utah, will be involved in the ARMCOM Explosive Waste Incineration Program to the following extent:
 - a. AEO will provide an APE-1236 Deactivation Furnace for each project. Equipment will be delivered to the construction site and turned over to the District Engineer.
 - b. AEO will provide, and deliver, all incinerator and Air Pollution Control (APC) System Controls.
 - c. AEO will provide, and deliver, both the standard and positive feed systems.
 - d. AEO will provide, and install, the APC System.
 - e. AEO will provide, and deliver, drawings, specifications, and operating manuals for the above equipment.
 - f. AEO will continue test burning ARMCOM explosive waste.
 - g. AEO and USAEHA will conduct emission acceptance tests.
 - h. AEO will coordinate directly with the District Engineer on construction problems relating to the above equipment and services.

DRSAR-ISC-A
SUBJECT: Letter of Confirmation

19 OCT 1976

3. Funds for the above work will be provided by the District Engineer from the MCA project authorizations.

FOR THE COMMANDER:

J. J. Weiss
JAMES J. WEISS
LTC, GS
Dir, Instl and Svc Dir



DEPARTMENT OF THE ARMY
TOOELE ARMY DEPOT
TOOELE, UTAH 84074

3665
Mr. Hill/sb/790-2825

MAY 31 1978

SDSTE-AEO

SUBJECT: Explosive Waste Incinerator Controls

Commander
U.S. Army Armament Materiel Readiness Command
ATTN: DRSAR-SF
Rock Island, Illinois 61299

1. References:

a. Letter DRXTE-AEO to DRSAR-SF, 6 Jul 77, subject: SITPA II Control Systems.

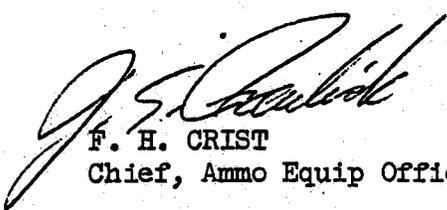
b. First Indorsement DRSAR-SF to DRXTE-AEO, 19 Jul 77.

2. Reference 1-a listed various optional approaches to configuring the SITPA II (Explosive Waste Incinerator) control panels to conform to a Class II, Group E, Division I hazardous location classification. We recommended our Option 3 which utilized NEMA 12 enclosures, air purged and pressurized. Your indorsement, at reference 1-b, listed that option, along with three others, as acceptable providing that the purging is Type X as defined in NFPA 496 (Purged Enclosures for Electrical Equipment in Hazardous Locations).

3. A description of our control panel purging system is at Inclosure 1 for your review and approval. Please advise of your acceptance or non-acceptance of the design.

FOR THE COMMANDER:

1 Incl.
as


F. H. CRIST
Chief, Ammo Equip Office

DRSAR-SF (31 May 78) 1st Ind
SUBJECT: Explosive Waste Incinerator Controls

Mr. Lookingbill/dlb/793-3383

20 JUN 1978

HQ, US Army Armament Materiel Readiness Command, Rock Island, IL 61299

TO: Commander, Tooele Army Depot, ATTN: SDSTE-AEO, Tooele, UT 84074

Review has been made of the purge system for main control console for explosive waste incinerator (EWI) as it would apply to Option 3, letter, DRXTE-AEO, 6 Jul 77, subject: SITPA II Control Systems. Approval is recommended.

FOR THE COMMANDER:

wd incl

David P. Skogman
DAVID P. SKOGMAN
ActC, Safety Office

DRSAR-SP (6 JUL 77) 1st Lt
SUBJECT: STIPA II Control Systems

Mr. Kulas/56/793-3483

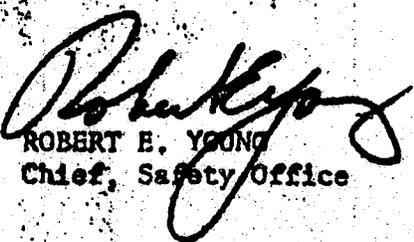
HQ, US Army Armament Materiel Readiness Command, Rock Island, IL 61201

19 JUL 1977

TO: Commander, Tooele Army Depot, ATTN: DRXTE-AEG/Str, Hill,
Tooele, UT 84074

1. The four options proposed in the basic letter have been reviewed. Options 2, 3, or 4 are considered acceptable by this office. If Option 3 is selected, assure that purging is type X as defined in NFPA 496.
2. If controls are located in the loading room, they should be kept to a minimum number. As many as possible should be located outside the loading room. The viewing of gauges, dials, controls, etc., could be accomplished through a viewing window.
3. A fifth option may be considered. It would consist of an electro-mechanical control system. Pneumatic controls could be located in the loading room (hazardous area), which actuate electrical controls located outside the loading room.

FOR THE COMMANDER:


ROBERT E. YOUNG
Chief, Safety Office



DEPARTMENT OF THE ARMY

TOOLIE ARMY DEPOT
TOOLIE, UTAH 84074

G. Jones/sb/790-2825

JUL 6 1977

DRXTE-AEO

SUBJECT: SITPA II Control Systems

Commander
U.S. Army Armament Materiel
Readiness Command
ATTN: DRSAR-SF
Rock Island, Illinois 61201

1. Reference: Explosive Waste Incinerator Study Report, 18 Mar 77, by Blank and Wesselink and Assoc.
2. The control and drive systems for the SITPA II facility are to be supplied by AEO-TEAD. The intent of AEO was to supply the same type controls and drives as currently furnished on the standard AFE 1236 furnace. However, section VI of reference 1 indicates that the SITPA II facility will be considered a Class II, Group E, Div. 1 hazard location.
3. The need for explosion proof enclosures adjacent to the Deactivation Furnace inside it's barricaded enclosure appears to be unnecessary; e.g. it makes little sense to put H.E. into the retort for burning and meanwhile outside the retort we provide explosion proof enclosures at high initial and maintenance costs. The use of explosion proof enclosures at the furnace control panels will greatly encumber the operator in controlling the Deactivation Furnace in that frequent access to some of the controls is necessary.
4. It would appear that there are at least four options arising from the proposed new hazard classification.
5. Option one is to review the need for explosion proof enclosures and attempt to eliminate the requirement. AEO accomplished this many years ago and has successfully handled exposed explosives throughout worldwide demilitarization operations with no adverse effects.
6. Option two would be to leave all motors and controls inside the barricaded furnace enclosure the same type as presently used and install the control systems in a space or room separate from the loading room. This would necessitate the operator leaving his work station to check and adjust the controls. This may be a bit awkward but is more realistic than placing them in NEMA 9 enclosures.

AEO FILE COPY

DRXEE-AEO

JUL 5 1977

SUBJECT: SITPA II Control Systems

7. Option three would be to leave the motors by the retrofit the same and enclose the controls in the loading room in two large NEMA 12 enclosures which are air purged and pressurized to 0.5 inches of water pressure. Cost would be approximately \$1,000 greater than cost for current control panel design.

8. Option four is to mount separately each motor starter, controller, switches, etc., in it's own explosion proof enclosure. These would be rack mounted and interconnected to a central control station enclosure. (The temperature observation and control is a problem with this option.) Cost would be approximately \$12,000 greater than cost for current control panel design.

9. Considerable thought should go into deciding which option is to be followed as the decision has great impact not only on the individual cost of each SITPA II, but will also have long range cost impact on any ancillary equipment that may be supplied for use in the loading room.

10. The position of this office is that Option Three is the most desirable if Option One is not considered. It is the least expensive approach (both first costs and maintenance expense); it permits operator access to the controls as required; and it simplifies the addition of controls for ancillary equipment that may be added at later dates.

11. An immediate response is necessary because this office has already initiated procurement action for two furnaces (for Louisiana and Holston AAP's).

12. Please address correspondence to:

Commander
Tooele Army Depot
ATTN: DRXEE-AEO, Mr. Hill
Tooele, Utah 84074
Autovon 790-2825
Commercial (801) 833-2825

FOR THE COMMANDER:

F. H. CRIST
Chief, Ammo Equip Office

Copy furnished:
CDR AARCOM, DESAR-ISC-P



DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
5001 EISENHOWER AVE., ALEXANDRIA, VA. 22333

DRCSE

31 AUG 1977

SUBJECT: Siting Criteria for Explosives Waste Incinerators and
Contaminated Waste Incinerators

Chairman
Department of Defense Explosives Safety Board
Room 6A-145,
Forrestal Building
Washington, DC 20314

1. Request safety approval of the proposed criteria presented below for siting of explosives waste and contaminated waste incinerators at DARCOM facilities. A review of site plans previously submitted for incinerator projects suggests a need for standardized safety requirements. The proposed criteria are general in nature and are based on currently proposed disposal concepts. The criteria will be adapted to satisfy unique safety requirements at each installation.
2. The explosives waste incinerator currently being tested is a modified APE 1236 deactivation furnace with pollution-abatement-equipment. The incinerator complex will include the furnace, an adjacent feed room and a service magazine. The following siting criteria are proposed:
 - a. Facilities within the incinerator complex will be located at a minimum of Inhabited Building Distance from facilities outside the incinerator complex; based on the larger quantity of explosives in either of the two facilities of concern.
 - b. The feed room will be afforded Category 1 (TM 5-1300) protection with respect to the incinerator.
 - c. Maximum quantity of explosives permitted in the feed room will be limited to a four hour working supply.

31 AUG 1977

DRCSF

SUBJECT: Siting Criteria for Explosives Waste Incinerators and Contaminated Waste Incinerators

K-18
d. Service magazines will be separated from other incinerator complex facilities by Intraline Distance based on the quantity of explosives at the service magazine.

e. When more than one incinerator complex is sited at an installation, the incinerators will be separated from each other by a minimum of Inhabited Building Distance and other incinerator complex facilities will be separated from each other by a minimum of Intraline Distance.

f. Construction that affords Category 1 (TM 5-1300) protection may be used in lieu of Inhabited Building Distance requirements.

g. Fragment Distance will be maintained between the incinerator complex facilities and other facilities in accordance with safety requirements.

h. Safety approval of site and general construction plans will be obtained in accordance with paragraph 3-6, DOD 5154.4S, and/or paragraph 5-27, AMCR 385-100.

3. The contaminated waste incinerator complex will consist of the incinerator, control room and storage facility. The following siting criteria are proposed:

a. Waste to be burned at this facility will consist of inert materials such as cardboard containers, paper, wood scraps, etc., that may be contaminated with trace amounts of explosives. Material in this category is considered to be Hazard Class 1, Division 4 for safety purposes. Verification of this hazard classification for material presented for disposal will be accomplished by installation personnel prior to transport of the waste to the incinerator complex.

b. Procedures for 100% inspection of the contaminated waste will be prepared and implemented by installation personnel to ensure that only trace amounts of explosives remain in or on the material to be burned.

c. Incinerator controls will be located within a weather-proof building separated from the incinerator by Inhabited Building Distance, with a minimum separation of 100 feet.

31 AUG 1977

DRCSF

SUBJECT: Siting Criteria for Explosives Waste Incinerators and
Contaminated Waste Incinerators

d. The storage facility will be a non-combustible, weather-proof building located at Intraline Distance from the incinerator and the control room, with a minimum separation of 80 ft. from either facility.

e. A 300 feet safety zone will be established around the incinerator. Only incinerator complex facilities will be located within this safety zone.

f. Incinerator complexes may contain more than one contaminated waste incinerator. Incinerators within the same complex will be separated from each other by Intraline Distance with a minimum separation distance of 80 feet.

g. Safety approval of site and general construction plans will be obtained in accordance with paragraph 3-6, DOD 5154.4S, and/or paragraph 5-27, AMCR 385-100.

4. Inclosures 1 and 2 are general site plans depicting the siting criteria presented above. Approval of this criteria will assist in the establishment of safety guidelines for the use of DARCOM facilities in the installation of the incinerator facilities and in the preparation of safety submissions.

FOR THE COMMANDER:

2 Incl
as

CF:
DRSAR-SF
DRCLIS-RI-IC
Dir, DARCOMFSA


WALTER G. QUEEN
Chief
Safety Office

DDESB-KT (31 Aug 77) 1st Ind
SUBJECT: Siting Criteria for Explosives Waste Incinerators and Contaminated
Waste Incinerators

Department of Defense Explosives Safety Board, Washington, DC 20314
19 September 1977

TO: Commander, US Army Materiel Development and Readiness Command,
ATTN: DRCSF, 5001 Eisenhower Ave., Alexandria, VA 22333

1. The siting criteria for explosives waste incinerators and contaminated waste incinerators outlined in basic correspondence have been reviewed and are considered acceptable from an explosives safety standpoint.
2. With reference to paragraph 2d, the DDESB proposes a revision to DOD 5154.4S as stated in memorandum to DDESB Members, dated 25 April 1977, Subject: Clarification of DOD Standard 5154.4S. This revision proposes to increase the protection level at control stations to an overpressure not to exceed 3.5 psi which can normally be expected at a distance of $18W^{1/3}$. This level of protection may be achieved by suitable suppressive construction at the explosion source or by protective construction at the exposed site.

2 Incl
wd

M. S. Stuenkel
for P. G. KELLEY, JR.
Colonel, USA
Chairman

CF:
DAIG-SD

DRCSF-E (31 Aug 77) 2d Ind

HQ, US Army Materiel Development & Readiness Command, Alexandria, VA 22333
27 September 1977

→ TO: Director, DARCOM Field Safety Activity, ATTN: DRXOS-ES, Charlestown IN 4

1. DDESB approval of the siting criteria presented in the basic letter is contained in the 1st Indorsement.
2. In order to assure standardization, the approved guidelines should be disseminated to those installations contemplating the installation of waste incinerators.

FOR THE COMMANDER:

1 Incl
DDESB Memo 25 Apr 77

L. L. Motherseugh
L. L. MOTHERSEUGH
Chief, Engineering
Safety Office

DRXOS-ES-SP (31 Aug 77) 3rd Ind
SUBJECT: Siting Criteria for Explosives Waste Incinerators and
Contaminated Waste Incinerators

USA DARCOM Field Safety Activity, Charlestown, IN 47111 13 October 1977

TO: Commander, USA DARCOM Installation and Services Activity, ATTN:
DRCIS-RI-IC, Rock Island, IL 61201

1. Reference letter, DRSAR-SF, 24 Jun 77, with DRCIS-RI-IC 1st Ind,
18 Jul 77, subject: Quantity Distance Siting Criteria for Explosive and
Contaminated Waste Incinerator Projects.

2. The approved siting criteria presented above is forwarded in response
to the referenced letter. It is requested that this criteria be distributed
to appropriate DARCOM installations and Corps of Engineer organizations
for guidance.

3 Incl
Added 2 incls
2. & 3. General Site Plans

RAY L. MYERS
Director

CF:
DRSAR-SF w/incl
~~DRSMI-O~~ w/incl
DRDAR-SF w/incl
DRSDS-GSA w/incl

APPENDIX B
PHOTOGRAPHS OF TYPICAL
EXPLOSIVE WASTES

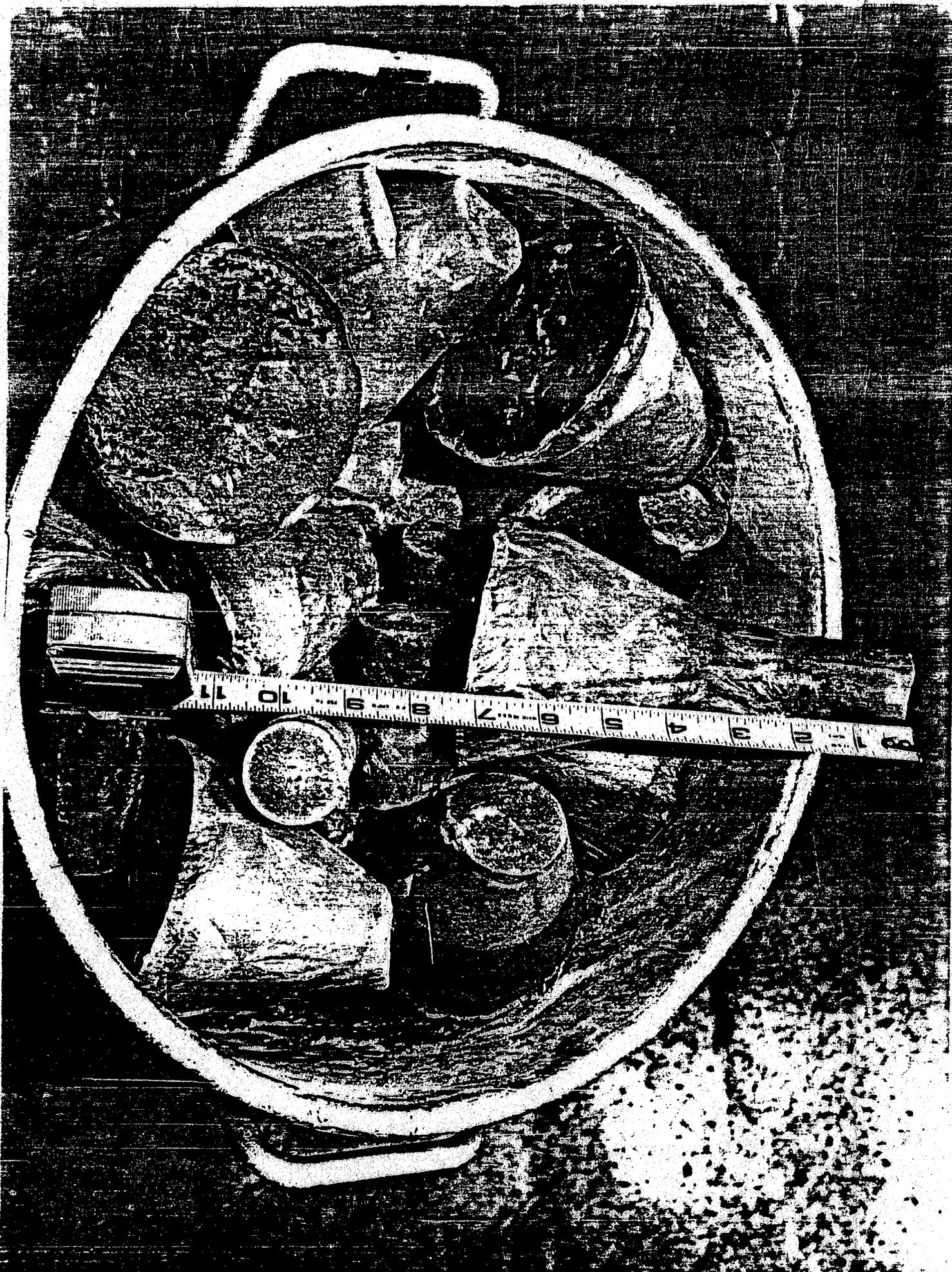
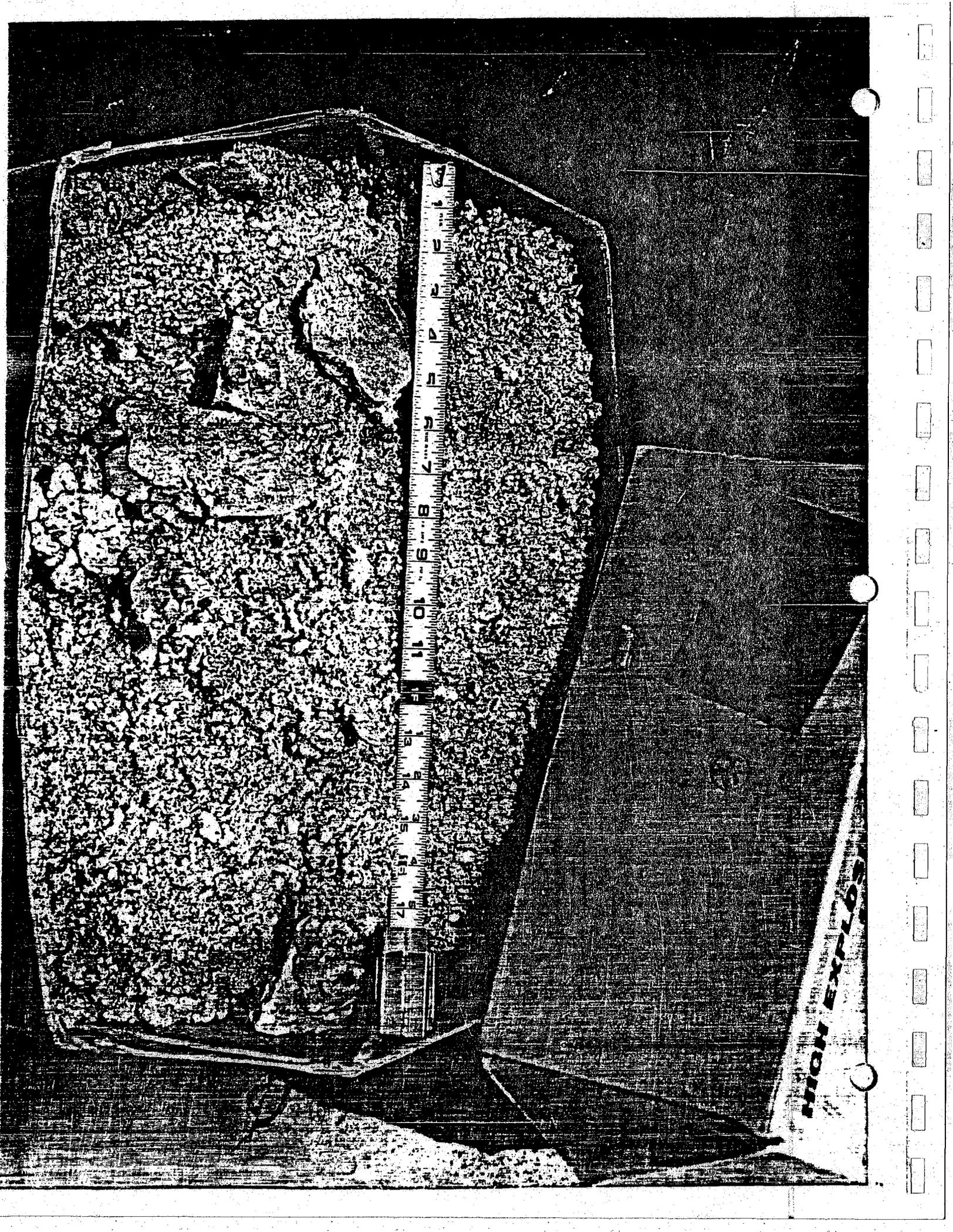


Photo No.

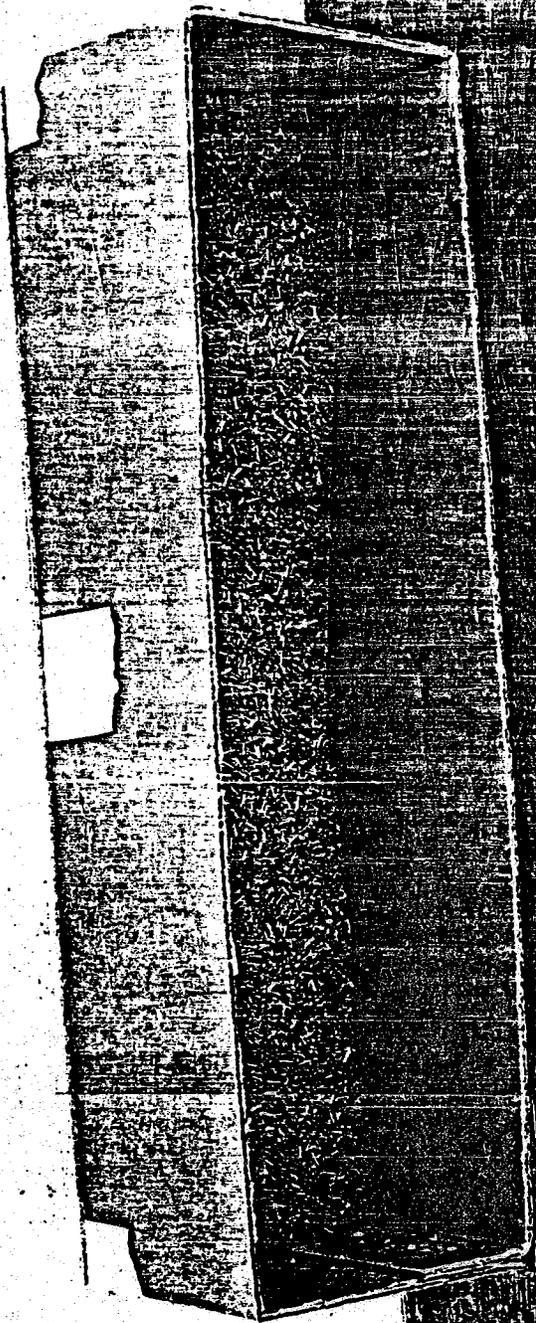


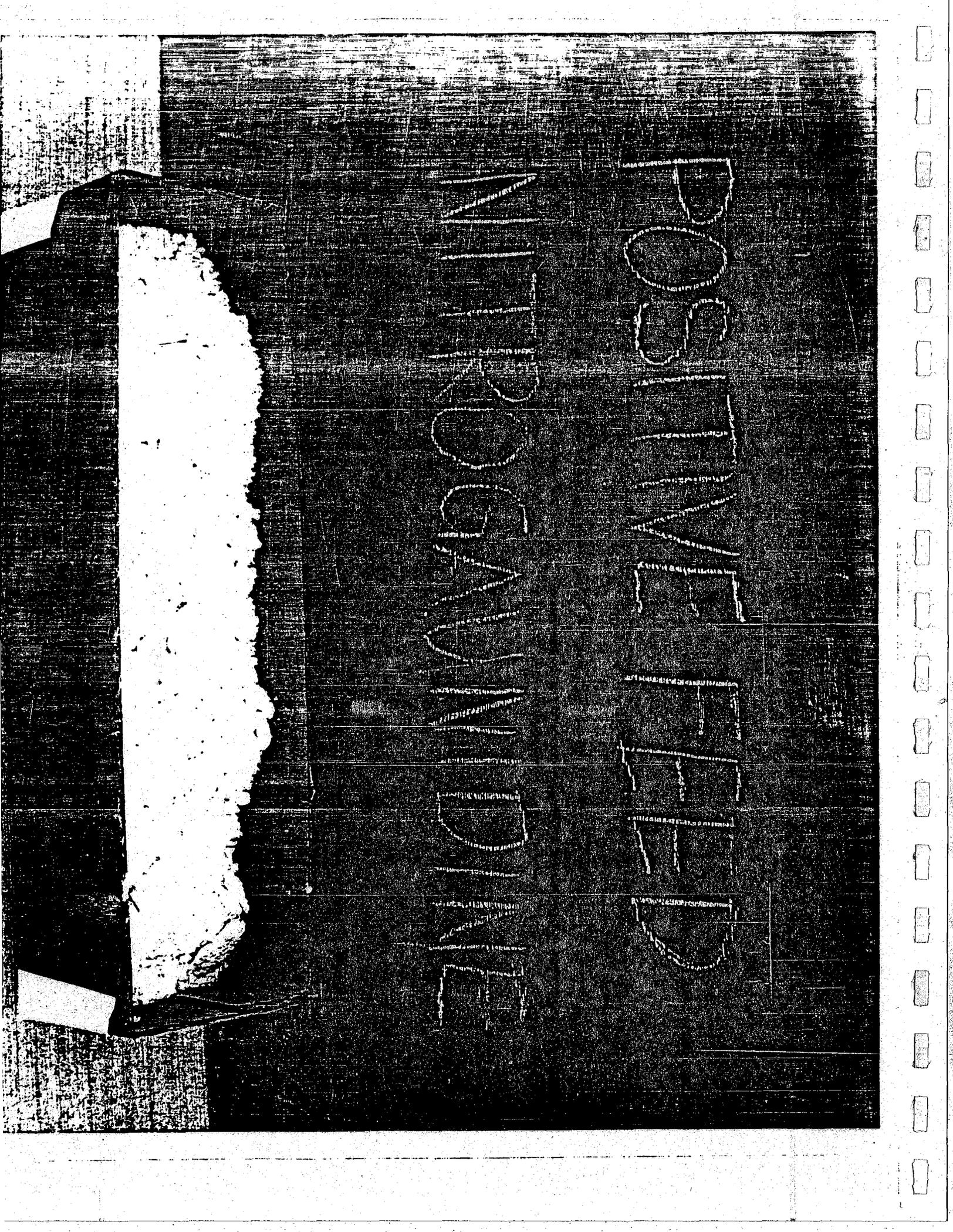


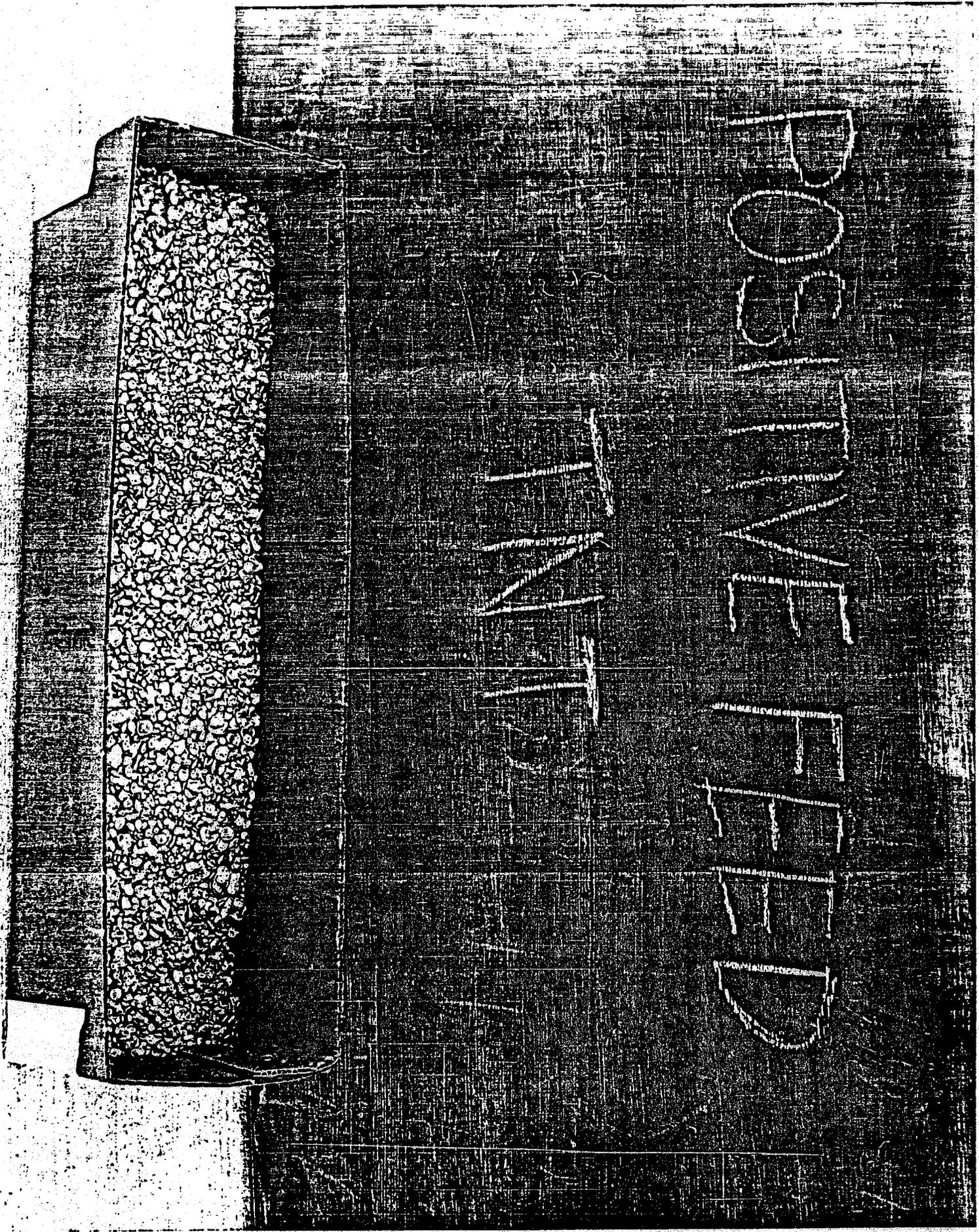
FROM EXPLOR

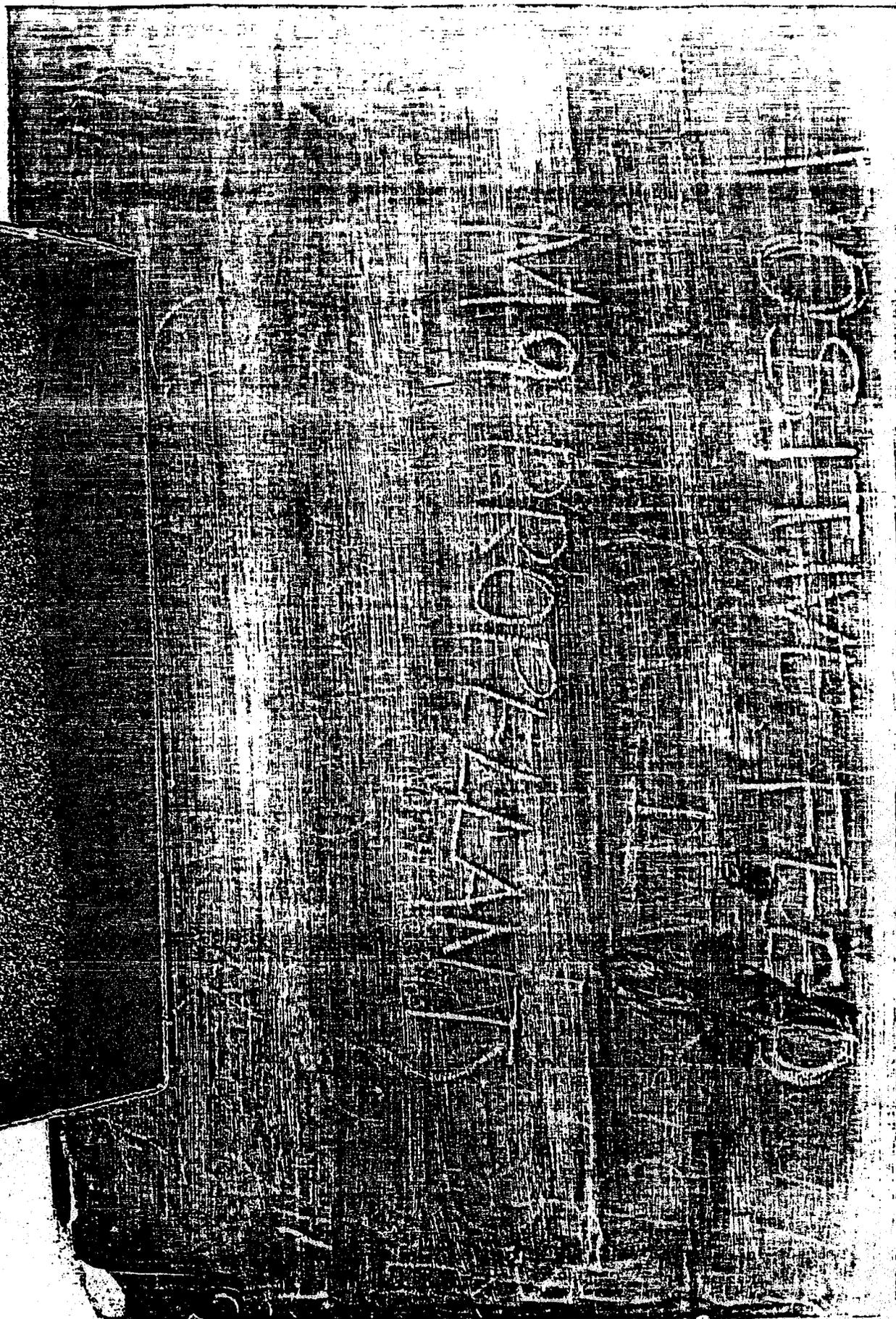
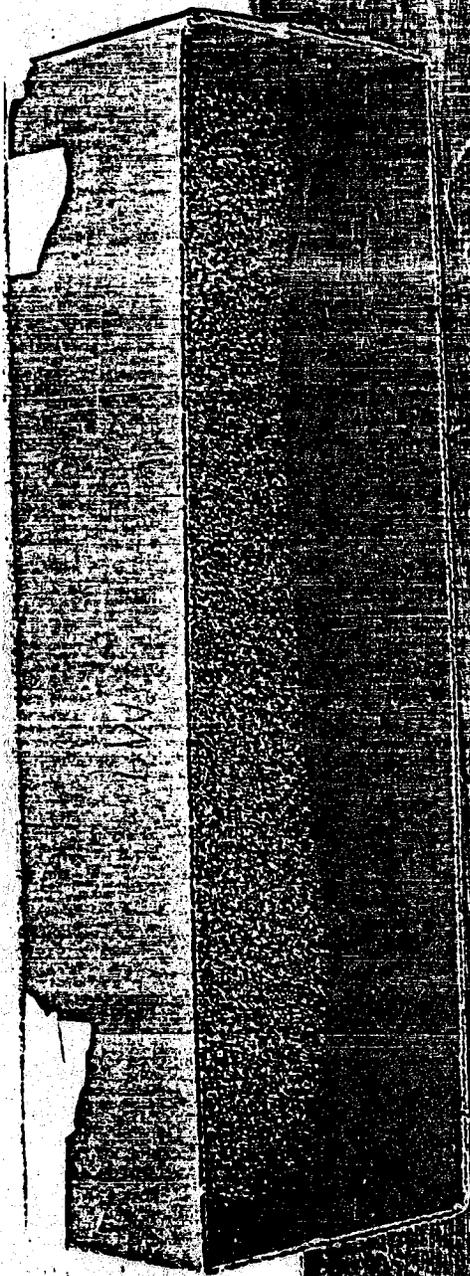


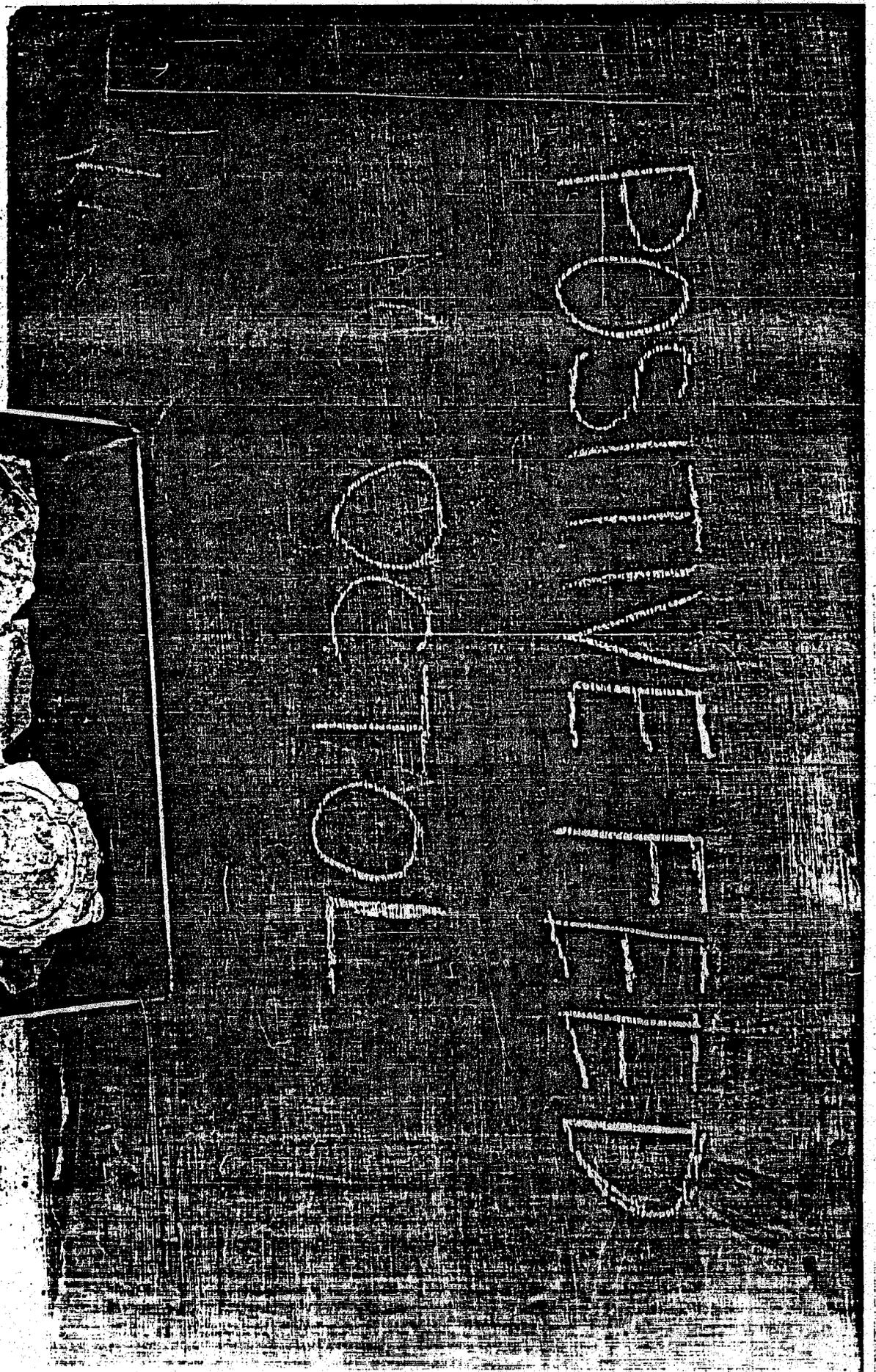
DOMINE DEUS
M PROPHETA











APPENDIX C
ENVIRONMENTAL LOADS
ON EQUIPMENT .

12 Oct 70

SDSTE-AEO

SUBJECT: Design Data for Explosive Waste Incinerator Air Pollution Control System

District Engineer
US Army Engineer District, Mobile
ATTN: SAMEN-MM (Mr. Rodgers)
Mobile, Alabama 36628

1. This office was requested to provide design information to Mobile District's AE firm pertinent to sizing of foundations and anchor systems for the Government furnished equipment; specifically, the Air Pollution Control System components. The design data was to be in the form of moments at the point of anchorage of the equipment components resulting from various environmental and blast loads acting on the equipment. The blast loads would be highly infrequent conditions resulting from unanticipated high-order detonations within the furnace.

2. We have calculated the environmental loads and have attached them at Inclosure 1. For purposes of standardization, we have assumed worst-case conditions, using design data from all the potential EWI sites. Those design parameters are:

Live Load	30 psf
Wind Load	25 psf
Seismic Zone	III

An analysis of the effects of blast loads on the equipment is considerably more complex than the environmental loading analysis. The three major equipment components (baghouse, cooler and stack) each present a different problem, the stack being fairly easy to analyze. The blast loading analysis of the baghouse and cooler should, we feel, encompass a fairly detailed analysis of the structure itself, and the composite construction (steel frame, sheet metal panels, etc.) requires lengthy calculations to describe the metal response under the dynamic loading. Idealization of the structure is necessary to facilitate the calculations, but we feel that the level of idealization permitted for these structures still leave a considerable workload which would require additional funding and time to be accomplished by this office.

SDSTE-AEO

SUBJECT: Design Data for Explosive Waste Incinerator Air Pollution
Control System

3. Inasmuch as we do not have funds to accomplish the detailed blast analyses; and inasmuch as time constraints (i.e. submittal by AE of final designs by 21 Oct 78) don't permit the lengthy analysis, we suggest the AE proceed with anchor and foundation designs based on environmental loads and that Huntsville Division accomplish the blast load analysis which may or may not result in a 'downstream' change to the AE's anchor designs. Blast pressure data may be obtained from AEO Report No. 31-78, Final Report for Determining Explosive Limits of the Present Design of the APE 1236 Deactivation Furnace and Enclosure, dated July 1978. This report summarizes the data previously provided to Huntsville for enclosure designs. A copy of this report is submitted under separate cover to Huntsville Division, ATTN: HNDED-CS (Ron Lein).

4. If funds can be provided, this office can do the blast load analysis.

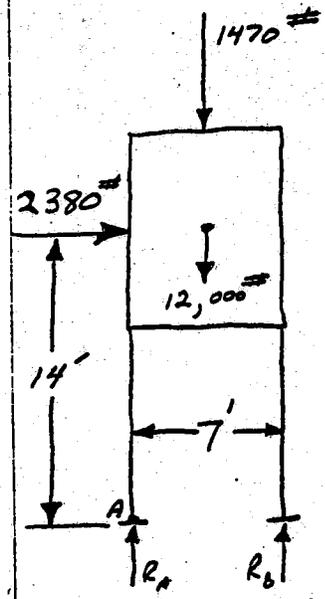
FOR THE COMMANDER:

1 Incl
as

F. H. CRIST
Chief, Ammo Equip Office

BAGHOUSE MOMENT CALCULATION

F.B.D.



30 PSF LIVE LOAD

$30 \text{ PSF } (7' \times 7') = 1470 \text{ \#}$

25 PSF WIND LOAD

$F = 25 \underbrace{(2 \times 0.33' \times 11.33')}_{\text{LEG AREA}} + 25 \underbrace{(7' \times 10.54')}_{\text{BAGHOUSE BODY AREA}}$
 $+ 25 \left[\left(\frac{1}{2} \right) (1.67' + 3.33') (5.58') \right] = 2380 \text{ \#}$
 BAGHOUSE FUNNEL AREA
 (TRAPEZOID SHAPE ASSUMED)

$R_A = R_B = 6735 \text{ \#}$

$\rightarrow M_A = 2380 \text{ \#} (14') - 6735 \text{ \#} (7')$
 $+ 12,000 \text{ \#} (3.5')$

$M_A = 33,320 \text{ ft} \cdot \text{\#}$

SEISMIC LOAD (ZONE III $\Rightarrow Z=1.0$)

$V = ZKCW$ (TM 5-809-10)

- FORMULA FOR ELEVATED TANKS - BRACED FRAME

- V = TOT. LATERAL LOAD
- Z = SEISMIC COEFF. (ZONE III)
- K = COEFF. (3.0)
- W = WGT. OF STRUCTURE
- C = COEFF. OF BASE SHEAR
- $C = \frac{0.05}{\sqrt{T}}$
- $T = \frac{0.05 H_N}{\sqrt{D}}$

$T = \frac{0.05 (21.875')}{\sqrt{7}} = 0.413$

$C = \frac{0.05}{\sqrt{0.413}} = 0.067$

- H_N = HGT. ABOVE BASE
- D = BUILDING DIMENSION PARALLEL TO FORCE
- W = 12,000 \# (WITH ACCESSORIES)

$V = ZKCW:$

$V = (1)(3)(0.067)(12,000)$

$V = 2412 \text{ \#}$ $M = Vd$

$M = 2412 \text{ \#} (14') = 33,768 \text{ ft} \cdot \text{\#}$

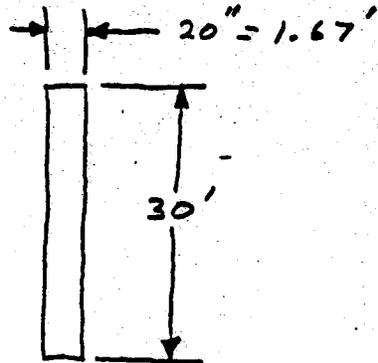
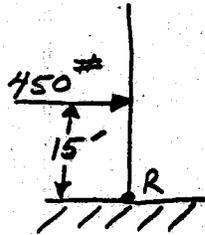
$33,768 \text{ ft} \cdot \text{\#} > 33,320 \text{ ft} \cdot \text{\#}$

•• DESIGN FOR MOMENT CREATED BY SEISMIC LOAD ($M = 33,768 \text{ ft} \cdot \text{\#}$)

EXHAUST STACK MOMENT CALCULATION

F.B.D.

TREAT AS
CANTILEVER BEAM



25 PSF WIND LOAD

$$25 \text{ PSF} (30' \times 1.67') = \underline{1253 \#}$$

U.B.C. TABLE 236 Pg. 139

MULTIPLICATION FACTORS FOR ROUND STRUCTURES = 0.6

$$1253 (0.6) = \underline{752 \#}$$

$$\underline{M_R = Fd = 752 \# (15') = 11,280 \text{ ft-}\#}$$

SEISMIC LOAD (ZONE III, Z=1.0)

$$V = Z C_p W \quad (\text{TMS-809-10})$$

- FORMULA FOR VERTICAL TANKS ON THE GROUND

$$Z = 1.0$$

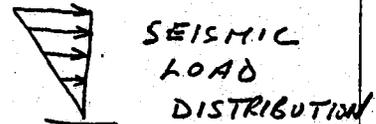
$$C_p = 0.1$$

$$W = 1800 \#$$

$$V = (1.0)(0.1)(1800 \#) = 180 \#$$

$$M = Fd \quad d = \frac{2}{3} H = \frac{2}{3}(30) = 20'$$

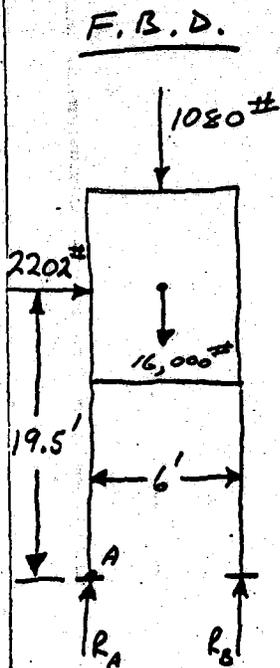
$$\underline{M = 180 \# (20') = 3600 \text{ ft-}\#}$$



$$11,280 \text{ ft-}\# > 3600 \text{ ft-}\#$$

DESIGN FOR MOMENT CREATED
BY THE WIND (M = 11,280 ft-#)

GAS COOLER MOMENT CALCULATION



30 PSF LIVE LOAD

$$30 \text{ PSF } (6' \times 6') = 1080 \#$$

25 PSF WIND LOAD

$$F = 25 \underbrace{(2 \times 0.33' \times 13')}_{\text{LEG AREA}} + 25 \underbrace{(6' \times 11.5')}_{\text{GAS COOLER BODY AREA}}$$

$$+ 25 \left[\frac{1}{2} (5' + 2') (3') \right] = 2202 \#$$

CONVEYOR FACE AREA (TRAPEZOIDAL SHAPE ASSUMED)

$$\rightarrow M_A = 2202 \# (19.5') + 17,080 \# (3') - 8540 \# (6')$$

$$\underline{\underline{M_A = 42,939 \text{ ft} \cdot \#}}$$

SEISMIC LOAD (ZONE III, Z=1.0)

$V = ZKCW$ (TM 5-809-10)
- FORMULA FOR ELEVATED TANKS - BRACED FRAME

$Z = 1.0$
 $K = 3.0$
 $W = 16,000 \#$

$$T = \frac{0.05 (27.25')}{\sqrt{6}} = 0.556$$

$$C = \frac{0.05}{\sqrt[3]{0.556}} = 0.061$$

$V = ZKCW$

$V = (1.0)(3.0)(0.061)(16,000)$

$\underline{\underline{V = 2928 \#}}$

$M = Fd = 2928 \# (19.5')$

$\underline{\underline{M = 57,096 \text{ ft} \cdot \#}}$

$57,096 \text{ ft} \cdot \# > 42,939 \text{ ft} \cdot \#$

DESIGN FOR MOMENT CREATED BY SEISMIC LOAD ($M = 57,096 \text{ ft} \cdot \#$)

APPENDIX D
UTILITIES REQUIREMENTS

EWI UTILITY REQUIREMENTS

ELECTRICAL						#2 Fuel Oil	Water	Compressed Air @ 100 psig
HP	Volt	Ø	Motor Code Ltr	Demand Factor				
Deactivation Furnace						6 min. 21 max. 12 ave.	1-2 gpm	
Feed Conveyor	1/2	200	3	R	.8			
Discharge Conveyor	1	200	3	N	.8			
Retort Drive	5	200	3	J	.5			
Combustion Air Blower	5	200	3	J	.6			
Oil Pump	1/4	200	3	S	-			
Positive Feed System								
Transfer	1/4	200	3	S	.3			10 cfm
Ram	1	200	3	N	.2			
Controls	3 amps	115	1	-	-			
Air Pollution Control System								
ID Fan	40	200	3	A	.8			16 cfm
Gas Cooler Fans (4@ 1 1/2 Hp)	6	200	3	J	.7			
Air Compressor	7 1/2	200	3	H	.3			
Discharge Valve (2 @ 1/2 Hp)	1	200	3	R	.4			
System Controls								
Purge Fan	1/4	115	1	-	-			
Controls	10 amps	115	1	-	-			
TOTAL ENERGY REQUIREMENT						<u>54 KW</u>		

APPENDIX E
PRELIMINARY REPORT ON
COMPOSITION A-5 INCIDENTS



DEPARTMENT OF THE ARMY
TOOELE ARMY DEPOT
TOOELE, UTAH 84074

Mr. Hill/cd/790-2825

SDSTE-AEO

SUBJECT: Preliminary Report on Composition A-5 Incidents

Commander
U.S. Army Armament Materiel Readiness Command
ATTN: DRSAR-ISE (Mr. Wash)
Rock Island, Illinois 61201

During our burn-testing of Composition A-5 in support of the EWI Program, we experienced some detonations in the furnace. At Inclosure 1 is a preliminary report of those incidents and some testing and analyses that we have done.

FOR THE COMMANDER:

1 Incl
as

A handwritten signature in black ink, appearing to read "F. H. Crist".

F. H. CRIST

Chief, Ammunition Equipment Office

On Wednesday, 1 November 1978, a representative of AEO met with C. F. Davis and G. Daurelle of Hercules Inc. in Magna, Utah. The subject was the analysis of the latest sample of Composition A-5 which they had been testing. Copies of the two test reports they have done are included for comparison of results. Their most recent report does include some possible explanations of the problems we have had with this explosive.

The second analysis was more comprehensive than the first but still does not provide any solid information of any unusual data that points to a specific cause of the explosions. In fact, after discussion with the people at Hercules they thought that the two may have had different causes.

The second sample of Composition A-5 was drier than the samples from the first tests. The only other marked difference between the samples is in the impact sensitivity. The second sample had a TIL of 11 cm vs 33 and 51cm for the first two samples. There are reasonable explanations for this difference based on particle size differences.

If various small size range samples of material are tested for impact sensitivity they will generally give reasonably good agreement. If however the sample contains a wide particle size range with many larger size particles present the sample will tend to be more sensitive to impact. This is because the larger size particles will set higher than the remainder of the material on the test plate and it will be these larger particles which absorb most of the initial shock in the

test which causes them to kick over the remainder of the material causing an explosion.

The second sample also contained a significant percentage of fines and although no dust explosibility tests were done, I was told that the size range particles for which RDX is most sensitive were present and there certainly are available hot spark sources available in the furnace so that this is a very real possibility.

There was an abnormally large amount of HMX in the second test sample but it was of the β -crystalline form, and therefore not significantly different than the RDX itself conditions necessary for the formation of the much more sensitive form are not considered at all likely to occur and therefore has been ruled out as a cause of the explosion.

Hercules advanced three possibilities to explain the two explosions that we had and they are basically outlined in their letter. The possibility of a dust explosion was suggested based on the presence of significant fines in the second analysis (no sizing was done on the first samples). One of the cans could tip and the air flow would kick up a dust cloud which could be ignited by a spark of already burning material causing an explosion. There were particles present in the size range for which RDX dust is most sensitive. This proposal was advanced as the most likely explanation for the second (1 lb) explosion.

Another possibility involved the quick ignition of the larger particles on the surface by the furnace heat. These burning particles then ran on and kicked the remaining material into a detonation. The larger

particles are easier to ignite than the smaller sizes.

A third possibility, and one which would be most applicable to the first (4 lb) explosion, is a subsurface ignition of the RDX. If the RDX were present at a certain critical depth around the ignition point it could be kicked over into a detonation. This type of incident is very dependent on the configuration of the container and the explosive.

The March 1978 incident left a bulge on the retort. The shape of the bulge is such that it looks as if a can fell on the Composition A-5 which then detonated. The shape of the bulge roughly corresponds to that of a can and shrapnel marks 180° opposite indicate that this is a likely explanation. If the can were on top of the explosive and subsurface ignition were to occur, the Composition A-5 might be confined at a depth sufficient to detonate the mixture.

These explanations which have been advanced do provide some insight into what might have occurred in the furnace to cause the explosion. However, additional testing is the only way to obtain the data that could fill in a lot more of the picture. Many tests are possible and desirable but beyond the capabilities of this office to conduct. Hercules and certainly some other organizations that deal with explosives have full time hazard analysis sections whose services are available on a contract basis. In light of the fact that these EWI's are going in at fourteen sites around the country and to date, no explosives hazard analysis has been performed, it would be in our own best interests to look into contracting for this type of service. This would allow us to have a disinterested expert group analyze the

the operation and make suggestions and perform tests whose results and recommendations could help to avoid another incident such as has already occurred or perhaps prevent something much more serious from occurring.

13 April 1978

TO: Terry Mathews

FROM: *G. M. Daurelle*
G. M. Daurelle

SUBJECT: ANALYSIS OF COMP A-5 FOR TOOELE ARMY DEPOT

Analysis of two lots of Comp A-5 have been completed as per your purchase request, DAAG49-78-M-2044.

1. Visual Observation

Two samples of Comp A-5 were supplied; one marked "wet" and the other "dry." Both samples were free-flowing and contained no free liquid.

Microscopic examination of the samples showed both were predominantly RDX. The larger RDX crystals contain some mother liquor. A few percent RDX is present in both samples. The particle size of the "dry" sample looks somewhat larger than that of the "wet" sample.

2. Moisture

	<u>Dry</u>	<u>Wet</u>
Moisture (Gas Chromatograph)	.069%	.059%

3. Thermal Stability

Fischer-Johns Autoignition (Heating Rate ~ 30°C/min)	242°C	247°C
---	-------	-------

Modified Taliani (93.3°C for 23 Hrs)	1 mm Hg	4 mm Hg
---	---------	---------

4. Sensitivity (1,2)

Impact (2 kg wt)	33 cm	51 cm
------------------	-------	-------

Friction	120 lbf @ 8 ft/sec	220 lbf @ 8 ft/sec
----------	--------------------	--------------------

ESD	.025 Joules	.05 Joules
-----	-------------	------------

5. Chemical Analysis

Stearic Acid

Dry
1.09%

Wet
1.13%

IR Scan

Both samples were comparable to a control scan on RDX. The dry sample was slightly "noisier."

Conclusion

Based on these tests we conclude that there is no basic difference in the samples. The differences noted are typical of lot-to-lot variation.

GD/afo

NO NORMAL PARAMETER
TEST WOULD BE DIFFERENT FROM
MACHINE TO MACHINE.

COMP AS , S 98.5% RDX
1.5% STEARIC ACID

- (1) Threshold Initiation Values - Twenty no reactions; reaction at next test level.
- (2) Ten micron RDX (dry) gave identical values as "wet" sample.



HERCULES AEROSPACE DIVISION
HERCULES INCORPORATED

BACCHUS WORKS · MAGNA, UTAH 84044 · TELEPHONE (801) 250-5911

1 November 1978

SP732/01-10-13/1078

Mr. Robert Durfee
Tooele Army Depot
Tooele, Utah

Subject: Testing of Special Sample of Composition A-5
Project 732

Dear Sir:

The sample of Comp A-5 was received on our plant and the following tests were performed, as requested.

1. Moisture
2. Chemical Analysis
3. Differential Thermal Analysis (DTA)
4. Thermal Stability
5. Sensitivity
 - a. Impact
 - b. Friction

The material received appeared as a dry powder, contained a quantity of black flecks, was an off-white color, contained large ingredient particles, and was non-homogenous in texture.

Results of the tests conducted are as follows:

1. Moisture analysis (by Gas Chromatograph)
0.006%

2. Chemical Analysis

Black particles were iron scale

Steric Acid 1.05%

HMX detected ~ 25% of Beta Crystalline Form (particle size ~ 30-250 μ)
Remainder RDX

Crystals present were on the order of 300-700 μ with a large number in the 50-300 μ range with fines as small as 2 μ . The amount of HMX present in this recent Comp A-5 sample is abnormal. You would normally expect 3-8% to be present though as high as 10% is common due to the method of RDX manufacture. We are unable to determine if the quantity of HMX was present in parent material or occurred later.

The following paragraph is excerpted from a memo dated 13 April 1978 to Terry Mathews of TAD, which alludes to sample differences.

"Microscopic examination of the samples showed both were predominately RDX. The larger RDX crystals contain some mother liquor. A few percent HMX is present in both samples. The particle size of the "dry sample" looks somewhat larger than that of the "wet" sample."

3. DTA

The material indicates a large endotherm at 189°C with an exotherm at 210°C.

4. Thermal Stability (Fisher Johns Autoignition)

245°C

5. Sensitivity

Threshold Initiation Level*

Impact 11 cm
Friction 240 lbf @ 8 fps
ESD 0.075 Joules

The data indicates a material which is more impact sensitive than other Comp A-5 previously tested. The chemical analysis indicates some abnormality which may be significant in light of your recent oven incidents. A comparison of the Comp A-5 data is given below.

	<u>Wet**</u>	<u>Dry**</u>	<u>"Oven"***</u>	<u>Class A RDX</u>
% H ₂ O	.059	.069	.006	--
% Steric Acid	1.13	1.09	1.05	--
Impact (cm)	51	33	11	26
Friction (lbf @ fps)	240 @ 8	130 @ 8	240 @ 8	100-200 @ 8
ESD (Joules)	0.05	0.025	0.075	.075
FJAI (°C)	242	247	245	

Based on conversations with you and our experience with HMX and RDX, several possibilities of potential causes of the furnace incidents are indicated.

* Level of energy input which results in 20 consecutive trials with no reaction while at the next highest level at least one reaction occurs.

** Previous data.

*** Current A-5 sample related to furnace incidents.

1. Dust explosion - because of fine particles and ignition source present.
2. Surface "flash" (caused by large particles present) running to explosion.
3. Subsurface ignition transiting to explosion.

Our data indicates that sensitivity of RDX does vary according to particle size and that some particle sizes are extremely sensitive to initiation in a dust cloud. If the understanding of how your furnace operates is correct this is a likely cause of your recent problems.

Large RDX particle sizes have been shown in our combustion work to burn rapidly. Your system could be analogous to a rifle shell with an insufficient powder charge which when placed in the rifle causes a significantly increased ignition surface. Once ignited a "flash" occurs causing high pressure at high pressurization rates which causes barrel rupture.

The third item seems less likely though it is a possibility. HMX exhibits extremely low material heights required to cause explosion and/or detonation. RDX would be expected to behave in a similar manner. This particular scenario would be highly dependent on factors such as material and carrier configuration and oven conditions.

We hope that the information supplied to you is of benefit in your investigation. Also, we hope that the comments on potential causes may be of help. If we can be of further assistance, please feel free to contact me.

Very truly yours,


C. F. DAVIS, Hazards Analyst
Hazards Analysis Group

CFD/af0

cc: E. A. Mettenet
R. L. Schaefer
G. A. Savoy
G. M. Daurelle
B. A. Findley

IV. Technical Paper —
Pollution From Open Air Detonation

AEO Report 27-79

December 1972

AMMUNITION EQUIPMENT OFFICE
TOOELE ARMY DEPOT
TOOELE, UTAH 84074

POLLUTION FROM OPEN AIR DETONATION AND OPEN BURNING

PREPARED BY:

APPROVED BY:

Ralph W Hayes

RALPH W. HAYES
Asst, C, Ammo Equip Office

Kenneth T Smith
for F. H. CRIST
C, Ammunition Equipment Office

POLLUTION FROM OPEN AIR DETONATION AND OPEN BURNING

INTRODUCTION

The Armed Forces have been forced to consider environmental effects of explosive disposal. In many cases it has been assumed that detonation or burning of explosives on a demolition range is completely unacceptable eventhough no data was available as to actual pollution levels produced by these activities. As other means of explosive disposal are being developed, an economic analysis of alternative methods can only be made if the actual pollution reduction is known. This report attempts to summarize a literature search on this subject and to report investigations conducted by the Ammunition Equipment Office.

GASEOUS POLLUTANTS FROM DETONATION

A literature search revealed that almost all work that had been done on products of detonation considered detonation in a vacuum. Dr. Melvin Cook, in his book The Science of High Explosives, has done a theoretical study of the products of detonation of many explosives in a vacuum. Dr. Donald Ornellas at Lawrence Radiation Laboratories has also done experimental work in this area. Since the products of detonation in a vacuum differ greatly from those expected on a demolition range, these works are mentioned as a reference only.

The literature search revealed that the Soviet Union has conducted a study in this area, and recently the Burlington and Pantex AEC Plants have performed work in this area.¹ AEO conducted tests also to substantiate

¹All references to Burlington work were obtained from progress reports entitled, "Disposal of Waste or Excess High Explosive"

the literature search.

The results of tests at atmospheric conditions at Burlington and AEO are very encouraging since the combustion appeared to be nearly complete in all explosives tested. The Russian study indicated more pollutants being formed, but this may have been because of the difference in experimental techniques.

Russian Studies

Table 1 shows the results of the Russian studies on grain-granulite 80/20 and TNT. Their studies were done to simulate blasting in open pit mining rather than explosive disposal. The charges were buried in the ground 10-15 meters for the purpose of breaking loose ore. This may account for the fact that greater amounts of pollutants were formed in these tests than those conducted by Burlington and AEO. Although there is no mention of the size of these charges, it is assumed they are several times smaller than the amounts of explosives commonly detonated during disposal. The deep burial of small charges may serve to exclude air that could carry the combustion process to completion.

Burlington Tests

Tests conducted at Burlington consisted of detonating 25 gram charges of HMX, TNT, and PEIN in a chamber containing enough air that free oxygen could remain after the blasts. The tests showed that CO₂, H₂O, and N₂ (all non-pollutants) were the main products formed from all three tests. A slight amount of NH₃ was found dissolved in the water collected from all

three tests along with a small amount of NO_x (.19 mole/mole of explosive) in the test using TNT.

AEO Tests

AEO tests were conducted on 15-25 gram charges of tetryl and Comp B in a chamber containing enough air that the composition of gas remaining in the chamber after the blasts still contained 5-10% free oxygen. A gas analysis on both tests revealed the formation of CO_2 and N_2 with only a trace amount of gaseous unburned hydrocarbons. A trace amount of CO was also found in the Comp B test. The trace amounts were less than .1% by volume compared to the formation of CO_2 to the extent of 10% by volume. No attempt was made to collect H_2O and it was allowed to precipitate in the chamber.

OPEN AIR BURNING

Burlington has conducted tests by burning approximately .6 grams of various explosives. Assuming that the products formed in small scale tests are in the same proportion as those produced in large scale open burning, the results obtained are shown in Table 2.

The work on open air burning measured the particulate produced (soot) as well as gaseous pollutants.

DISCUSSION OF RESULTS

Results obtained from these small scale tests seem very encouraging. It would appear that detonation rather than burning produces less gaseous pollutants. Detonation obviously produces more particulate in the air.

No attempt has been made in this report to define the particulate pollutants produced by detonation. Although vast quantities of particulate are hurled into the air, most of this settles out right away and can hardly be termed suspended particulate. It is only the very small particulate that is harmful. Any Federal standard on particulate levels would probably have to be made on measurements of ambient air not immediately in the blast area, thus measuring instruments would not be effected by the particulate that settles out right away.

Any conclusions drawn from the gaseous pollutant on these small scale tests are based on the assumption that large scale disposal produces products in the same proportion. This may not be exactly true since some pollutant formation, NO_x particularly, is very dependant on the combustion temperature and cooling rate. Burlington currently has a program of sampling ambient air in the surrounding vicinity of explosive burning. During the month of June 1972 an arithmetic mean of .044 ppm NO_2 was measured with a burning rate of 4-17,000 pounds of explosive in a twenty-four hour period. This compares favorably with the national standard of .05 ppm annual arithmetic mean.

CONCLUSIONS

It appears that it is invalid to automatically assume that detonation and open air burning are the worst polluters of all explosive disposal methods. As this report shows, the gaseous pollutants produced by these methods, detonation especially, may not be beyond the acceptable standard.

Perhaps an investigation by the Environmental Protection Agency could show that particulate concentrations produced by detonation could actually be allowed under present standards if allowances are made for the large unarmful particles that readily settle out of the atmosphere.

Explosive	Ore, rock	Strength indicator of rock according to scale of Prof. Protod'yakonov	Content of noxious gases per 1 kg explosives, l		
			CO	NO ₂	total*
Grain-granulite 80/20	Magnetite hornfels	14 - 16	15.5	2.54	32.0
		13 - 15	13.0	3.33	34.6
	Magnetite and semioxidized hornfels	12 - 13	12.2	3.48	34.8
	Substandard hornfels and shales	10 - 12	10.2	7.0	55.7
Grain-granulite 50/50	Shales	9 - 10	9.4	7.7	59.4
	Magnetite hornfels	13 - 15	33.2	2.82	51.5
	Substandard and magnetite hornfels	12 - 13	30.8	3.34	52.4
TNT	Magnetite hornfels	16 - 18	70.2	2.02	83.1
		14 - 16	65.4	2.91	84.4
		13 - 15	57.8	1.54	74.3
	Substandard and magnetite hornfels	12 - 14	52.2	3.19	72.8

* Calculated relative to carbon monoxide.

TABLE 1

**ESTIMATED DAILY POLLUTION EMISSION
FROM BURNING EXPLOSIVES**

<u>Pollutant</u>	<u>Burning 3.8 Tons PBX-9404</u>	<u>Burning 3.8 Tons LX-09</u>	<u>Burning 3.8 Tons Comp-B-3</u>	<u>Burning 3.8 Tons TNT</u>	<u>Autos Adjacent to Plant</u>
Carbon Monoxide (lbs.)	23	4	19	213	2499
Oxides of Nitrogen (lbs.)	144	110	141	570	192
Hydrocarbons (lbs.)	-0-	-0-	-0-	4	218
Phosphorous Pentoxide (lbs.)	49	-0-	-0-	-0-	No Standard
Hydrochloric Acid (lbs.)	87	-0-	-0-	-0-	No Standard
Hydrofluoric Acid (lbs.)	-0-	23	-0-	-0-	-0-
Soot (lbs.)	-0-	-0-	-0-	684	No Standard

NOTE: The automotive figures are based on 10,380 daily vehicles (Iowa Highway Commission count) travelling 2.8 miles each (along the Burlington defense plant perimeter). Each vehicle is assumed to barely comply with Federal Emission Standards for automobiles as published in Environmental Science and Technology(6). The value of 3.8 tons is the average daily amount burned for all explosives combined from both divisions A and B at the Burlington Plant.

TABLE 2

AEO TEST DATA

EXPLOSIVE

CHAMBER GAS ANALYSIS, PERCENT BY VOLUME

	O ₂	N ₂	CO ₂	CO	CH ₄	NO _x
Comp B 26.1 gms	6.98	83.12	9.90	Tr	Tr	ND
Comp B 26 gms	7.3	80.1	12.6	ND	ND	ND
Tetryl 17.7 grms	13.0	79.0	8.0	ND	ND	ND
Tetryl 29.3 grms	4.9	75.5	19.5	ND	ND	ND

Chamber Volume 6 Cu. Ft.

Tr - Trace

ND - Not Detected

TABLE 3

V. Technical Paper — Open Air Detonation Of TNT

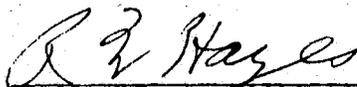
DIRECTORATE FOR AMMUNITION EQUIPMENT
TOOELE ARMY DEPOT
TOOELE, UTAH 84074

OPEN AIR DETONATION OF TNT

PREPARED BY:


HOWARD HODGES, 2LT, CE
Chemical Engineer

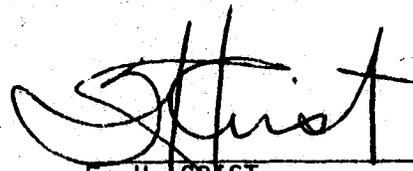
CONCURRED:


RALPH W. HAYES
Deputy Dir. f/Ammunition Equipment

REVIEWED BY:


GERALD N. JONES
C, Chemical Systems Division

APPROVED BY:


F. H. CRIST
Director f/Ammunition Equipment

SUMMARY

The determination of the quantity and types of gaseous by-products created from an open detonation of trinitrotoulene (TNT) is a difficult issue. Very little work has been conducted in this field and what has been done reveals conflicting results. The quantity of gaseous by-products did not agree completely between researchers cited in this study for any species. In some examples, the types of gaseous by-products differed between sources. With one exception, all work to this point involves small scale detonation analysis. The ultimate premise of this study is to predict detonation by-products for TNT quantities of 1 to 2 tons.

This study has attempted to bring all of the sources into perspective and simultaneously conduct an independent study on open air detonation. A literature search revealed several sources of previous work. The premise for most of this work was small scale, inclosed laboratory analysis. The detonation by-products depend on many factors; loading density, method of initiation, confinement, the chemistry of the surrounding media, and the gas expansion characteristics. Thus, a correlation problem with this work and open air detonation work exists. Scaling-up small scale work to large scale in-situ detonations is also a problem. The explosion characteristics change with charge size.

This study includes a literature search for previous work, a computer analysis using an isentropic (constant entropy) equilibrium program for theoretical predictions, the toxicity of key noxious species, the formation of these species, scale-up problems, an economic comparison between open air detonation and its alternative, and a simulated open detonation experiment.

The most noxious gaseous by-products are carbon monoxide (CO), nitrogen oxides (NO_x), and hydrogen cyanide (HCN). Using the programs predictions, which were high by comparison, atmospheric dispersion calculations were conducted. HCN and NO_x appear to pose no harmful effects. CO, on the other hand, may possess a potential danger. An ambient concentration of 8000 ppm was calculated. It should be noted that these calculations are

very rough estimates and that several side reactions may oxidize CO to carbon dioxide (CO₂). The toxicity of carbon monoxide is dependent on two factors, concentration and duration. Although the concentration may be high, the duration of exposure would be very small, a few seconds.

This study and subsequent experiment brought together a large percentage of the work thus far conducted on TNT detonation. It should be noted that 95% of the information concerns either theoretical predictions or small scale experimentation. Large detonations have vastly different conditions than small scale. Therefore the correlation between large and small is not a reliable one. Two follow-up studies should be conducted. One would expand the experiment presented here-in to develop sampling technique and expertise. With this gain in knowledge, a study using the charge size found in actual demil operations should be conducted. From this study an Environmental Impact Statement could be prepared and the problem put to rest.

TABLE OF CONTENTS

	<u>PAGE</u>
SUMMARY SHEET.....	i
TABLE OF CONTENTS.....	iii
LIST OF FIGURES.....	iv
LIST OF TABLES.....	v
INTRODUCTION.....	1
BACKGROUND.....	2
DETONATION AND DEFLAGRATION.....	2
PREVIOUS DETONATION ANALYSIS.....	4
TECHNICAL DISCUSSION.....	12
THEORETICAL DETONATION PRODUCTS.....	12
THEORETICAL COMPUTER ANALYSIS.....	14
DISPERSION ESTIMATES.....	24
TOXICOLOGY.....	28
GAS FORMATION.....	30
PROBLEMS WITH SCALE-UP.....	32
ECONOMICS.....	33
EXPERIMENT.....	35
INTRODUCTION.....	35
BACKGROUND.....	35
EXPERIMENTATION.....	37
CONCLUSION.....	42
CONCLUSION.....	43
APPENDIX A.....	A-1
APPENDIX B.....	B-1
APPENDIX C.....	C-1

LIST OF TABLES

	<u>PAGE</u>
TABLE 1 RUSSIAN STUDY OF NOXIOUS GASES PRODUCED PER.....7 KILOGRAM OF TNT AS A FUNCTION OF SURROUNDING MEDIA STRENGTH	7
TABLE 2 AFTER DETONATION PRODUCTS OF TNT AND COMPOSITION B.....8 LAWRENCE LIVERMORE LABORATORIES	8
TABLE 3 AFTER DETONATION GASES, EXPERIMENTAL CONCLUSIONS,.....9 RALPH HAYES	9
TABLE 4 DETONATION PROPERTIES OF TNT AS A FUNCTION OF DENSITY.....13	13
TABLE 5 AEROTHERM ISENTROPIC EQUILIBRIUM PROGRAM CONSTANT.....16 PRESSURE	16
TABLE 6 AEROTHERM ISENTROPIC EQUILIBRIUM PROGRAM CONSTANT.....18 TEMPERATURE	18
TABLE 7 DETONATION PROPERTIES OF TNT AS A FUNCTION OF DENSITY,.....21 AEROTHERM	21
TABLE 8 MOLES OF AFTER-DETONATION GASES PER KG TNT.....23	23

INTRODUCTION

Faced with the disposal of out dated and unserviceable munitions, the Army has utilized several disposal methods. With the emphasis on the environment, methods such as incineration have replaced earlier usage of open air detonation and uncontrolled burning. However, little work has been conducted to determine the environmental insult, if any, of open air detonation. Open air detonation is hypothesized to be environmentally harmful and is thus discouraged. This notion of harm is not well founded. A qualitative as well as quantitative determination of open air detonation needs to be explored.

There are several reasons why open air detonation should be thoroughly evaluated and carefully considered. The first primary motivator is economics. Is open air detonation less expensive than its alternate, incineration? Another consideration is the technical feasibility of incineration or any other alternative. A final consideration is the safety of the alternatives.

When munitions are handled, the risk of injury exists. As the number of times a munition is handled increases, as is necessary for incineration, the injury possibility likewise increases.

Is open air detonation less expensive? Each year escalates the price tag of incineration systems. Currently, the Projectile Saw/Explosive Waste Incinerator, the primary alternative, has a \$1.7 million price tag. Present and future budgets may not be able to absorb these costs. A later section will study this in more depth.

The technical feasibility of incineration may also come under some scrutiny. Combustion products are as hard to predict as detonation products. Although incineration is cleaner, the reduction of pollutants may not justify the costs.

Very little work has been conducted in the analysis of detonation by-products. Generally, most work was conducted in the laboratory, using small quantities of explosive and performing detonations in evacuated

calorimeters. This work gives valuable information from a controlled basis but lacks the realism of an open air detonation. Much can be learned from a controlled explosion but conditions are drastically altered when 100g of explosive in a vacuum are substituted by 2 tons of explosive in the open desert.

This study was approached from several aspects. First a literature search was conducted to discover the characteristics of an explosion and previous work done in the field of explosive detonation. Second, theoretical detonation products were derived from a thermodynamic computer analysis. Third, estimates of the dispersion of detonation products are looked at. Fourth, the formation and toxicity of carbon monoxide (CO) and nitrogen oxides (NO_x) are discussed. Fifth, the ability to scale up from small scale detonations to large scale explosions is analyzed. Sixth, an economic comparison is conducted between incineration and open air detonation. Finally, an experiment of our own was conducted to simulate an open air detonation.

Background

Detonation and Deflagration

Before an adequate analysis of the effects of detonation can be approached, a good working knowledge of the detonation phenomenon is necessary. In addition, detonation needs to be contrasted with deflagration.

Detonation is a chemical reaction occurring within a shock wave known as a detonation wave. Detonation involves the evolution of heat and gases at an extraordinarily rapid speed. Very hot pressurized gases are left in a detonation aftermath. The detonation wave propagates through the explosive at very high yet constant and reproducible rates. For example, TNT, has a rate of detonation of 5000 to 7000 meters per second. Detonation can be described as a distinct discontinuity, moving through an explosive at a constant velocity D . Figure 1 illustrates this concept.

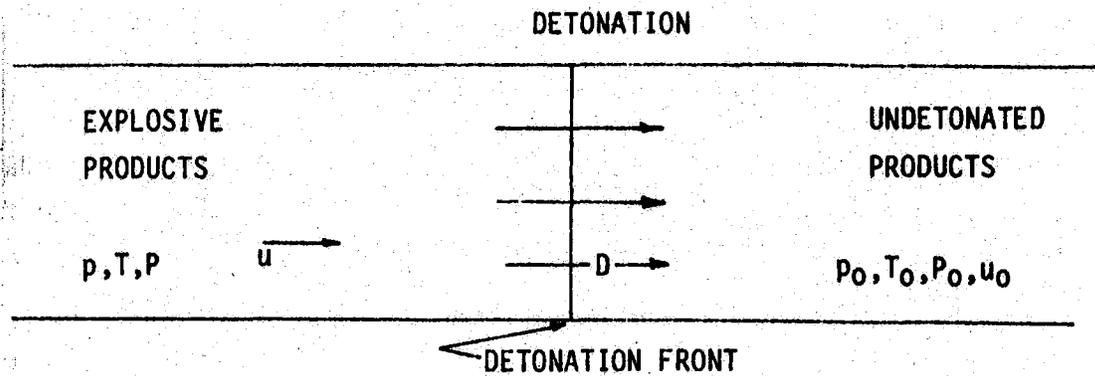


FIGURE 1

P = Pressure

p = Density

T = Temperature

u = Particle Velocity

D = Detonation Velocity

o Subscript = Initial Conditions

(FROM: J.S. Rienhart and J. Pearson, "Explosive Working of Metals", Pergamon Press Book, The Macmillan Company (1963))

Initiation of a detonation is preceded by a combustion process known as deflagration. Deflagration (burning) and detonation differ in that the deflagration gaseous by-products move away from the reacting surface whereas detonation gaseous by-products move towards the reacting surface creating a pressure surge and thus a shock wave.

Figure 2 illustrates the detonation process as a function of time and reaction rate. Detonation occurs at a finite time after initiation. The difference between low and high explosions is also well illustrated in Figure 2.

Previous Detonation Analysis

Several scientists have conducted experiments on the gaseous by-products of an explosive detonation. Many different types of apparatus were used to conduct the experiment and analyze the gaseous by-products. Generally, detonations were conducted in a bomb calorimeter under a vacuum.

The Bichel Gauge is used to measure carbon monoxide (CO) concentrations from an explosive detonation. In a Bichel Gauge test 200 grams of an explosive is fired at low loading densities in an evacuated chamber with a 15 liter volume.

A Crawshaw-Jones apparatus is used to determine nitrogen oxides (NO_x) formed during an explosion. The apparatus is composed of a steel cannon with a 2 inch by 21 inch cylindrical borehole. Gaseous by-products are discharged into an evacuated cylinder with a 90 liter capacity. Temperature and pressure readings are taken at 5 minute intervals until equilibrium is attained.

The Bureau of Mines in Bruceton, Pennsylvania, detonated explosives in mines and tunnels. The after-detonation products formed were collected, analyzed, and compared to results obtained from the Bichel Gauge, Crawshaw-Jones Apparatus, and similar types of experiments. A general conclusion was made that after-detonation products formed under actual conditions is substantially different from laboratory work.²

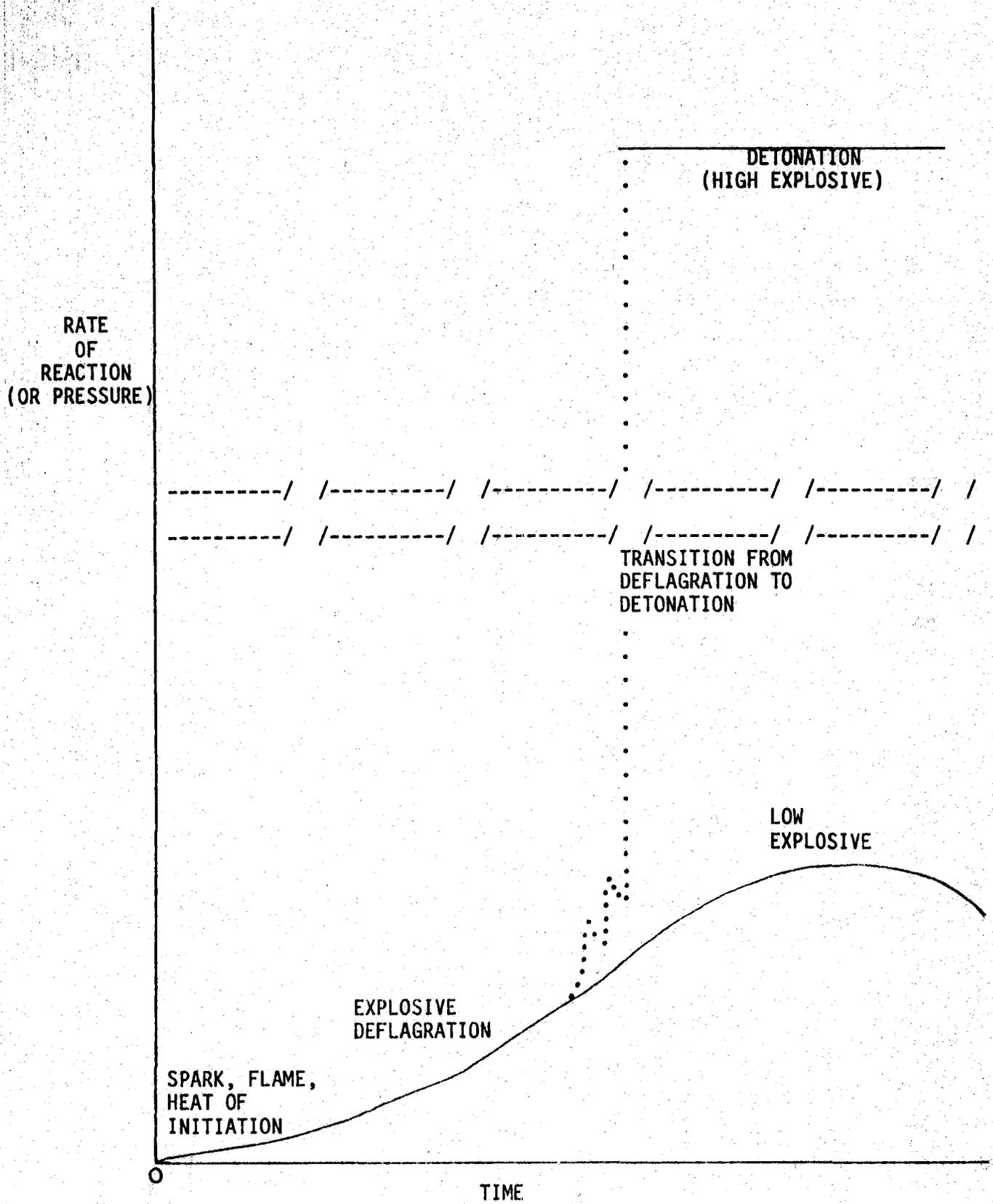
Dr. Melvin Cook at the University of Utah conducted laboratory experiments of explosive detonation under vacuum conditions. Dr. Cook concluded that fumes encountered in the Bichel Gauge, Crawshaw-Jones Apparatus, Trauzl Block, or other methods generally do not agree among themselves or with fumes generated in actual field applications. Several reasons can be attributed to this phenomena. Detonation-products depend on many factors; loading density, mode of initiation, confinement, the chemistry of the surrounding media, and whether the gases expand adiabatically and reversibly, freely, or against burdens.³

2 A.G. Streng, "Evaluation of Toxic After-Detonation Gases Formed by Industrial Explosives", Germantown Laboratories Inc. Philadelphia, PA.

3 M.A. Cook, "The Science of High Explosives", ACS Monograph Series, Reinhold Publishing Corp (1958).

From M.A. Cook, "The Science of High Explosives", ACS Monograph Series Reinhold Publishing Corp (1958).

FIGURE 2



Appreciating the basic weaknesses of laboratory experimentation, two German scientists, Beyling and Drekopf, captured detonation fumes in actual field conditions. The most important observation produced was that undetonated explosive or explosive ingredients were found in the products of detonation.

Burlington and Pantex AEC conducted detonation tests on HMX, TNT, and PETN. A 25 gram open air detonation was observed to have complete combustion. Nitrogen (N_2), carbon dioxide (CO_2), and water (H_2O) were the major detonation products and trace amounts of ammonia (NH_3) and nitrogen oxides (NO_x) were found in the aftermath of TNT.

Russia has also done some investigation into after detonation gas analysis. The premise for their work was the association of explosives in mining operations to help enhance miner safety. The results are found in Table 1. Basically the study found that the after-detonation gas could contain 300-500 mg/m^3 of particulate, carbon monoxide (CO), and nitrogen oxides (NO_x). Gas adsorption into the rock was apparent as noxious gases were liberated from the rock near the blast over a 2-15 hour period.

TABLE 1

RUSSIAN STUDY OF NOXIOUS GASES PRODUCED PER KILOGRAM OF TNT AS A FUNCTION OF SURROUNDING MEDIA STRENGTH

<u>EXPLOSIVE</u>	<u>ORE, ROCK</u>	<u>STRENGTH INDICATOR OF ROCK ACCORDING TO SCALE OF PROF. PROTOD'YAKONOV</u>	<u>CONTENT OF NOXIOUS GASES PER 1 KG OF EXPLOSIVE, L</u>		
			<u>CO</u>	<u>NO₂</u>	<u>TOTAL</u>
TNT	MAGNETITE	16-18	70.2	2.02	83.1
	HORNFELS	14-16	65.4	2.91	84.4
		13-15	57.8	1.54	74.3
	SUBSTANDARD AND MAGNETITE HORNFELS	12-14	52.2	3.19	72.8

Several observations can be derived from this data. First, as was pointed out by Dr. Cook, the after detonation gases depend on surrounding media. From Table 1, as the strength indicator of the rock increased, so did the volume of noxious gases. Secondly, the test study was for confined TNT explosions, not open air detonation addressed in this study.

Dr. Donald L. Ornellas of Lawrence Livermore Laboratory conducted experiments involving after detonation products in a vacuum environment. Table 2 lists his findings.

TABLE 2

AFTER DETONATION PRODUCTS OF TNT AND COMPOSITION B, LAWRENCE LIVERMORE
LABORATORIES

EXPLOSIVE	TNT	COMPOSITION B
PRODUCTS (MOLES/MOLE OF EXPLOSIVE)		
CO	1.98	0.88
CO ₂	1.25	0.66
C(s)	3.65	0.51
H ₂ O	1.60	0.81
H ₂	0.46	0.36
N ₂	1.32	0.94
NH ₃	0.16	No Information
CH ₄	0.099	No Information

The Directorate for Ammunition Equipment, TEAD, Tooele Utah, in 1972 conducted work in the area of open air detonation. In his paper "Pollution from Open Air Detonation and Open Burning", Ralph Hayes conducted an experiment in which Composition B and Tetryl were detonated in a 6 cubic feet chamber. The gas was allowed to reach equilibrium and then siphoned out of the chamber. Table 3 gives the data accumulated.

The first experiment, code named Middle Gust 1, was a half buried 20 ton explosion in moist sandy clay. Fluorescent beads were located at 150 feet, 200 feet, 350 feet, 500 feet, 1000 feet, and 2000 feet from ground zero to study ground sweepup. The observations included:

- a. Ground sweepup only involved the particles located at the 150 and 200 feet locations.
- b. Sweepup of particles less than 5u (microns) in diameter were only found in the stem and none in the main cloud. No coupling existed between the main detonation cloud and the stem.
- c. Dust concentrations declined at a rate of 20% per minute due to fallout and cloud expansion.

The second experiment Middle Gust II, involved a 100 ton simulated air blast. The charge was elevated one radius above ground. The ground was wet sandy clay. The most significant observation from this detonation concerned dust concentration Middle Gust II produced only 1/6 as much dust as Middle Gust I, a detonation blast of only 1/5 the magnitude. Therefore, it can be concluded that air blasts are better from a fallout standpoint.

Mine Throw I, a 100 ton blast in an old nuclear crater, was the third experiment. Due to the mechanical attrition of the soil from the previous nuclear blast, dust concentrations were very high. Concentrations exceeded 1 to 2 grams per cubic meter. This compares to a concentration of only 0.01 grams per cubic meter in Middle Gust II.

The next experiment, Mixed Company I, was a 20 ton detonation, half-buried over sandstone beds. The weathered sandstone contributed to a lower particle size spectra than found during the Middle Gust I and Mine Throw I detonations.

Middle Gust IV was a 100 ton blast conducted over dry sandy clay. The yield, configuration, and soil type for this experiment was identical to another experiment, Middle Gust III, except that Middle Gust III's soil had higher moisture content. Dust concentrations in Middle Gust IV's cloud was two to four times less than Middle Gust III's cloud at comparable cloud locations. Only the simulated air blast, Middle Gust II, had lower dust concentrations. Apparently, from the above comparison, water present in moist soil, as in Middle Gust III's case, contributes to the quantity of dust. The moisture, as it is converted to steam by the explosion fireball, increases the dust concentration. This indicates that greater moisture content increases dust fallout problems.

The dusts associated with high explosive detonations fall in a wide spectrum from a true aerosol to large ejecta blocks. The after detonation dust cloud particles typically have peaks in the 400-600u diameter. These particles are similar to mist or a light rain and precipitate rapidly causing mass segregation of the after detonation dust cloud.

Gaseous detonation products were also analyzed by the Meteorology Research Inc. A 1.5 lb. TNT detonation in a 800 ft³ chamber were compared with the 500 ton Mixed Company III experiment. The large scale detonation had lower nitrogen dioxide (NO₂), comparable nitric oxide (NO), and higher ammonia (NH₃), methane (CH₄), and carbon monoxide (CO) than predicted by the small scale test. High concentrations of ammonia, methane, and carbon monoxide may indicate oxidation of detonation products is less complete during large scale tests where considerable slow burning is observed after the initial detonation.

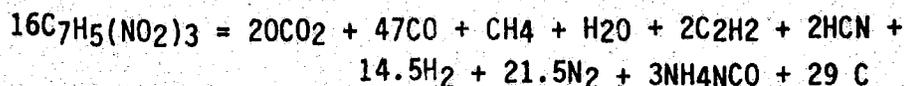
Sierra Army Depot, Herlong, California, took daily air samples during open air detonation operations during the time frame of 4 October to 4 November, 1978. Samples were taken using high volume air samplers as prescribed by the Army Environmental Hygiene Agency and the California Air Resources Board. From a 22 sample data bank, an Environmental Impact Statement was written. The document states: "The open detonation operations had no measurable impact on the Sierra Army Depot regional air quality during the study period. The visible impact could be minimized by temporal separation of the detonations by 2 to 3 minutes. These results may be useful to other installations in assessing the air quality impacts of other open detonation operations."⁵

⁵ John P. Piercy, "Open Detonation Environmental Assessment No. 43-21-0068-79, Sierra Army Depot, Herlong, CA, 4 October-4 November 1978".

TECHNICAL DISCUSSION

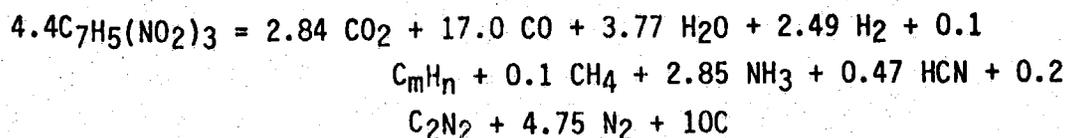
Theoretical Detonation Products

Decomposition of TNT under detonation depends on many factors; TNT density, chemistry of surrounding media, resistance to expansion of detonation gases, mode of initiation and confinement. Tadeusz Urbanski ⁶ states that decomposition under detonation may be represented by:

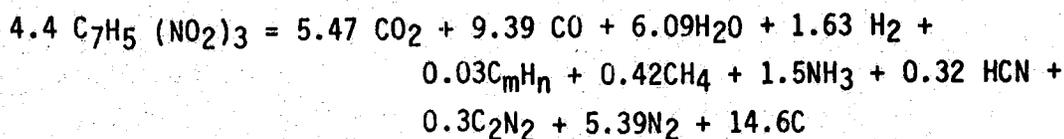


Schmidt ⁶ gave several modes of TNT decomposition based on 1000 grams of TNT as a function of density:

(1) Density = 1.0 grams/cm³



(2) Density = 1.59 grams/cm³



To illustrate how the loading density affects the products of TNT detonation, DR. D.W. Robinson ⁴ calculated gaseous by-products using the $\alpha(V)$ equation of state:

$$PV = nRT + \alpha(T,V) P$$

⁶ Tadeusz Urbanski, "Chemistry and Technology of Explosives", The MacMillan Company, New York (1964)

TABLE 4
 DETONATION PROPERTIES OF TNT AS A FUNCTION OF DENSITY

Density, ρ (g/cc)	0.3	0.8	0.95	1.11	1.27	1.47
LOG F	0.33	2.12	2.69	3.31	3.98	4.8
a (cc/g)	0.82	0.22	0.15	0.11	0.08	0.058
CO (moles/kg)	24.3	16.2	12.1	8.15	4.5	1.8
CO ₂	0.5	3.3	5.2	6.6	8.3	9.5
H ₂	5.5	1.1	0.9	0.2	0.1	
H ₂ O	1.4	2.6	2.4	2.5	1.9	1.3
N ₂	5.5	4.9	5.2	5.3	5.6	5.9
CH ₄	1.4	1.4	1.0	0.5	0.3	0.1
NH ₃	0.1	0.5	0.5	0.5	0.5	0.4
CH ₃ OH	-	0.8	1.6	2.5	3.4	4.3
HCN	2.2	3.1	2.8	2.2	1.6	1.1
C ₂ H ₂	0.5	0.4	0.3	0.2	0.1	-
C	2.3	5.0	7.4	10.2	12.5	14.2
n (moles gas/kg)	41.5	34.6	31.8	28.8	26.3	24.2
Q (kcal/g)	0.62	0.79	0.87	0.98	1.07	1.13
C _v (kcal/kg/°K)	0.292	0.321	0.334	0.349	0.365	0.375
T ₂ (ok 10 ⁻³)	2.77	3.35	3.58	3.82	3.981	4.05
P ₂ (ootm 10 ⁻⁴)	0.8	4.4	6.1	8.4	11.1	14.1

This table illustrates two points. First, one parameter, density, causes a wide variation in after detonation products. As stated before, there are many variable parameters. Secondly, theory does not agree with itself. In Table 4 above, Dr. Robinson claims a CO content of 8.5 moles/kg, Urbanski claims 12.9 moles/kg, and Schmidt claims 17 moles/kg at a density of 1.0 to 1.11 g/cc.

Theoretical Computer Analysis

The United States Air Force Rocket Propulsion Laboratory developed a one-dimensional isentropic equilibrium program. The program gives thermodynamic equilibrium combustion products. Although designed for the analysis of rocket propellents, explosives can be injected for analysis.

Two analysis were conducted initially. Using detonation temperatures and pressures from Rinehart and Pearson, values were placed in the input. One computer run concerned the production of various after detonation gases as a function of temperature at constant pressure. The second considered after detonation gases as a function of pressure at constant temperature.

Table 5 is a summation of the constant pressure calculations. Figure 3 graphically illustrates the number of moles of after detonation gases at a median detonation pressure of 15,000 atm. per 1 kg of TNT. As illustrated, the formation of carbon monoxide, carbon dioxide, water, and hydrogen molecules remain nearly constant over the temperature spectrum. Nitrogen molecules of the surrounding air remains relatively inert to reaction as illustrated by the straight line across the temperature spectrum. As detonation temperature increases, methane and ammonia formation decreases, hydrogen cyanide increases slightly, and nitrous oxide and nitric oxide formation increases very sharply.

Table 6 is a summation of constant temperature calculations. Figure 4 graphically illustrates the number of moles of after detonation gases at a median temperature of 3000°C per 1 kg of TNT. As in the constant pressure calculations, nitrogen molecule, carbon dioxide, water, carbon monoxide, and hydrogen molecule remain relatively unaltered across the pressure spectrum. As detonation pressure increases, nitric oxide formation decreases and hydrogen cyanide, ammonia, and methane formation increases.

TABLE 5
AEROTHERM ISENTROPIC EQUILIBRIUM PROGRAM CONSTANT PRESSURE

t (°C)	1500	2000	3000	3500	4500	5000
P (atm x 10 ⁵)	1.5	1.5	1.5	1.5	1.5	1.6
p (g/cc)	2.87	2.14	1.48	1.28	1.00	0.896
n (moles gas/kg)	35.90	37.52	37.78	37.84	38.26	38.71
CO (moles/kg)	10.34	12.65	13.17	13.25	13.48	13.68
CO ₂	3.996	2.580	2.159	2.072	1.80	1.555
H ₂	1.538	2.430	2.376	2.317	2.279	2.314
H ₂ O	2.192	2.701	3.002	3.021	2.739	2.400
N ₂	16.89	16.89	16.91	16.90	16.78	16.65
CH ₄	7.916E-01	9.826E-02	2.361E-03	7.906E-04	1.964E-04	1.409E-04
NH ₃	1.029E-01	8.586E-02	3.531E-02	2.682E-02	1.927E-02	1.775E-02
CH ₃ OH	6.894E-02	4.678E-04	1.179E-04	7.744E-05	4.753E-05	4.240E-05
HCN	2.729E-02	5.025E-02	4.644E-02	4.594E-02	5.293E-04	6.380E-02
C ₂ H ₂	2.478E-04	4.474E-04	1.992E-04	5.293E-04	1.507E-04	1.977E-04
N ₂ O	5.732E-10	6.798E-08	2.156E-05	1.232E-04	1.184E-03	2.380E-03
NO _x	1.175E-07	1.469E-05	4.005E-03	2.498E-02	2.286E-01	4.494E-01

Figure 3
 AEROTHERM ISENTROPIC EQUILIBRIUM PROGRAM
 MOLES GAS PER KG TNT AT CONSTANT PRESSURE

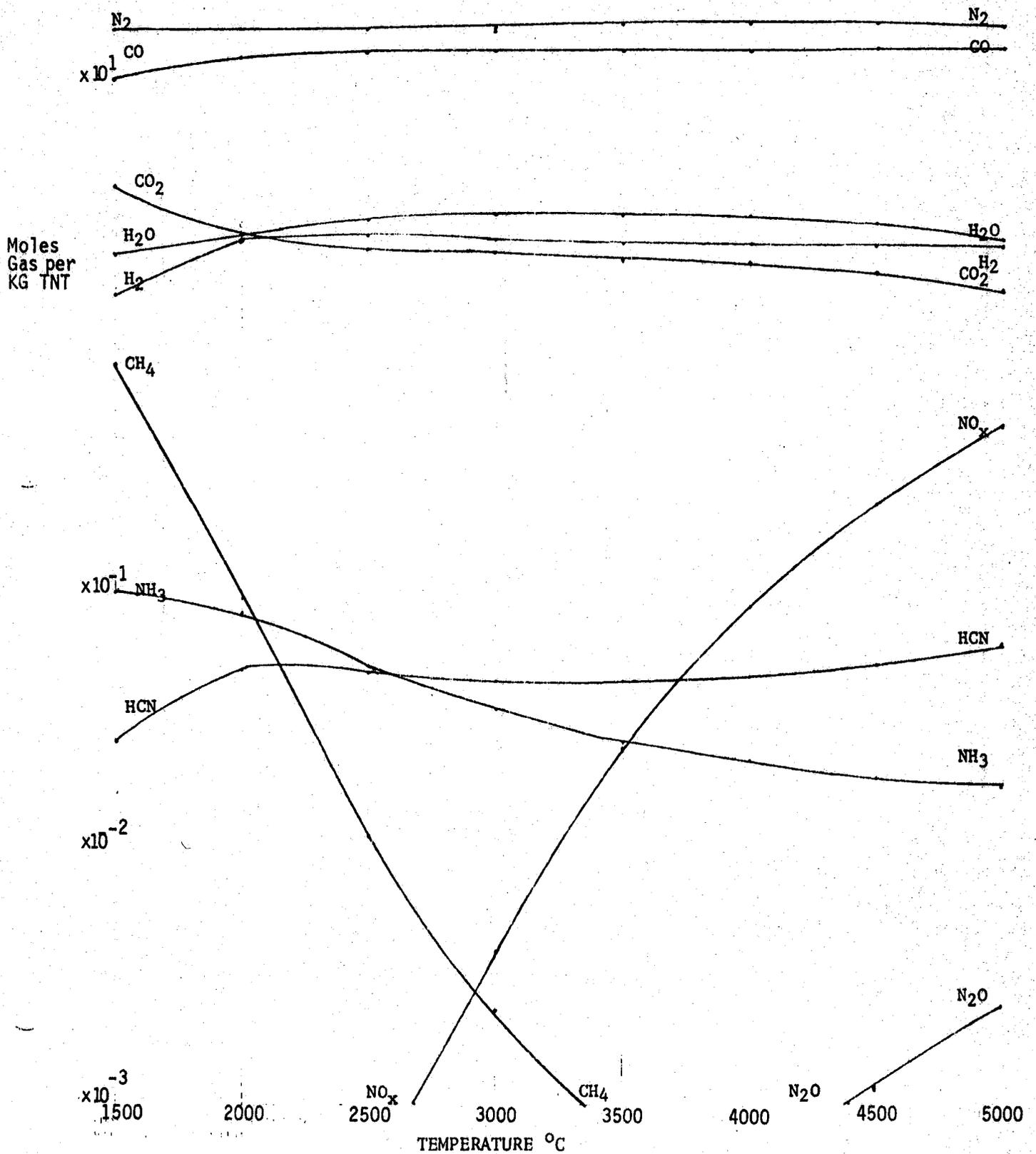
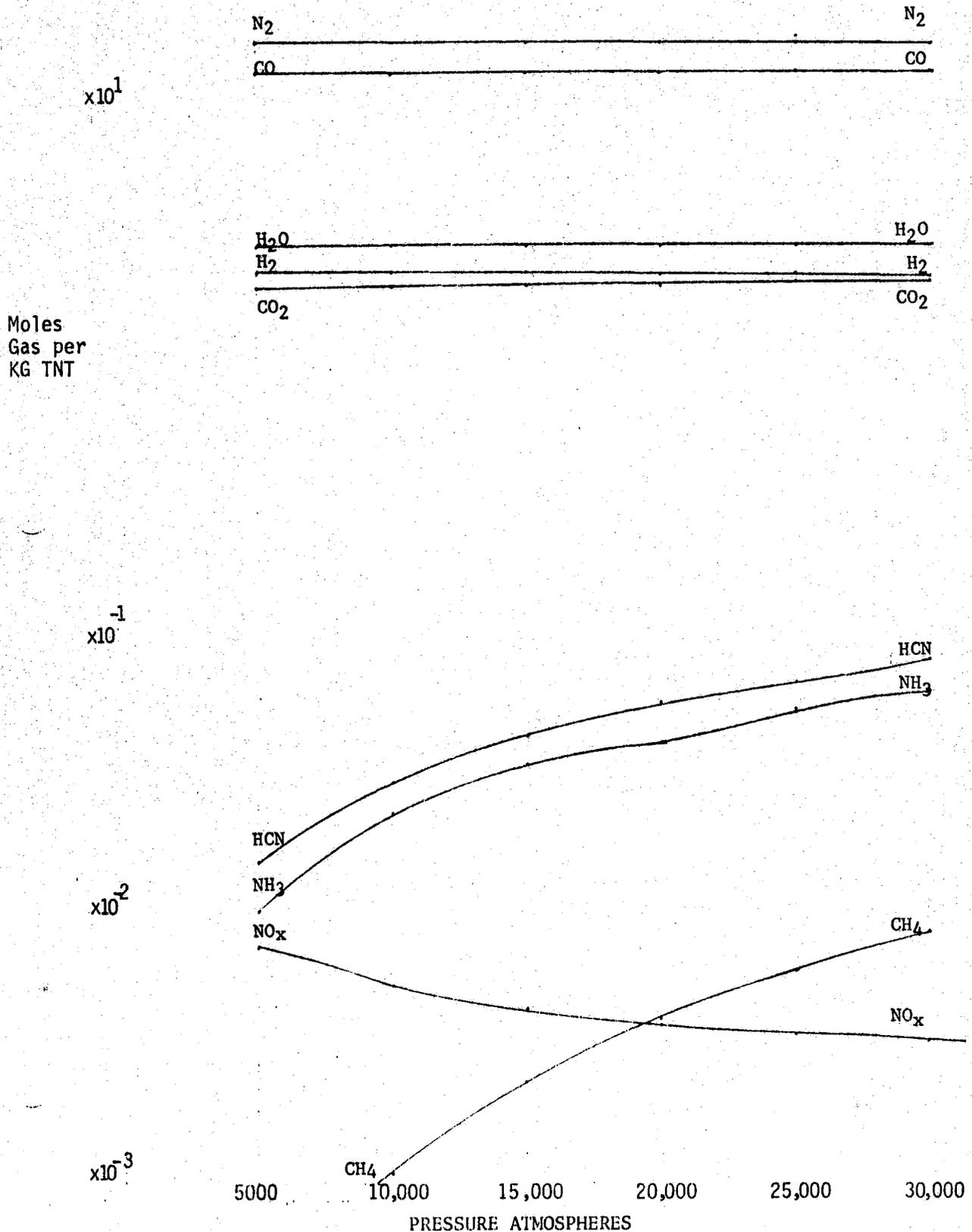


TABLE 6
AEROTHERM ISENTROPIC EQUILIBRIUM PROGRAM CONSTANT TEMPERATURE

P (atm x 10 ³)	5	10	15	20	25	30
t (°C)	3000	3000	3000	3000	3000	3000
p (g/cc)	0.492	0.985	1.479	1.974	2.470	2.967
n (moles gas/kg)	37.88	37.82	37.78	37.74	37.70	37.66
CO (moles/kg)	13.26	13.21	13.17	13.13	13.08	13.04
CO ₂	2.12	2.14	2.15	2.18	2.20	2.21
H ₂	2.43	2.40	2.38	2.35	2.32	2.29
H ₂ O	3.00	3.00	3.00	3.00	3.00	2.99
N ₂	16.94	16.93	16.91	16.90	16.88	16.87
CH ₄	2.908E-04	1.119E-03	2.425E-03	4.153E-03	6.239E-03	8.651E-03
NH ₃	1.041E-02	2.395E-02	3.530E-02	4.624E-02	5.672E-02	6.684E-02
CH ₃ OH	1.460E-05	5.351E-05	1.167E-04	2.019E-04	3.071E-04	4.299E-04
HCN	1.616E-02	3.161E-02	4.645E-02	6.068E-02	7.424E-02	8.730E-02
C ₂ H ₂	2.595E-05	9.213E-05	1.976E-04	3.367E-04	5.051E-04	6.968E-04
N ₂ O	2.058E-05	2.137E-05	2.164E-05	2.189E-05	2.213E-05	2.239E-05
NO _x	7.697E-03	5.509E-03	4.548E-03	3.981E-03	3.600E-03	3.322E-03

Figure 4
 AEROTHERM ISENTROPIC EQUILIBRIUM PROGRAM
 MOLES GAS PER KG TNT AT CONSTANT TEMPERATURE



To illustrate the discrepancy between theoretical predictions, Dr. Robinson's data was placed into the Aerotherm Program. Table 7 summarizes the Aerotherm run while Figure 5 graphically contrasts Aerotherm and Dr. Robinson's predictions.

A quick glance between the equilibrium program and Dr. Robinson's predictions show considerable variance. This illustrates the differences between different sources of theory. It is easy to contrast these two sources with the predictions given by Urbanski and Schmidt. Four sources of after detonation products which yield four totally different predictions.

Theory is not only non-reproducible among itself but it does not easily align itself with actual experimentation. An example of this observation is easily shown by contrasting Dr. Donald L. Ornellas of Lawrence Livermore Labs experimental data with that of the four sources in this section. Table 8 contrasts the five sources for various by-products.

TABLE 7
 DETONATION PROPERTIES OF TNT AS A FUNCTION OF DENSITY AEROTHERM

p (g/cc)	0.3	0.8	0.95	1.11	1.27	1.47
n (moles gas/kg)	37.81	37.60	37.49	37.39	37.28	37.14
t (°k °10 ⁻³)	2.77	3.55	3.58	3.82	3.98	4.05
p (atm x 10 ⁻⁴)	0.8	4.4	6.1	8.4	11.1	14.1
CO (moles/kg)	13.12	12.98	12.86	12.74	12.59	12.43
CO ₂	2.24	2.20	2.25	2.27	2.31	2.37
H ₂	2.51	2.19	2.11	2.01	1.91	2.82
H ₂ O	2.91	3.01	3.00	3.01	3.00	2.98
N ₂	16.93	16.84	16.81	16.76	16.71	16.67
CH ₄	3.49E-03	8.47E-03	1.42E-02	1.47E-02	1.70E-02	2.12E-02
NH ₃	2.88E-02	8.01E-02	1.04E-01	1.20E-01	1.39E-01	1.61E-01
CH ₃ OH	6.31E-05	7.66E-04	1.19E-03	1.75E-03	2.51E-03	3.53E-03
HCN	2.71E-02	1.21E-01	1.58E-01	2.03E-01	2.50E-01	2.94E-01
C ₂ H ₂	8.77E-05	1.19E-03	2.01E-03	3.07E-03	4.42E-03	6.04E-03
C						

TABLE 8
 MOLES OF AFTER-DETONATION GASES PER KG TNT

<u>GAS (MOLES/KG TNT)</u>	<u>ORNELLAS</u>	<u>ROBINSON^a</u>	<u>AEROTHERM^b</u>	<u>SCHMIDT^c</u>	<u>URBANSKI</u>
CO	8.72	1.8	12.43	9.39	12.93
CO ₂	5.50	9.5	2.37	5.47	5.50
C (S)	16.07	14.2		14.6	7.98
H ₂ O	7.04	1.3	2.98	6.09	7.98
H ₂	2.03		1.82	1.63	3.99
N ₂	5.81	5.9	16.67	5.39	5.92
NH ₃	0.70	0.4	0.16	1.5	-
CH ₄	0.44	0.1	0.02	0.42	0.28
C ₂ H ₂			0.006	0.3	0.55
HCN		1.1	0.29	0.32	0.55
CH ₃ OH		4.3	0.004		

a. Robinson, values from a density of 1.47 grams/cm³

b. AEROTHERM, values from a density of 1.47 grams/cm³

c. Schmidt, values from a density of 1.59 grams/cm³

Dispersion Estimates

The amount of noxious gases released to the atmosphere in an explosion is not necessarily the amount of gases exposed to the human population. The gases disperse in all directions. They are diluted and propagate outwards in a quickly expanding mushroom cloud which is dispersed by wind.

To gain some insight on what levels of noxious gases would be encountered by the population, Turner's Workbook of Atmospheric Dispersion Estimates, U.S. Environmental Protection Agency, is utilized. Turner's Workbook calculations are at best, estimates. Many variables are present which are situational and thus will vary each time a detonation is conducted; different emission rates for different types of explosives, different types of emissions for different types of explosives, changing meteorological conditions for each detonation, different topography at detonation sites, and many other variables Turner illustrates.

The examples presented in this section will estimate ground concentrations of three noxious gases, nitrogen oxides (NO_x), hydrogen cyanide (HCN), and carbon monoxide (CO), at four kilometers from the detonation site. The examples assume the following:

1. The downwind distance is 4 km.
2. The effective emission height is 100m.
3. The surface wind speed at 10 meters is 3m/sec.
4. Concentration is along the centerline of the cloud.

These assumptions are estimates of a "typical" condition. Each detonation will encounter totally different values. The variables are too dependent on weather conditions and other changing parameters to place concrete values.

The emission rate for carbon dioxide, hydrogen cyanide, and nitrogen oxides are taken from the Aerotherm calculations found in Table 6 of the Theoretical section.

<u>GAS</u>	<u>Moles Produced/kg TNT</u>
Carbon Dioxide (CO)	13.26
Hydrogen Cyanide (NCN)	1.616 x 10 ⁻²
Nitrogen Oxides (NO _x)	7.677 x 10 ⁻³

Sutton's equation (Re: Workbook of Atmospheric Dispersion Estimates)

$$X(x,y,0;H) = \frac{2Q_T}{(2\pi)^{3/2} \sigma_x \sigma_y \sigma_z} \exp\left[-\frac{1}{2} \left(\frac{x-ut}{\sigma_x}\right)^2\right] \exp\left[-\frac{1}{2} \left(\frac{H}{\sigma_z}\right)^2\right] \exp\left[-\frac{1}{2} \left(\frac{y}{\sigma_y}\right)^2\right]$$

Where: X = concentration, gm/m³

Q_t = total mass of the release gm/sec

H = effective emission height = 100m

u = mean wind speed = 3m/sec

t = time = 136 sec = 30 sec cloud formation + 1333 sec travel time

σ = dispersion statistics following the motion of the expanding puff

σ_x^{*} = horizontal dispersion coefficient = 120m

σ_y^{*} = lateral dispersion coefficient = 120m

σ_z^{*} = vertical dispersion coefficient = 50m

x = downwind distance = 4 km = 4000m

y = lateral distance = 0, assume centerline concentration

* From Table 5-2, Turner's Workbook of Atmospheric Dispersion Estimates, neutral conditions.

Assume 500 pounds TNT detonation
 $500 \text{ lb} \times \frac{4.54 \text{ gm}}{1 \text{ lb}} = 2.27 \times 10^5 \text{ gm}$

Qt Values

CO: 13.26 moles CO produced/1000gm TNT
28 gm/gm mole CO

$$\frac{13.26 \text{ moles CO}}{1000 \text{ gm TNT}} \times 2.27 \times 10^5 \text{ gm TNT} \times \frac{28 \text{ gm CO}}{\text{mole CO}} = 8.428 \times 10^4 \text{ gm CO}$$

HCN: 1.616×10^{-2} moles HCN produced/1000 gm TNT
27 gm/gm mole HCN

$$\frac{1.616 \times 10^{-2} \text{ moles HCN}}{1000 \text{ gm TNT}} \times 2.27 \times 10^5 \text{ gm TNT} \times \frac{27 \text{ gm HCN}}{\text{mole HCN}} = 99.04 \text{ gm HCN}$$

NO_x: 7.697×10^{-3} moles NO_x produced/1000 gm TNT
30 gm/gm mole NO_x using NO as the basis

$$\frac{7.677 \times 10^{-3} \text{ moles NO}_x}{100 \text{ gm TNT}} \times 2.27 \times 10^5 \text{ gm TNT} \times \frac{30 \text{ gm NO}_x}{\text{mole NO}_x} = 52.42 \text{ gm NO}_x$$

Sutton's equation for CO:

$$\chi(x, y, 0; H) = \frac{2(8.428 \times 10^4)}{(2\pi)^{3/2}(120)(120)(50)} \exp\left[-\frac{1}{2}\left(\frac{4000 - 3(1363)}{120}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{100}{120}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{0}{120}\right)^2\right]$$

$$\chi(x, y, 0; H) = 7.978 \times 10^{-3} \text{ g/m}^3 = 7978 \mu\text{g/m}^3$$

Sutton's equation HCN:

$$X(x, y, 0; H) = \frac{2(99.04)}{(2\pi)^{3/2}(120)(120)(50)} \exp\left[-\frac{1}{2}\left(\frac{4000-3(1363)}{120}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{100}{120}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{0}{120}\right)^2\right]$$

$$X(x, y, 0; H) = 9.38 \times 10^{-6} \text{ g/m}^3 = 9.38 \mu\text{g/m}^3$$

Sutton's equation for NO_x:

$$X(x, y, 0; H) = \frac{2(52.42)}{(2\pi)^{3/2}(120)(120)(50)} \exp\left[-\frac{1}{2}\left(\frac{4000-3(1363)}{120}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{100}{120}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{0}{120}\right)^2\right]$$

$$X(x, y, 0; H) = 4.96 \times 10^{-6} \text{ g/m}^3 = 4.96 \mu\text{g/m}^3$$

As noted above, considerable carbon monoxide may be present but very little hydrogen cyanide or nitrogen oxides. Two factors must be considered in this analysis. One, Turner's Workbook is an estimation process dependent on many fluctuating variables. Second, the amounts of noxious gases were taken from one source of this study. As noted before, the study's sources do not reinforce each other. They are all different.

Toxicology

With the open detonation phenomena, there are two major areas of concern. First, highly toxic gases that are possible after-detonation products must be carefully analyzed. Secondly, since the explosive is to be detonated in the open; soil, dust, rocks, and miscellaneous debris may become airborne. These particles may drift in air currents and the tiny ones may be inhaled by people many miles from the detonation site. Therefore both of these cases will be discussed.

Toxicity of Carbon Monoxide (CO)

The most dangerous gases and vapors are those which have a delayed action. They enter the lung without interference. This is possible since these gases are not marked by an irritant action on the upper respiratory passage or by a powerful odor. Carbon monoxide is such a gas. It is odorless, colorless, and tasteless gas which enters the lung undetected by the individual.⁸

The solubility of irritant gases determines how the gas attacks the body. Easily soluble gases attack the upper airways since they are dissolved by the aqueous areas in this region. Insoluble gases pass the upper airways and settle into the very sensitive bronchioles and alveoli. Carbon monoxide being a nonirritating gas produces no action in the airways, bronchioles, or alveoli but rather is capable of entering the bloodstream and damaging many areas of the body. Carbon monoxide is capable of this due to its solubility and chemical affinities.

The toxic and lethal effect of carbon monoxide are due to one time exposures of very high concentrations in confined spaces for a duration of several hours. These lethal concentrations are usually above 500 PPM. The current threshold limit value is 50 PPM.

⁸ C.P. Stewart and A. Stolman, "Toxicology Mechanisms and Analytical Methods, Academic Press, New York (1964)

Toxicity of Nitrogen Oxides (NO_x)

Nitrogen oxides are relatively insoluble. They therefore pass through the upper airways and attack the very sensitive bronchioles and alveoli. This injury to the bronchioles and alveoli result as incapacitating gas exchange.

Nitrogen oxides are relatively more toxic than carbon monoxide. The threshold limit value for nitrogen oxides is 5 PPM.

Toxicity of Dust Particles

The toxicity of dust is centered around the fibrotic changes produced in the lung by dusts containing silica. Most toxicity data and literature almost exclusively studies the pulmonary disease known under the general term pneumoconiosis. In particular, silicosis is the most popular.

Particles larger than 10 microns in diameter are filtered in the nasal cavity. These particles are removed from the tracheobronchial tree by ciliary action. Particles in the 1 to 3 micron diameter remain suspended in the air flow and pass through the bronchioles into the alveoli. It is this very sensitive area where problems can occur.

Chronic pulmonary disease is generally a result of long-term exposure to toxic dusts. Generally, a length of time in excess of 20 years is encountered before the disease becomes symptomatic.⁹

For inorganic dust there are generally no harmful side-effects. There is no fibrosis, physical impairment, or disease. The only major side-effect is increased mucous formation and mucous gland formation. This is the case expected in applications of open air detonation. However, if a large amount of silicone exists, problems may arise but only after continuous exposure of long (years) durations.¹⁰

9 Morton M Ziskind, M.D., "Occupational Pulmonary Disease", Clinical Symposia, Volumes 3 Number 4 (1978)

10 Patty's "Industrial Hygiene and Toxicology"

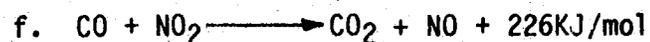
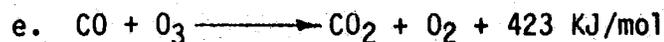
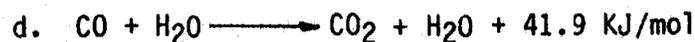
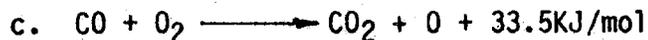
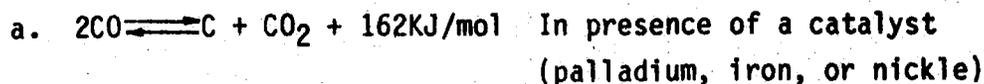
Gas Formation

Carbon Monoxide (CO) Formation

Carbon monoxide is a result of incomplete combustion of carbonaceous compounds. Carbon monoxide is a stable molecule even though both the carbon atom's and oxygen atom's outer electron shell is not always filled with eight electrons.

Carbon monoxide is relatively unreactive at atmospheric conditions (25 c and 1 atm) but becomes very reactive at high temperatures. Carbon monoxide at high temperature behaves as an unsaturated molecule and acts as a very powerful reducing agent.

There are several possible reactions of carbon monoxide at high temperatures. These high temperatures are possible and conditions may be suitable when TNT or other explosives are detonated. The reactions are:



At normal conditions, reactions a thru f do not occur. However, the pressures and temperatures associated with explosive detonation may be sufficient to allow these reactions to occur. There must be sufficient energy available to overcome the high activation energy barriers.

Nitrogen Oxides (NO_x) Formation

When ordinary air is heated from 1500 to 2000°C, the nitrogen and oxygen molecules may decompose and recombine to form nitrogen oxides. If allowed to cool slowly, these nitrogen oxides break apart and recombine to form the original nitrogen and oxygen molecules. In a detonation, the very rapid generation of heat and variable cooling rate may leave nitrogen oxides frozen.

The size and type of explosion is a major factor concerning whether the NO_x molecule remains frozen or is able to decompose and return back into the original N_2 and O_2 .

Problems with Scale-Up

In several places in the literature, the idea of scale-up was discussed. In general, the results from a small scale test can not be used to accurately predict a large scale detonation. Also, testing in closed vessels does not accurately predict open tests.

Dr. Cook and the Bureau of Mines stated the problem of trying to associate laboratory work to large scale open air detonations. The lab work gives guidance but is not a substitute for actual tests.

Burlington and Pantex stated that nitrogen oxide formation is very dependent on temperature and cooling rate and therefore small scale tests may not accurately duplicate large scale tests.

In the large scale tests by Meteorology Research Inc., several discrepancies were noted. Hydrogen cyanide was a product in small scale tests but not in large scale TNT detonations. Carbon monoxide, ammonia, and methane are in concentrations above that predicted by small scale tests. Ethane, propane, butane, 1-butene, and benzene were present in large detonations but not small. Small scale tests are no substitute for direct in field application tests. An increase in charge size may effect the oxidation of primary reaction products.

A major discrepancy in correlating data from closed vessel tests to open air is the factor of side reactions. In a closed vessel, molecules can bounce off the walls, collide with other molecules, and form additional molecules. This phenomenon is reduced in the open. In the open, the frequency of collision is reduced and thus the original detonation products diffuse outward relatively unaltered.

The notion of scaling a small detonation to one many magnitudes larger is seen to be impracticable. Small scale experiments can help predict the types of gaseous by-products produced. However, you cannot extrapolate data from 1-2 pound detonations to 1-2 ton detonations and accurately place quantitative parameters on the by-products.

Economics

The major alternative to open air detonation of munitions is to cut the bomb or projectile into serviceable pieces and incinerate them. The Directorate for Ammunition Equipment has designed a projectile saw and the Explosive Waste Incinerator (EWI) for such a situation.

The current installed cost of this system, projectile saw plus the EWI, is \$1.7 million. In addition, operating costs are \$345,960 per year. Table 9 lists the costs by item.

TABLE 9
OPERATING COSTS OF THE EXPLOSIVE WASTE INCINERATOR

<u>ITEM</u>	<u>COST/HR</u>	<u>COST/YR^a</u>
Operating Personnel (EWI) 4		\$208,000
Operating Personnel (Projectile Saw) 2	\$26.00	\$104,000
Container Replacement	-	5,000
Electricity, 54 KW/hr at \$0.04/KW/hr	2.16	4,320
Fuel Oil, #2 12 gal/hr at \$0.818/gal	9.82	19,640
Maintenance (25 yr. life)	-	5,000
		<u>\$345,960*</u>

a. Projected on 250 day operation at 8 hrs per day.

*Does not include utility and maintenance cost of projectile saw.

Open air detonation requires the use of existing detonation grounds and specialized personnel. At Tooele Army Depot, the demolition range runs with 4 operating personnel and 1 supervisor. Projecting an 8 hour day and 250 day year, personnel cost is \$260,000 per year.

The cost of projectile saw/EWI system may be too steep for individual installation's budgets. A capital equipment cost of \$1.7 million and an operating cost that exceeds open air detonation by over \$85,000 a year is a large price to pay. In addition, a current study indicated that 5% of Department of Army Readiness Command (DARCOM) energy useage was for demil operations. This energy use could be alleviated with the continuation of open air detonations. This is a real savings in both money and energy use.

The projectile saw/EWI system is a feasible though costly alternative in most applications of open air detonation. However, this system is not a total substitute. The Army inventory consists of several types of munitions for which the projectile saw/EWI system is not well suited. In addition, some munition's demil is beyond present day technology. Examples of these problem munitions are cluster bombs and some hazardous munitions in which additional handling is not safe. The design of systems to handle these types of munitions would be astronomical with present state-of-the-art technology. Therefore, economics and safety criteria require some continuation of open air detonation even if the projectile saw/EWI system were readily available and utilized.

Experiment

Introduction

After conducting an extensive literature search and simulating a detonation on a computer, the final task was to go into the field, conduct experimental detonations, and perform extensive gas analysis on the after detonation by-products.

There are four major reasons for an experimental follow-up to the open detonation question. First, the theoretical data already presented is a good base to work on but is no substitute for actual in-situ detonation and subsequent analysis. Secondly, the literature search revealed that most work was in a total laboratory environment with very little correlation to an open environment. Third, most data found in the literature search indicated vast discrepancies in the quantity and sometimes types of gaseous after-detonation by-products produced. Experimentation needs to be conducted to establish reproduceable data on the types and quantities of gases produced. A degree of confidence needs to be established so that a future environmental impact can be assessed. Finally, since scale-up presents problems and very little work has been done in this field, state-of-the-art technology and expertise needs to be developed so that actual large scale detonations may be performed and competently analyzed for gaseous by-products.

Background

To conduct this experiment, a suitable area for detonation needs to be located. Present state-of-the-art technology in gas capturing techniques prohibited actual open air detonations. To facilitate gas capture, a closed vessel was used but the charge size was appointed that would "simulate" open air.

The Explosive Containment Cell (ECC) (see figure 6) was chosen as the



EXPLOSIVE CONTAINMENT CELL

Figure 6

experimental vessel. This vessel allowed control of detonation and gas collection.

A minimum of 500% excess air was present in the ECC for each experimental detonation. The value of 500% was arbitrarily chosen as a representation of "open air". This gave at least an attempt to experimentally approach the type of work for which the study is designed, namely open air detonation of explosives. The value of 500% was felt to adequately imitate the infinite dilution effect of detonating explosives in the open. See Appendix A for charge sizing.

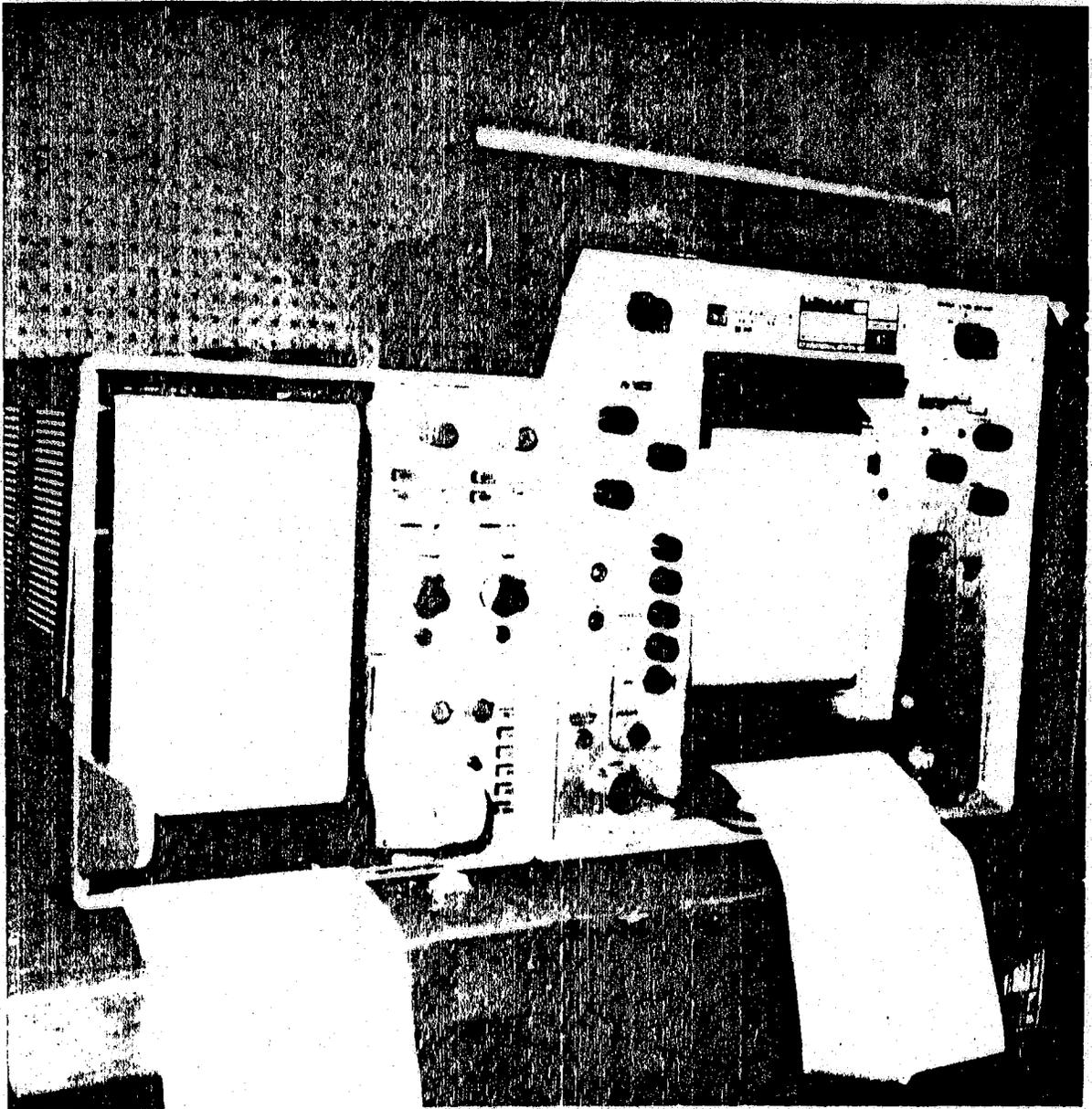
The experiment was conducted in two major phases. The first phase consisted of four preliminary detonations to test the equipment and to insure pressures and temperatures generated by TNT detonations did not exceed the equipments' limits. The second phase consisted of seven detonations, one of 75 grams and six of 100 grams, in which generated gases were collected and analyzed. For a description of the experiment set-up, see Appendix B.

This experimentation site is controlled from a control trailer approximately 100 yards from the ECC. The solenoid valve and blasting cap are controlled from the trailer. The pressure transducers and thermocouples are monitored by recorders in the control trailer (see figure 7).

Experimentation

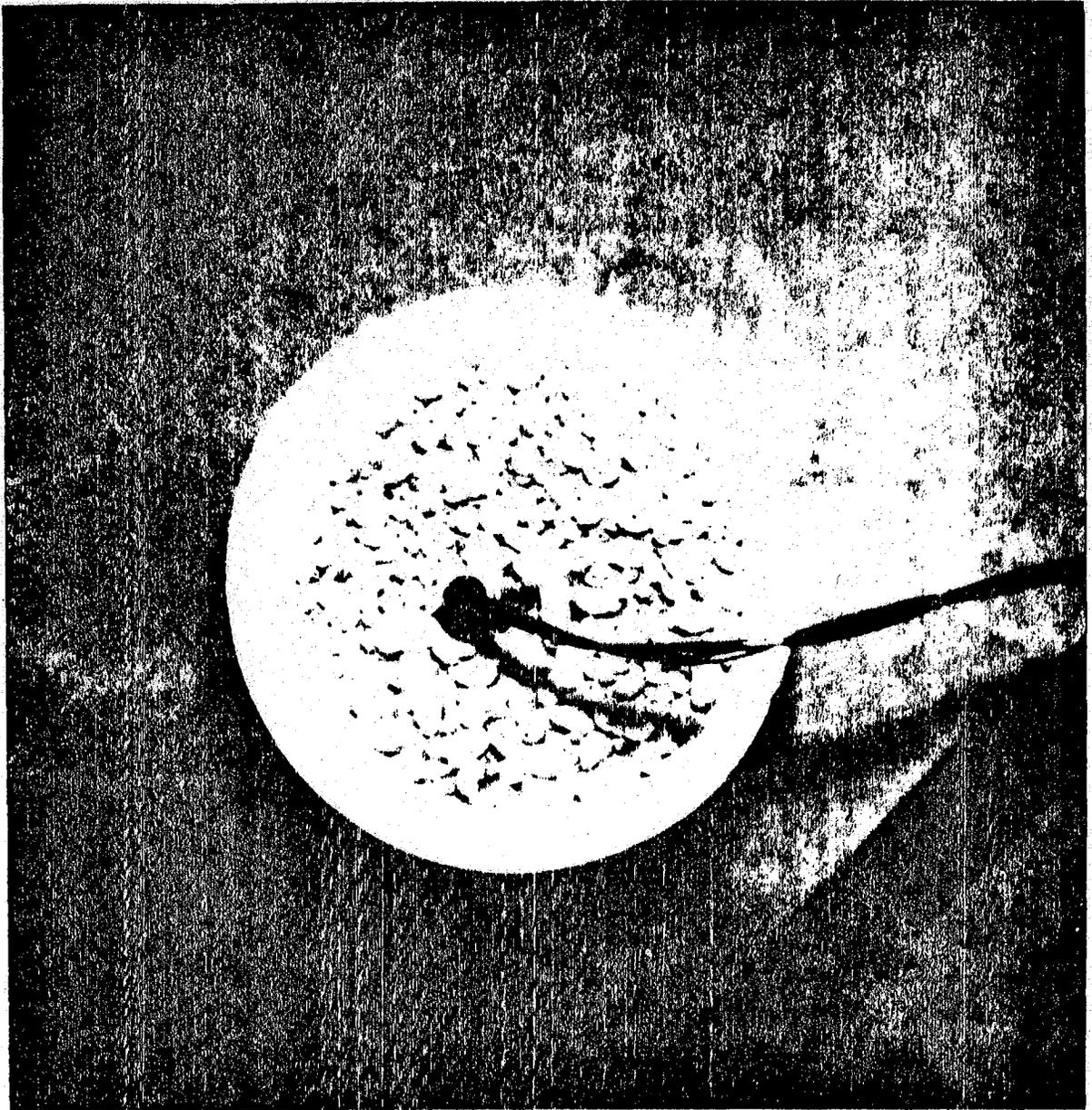
The first phase experiments were conducted to insure the pressures and temperatures encountered would not hurt any equipment. Also, equipment familiarization would be obtained by operating personnel. The pressures encountered did not exceed 12 psig and temperatures went to equilibrium at 250°F inside the ECC. The solenoid valve encountered 16 psig pressures and ambient temperatures. TNT detonations of 100 grams did not have any adverse effect on the equipment.

In the first set of tests of phase two, two different amounts of TNT were detonated; 100 grams and 75 grams. The TNT is a nonuniform mechanical mixture of powder, granules, and pellets. The charge is initiated by an M-6 military blasting cap (see figure 8). The solenoid valve was closed and a vacuum pump evacuated the stainless steel collection vessel and the copper hookup line from the collection vessel to the solenoid valve. Two seconds



PRESSURE AND TEMPERATURE RECORDERS

Figure 7



100 GRAMS TNT CHARGE WITH M-6 MILITARY BLASTING CAP

Figure 8

after detonation, the solenoid valve was opened and a sample of gas was collected. The collection vessel (see figure 9) was then sealed and sent to the Analytical Chemistry Department at Brigham Young University in Provo, Utah. (For analytical work see Appendix C).

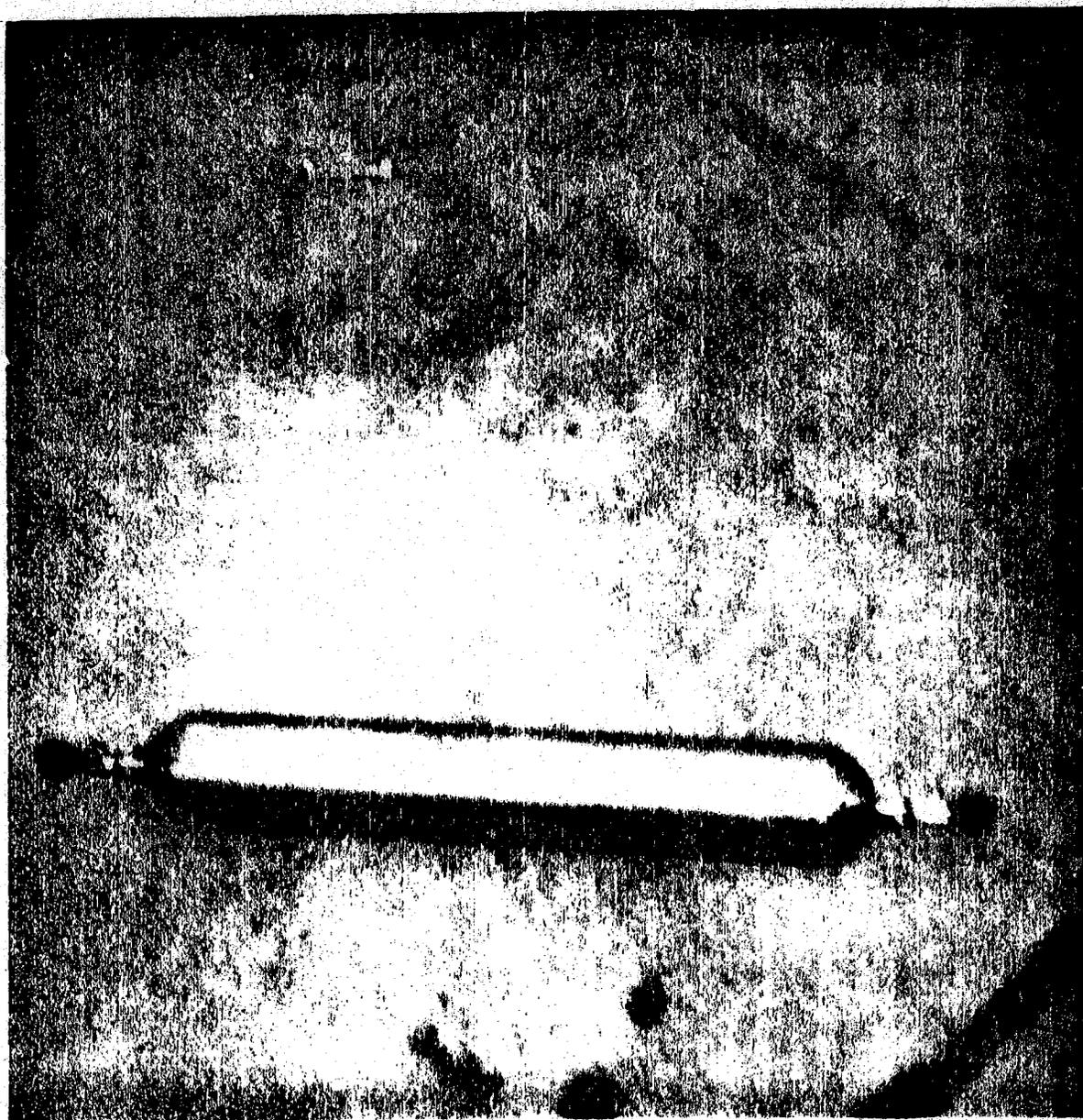
The solenoid valve was opened two seconds after detonation. It was postulated that a representative sample could be obtained from the detonation wave as it propagated outward. The idea of collecting gas from the detonation wave also would help the problem of trying to simulate open air detonation in a closed vessel. By capturing the initial gases, the theory of recombination of activated molecules in a closed system was alleviated. Equilibrium is postulated as non-existent in the open air and thus the experiment was not allowed to go to equilibrium.

These first two experiments were slightly unsuccessful in that the analytical work picked up little change from ambient air. Theory predicts several by-products not discovered. The idea of picking up only the detonation wave gases seems invalid. Therefore, the second set of experiments involved gas collection two minutes after detonation so that a good sample can be collected.

The second set involved three 100 gram detonations of TNT. One detonation was initiated by the M-6 military blasting cap. The other two detonations were initiated by smaller commercial blasting caps.

The commercial blasting caps initiated a low order detonations which were not sampled. The detonation initiated by the M-6 military blasting cap went high order and a gas sample was collected by opening the solenoid valve two minutes after detonation and allowing the gas to fill an evacuated stainless steel collection vessel.

Again, the analytical work indicated a sample which did not conform to theory. However, the data was better than the first set of experiments. For a detailed discussion of the analytical work, see Appendix C. The method of collection was discussed by Ammunition Equipment Directorate personnel and Brigham Young University personnel. The sampling technique was changed for the third set of experiments.



STAINLESS STEEL COLLECTION VESSEL

Figure 9

In the third set of experiments, two 100 gram charges were detonated. Analysis was conducted using the Matheson Kitagawa precision detector tubes and Drager gas analysis tubes. Two minutes after detonation of the charge, the solenoid valve was open, and a gas sample was collected in the stainless steel collection vessel. The closed end of the collection vessel was opened and a sample was drawn through the detector tubes (Matheson Kitagawa or Drager).

Conclusion

The complete results of the experiment can be found in great detail in Appendix C. Again, these results do not align themselves with literature or computer values. The experiment had several sampling problems associated with it which were gradually worked out. However, actual large scale detonation analysis should be the next step in the goal of obtaining a final resolution to this problem.

CONCLUSION

The qualification and quantification of after detonation gaseous by-products of Trinitrotoulene (TNT) is seen to be a controversial subject. Each source of information presents different amounts of gases produced and in some instances, different types of gases produced when TNT is exploded. In most cases, the determination of after detonation gaseous by-products was conducted in a laboratory environment or a very controlled experiment. The correlation of laboratory work with in-situ detonation is not very dependable.

The use of scale-up from a hundred grams to several hundred pounds is not applicable in this situation. Detonation products depend on many factors such as loading density, method of initiation, confinement, the chemistry of the surrounding media, and the gas expansion characteristics. Each one of these parameters change when in-situ detonation is used instead of laboratory work.

The dispersion calculations indicate that a high concentration of carbon monoxide may be encountered from a 500 pound detonation. An 8000 ppm value was calculated. This is well above any standards established by the Environmental Protection Agency. However, several considerations require contemplation. First, the dispersion calculations are rough estimates. The formula's variables were estimated assuming a "typical" day and straight line dispersion. The amount of carbon monoxide produced was taken from one source, the Aerotherm program, which was considerably higher than most of the other predictions. Secondly, with the temperatures and pressures encountered in large detonations, carbon monoxide may combine with oxygen, water, ozone, or nitric oxide to produce carbon dioxide as illustrated in the gas formation section. Finally, if 8000 ppm of carbon monoxide were encountered, the exposure to a single human being would be very short in duration. Health problems and death from carbon monoxide poisoning occurs after continuous exposure for several hours of high concentrations. The values calculated for dispersion should be an indication that problems may exist but no concrete evidence is presently available. Continued study

is necessary but it is believed that health impacts are very slight.

Nitrogen oxide and hydrogen cyanide dispersion calculations indicate no problems will exist. Again, these are rough estimates and with the temperature and pressure encountered in large detonations side reactions may alleviate nitrogen oxide and hydrogen cyanide formation.

The experiment attempted to simulate an open air environment and develop sampling techniques. However, the premise of the study was small scale, 100 grams. It presents some very valuable background information but is no substitute for actual large scale tests of the magnitude that future open air demil operations will work under.

It is recommended that a follow on large scale study be developed. This study positively indicates that there would be an excellent probability that such a large scale program could provide convincing evidence that health effects are nil from detonation of TNT and Comp B filled items on properly controlled demolition ranges. This evidence would pave the way for EPA and state environmental authority agreements to permanently sanction specified large scale open air demilitarization.

APPENDIX A

Sizing of TNT charge for Open Air Detonation Study

TNT (trinitrotoluene) $C_7H_5N_3O_6$

Assume TNT decomposes according to equation 1:



Air: 79% N_2 and 21% O_2

Density of air = 1220 gm/m³

Volume of ECC = 113 ft³

Change ECC volume from ft³ to m³:

$$(2) \quad 113 \text{ ft}^3 \times \frac{.02832 \text{ m}^3}{\text{ft}^3} = 3.20 \text{ m}^3$$

Number of grams of air inside ECC:

$$(3) \quad \frac{1220 \text{ gm}}{\text{m}^3} \times 3.20 \text{ m}^3 = 3904 \text{ gm}$$

N_2 : molecular weight = 28

O_2 : molecular weight = 32

Air: molecular weight = .79 (28) + .21 (32) = 28.84

Number of moles of O_2 in ECC:

$$(4) \quad \frac{3904 \text{ gm}}{28.28 \text{ gm/gmole}} \times .21 = 28.434 \text{ gmole } O_2$$

Need 8.25 g moles O_2 /g mole TNT (see equation 1).

Molecular weight of TNT = 227

Want minimum of 500% excess O_2 .

$$(5) \quad 8.25 (6) = 49.5 \text{ g mole } O_2/\text{g mole TNT}$$

Let x = amount of TNT in g moles

$$(6) \quad 49.5 x = 28.4 \\ x = .57 \text{ g mole TNT}$$

$$(7) \quad .57 \text{ g mole TNT} \times \frac{227 \text{ g}}{\text{g mole TNT}} = 130 \text{ g}$$

Assume 80% atmosphere at elevation of Tooele, Utah (5000 ft)

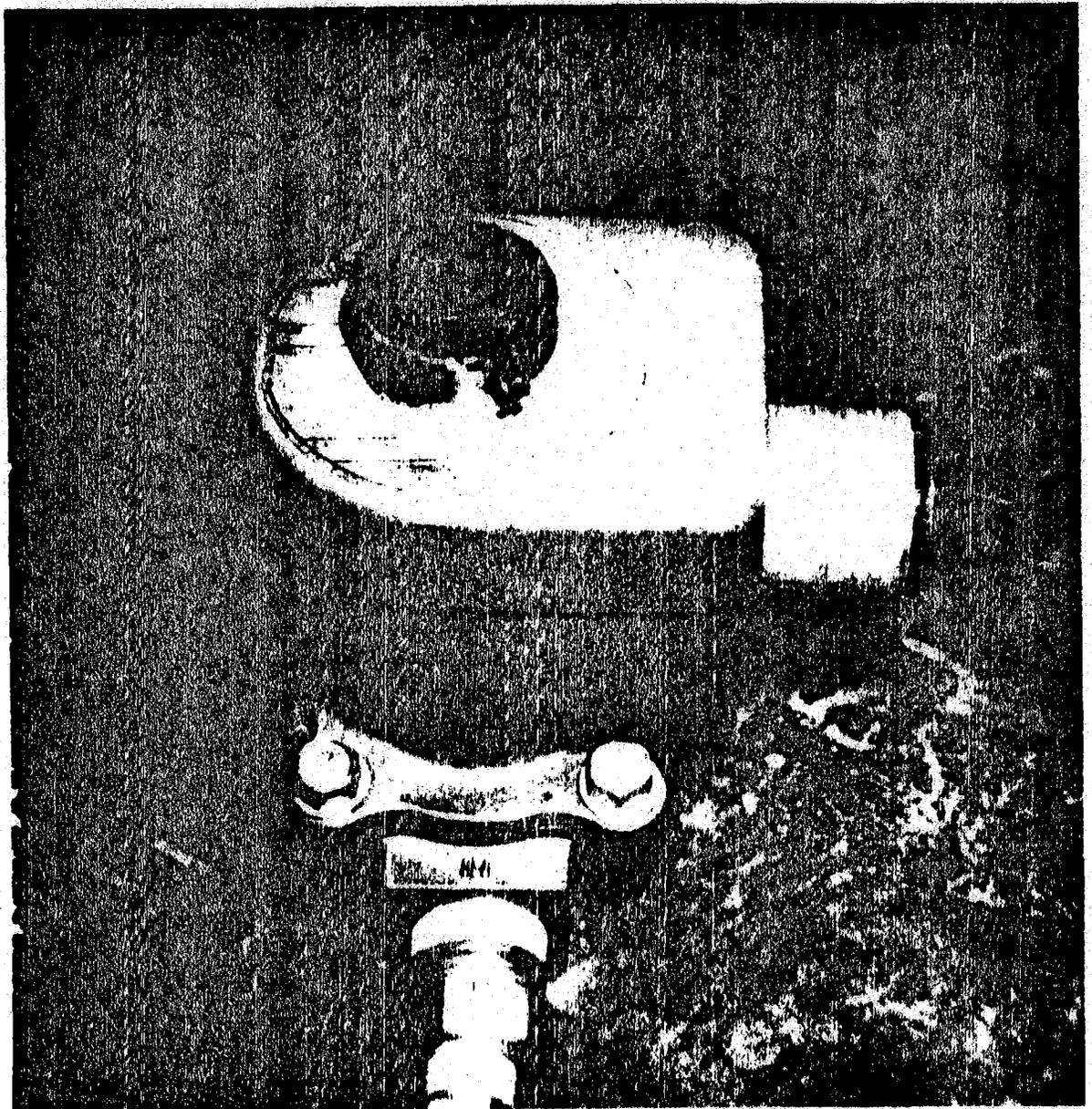
$$(8) \quad 130 \text{ g} (.80) = 104 \text{ g} = .23 \text{ lb TNT maximum charge size.}$$

APPENDIX B

The experiment was conducted in an Explosive Containment Cell (ECC). The ECC is a totally enclosed 6 ft. diameter sphere made of 1 inch steel. Figure 6 on page 35 is a photograph of the ECC.

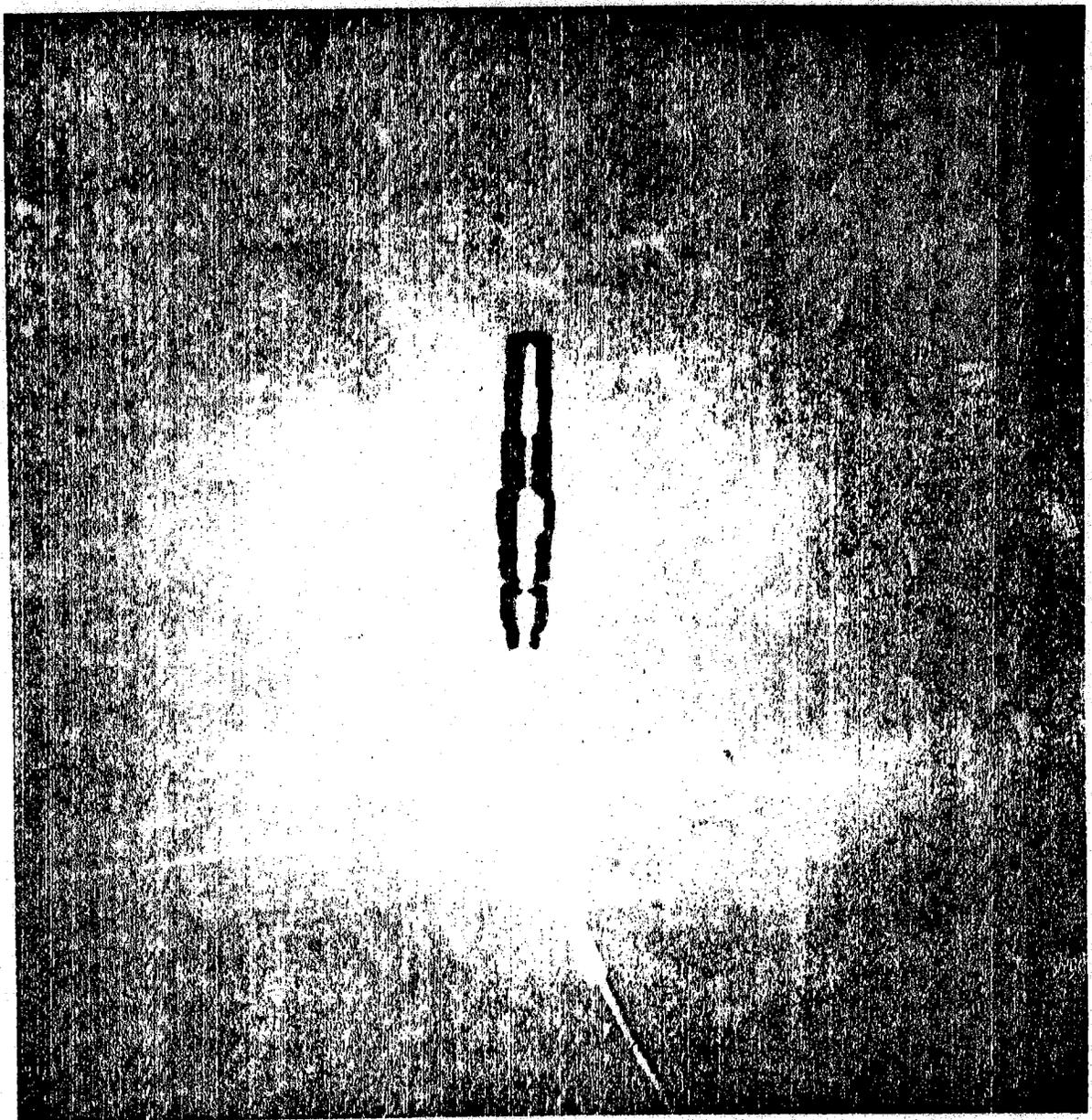
Two major problems existed in this experiment. One was how to collect the after-detonation gases and the second was to insure the equipment could withstand the temperatures and pressures encountered. To capture samples of after-detonation gases, a "t" copper fixture was made with a hook-up to a stainless steel collection vessel (see figure 9 on page 40) and an electrically controlled solenoid valve at the "t" cross (see figure 10). To monitor the pressures and temperatures encountered by the collection vessel, a thermocouple and pressure transducer were placed in the arms of the "t" fixture. These indicators gave the conditions of the gas samples. The pressure transducer was a BLH D-H 0-350 psig S/N 40495 (see figure 11). The thermocouple is shown in figure 12. To monitor the explosion, a Kistler 201 B4 0-200 psig S/N 285 transducer was placed in a fitting atop the ECC (see figure 13). In addition, a thermocouple was suspended inside the ECC.

The TNT was suspended by a "y" cable fixture so that it was approximately in the middle of the ECC (see figure 14). The stainless steel collection vessel and the copper tubing connection to the solenoid valve were evacuated by a vacuum pump. The TNT is detonated by an electric blasting cap and the solenoid valve is electrically opened a specified time after the TNT detonation.



SOLENOID VALVE IN "T" FIXTURE

Figure 10



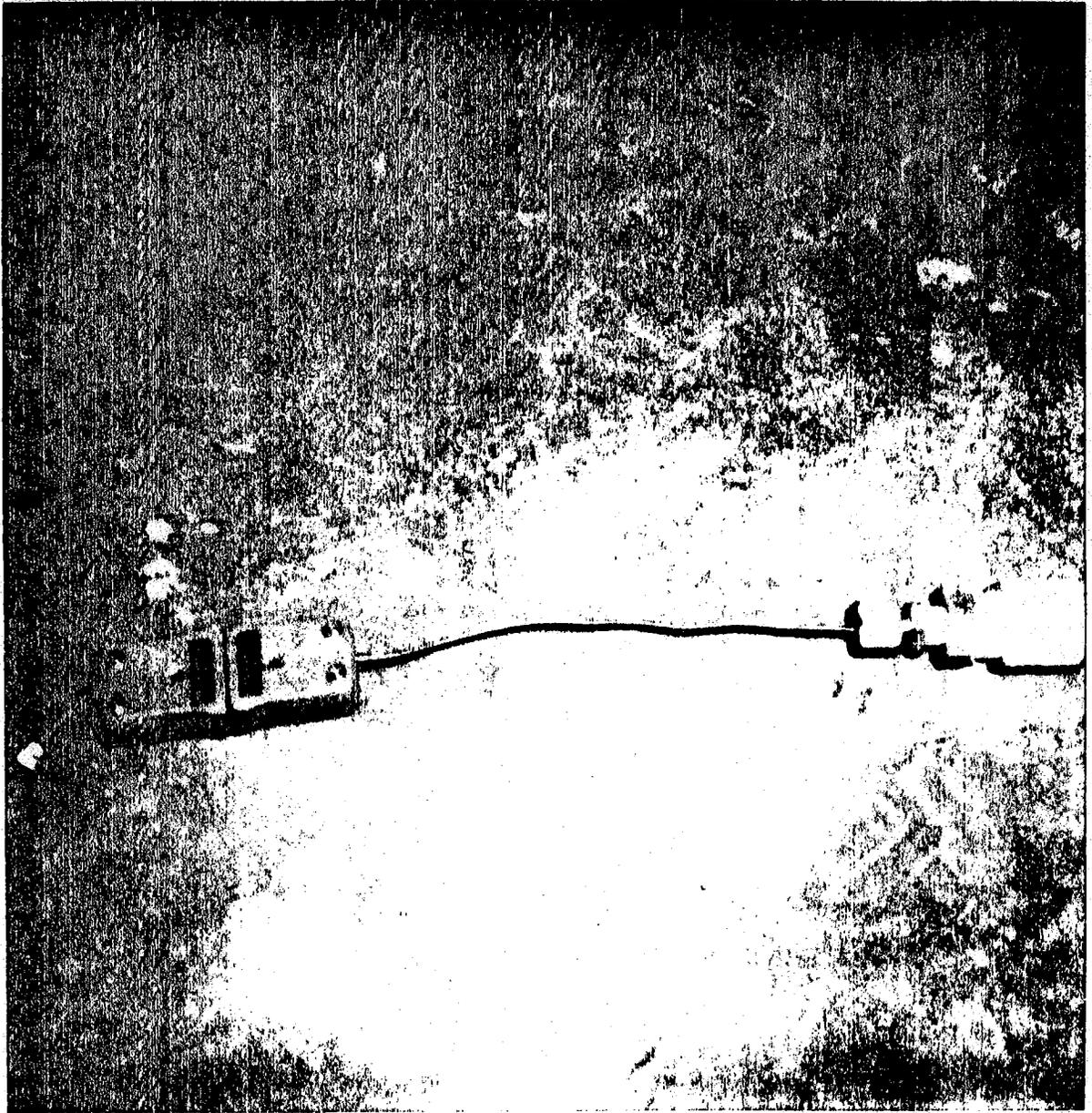
KISTLER 201 B3 PRESSURE TRANSDUCER

Figure 11



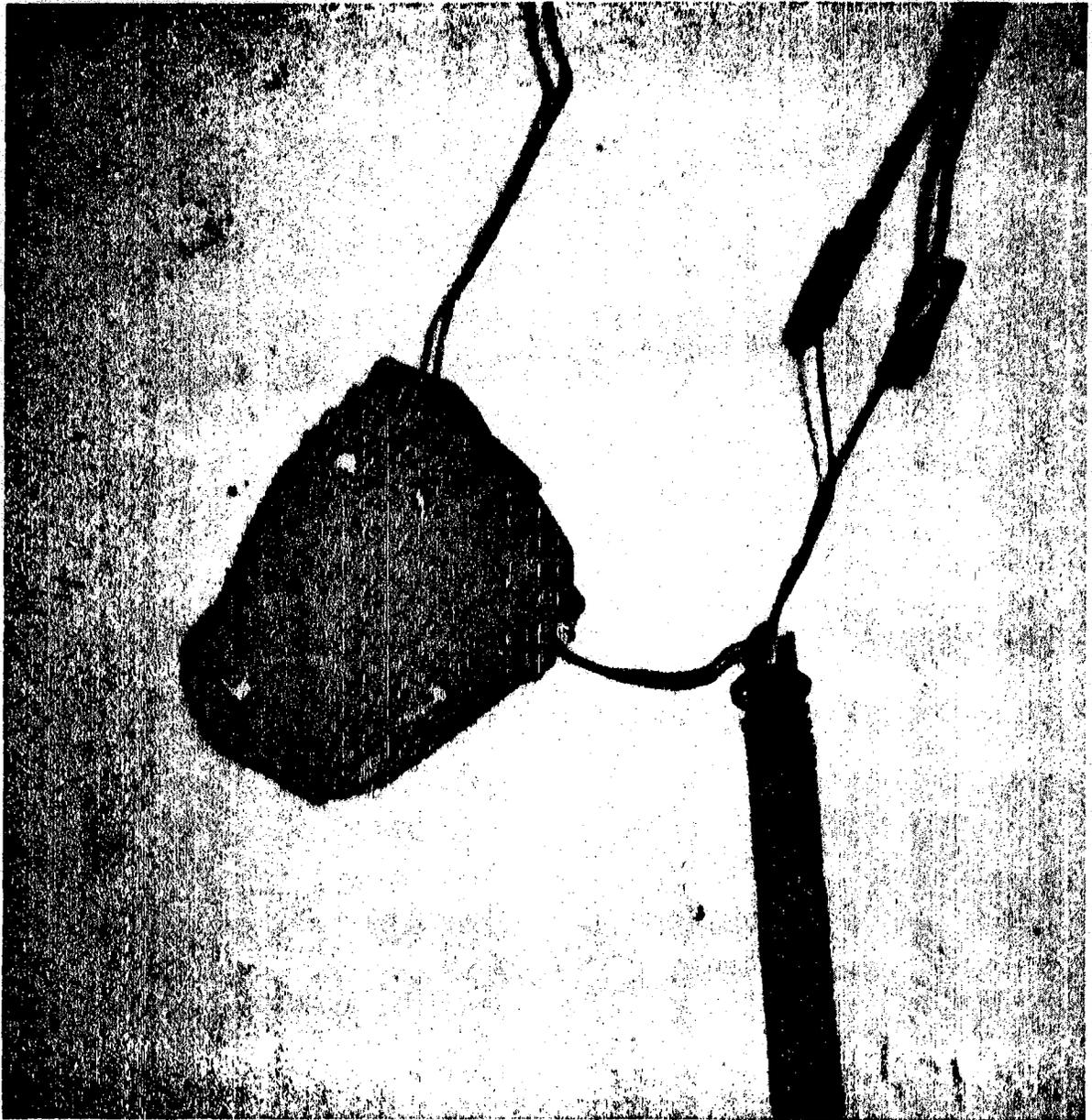
BLH D-H PRESSURE TRANSDUCER

Figure 12



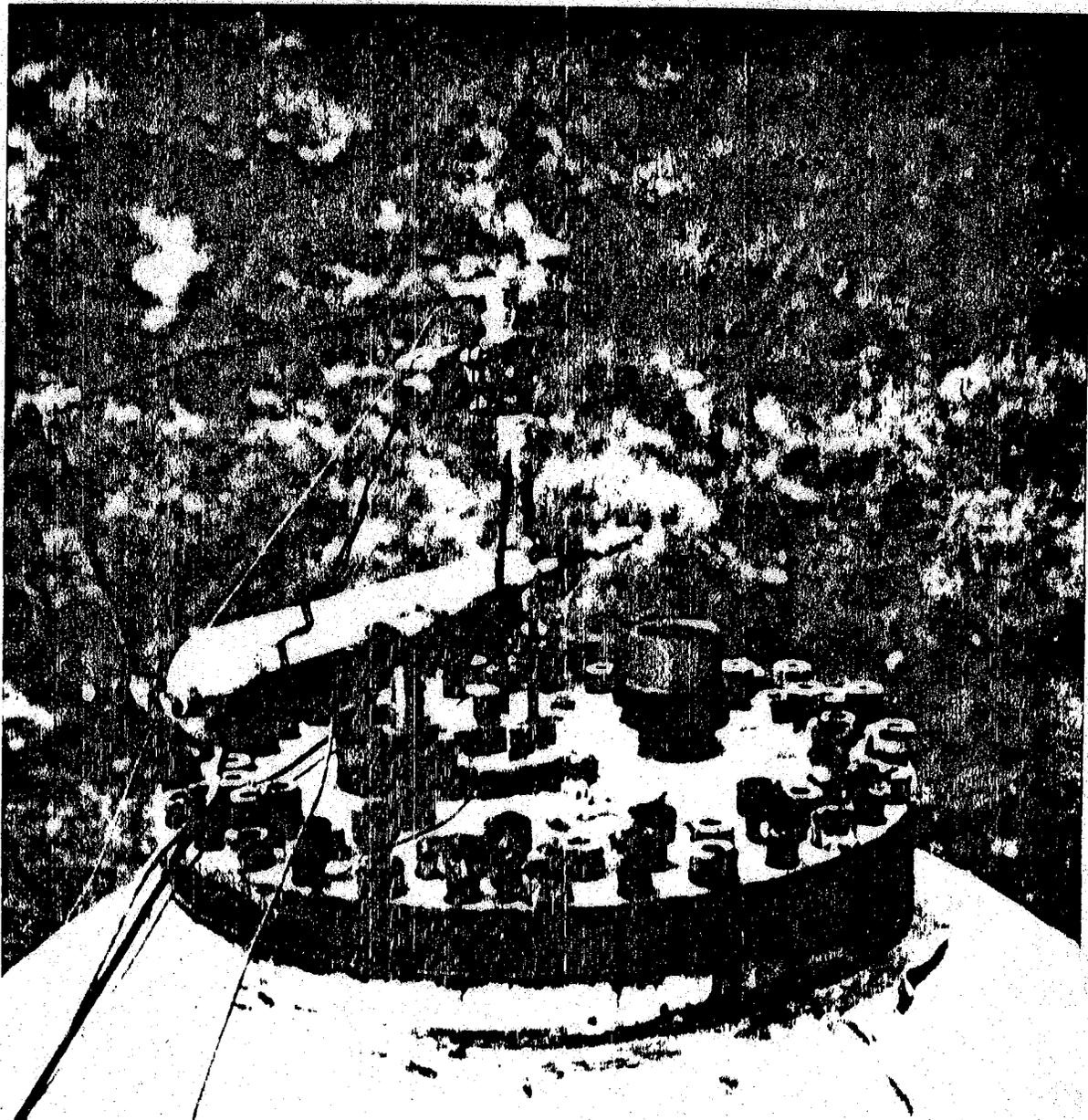
THERMOCOUPLE

Figure 13



TNT CHARGE SUSPENDED ON "Y" CABLE

Figure 14



EXPLOSIVE CONTAINMENT CELL SET-UP

Figure 15

APPENDIX C

TNT COMBUSTION GAS ANALYSIS

submitted to:

2Lt. Howard Hodges
Ammunition Equipment Office, Bldg. 1005
Tooele Army Depot
Tooele, Utah 84074

submitted by:

Alpine West Laboratories
P.O. Box 7521, University Station
Provo, Utah 84602

January 22, 1981

INTRODUCTION

The objective of this study was to determine the composition of the combustion gas resulting when one-hundred grams of trinitrotoluene (TNT) were detonated in a simulated open-air explosion. Essentially, three different methods were used to identify and to quantify the components of the combustion gas. For samples which were transported to our laboratory, both mass spectrometry and gas chromatography were employed. Mass spectrometry was used to identify possible constituents while gas chromatography was used to quantify the various components. In addition, gas analysis tubes were used to do selective component identifications and quantifications in "on-site" analyses. This report briefly outlines the methodology used for these analyses and describes the results which were obtained.

EXPERIMENTAL

Mass spectrometry was done using a Hewlett-Packard 5982 mass spectrometer coupled to a 5934A computer. A small amount of sample gas was slowly leaked into the ion source of the mass spectrometer through the direct probe inlet valve. A mass range of 10 to 200 a.m.u. was scanned at 5 A/D measurements. The pressure in the ion source was raised to $1-2 \times 10^{-6}$ torr with the sample gas.

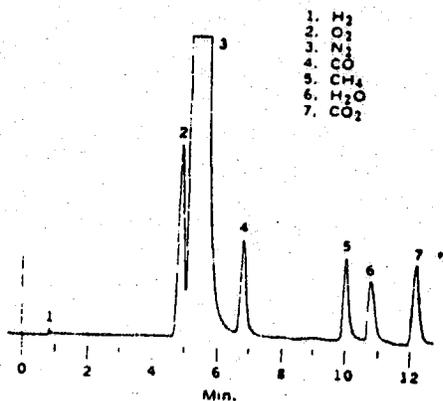
Two gas chromatographic systems involving different columns were used. In both cases the columns were appropriately mounted in a Hewlett-Packard 5710A gas chromatograph equipped with a thermal conductivity detector (TCD). 2000 microliters (2.0 milliliters) of sample gas were withdrawn through a septum from the sample cylinder with a gas tight syringe and injected into

the gas chromatograph. In some instances 250 microliter samples were injected so only the major components were observable. The gas chromatograph was temperature programmed from 20°C to 180°C at 16°C per minute. The oven was held isothermal at 20°C (required sub-ambient operation) for four minutes prior to ramping the temperature after the injection. 40 ml/minute of helium was used as the carrier gas in both the analytical and reference columns. For maximum sensitivity the TCD current was set to 340-350 mA and the attenuation was adjusted to one. When smaller samples were injected the TCD current was set to 135 mA and the attenuation to four for less sensitive operation.

The first chromatographic system consisted of an eight foot by one-eighth inch Carbosieve S column (Supelco). This system provided good separation of oxygen and nitrogen as well as carbon monoxide, carbon dioxide, and water. The nitrogen compounds, however, are irreversibly adsorbed. A description of this system and a chromatogram showing the compounds it separates is shown in Figure 1-A (1). The second system consisted of an eight foot by one-eighth inch Porapak Q column in series with a Porapak R column of the same dimensions. This system effectively allowed the N₂O and the NO₂ to be chromatographed. However, the NO was not resolved from the "air" peak. A description of this system and the compounds it separates is found in Figure 1-B (2).

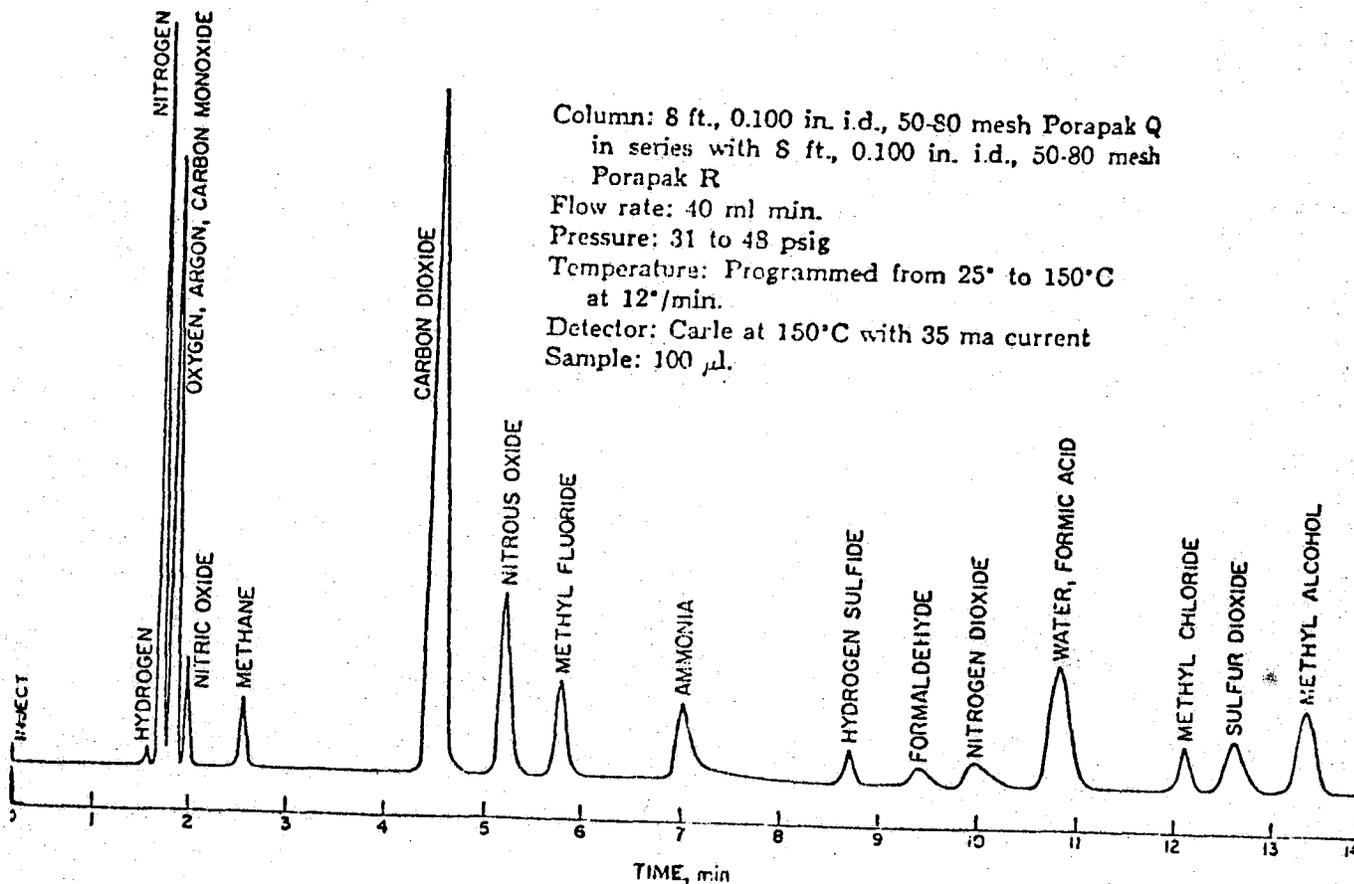
The signal from the chromatograph was digitized and integrated with a SpectraPhysics AutoLab Minigrator. The absolute units obtained for each peak in a chromatographic run were multiplied by the response factor for that compound, the total units for each run summed, and the relative percentage of each component calculated. In some instances, parts-per-million (ppm) were calculated rather than percentages. The response factors were

Analysis of Permanent Gases



Column: 7 ft. x 1/8" SS with Carbosieve S, 100/120 mesh, Col. Temp.: 35°C to 175°C, 4 min. hold, prog. at 25°C/min., Flow Rate: 40ml/min., helium, Det.: thermal conductivity, 150MA, 4X on range 0.5mv, Sample Size: 0.5ml of 1% mixture in N₂, Instrument: Varian, Model 3700.

FIGURE 1-A



Column: 8 ft., 0.100 in. i.d., 50-80 mesh Porapak Q in series with 8 ft., 0.100 in. i.d., 50-80 mesh Porapak R
 Flow rate: 40 ml min.
 Pressure: 31 to 48 psig
 Temperature: Programmed from 25° to 150°C at 12°/min.
 Detector: Carle at 150°C with 35 ma current
 Sample: 100 µl.

FIGURE 1-B

calculated (3) and in some instances estimated (4) from published work involving the analysis of similar permanent gas samples.

The on-site analyses were done using Matheson Kitagawa precision detector tubes and Drager gas analysis tubes. Combustion gas was drawn through these tubes according to the directions of the manufacturer by connecting one end to the sample cylinder and the other end to a one-hundred milliliter air pump. The concentrations of the specific gases were then obtainable directly by reading the color response from the calibrated tubes.

RESULTS AND DISCUSSION

The mass spectrum of gas sample #1 is shown in Figure 2. Table 1 lists the absolute abundance of all ions found during the mass spectral scan. The ions responsible for these masses are also listed. The major components were m/e of 28 (N_2), 32 (O_2), 40 (Ar), and 44 (CO_2). Some water vapor as well as monatomic nitrogen and oxygen were also present. The argon arises from background contamination of room air in the instrument as attested by a "blank" mass spectrum. The m/e of 34 can not be directly related to any known species, but is probably an intermediate formed in the ion beam. The m/e of 17 could possibly be attributed to ammonia (NH_3), but specific analysis for NH_3 (on a different, but similarly obtained sample) using a gas analysis tube (Drager tube CH 20501) which has a detection limit of 5 ppm failed to detect any NH_3 .

The absolute abundance of the ions in Table 1 was not used to calculate quantitative concentrations for the species since the mass spectrometer response factors were unobtainable. Rather, the gas chromatographic analyses were used for these quantitative measurements. Components were identified on the gas chromatograph by comparing retention indices to those obtainable

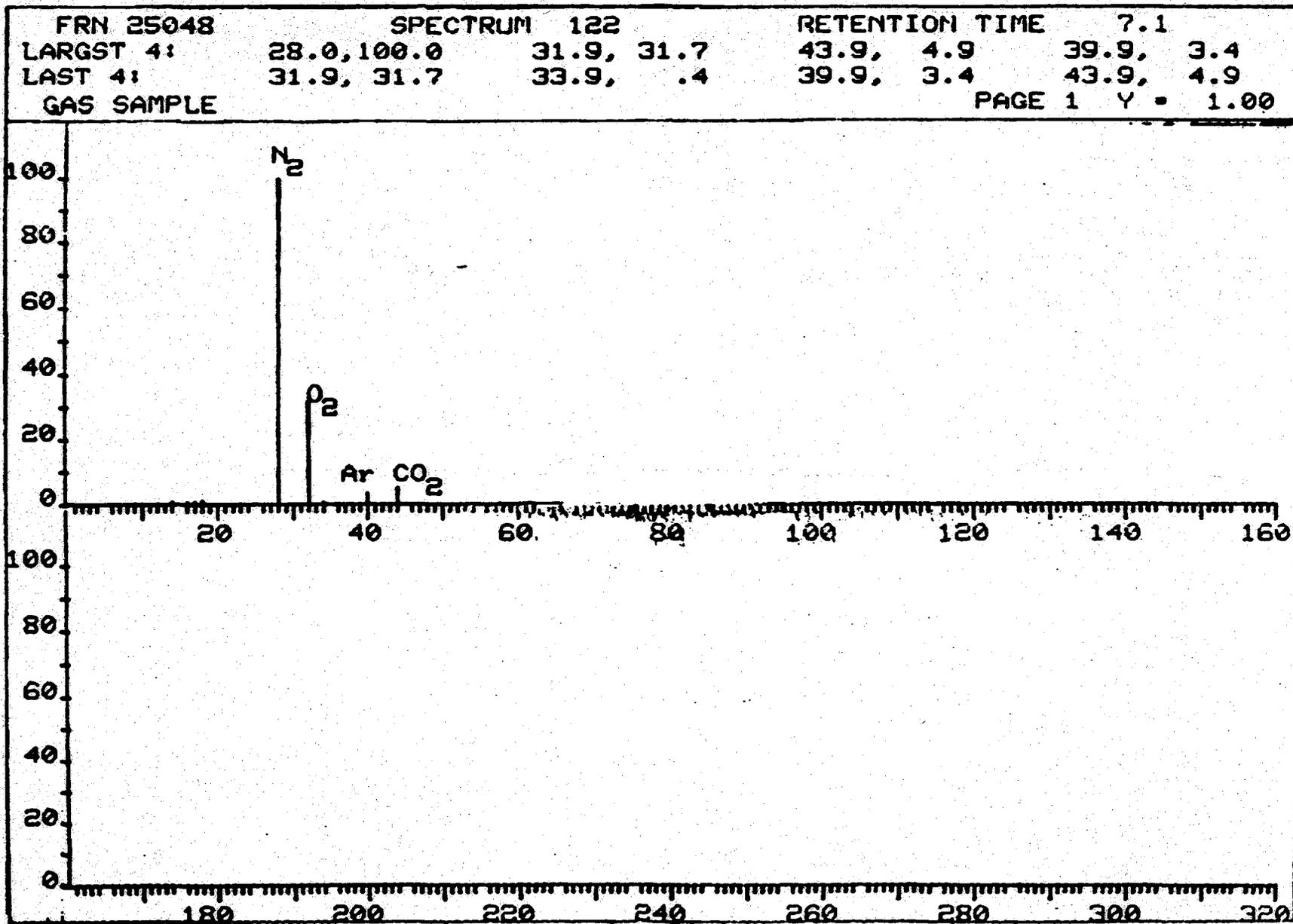


FIGURE 2

FRN 25048 SPECTRUM 122 RET. TIME = 7.1

MASS	ABUND	
14.1	42.	N
16.0	28.	O
17.0	23.	OH ⁻
18.0	51.	H ₂ O
28.0	5037.	N ₂
31.9	1596.	O ₂
33.9	20.	?
39.9	173.	Ar
43.9	246.	CO ₂

>PAUSE

TABLE 1

GAS SAMPLE,
ABSOLUTE COUNTS

from Figure 1.

The results of the low sensitivity gas chromatographic analyses of sample #1 are listed in Table 2. The data obtained from both the Carbo-sive and Porapak columns are shown. (The calculations used in obtaining these data and all other gas chromatographic data are included as an appendix to this report). As would be expected, oxygen and nitrogen were present in the highest concentration. Their ratio is different than that of normal air (c.a. 80% N_2 and 20% O_2), however, suggesting that either the O_2 is depleted or that the N_2 is enriched. Actually, both factors are probably significant. One would certainly expect that the O_2 would be depleted during the detonation, and also that molecular N_2 would be produced during the oxidation of TNT. The carbon dioxide and water are also expected products of combustion.

In addition to the expected products of complete combustion, several additional components were identified and quantified. The results of the high sensitivity analysis of sample #2 are given in Table 3. The major components (O_2 , N_2 , CO_2 , and H_2O) have slightly different concentrations than were obtained on sample #1. These differences, while not significant, are probably sample oriented or due to a slight change in the linearity of the instrument when operated at extended sensitivities. Although the CO concentration is not much less than the H_2O concentration it was not observable at lower sensitivities because it has a large response factor. That is, an equal amount of CO does not give as large of a detector response as does H_2O . The presence of the NO_x compounds is not at all surprising, either. As determined from the gas analysis tube analyses, NO (discussed below) was also present and evidently eluted with the "air" peak on the Porapak columns.

TABLE 2.
Low Sensitivity Analysis (Sample #1).

Carbosieve Column

Component	Relative Percentage
O ₂	11.55 ± 0.63
N ₂	86.20 ± 0.35
CO ₂	2.25 ± 0.28

Porapak Columns

O ₂	98.36 ± 0.03	11.62 ± 0.64
N ₂		86.74 ± 0.64
CO ₂		1.54 ± 0.01
H ₂ O		0.11 ± 0.00

TABLE 3.
High Sensitivity Analysis (Sample #2).

Carbosieve Column

Component	Relative Percentage
O ₂	8.89 ± 0.09
N ₂	88.28 ± 0.22
CO ₂	1.88 ± 0.27
H ₂ O	0.72 ± 0.12
CO	0.23 ± 0.05

Porapak Columns

air	97.79 ± 0.13
CO ₂	1.39 ± 0.07
H ₂ O	0.77 ± 0.03
N ₂ O	64 ± 8.4 ppm
NO ₂	193 ppm

The data obtained from the on-site analyses of sample #3 using the gas analysis tubes are given in Table 4. Both the NO₂ and CO₂ concentrations are significantly lower than those obtained by gas chromatographic analysis. The possibility that the gas chromatographic obtained concentration of NO₂ being too high is a possibility, but certainly not for the concentration of CO₂. Several independent gas chromatographic analyses of different samples (1&2) on two different systems (Carbosieve and Porapak) all yielded consistent results which were higher than those obtained with the gas analysis tubes. Consequently, the data obtained from the gas analysis tubes must be considered as the minimum limit with the possibility of a higher concentration existing. HCN is a possible combustion product and was verified to exist in low concentrations. Care was taken that the results of the gas tube analyses were not misinterpreted due to interference compounds.

TABLE 4.

Gas Tube Analysis (Sample #3)

Component	Concentration
NO ₂	12 ppm
NO	80 ppm
CO ₂	0.2 %
HCN	5 ppm

CONCLUSION

Combining the data from Tables 1-4, an average composition of the combustion gas samples has been tabulated in Table 5.

TABLE 5.
Averaged Composition of Combustion Gas

Component	Concentration
N ₂	87.22 %
O ₂	10.22 %
CO ₂	1.77 %
H ₂ O	0.53 %
CO	0.23 %
NO ₂	193 ppm
NO	80* ppm
N ₂ O	64 ppm
HCN	5* ppm
H ₂	4 ppm

* minimum level

REFERENCES

1. Supelco Chromatography Supplies, Catalog 17, page 18, 1980.
2. W.F. Wilhite and O.L. Hollis, J. Gas Chromatogr., 6, 84(1968).
3. J.L. Marchio, J. Chromatogr. Sci., 9, 432(1971).
4. J.I. Landau and E.E. Petersen, J. Chromatogr. Sci., 12, 362(1974).

DATA SUMMARY AND CALCULATIONS (continued)

Sample #1

Ponapak Q & R columns

- N_2 & O_2 elute together
- from Carbosieve column analyses we know the ratios of N_2 to O_2 and thus a weighted response factor for them can be calculated.

	<u>O_2 & N_2 percentages</u>		
Run #1	11.13	88.87	
Run #2	12.01	87.99	
Run #3	12.30	87.70	
Ave.	11.81	88.19	
std. dev.	± 0.61	± 0.61	

R.F. O_2 & N_2	=	$\frac{2.32(11.81) + 3.13(88.19)}{100}$
		= 3.03

Run #4

$(N_2 \& O_2)$	⇒	10,962 units	x 3.03	=	33,262.42 units	98.36%
CO_2	⇒	142 units	x 3.64	=	516.88 units	1.58%
H_2O	⇒	9 units	x 4 [±]	=	x 36 units	0.11%
					33,815.30	100.0%

Run #5

$(N_2 \& O_2)$	⇒	11,421 units	x 3.03	=	34,605.63 units	98.38%
CO_2	⇒	150 units	x 3.64	=	546.00 units	1.55%
H_2O	⇒	10 units	x 4 [±]	=	40.00 units	0.11%
					35,191.63 units	99.99%

± estimated response factor

DATA SUMMARY AND CALCULATIONS (continued)

Averages of Runs # 4 & 5

$(N_2 \& O_2) - 98.36\% \pm 0.03\%$ (0.03% RSD)
 $CO_2 - 1.54\% \pm 0.01\%$ (0.92% RSD)
 $H_2O - \underline{0.11\%} \pm 0.00$
 100.01%

- using %'s of N_2 & O_2 as in the calculation of the response factors, the N_2 & O_2 can be separated.

$O_2 \Rightarrow 11.62\%$
 $N_2 \Rightarrow 86.74\%$
 $CO_2 \Rightarrow 1.54\%$
 $H_2O \Rightarrow 0.11\%$

Sample #2

Carbosieve Column

Compound	Relative %'s				Ave.
	Run #1	Run #2	Run #3	Run #4	
H_2	3.9×10^{-4} 3.9 ppm	3.4×10^{-4} 3.4 ppm	1.2×10^{-4} 1.2 ppm	7.6×10^{-4} 7.6 ppm	4.03 ± 2.6
O_2	8.82	8.96	8.98	8.81	8.89 ± 0.09
N_2	87.96	88.35	88.49	88.30	88.28 ± 0.1
CO	0.25	0.26	0.18	0.29	0.23 ± 0.05
H_2O	0.80	0.77	0.76	0.53	0.72 ± 0.12
CO_2	2.17	1.71	1.59	2.04	1.88 ± 0.27
	100.00%	99.99%	100.00%	99.97%	100.00%

DATA SUMMARY AND CALCULATIONS (continued)

Sample #2

Porapak Column

Compound	Relative Percentages		Ave.
	Run #5	Run #6	
O ₂ /N ₂ , etc.	99.69	97.88	97.79 ± 0.13
CO ₂	1.44	1.34	1.39 ± 0.07
N ₂ O	58 ppm	70 ppm	64 ppm ± 8.4
NO ₂	193 ppm	—	193 ppm
H ₂ O	$\frac{0.79}{99.92\%}$	$\frac{0.75}{99.97\%}$	$\frac{0.77 \pm 0.03}{99.95\%}$

Sample #2

Carbosieve Column Analysis - DATA

Run #1

Peak #	Compound	Counts	Response factor	Corrected Counts	%
1	H ₂	26	1.00	26.00	3.9 × 10 ⁻⁴
2	O ₂	254,857	2.32	591,268.24	8.82
3	N ₂	1,883,825	3.13	5,896,372.25	87.96
4	CO	1016	16.45	16,713.20	0.25
5	H ₂ O	13,411	4.0 [±]	53,644	0.80
6	CO ₂	39,959	3.64	145,450.76	2.17
				6,703,494.45	100.00%

± estimated response factor

DATA SUMMARY AND CALCULATIONS (continued)

Sample #2

Carbosieve Column Analysis

Run #2

Peak #	Compound	Counts	Response Factor	Corrected counts	%
1	H ₂	25	1.00	25	3.4 x 10 ⁻⁴
2	O ₂	282,913	2.32	656,358.16	0.96
3	N ₂	2,067,624	3.13	6,471,663.12	88.35
4	CO	910	16.45	14,969.50	0.20
5	H ₂ O	14191	4.0 [±]	56,764.00	0.77
6	CO ₂	34321	3.64	124,928.44	1.71
				<u>7,324,708.22</u>	<u>99.99%</u>

Run #3

1	H ₂	9	1.00	9	1.2 x 10 ⁻⁴
2	O ₂	279,806	2.32	649,149.22	0.98
3	N ₂	2,044,171	3.13	6,398,255.23	88.49
4	CO	806	16.45	13,250.70	0.18
5	H ₂ O	13,794	4.0 [±]	55,176.00	0.76
6	CO ₂	31,552	3.64	114,849.28	1.59
				<u>7,230,698.13</u>	<u>100.00%</u>

Run #4

1	H ₂	27	1.00	27.00	7.6 x 10 ⁻⁴
2	O ₂	134,100	2.32	311,112	8.81
3	N ₂	996,544	3.13	3,119,389.22	88.3
4	CO	614	16.45	10,100.30	0.29
5	H ₂ O	4,661	4.0 [±]	18,644.00	0.53
6	CO ₂	19,817	3.64	72,133.88	2.04%
				<u>3,531,256.40</u>	<u>99.97%</u>

DATA SUMMARY AND CALCULATIONS (continued)

Sample #2

Pirapak columns

Run #5

Peak #	Compound	Counts	Response factor	Corrected Counts	%
1	O ₂ /N ₂ etc.	2,302,205	3.06	7,279,765.48	97.69
2	CO ₂	29,456	3.64	107,219.84	1.44
3	N ₂ O	144	3.0 ±	432.00	50 ppm
4	NO ₂	480	3.0 ±	1,440.00	193 ppm
5	H ₂ O	14759	4.0 ±	59036.0	0.79
				<u>7,447,893.32</u>	<u>99.92%</u>

Run #6

1	O ₂ /N ₂ etc.	2,402,009	3.06	7,350,147	97.88
2	CO ₂	27,425	3.64	99,827.00	1.34
3	N ₂ O	174	3.0 ±	522.00	70 ppm
4	NO ₂	*	3.0 ±	*	*
5	H ₂ O	13,969.68	4.0 ±	55,878.72	0.75
				<u>7,506,374.72</u>	<u>99.97%</u>

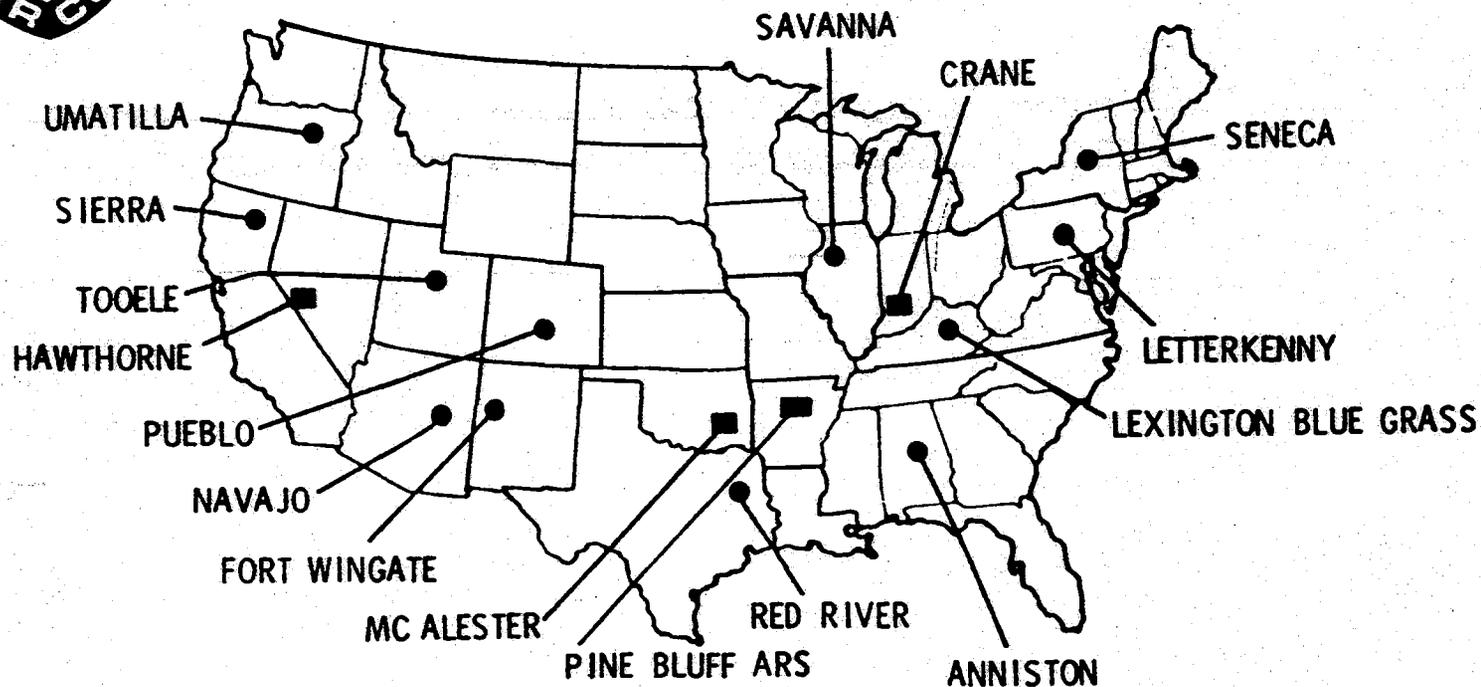
± estimated response factor

* data obscured

VI. Excerpts From TM 9-1300-277 Descom And
ARRCOM Demil Capabilities



SINGLE MANAGER FOR CONVENTIONAL AMMUNITION AMMUNITION STORAGE LOCATIONS



ARD 81-0212

- UNDER COMMAND OF US ARMY DEPOT SYSTEMS COMMAND
- UNDER COMMAND OF US ARMY ARMAMENT MATERIEL READINESS COMMAND

Figure 9-1. Ammunition storage locations.

Table 9-1. DESCOM and ARRCOM Capabilities Summary

Depot	Washout capabilities	Deactivation capabilities	Detonation capabilities	Open burning capabilities
ANNISTON AD	1 APE 1300 OPERATIONAL	2 APE 1050 POPPING FURNACES 1 APE 1236 W/APE 1276	22 SITES 15 LB ABOVE 6 SITES 10,000 BELOW W/10 FEET EARTH COVER	4 SITES; 1 CAGE 50 LB EACH TIME
CRANE	1 EACH NON-STANDARD STEAMOUT W/O POLLUTION CONTROL 1 EACH WASHOUT PLANT. NO POLLUTION CONTROL REQUIRED	2 DEACT FURNACE W/AP CONTROL 1 SMALL PRIMER POPPING FURNACE W/AP CONTROL	70 SITES 500 LB BELOW	2 LARGE SITES - NO RESTRICTIONS
FORT WINGATE DA	1 APE 1300 REQUIRES REFURB, WATER TREATMENT AND CHAR-COAL FILTER	1 APE 1236 W/O APE 1276	8 SITES 5,000 LB ABOVE/10,000 LB BELOW	5 SITES NO CAGES 10,000 lb
HAWTHORNE AAP	1 NON-STANDARD LARGE ITEM 1 NON-STANDARD TO 750 LB	2 DEACT FURNACE W/O AP CONTROL	10 SITES, 3,000 ABOVE	2 SITES - NO RESTRICTIONS
LETTERKENNY AD	APE 1300 W/O CHAR-COAL FILTER	APE 1236 W/APE 1276	14 SITES 20 LB ABOVE/150 LB BELOW	3 SITES 6 CAGES 4,000 LB SMOKELESS/SITE
LEX BLUE-GRASS ADA	APE 1300 W/PA	APE 1236 W/APE 1276	30 SITES 50 LB BELOW W/6 FEET EARTH, 100 LB W/7 FEET EARTH	NO O.B. EXCEPT BY PERMIT
MCALESTER AAP	2 EACH NON-STANDARD. NO PA REQUIRED.	DEACT FURNACE WITH APE 1276	10 SITES 150 LB W/4 FEET EARTH	OPEN AREA RESTRICTED UNTIL CAGES ARE MANUFACTURING
NAVAJO	INOPERABLE	APE 1009 W/O APE 1236 FY81 INST PLANNED	14 SITES 5,000 LB ABOVE/10,000 LB BELOW W/6 FEET EARTH	1 SITE W/CAGE 14 SITES - OPEN PIT

Table 9-1. DESCOM and ARRCOM Capabilities Summary-- Continued

Depot	Washout capabilities	Deactivation capabilities	Detonation capabilities	Open burning capabilities
PINE BLUFF	CHEMICAL ITEMS ONLY	1 DEACT FURNACE W/ SCRUBBER 1 CHAIN GRATE FURN W/SCRUBBER 1 FLUID BED INCINER- ATOR W/SCRUBBER	NONE	NONE
PUEBLO	APE 1300 AP UNKNOWN	APE 1236 W/APE 1276	14 SITES 50 LB ABOVE/ 4,000 LB TO 20,000 LB BELOW	4 SITES 1 CAGE
RED RIVER	APE 1300 W/O AP	APE 1009 W/APE 1276 2 APE 1236 W/APE 1276 (NOT OPERA- TIONAL)	4 SITES 100 LB ABOVE/ 3,000 LB BELOW	1 SITE HE 50,000 LB 1 SITE WP 3,000 LB 1 SITE SMOKELESS 60,000 I
SAVANNA DA	1 APE 1300 W/O AP	1 APE 1236 W/APE 1276	1 SITE 25 LB ABOVE/ 500 LB BELOW	9 SITES UNSAFE, UNSTABLE ONLY
SENECA AD	NONE	1 APE 1236 W/APE 1276	8 SITES 50 LB ABOVE AND BELOW	8 SITES 1 CAGE WEATHER CONDITION RESTRICTIONS
SIERRA AD	NONE	1 APE 1236 W/APE 1276	14 SITES 10,000 LB	2 SITES P&E ITEMS AND CONTAMINATED WASTE ONLY
TOOELE AD	APE 1300 W/FILTER	1 APE 1236 W/APE 1276 1 APE 1236 W/AFTER BURNER, SCRUBBER	9 SITES 1,550 LB ABOVE/5,000 LB BELOW W/8 FEET COVER 10 SITES 100 LB ABOVE/10,000 LB BELOW W/10 FEET COVER	10 SITES 5,000 LB/SITE 12 SITES 10,000 LB/SITE
UMATILLA DA	APE 1300 W/O WATER TREATMENT REQUIRES BOILER SYSTEM WATER TREATMENT SYSTEM	1 APE 1236 W/APE 1276	24 SITES 50 LB ABOVE/ 100 LB BELOW	1 SITE

Table 9-2. Conventional Ammunition Demilitarization Facilities and Capabilities

ANNISTON ARMY DEPOT

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Bldg 381— 14,578 sq ft. Center substantial dividing wall with operational bays. Power conveyors. Powder collection system. Full complement of APE disassembly and breakdown equipment (Pull apart, debanding, defuzing, holding fixtures and depriming machines).</p> <p>Bldg 680— 22,246 sq ft. Center substantial dividing wall with operational bays. Power conveyors. Powder collection system.</p> <p>Bldg 171— Disassembly barricade for remote disassembly of explosive items with 50 lb or less explosive.</p> <p>Bldg 179— Disassembly barricade for remote disassembly (television) of items with more than 50 lb of explosive.</p>	<p>Bldg 172— APE 1300 plant. Plant is operational. Requires charcoal filter system.</p>	<p>Bldgs 58 & 59— 12,998 sq ft. 2 APE 1050 Primer Popping Furnaces (Small Arms Ammo). Pollution abatement not required. Caliber .30 and Caliber .50. Disassembly, delinking, decoring, deleading machines. Power conveyors. Powder collection system. Power carloading equipment.</p> <p>Bldg. 393— 1,451 sq ft. APE 1236 furnace with APE 1276 Air Pollution System and BAG House Temperature Protection.</p>	<p>22 detonation sites with electrical firing system.</p> <p>Detonation restrictions: 15 lb above ground; 1,000 lb below ground with 10 ft of earth cover during ideal weather conditions.</p> <p>Alabama Air Pollution Commission, April 12, 1978, granted approval to continue the demilitarization of ammunition items of over 600 grains explosive at burning grounds and demolition pit subject to:</p> <ol style="list-style-type: none"> (1) Burning will be conducted only between the hours of 9:00 a.m. and 3:00 p.m. (2) Burning will be conducted only when there is good ventilation. (3) If in the future a more suitable technique and/or facility is designed, Anniston Army Depot will discontinue the current open disposal method and adopt the new technique/facility. 	<p>15 burning sites with electrical leads.</p> <p>1 burning cage; 50 lb net explosive maximum to be burned at one time.</p>

Table 9-2. Conventional Ammunition Demilitarization Facilities and Capabilities—Continued

TM 9-1300-277

ANNISTON ARMY DEPOT—Continued

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Bldg 600— 11,059 sq ft. Substantial dividing walls. Overhead hoist capacity 5,000 lb. Capability for downloading CBU units.</p> <p>Bldg 168— 10,080 sq ft. Substantial dividing walls.</p> <p>Power conveyors.</p> <p>Powder collection system.</p>				

FT. WINGATE ARMY DEPOT ACTIVITY

<p>Bldg 528— 21,644 sq ft. Center substantial dividing wall with operational bays. Power conveyors. APE disassembly and breakdown equipment (pull apart and depriming machines).</p>	<p>APE 1300 plant w/o water treatment system. Washout system is of old design. Requires refurbishing and operational check out.</p> <p>System requires water treatment and charcoal filter system.</p>	<p>APE 1236 furnace requires APE 1276 air pollution system.</p>	<p>8 detonation sites. Detonation restrictions; 5,000 lb above ground; 10,000 lb below ground.</p>	<p>5 burning sites. No burning cage. Burning restrictions 10,000 lb.</p>
--	--	---	--	--

LETTERKENNY ARMY DEPOT

Bldg 2383— 7,400 sq ft.
Dividing walls separate operational bays.
Power conveyor.
Powder collection system.

Bldg 3810— 22,000 sq ft.
Center substantial dividing wall. Power conveyors.
Powder collection system.

Bldg 5647— 4,000 sq ft.
Limited to missile disassembly.

Bldg 2377—
Disassembly barricade for remote disassembly of items with less than 50 lb of explosive.

Bldg 2763—
Disassembly barricade for remote disassembly of items with more than 50 lb of explosive.

Bldg 2365— APE 1300 plant w/o charcoal filter system. Requires dewatering, operational check-out and charcoal filter system.

Bldg 1456W— 6,000 sq ft.
Powder collection system.
APE 1236 furnace with APE 1276 Air Pollution System and BAG House Temperature Protection.

Class 1.1 not permitted to be processed because of 500 feet distance to recreation area.

14 detonation sites non-electrical.

Detonation restrictions; 20 lb above ground; 150 lb below ground.

Up to 500 lb of explosive may be detonated when optimum meteorological conditions are present.

3 burning sites.

6 burning cages.

2 elevated concrete pads with curbs for burning small arms ammunition bullets.

Burning restriction:
Maximum of 4,000 lb of smokeless powder can be burned per site on 3 sites.

Table 9-2. Conventional Ammunition Demilitarization Facilities and Capabilities—Continued

LEXINGTON BLUE-GRASS ARMY DEPOT ACTIVITY

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Bldgs 550,555,562— Each 18,000 sq ft (Bldgs 550,555 each have powder collection systems.) Center substantial wall with operational bays. Power conveyors. Full complement of APE disassembly and breakdown equipment.</p> <p>Bldg 1166— Disassembly barricade for remote disas- sembly of items with less than 50 lb of explosive.</p> <p>Bldg 1319— Disassembly barricade for remote disas- sembly of items with more than 50 lb of explosive.</p>	<p>APE 1300 Plant with pilot model char- coal filter system installed. Addi- tional charcoal column required.</p>	<p>Bldg. 273— Small Arms Breakdown Facility. APE 1236 Furnace with APE 1276 Air Pollution System.</p>	<p>30 detonation sites with electrical fir- ing system.</p> <p>Detonation restric- tion: 50 lb below ground with 4 feet earth cover; 100 lb below ground with 6 feet earth cover.</p> <p>Under ideal weather conditions, the upper limit may be used.</p> <p>NOTE: Upper limit seldom used because of blast pressures affecting neighbor- ing residences.</p>	<p>Burning area.</p> <p>Meteorological conditions dictate when munitions can be burned.</p>

The only open burning permitted by the Kentucky Environmental Protection Agency is for propellant which has reached a point of unacceptable stability.

Detonation is restricted to H.E. loaded munition on a specific item-by-item basis by the Kentucky Environmental Protection Agency.

NAVAJO ARMY DEPOT ACTIVITY

<p>Bldg 301— Partial center dividing walls with operational bays. Power conveyor. Powder collection system.</p> <p>TEAD survey 3/79 findings show need for deluge/fire protection modification if new mission assigned.</p> <p>Bldg 325— Small Arms Disassembly</p>	<p>Three major tank assemblies have been removed and installed at Tooele AD. Washout plant is completely inoperable. No cost estimate available.</p>	<p>APE 1009 furnace requires APE 1276 Air Pollution System.</p>	<p>14 detonation sites.</p> <p>*Detonation restriction: 5,000 lb above ground; 10,000 lb below ground with 6 feet earth cover.</p>	<p>1 burning site.</p> <p>14 white phosphorous burning site.</p> <p>WP subject to DA moratorium.</p>
---	--	---	--	--

*The limits indicated were recommended by Utah Study (20 years ago). Presently operating with self-imposed limitation of 1000 to 1200 pounds per shot.

PUEBLO ARMY DEPOT ACTIVITY

<p>Bldgs 711-741— Power conveyors. Powder collection system. APE disassembly and breakdown equipment.</p> <p>Bldg 761— Small Arms Breakdown power conveyors powder collection system. APE Disassembly and breakdown equipment.</p> <p>TV Disassembly Plant for disassembly of bombs, large separate loading shell, rocket motors, etc.</p> <p>Bldg AWS-4— Powder collection system.</p>	<p>APE 1300 washout and pelleting system and water reclamation system.</p>	<p>APE 1236 furnace with APE 1276 Air Pollution System BAG House Temperature Protection.</p>	<p>14 detonation pits/holes.</p> <p>Detonation restriction: 50 lb above ground; 4,000 lb to 20,000 lb below ground per pit hole.</p> <p>State EPQ requires particulate emission monitoring.</p>	<p>4 burning sites.</p> <p>1 burning cage.</p>
---	--	--	---	--

Table 9-2. Conventional Ammunition Demilitarization Facilities and Capabilities—Continued

RED RIVER ARMY DEPOT

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Bldg 1163— 16,280 sq ft. Bldg 1116— 15,540 sq ft. Center substantial dividing wall with operational bays. Power conveyor. Powder collection system. Full complement of APE disassembly and breakdown equipment.</p> <p>Bldg 1149— Disassembly barricade for remote disassembly of items with less than 70 lb of explosive.</p> <p>Bldg 1107— Disassembly barricade for remote disassembly of items with more than 70 lb of explosive.</p> <p>Both disassembly facilities equipped for quick installation of television observation equipment.</p>	<p>Bldg 1122— 3,674 sq ft. APE 1300 plant with water reclamation system. Requires operational check-out and charcoal filter system.</p> <p>4 aeration lagoons.</p>	<p>Bldg S-722— 6,240 sq ft. Small Arms Demilitarization Facility. American gas rotary heating machine with lead melting pot. Pollution abatement not required. APE 1009 Furnace with APE 1276 Air Pollution System w/BAG House. Caliber .30 and Caliber .50 Disassembly, delinking, and pull-apart machines. Power conveyors. Powder collection system.</p> <p>Bldg 1025— 2 APE 1236 Furnaces w/BAG House.</p>	<p>4 detonation sites with electrical firing system.</p> <p>Detonation restriction: 100 lb above ground; 3,000 lb below ground.</p> <p>8 static firing tanks for Hawk Missile Motors.</p>	<p>High explosive burning area 350,000 sq ft with an explosive limit of 50,000 lb.</p> <p>White phosphorous burning area 250,000 sq ft with an explosive limit of 3,000 lb (100 lb max high explosive shot).</p> <p>Smokeless powder burning area 250,000 sq ft with an explosive limit of 60,000 lb.</p> <p>Open burning of explosives and propellants approved by Texas Air Control Board 2 April 80.</p> <p>Destruction of chemical ammunition disapproved.</p>

SAVANNA ARMY DEPOT ACTIVITY

<p>Bldg 729— 16,176 sq ft. Dividing walls separate operational bays. Power conveyor. Powder collection system. Full complement of APE disassembly and breakdown equipment.</p> <p>Bldg 742— 27,550 sq ft. Dividing walls separate operational bays. Power conveyor.</p>	<p>Bldg 2208— APE 1300 plant requires dewinterizing operational checkout and charcoal filter system.</p>	<p>Bldgs 941-947— 1 APE 1236 Furnace with APE 1276 Air Pollution System.</p>	<p>1 detonation site.</p> <p>Detonation restriction: 25 lb above ground; 500 lb below ground.</p> <p>Illinois EPA prohibit open burning except for unsafe/unstable ammunition.</p>	<p>9 burning sites. 4 flashing areas. 1 burning cage.</p>
---	--	--	--	---

SENECA ARMY DEPOT

<p>Bldg 612— Disassembly building. Partial center substantial dividing wall with operational bays. Power conveyors. Powder collection system.</p>	<p>None</p>	<p>Bldg 367— 1-APE 1236 Furnace with APE 1276 Air Pollution System and BAG House Temperature Protection.</p>	<p>8 detonation sites.</p> <p>Detonation restriction: Quantity-distance restriction 100 lb.</p> <p>Depot restriction: 50 lb above or below ground.</p>	<p>8 burning sites. 1 burning cage.</p> <p>Burning restriction: Weather conditions and wind direction dictate when munitions can be burned.</p>
---	-------------	--	--	---

Table 9-2. Conventional Ammunition Demilitarization Facilities and Capabilities—Continued

SIERRA ARMY DEPOT

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Bldg 403— 10,800 sq ft. Partial center substantial dividing wall with operational bays. Power conveyors. Powder collection system. APE disassembly and breakdown equipment.</p>	<p>None.</p>	<p>APE 1236 Furnace with APE 1276 Air Pollution System with Pilot Model BAG House Temperature Protection System. Deactivation furnace operation licensed by State of California Lassen County.</p>	<p>14 detonation sites with electrical firing system. *Local detonation restriction—10,000 lb. Detonation and open burning operations licensed by State of California, Lassen County.</p>	<p>Open burning site. Open burning restriction: Limited to explosives and explosive contaminated combustible waste.</p>
<p>Bldg 640— 20,520 sq ft. Center substantial dividing wall with operational bays. Power conveyors. Powder collection system. APE disassembly and breakdown equipment.</p>				

*10,000 pounds per shot, number of shots per day limited only by time required to set up shots and clean the air. Normal operation calls for 1 - 14 shots at one minute intervals starting from 1430 to 1530 each weekday.

TN 9-1300-277

9-12

TOOELE ARMY DEPOT

<p>Bldg 1375—22,264 sq ft. Center substantial dividing wall with operational bay. Power conveyors. Powder collection system. Full complement of APE disassembly and breakdown equipment.</p> <p>Bldg 1303— Disassembly barricade for: remote; disassembly/sectioning; munitions with power hacksaw and closed circuit television.</p>	<p>Bldg 45— APE 1300 Plant is operational. Requires charcoal filter system.</p>	<p>North area— Bldg 1320 APE 1236 Furnace with APE 1276 Air Pollution System.</p> <p>South area— APE 1236 Furnace with Afterburner and Venturi. Cross Flow Scrubber or Dry Particulate Control System.</p>	<p>North area— 9 detonation sites with electrical firing system.</p> <p>Detonation restriction: 100 lb above ground; 5,000 lb below ground with 8 feet earth cover.</p> <p>Each detonation is dependent on weather conditions, wind direction temperature, inversion layer, and air quality.</p> <p>South area— 10 detonation sites w/o electrical firing system.</p> <p>Detonation restriction: 100 lb above ground; 10,000 lb below ground with 10 feet earth cover.</p>	<p>North area— 10 burning sites non-electrical.</p> <p>Burning restriction: 5,000 lb per site.</p> <p>South area— 12-burning sites non-electrical.</p> <p>Burning restriction: 10,000 lb each site.</p> <p>Open burning is governed by weather conditions.</p>
---	---	--	--	--

Table 9-2. Conventional Ammunition Demilitarization Facilities and Capabilities— Continued

UMATILLA DEPOT ACTIVITY

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Bldg 614— 16,500 sq ft. Center substantial dividing wall with operational bays. Power conveyors. APE disassembly and breakdown equipment.</p> <p>Bldgs 601-606— Disassembly barricade for remote disassembly (television not operational).</p> <p>Bldg 608— 18,400 sq ft. Essentially same configuration as Bldg 614 with same equipment and use.</p>	<p>Bldg 487— APE 1300 Plant w/o water treatment system. Requires refurbishing, operational checkout and new boiler system.</p> <p>System requires water treatment and charcoal filter system.</p>	<p>Bldg 206— APE 1236 Furnace with APE 1276 Air Pollution System and BAG House Temperature Protection.</p>	<p>24 detonation sites.</p> <p>Detonation restriction: 50 lb above ground; 50 lb below ground.</p> <p>Oregon Department of Environmental Quality currently permits open burning/open detonation to be conducted in accordance with Utah Study criteria. However, open burning/open detonation future operation is under review by Department of Environmental Quality.</p>	<p>Open burning site.</p>

TM 9-1300-277

9-14

munitions. A fluidized bed incinerator is undergoing modifications and is not yet operational.

1. ARRCOM installations' facilities and capabilities are detailed in table 9-3.

9-4. WESTERN DEMILITARIZATION FACILITY, RAWTHORNE NEVADA

a. Introduction. The Western Demilitarization Facility is located between the existing depot and the south shore of Walker Lake. Details of this facility and how it will serve the US Defense Establishment are described below. Site plan showing location of all principal buildings, roads, and rail lines is presented in figure 9-2.

b. Background. The present capability for demilitarization consists of small units in scattered locations around the country. These units are quite old, tend to be makeshift, and some processes do not meet today's environmental standards. This points up the need for modern centralized facilities.

c. Requirements. It was required that the new demilitarization facility exhibit these capabilities:

(1) Demilitarize all conventional ordnance items in the Department of Defense Inventory.

(2) Be of the latest state-of-the-art using only proven technology.

(3) Maximize the economic return on recoverable materials.

(4) Meet all federal, state, and local environmental standards.

(5) Guarantee the safety of the workers involved.

d. Overview. The Western Demilitarization Facility consists of nine operating buildings, five storage magazines, an administration building, a boiler facility and water treatment plant with three water storage ponds. The buildings are spaced so that a major explosion in any one building cannot set off a sympathetic explosion in another building. The facility is connected to the main depot by two rail

lines and two truck roads. A conventional road goes around the perimeter of the facility. The operating buildings are connected by a driverless tractor network so that ordnance items may be transferred by remote control. In general, ordnance arrives by way of truck and railroad, serving the off-loading dock where they are transferred to the preparation building for uncrating and disassembly. The resulting materials and component parts are then transferred to other operating buildings for further processing.

e. Off-Loading Dock. The Off-loading dock has two revetted chambers capable of accommodating either freight cars or trucks. The chambers are rated at 40,000 pounds of TNT. A detonation of this quantity in one cell would not cause a sympathetic detonation of explosives in the other.

f. Preparation Building. Materials from the off-loading dock arrive by driverless tractor at one end of the building. Here the material is unloaded and unpacked. Materials are then processed through one or more of the six work cells. All operations are remotely controlled from consoles in the control room on the other side of the building. Typical operations are pull-apart of gun ammunition, depriming of cartridge cases, collection of smokeless powder, and defuzing of projectiles. Bulk smokeless powder is transported by belt conveyor from cell No. 5 to the smokeless powder accumulation building. All other materials are loaded onto driverless tractor carts in the other end of the building.

g. Smokeless Powder Accumulation Building. Small-grain smokeless powder comes to this building by vacuum line and is collected in bag filters. Large grain powder comes by conveyor and is collected in hoppers. All powder is weighed, packaged, and hauled off by truck for resale or for use in the large item flashing chamber.

h. Mechanical Removal Building. The building is used for miscellaneous mechanical demilitarization operations including punching, shearing, sawing, and defuzing.

1. Large Cells. The three cells are rated at 3,000 pounds of TNT each, and are located near the mechanical removal building. Operations in the cells are remotely controlled from the control room

Table 9-3. Conventional Ammunition Demilitarization Facilities and Capabilities

TM 9-1300-277

CRANE ARMY AMMUNITION ACTIVITY

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Bldg 146— Substantial dividing walls separate operational bays. Power conveyors. Powder collection system. Disassembly and breakdown equipment.</p>	<p>Steamout Facility operational. Requires pollution abatement programmed FY80.</p> <p>Washout Plant operational. Pollution abatement not required.</p>	<p>2 Deactivation Furnaces with pollution control systems.</p> <p>1 Small Primer Popping Furnace with air and water pollution control systems.</p> <p>FY80 1 APE 1236 Furnace with APE 1276 Air Pollution System. Has been deferred due to lack of need per Indiana Air Pollution Control Board.</p>	<p>30 Detonation Sites with the following restrictions: 500 pounds per site with earth cover.</p> <p>Existing environmental constraint of open demolition area is variance from Indiana Air Pollution Control Board which expires April 1979.</p>	<p>1 Large Site with 12 fixtures for burning Hawk Missile Motors. Presently inactive—used for explosive smokeless or detonation by flashing.</p>

*CAAA is operating both explosive burning and explosive detonation sites under the provisions of APC-2, the Indiana Air Pollution Regulation that allows open burning and/or detonation of hazardous material. The permit (called a variance) that allows CAAA to operate these facilities is renewable on a calendar year basis. CAAA has been assured that the EPA has approved Indiana's SIP, and that the state APCB expects to continue renewing the permit indefinitely.

HAWTHORNE ARMY AMMUNITION PLANT

<p>All Disassembly and Breakdown is done at Demilitarization Bldgs 101-41, 101-44 and 102-31).</p>	<p>Bldg 101-41— Washout/Steamout Remote contour drilling. Large items—bombs, mines, torpedoes.</p> <p>Bldg 101-44— Washout/Steamout 3.5 Projectiles thru M117—750 pound bomb.</p>	<p>Bldg 102-31— 2 Deactivation Furnaces w/o pollution control system. APE 2001 breakdown machine. Small arms thru 20mm fuzes, primers.</p> <p>Deactivation Furnace operation was cited by EPA for emission violations. Operations suspended June 1979.</p>	<p>10 detonation sites.</p> <p>Detonation restrictions; 3,000 pounds above ground per site with sequential detonations.</p> <p>No current environmental restrictions.</p>	<p>2 Open burning areas.</p> <p>Burning restriction: No current environmental restriction.</p>
--	---	--	---	--

All present washout/steamout and deactivation furnace facilities will discontinue operation with start up of the Western Area Demilitarization Facility.

MCALESTER ARMY AMMUNITION PLANT

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Bldg 100— Disassembly breakdown and primer punch out of cartridge case of small arms ammunition including 20mm and 40mm.</p> <p>Bldg 126— Disassembly and defuzing of projectiles/warheads (3 inch, 5 inch, 6 inch, 90mm, 120mm, 5 inch Rocket Warhead.)</p> <p>Bldg 198— Disassembly, breakdown and defuze (2.75 Rocket Warhead, 75mm, 5 inch Rocket Warhead, 5 inch Rocket Motor).</p> <p>Bldg 201— Disassembly and breakdown (4.2 Mortar).</p> <p>Bldgs 109-111— Disassembly, breakdown, and defuzing of large projectiles (8 inch).</p> <p>Bldg 205— Disassembly, breakdown, and defuzing of large projectiles (6 inch, 8 inch, 16 inch).</p>	<p>Bldg 186— Disassembly and steamout plant operational (40mm, 75mm, 90mm, 105mm, 106mm, 120mm, 60mm, 81mm, 4.2 inch, 2.75, 5 inch). Pollution abatement not required.</p> <p>Bldg 445— Washout plant operational (8 inch, 16 inch projectiles). Pollution abatement not required.</p>	<p>Bldg 452— Deactivation furnace APE 1236 with APE 1276 Air Pollution System has been installed to Demilitarize Small Arms Ammunition, Primers, Fuzes, Boosters, and Detonators.</p> <p>Bldg 163— Small Arms breakdown and Primer Popping Furnace not operational (75% complete) pending completion of breakdown equipment, installation of pollution control system, and sprinkler system.</p>	<p>10 detonation sites.</p> <p>Detonation restriction: Depot imposed explosive limit 150 pounds with 15 feet embankments and 4 feet earth cover.</p>	<p>Open area.</p> <p>Burning restriction: Open burning depot limitation to explosives, explosive materials, and pyrotechnic flares until burning cages are manufactured.</p> <p>Completion of burning cages pending funding.</p> <p>6 cages required and clarification of open burning regulations for the State of Oklahoma.</p>

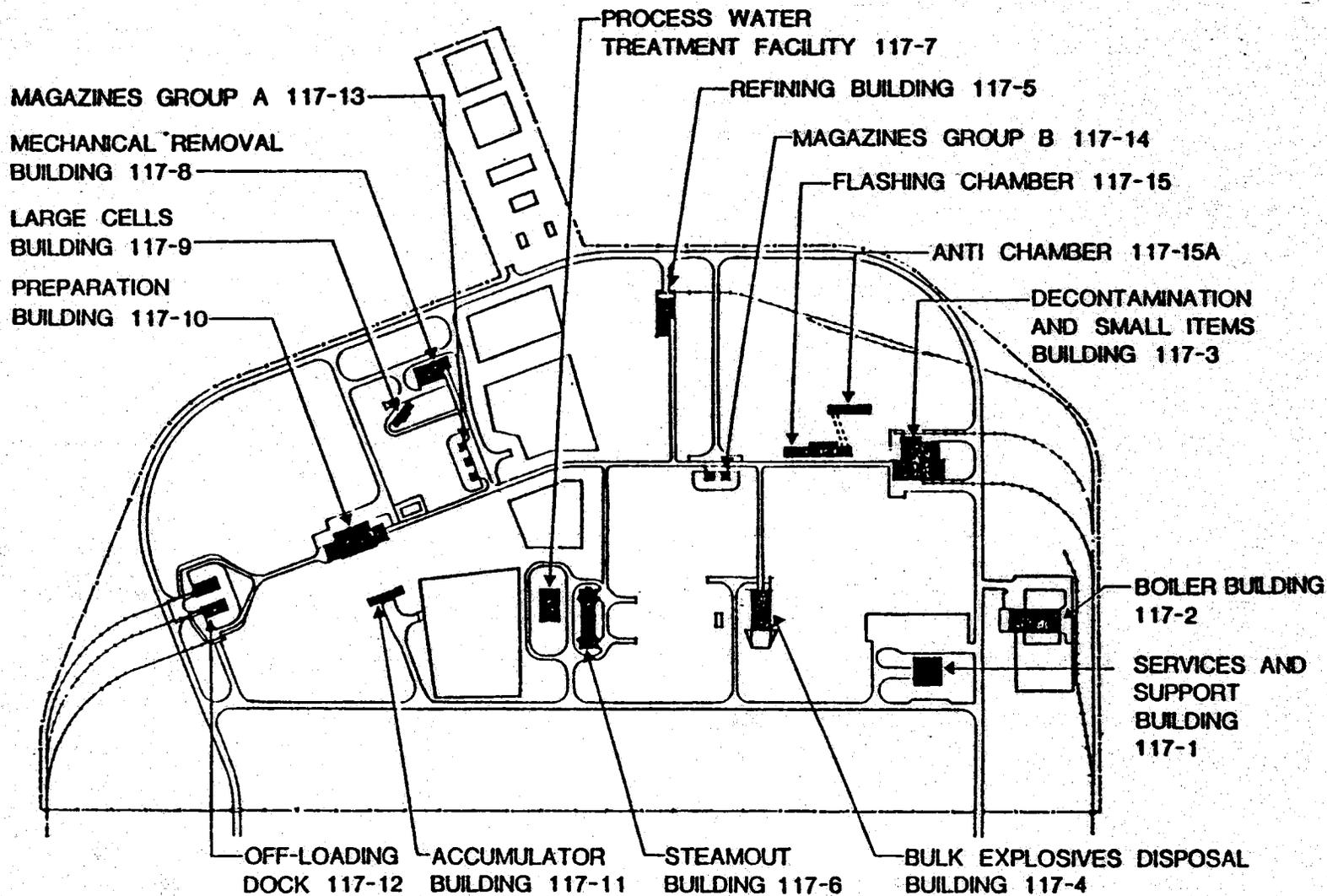
USE EXISTING LAP FACILITIES FOR DISASSEMBLY AND BREAKDOWN.

Table 9-3. Conventional Ammunition Demilitarization Facilities and Capabilities—Continued

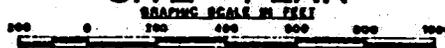
TM 9-1300-277

PINE BLUFF ARSENAL

Disassembly facilities	Washout	Deactivation furnace	Detonation	Open burning
<p>Current demilitarization capability is limited to white phosphorus (WP) munitions. The existing WP Demilitarization Facility Capability includes equipment and tooling for removal of WP from a variety of munitions.</p> <p>Operational limitations require equipment modifications for M34 Grenade M110, 155mm WP and CBU-12 and CBU-22 together with refurbishing line operation equipment.</p> <p>There is a WP Demilitarization and Download Facility, Incinerator Cluster together with supporting pollution abatement systems which provides a demilitarization capability for non-toxic chemical munitions.</p> <ol style="list-style-type: none"> 1. Incinerator complex: <ol style="list-style-type: none"> a. Rotary Kiln Furnace with After Burner Scrubber System. b. Chain Grate Conveyor Furnace with After Burner Scrubber System. c. Fluid Bed Incinerator with Scrubber System and Associated Slurry Preparation. 2. Download Facility 3. WP Demilitarization Facility 4. Colored Smoke Demilitarization Facility. 				<p>No open burning as established by 1977 Clean Air Act.</p> <p>The Arkansas Air Pollution Control Code requires a state permit to open burn.</p> <p>No permit has been applied for all white phosphorus waste being held pending completion of the incinerator complex.</p>



SITE PLAN



ARD 81-0213

Figure 9-2. Site plan showing locations of all principal buildings, roads, and rail lines.

in the mechanical removal building. One cell will house a major caliber defuzer capable of defuzing projectiles up to 16 inches in diameter. The other two cells will contain large band saws for sawing mine cases, depth charges, and large rockets.

j. Refining Building. It is desirable to recover explosives from ordnance items without contamination from steam or water. This is accomplished by a "melt-out" process in which live steam is applied to the outer surface of the item. In the refining building, racks containing the ordnance items are lifted to the top deck by overhead crane and placed in steam enclaves. The molten explosive is collected in hoppers and poured into a "flaking" conveyor where it solidifies into small pieces. The pieces are packaged and hauled away by driverless tractor for storage and resale.

k. Bulk Incinerator Building. Certain explosive materials have no reuse or resale value and must be disposed of by incineration. These materials are moved by driverless tractor to the bulk incinerator building in 55-gallon drums where they are ground up and mixed with water to form a slurry. The slurry is then pumped to two rotary kilns for incineration. An afterburner is provided to reduce the contamination of the resulting smoke. The smoke also passes through a bag filter. Each incinerator can consume 550 pounds of explosive per hour.

l. Washout/Steamout Building. The washout/steamout building has two towers, each of which has an overhead crane. Large items such as mines and depth charges are lifted to the upper work

deck and washed or steamed out. The explosive flows by gravity down through a dryer and onto a flaking conveyor and then is packaged for storage or incineration. A water treatment facility is located adjacent to the washout/steamout building. All process water used will be filtered and recycled.

m. Decontamination Building. The decontamination building contains three rotary furnaces similar to APE 1236. They are used to demilitarize complete rounds of small caliber ammunition, fuzes, and primers. In order to insure that metal parts sold for scrap are completely free from explosive contamination, they must be flashed by raising them to a temperature higher than that necessary to cause the explosive to burn. Medium caliber projectiles are loaded onto racks and moved by an overhead conveyor through a flashing furnace and then past a water spray for cooling. Items too large for the conveyor are loaded onto steel carts and moved into the large items flashing chamber where a powder train is used for flashing. Bag house filters are used to remove any particulates from the smoke resulting from all incineration operations.

n. Administration Building and Boiler Building. The administration building will house offices, a cafeteria, a quality assurance laboratory, and a boiler facility which can be fired by either coal or oil, and has three boilers, each capable of generating 5,000 pounds of steam per hour. Effluent air from the facility is filtered through a series of baghouses before being released to the atmosphere.

o. Magazines. Five magazines are provided for short-term storage to support operations. These magazines are of conventional design.

VII. Cost Estimate Back-Up Sheets



BOOKER ASSOCIATES

FINAL PAGE NO. _____

COST ESTIMATE

EXIST. SYSTEM MODIFIED
GRINDING & CONVEYING SYSTEM

PROJECT NAVAL ORD. STA.

BLDG GRINDING & CONVEYING SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH.

JOB NO. E-2278 DATE 8-5-83 T.O. BY: _____

CK. BY: WN EST. BY: _____

CK. BY: WN PAGE 1 OF 3

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
<u>REMOVAL OF EXIST MECH. COMPONENTS</u>							
<u>VIBR. CONV. M-108</u>	<u>88</u>	<u>HR</u>	<u>30</u>	<u>2640</u>			
<u>" " M-107</u>	<u>28</u>	<u>"</u>	<u>"</u>	<u>840</u>			
<u>" " M-106</u>	<u>88</u>	<u>"</u>	<u>"</u>	<u>2640</u>			
<u>" " M-102</u>	<u>116</u>	<u>"</u>	<u>"</u>	<u>3480</u>			
<u>" " M-103</u>	<u>116</u>	<u>"</u>	<u>"</u>	<u>3480</u>			
<u>8" PINCH VALVE</u>	<u>44</u>	<u>"</u>	<u>"</u>	<u>1320</u>			
<u>VIBR. CONV. M-109</u>	<u>88</u>	<u>"</u>	<u>"</u>	<u>2640</u>			
<u>" " M-110</u>	<u>88</u>	<u>"</u>	<u>"</u>	<u>2640</u>			
<u>GRINDER G-100</u>	<u>116</u>	<u>"</u>	<u>"</u>	<u>3480</u>			
<u>SPIRAL VIBR. M-104</u>	<u>144</u>	<u>"</u>	<u>"</u>	<u>4320</u>			
				<u>27480</u>			

Total This Page

COST ESTIMATE

PROJECT NAVAL ORD. STA.

BLDG EXIST. SYSTEM MODIFIED GRINDING & CONVEYING SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____ DISCIPLINE MECH.

JOB NO. E-2278 DATE 8-5-83 T.O. BY: WW CK. BY: _____

EST. BY: WW CK. BY: _____ PAGE 2 OF 3

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>MODIFICATION OF EQUIP.</u>								
VIBR. CONV. M-102	60	HR	30	1800				
" " M-108	88	"	"	2640				
<u>REINSTALLING EXIST. EQUIP.</u>								
VIBR. CONV. M-102	116	HR	30	3480				
" " M-108	116	"	"	3480				
GRINDER G-100	144	"	"	4320				
<u>INSTALLATION OF NEW EQUIP.</u>								
TRIP GATE	44	HR	30	1320		1500		
LIFT BELT CONV.	176	"	"	5280		12,000		
ELECTRICAL	288	"	"	8640		3500		
PIPING & SPRAY & DELUGE	348	"	"	10440		3000		
				41400		20,000		

COST ESTIMATE

EXIST. SYSTEM MODIFIED
GRINDING & CONVEYING SYSTEM

PROJECT NAVAL ORD. STA.

BLDG GRINDING & CONVEYING SYSTEM

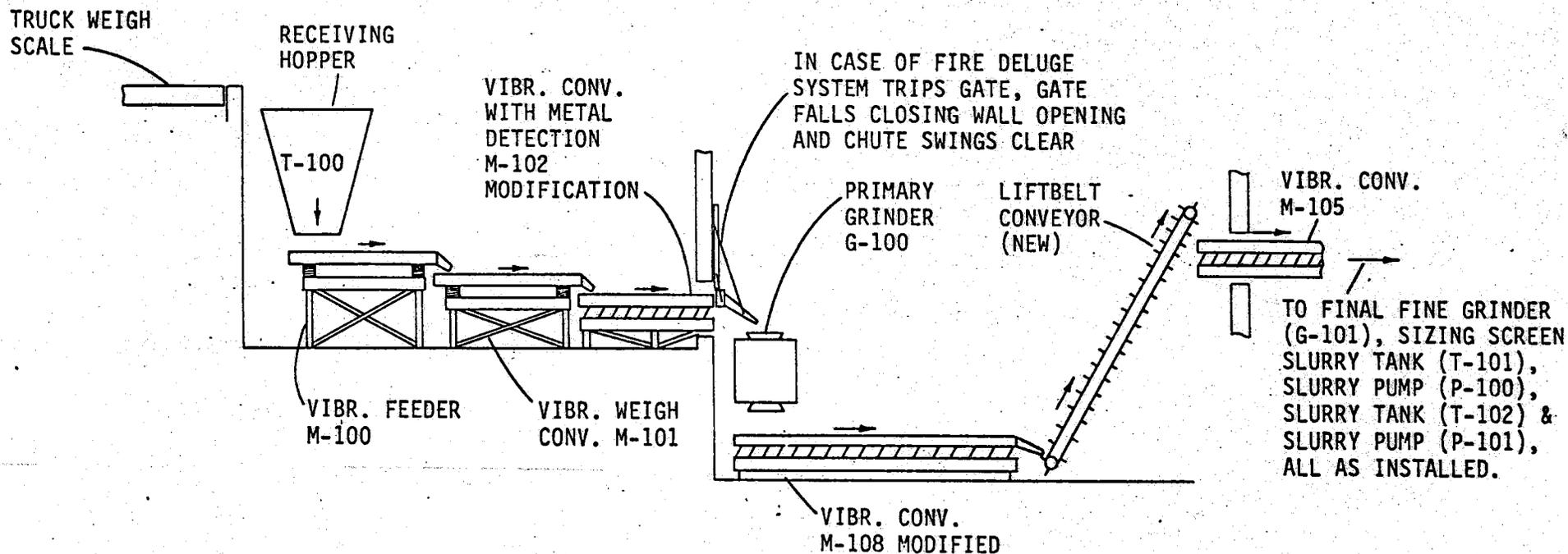
INDIAN HEAD, MD.

BLDG NO. _____ DISCIPLINE MECH

JOB NO E-2278 DATE 8-27-83 T.O. BY: WW CK. BY: _____

EST. BY: WW CK. BY: _____ PAGE 3 OF 3

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
EXISTING SYSTEM MODIFIED. SUMMARY							
Pg. 1				27480		—	
Pg. 2				41400		20000	
				68880		20000	
LABOR/US. 15% - SALES TAX 5%				10332		1000	
				79212		21000	
GENERAL CONDITIONS				7921		2100	
				87133		23100	
CONTRACTOR MARK-UP 25%				21783		5775	
				108916		28875	
CONTINGENCIES 2.5%				27229		7219	
				136145		36094	172239
				SAY \$172,200.00			



NOTES:

- 1) ALL EXISTING EQUIPMENT REUSED EXCEPT SPIRAL VIBRATING CONVEYOR. SPIRAL CONVEYOR REPLACED BY NEW LIFT BELT CONVEYOR.
- 2) EXISTING SPRAY SYSTEM MODIFIED TO SERVICE MODIFIED SYSTEM.

EXISTING SYSTEM MODIFIED



BOOKER ASSOCIATES

FINAL PAGE NO. _____

COST ESTIMATE PROPOSED SYSTEM

PROJECT NAVAL ORD. STA.

BLDG GRINDING & CONVEYING SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH.

JOB NO E-2278 DATE 10-12-83 T.O. BY: WW CK. BY: _____

EST. BY: WW CK. BY: _____

PAGE _____ OF _____

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>PROPOSED SYSTEM - SUMMARY</u>								
Pg. 1				31440				
Pg. 2				30120		400		
Pg. 3				30960		50200		
TOTAL				92520		50600		
LABOR INS. 15% - SALES TAX 5%				13878		2530		
				106398		53130		
GENERAL CONDITION				10640		5313		
				117038		58443		
CONTRACTOR MARK-UP 25%				29260		14611		
				146298		73054		
CONTINGENCIES 25%				36575		18269		
				182873		91318		274191
				\$		<u>274,200⁰⁰</u>		

COST ESTIMATE

PROPOSED SYSTEM

BLDG *GRINDING & CONVEYING SYSTEM*

PROJECT *NAVAL ORD. STA.*

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE _____

JOB NO *E-2278* DATE *10-12-83* T.O. BY: *WU* CK. BY: _____

EST. BY: *WU* CK. BY: _____

PAGE *3* OF _____

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
<u>INSTALLATION OF NEW EQUIP.</u>							
TRIP GATE	44	HR	30	1320		1500	
10'-0" LIFT BELT CONV.	176	"	"	5280		12000	
GRINDER (FLYING KNIFE)	176	"	"	5280		30000	
ELECTRICAL	288	"	"	8640		3500	
PIPING (SPRAY & DELUGE)	348	"	"	10440		3200	
				30960		50200	



BOOKER ASSOCIATES

FINAL PAGE NO. _____

COST ESTIMATE

PROPOSED SYSTEM

PROJECT NAVAL ORD. STA.

BLDG GRINDING & CONVEYING SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH

JOB NO E-2278 DATE 10-12-83 T.O. BY: WU CK. BY: _____

EST. BY: WU CK. BY: _____

PAGE 2 OF _____

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
TANK T-101	88	HR	30	2640				
PUMP - P-100	12	"	30	360				
TANK - T-102	116	"	30	3480				
PUMP - P-101	12	"	30	360				
PUMP - P-104	12	"	30	360				
MISCL. PIPING	144	"	30	4320				
<u>MODIFICATIONS OF EQUIPMENT</u>								
VIBR. CONV. M-102	60	HR	30	1800				
VIBR CONV. M-106	80	"	30	2400				
<u>REINSTALLATION EXIST. EQUIP.</u>								
VIBR. CONV M-102	116	HR	30	3480				
VIBR CONV. M-106	132	"	30	3960				
TANK T-102	116	"	30	3480		200		
PUMP P-101	116	"	30	3480		200		
				30120		400		

Total This Page

COST ESTIMATE

PROPOSED SYSTEM

PROJECT NAVAL ORD. STA.

BLDG GRINDING & CONVEYING SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH.

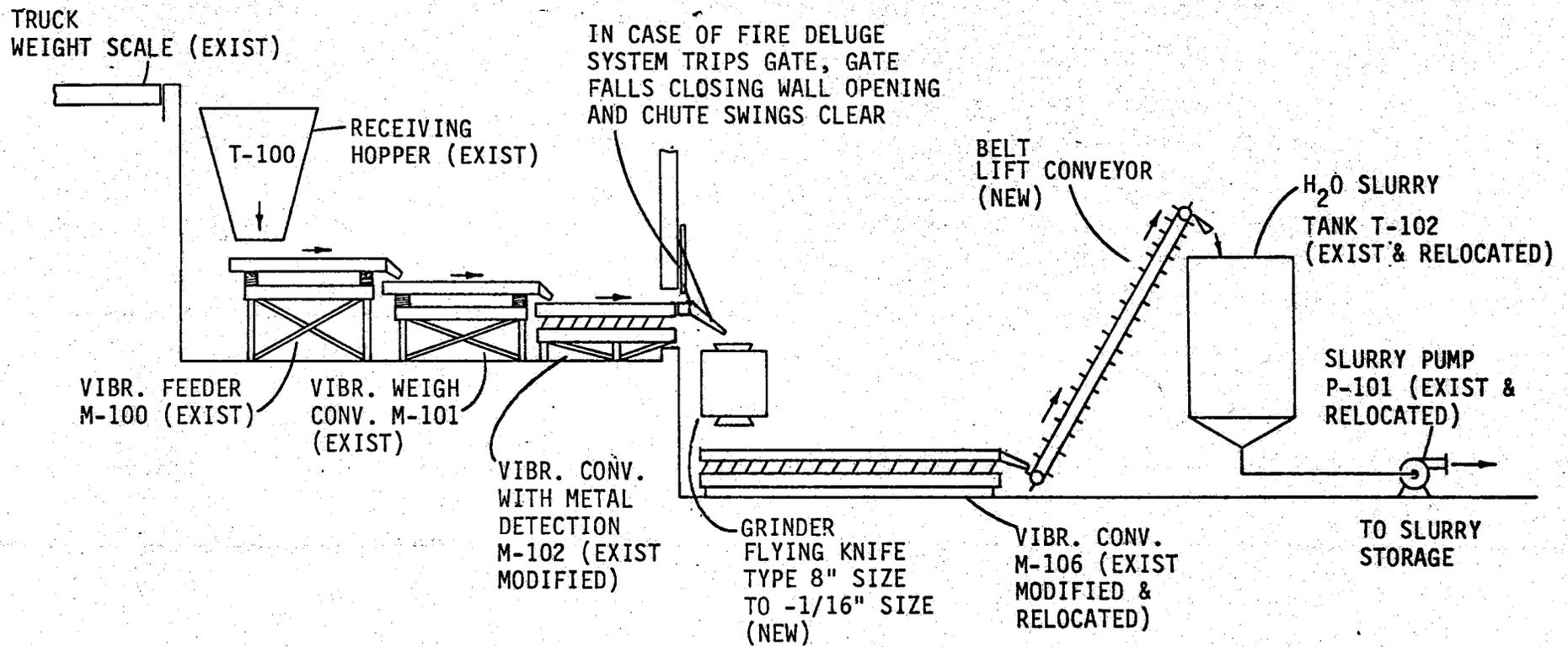
JOB NO. E-2278 DATE _____

T.O. CK.
BY: BY:

EST. CK.
BY: BY:

PAGE 1 OF _____

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>REMOVAL OF EXIST MECH. COMPONENTS</u>								
<u>VIBR. CONV. M-108</u>	<u>88</u>	<u>HR</u>	<u>30</u>	<u>2640</u>				
<u>" " M-107</u>	<u>28</u>	<u>"</u>	<u>"</u>	<u>840</u>				
<u>" " M-106</u>	<u>88</u>	<u>"</u>	<u>"</u>	<u>2640</u>				
<u>" " M-102</u>	<u>116</u>	<u>"</u>	<u>"</u>	<u>3480</u>				
<u>" " M-103</u>	<u>116</u>	<u>"</u>	<u>"</u>	<u>3480</u>				
<u>8" PINCH VALVE</u>	<u>44</u>	<u>"</u>	<u>"</u>	<u>1320</u>				
<u>VIBR. CONV. M-109</u>	<u>88</u>	<u>"</u>	<u>"</u>	<u>2640</u>				
<u>" " M-110</u>	<u>88</u>	<u>"</u>	<u>"</u>	<u>2640</u>				
<u>GRINDER G-100</u>	<u>116</u>	<u>"</u>	<u>"</u>	<u>3480</u>				
<u>SPIRAL VIBR. M-104</u>	<u>144</u>	<u>"</u>	<u>"</u>	<u>4320</u>				
<u>VIBR. CONV. M-105</u>	<u>88</u>	<u>"</u>	<u>"</u>	<u>2640</u>				
<u>8" PINCH VALVE</u>	<u>44</u>	<u>"</u>	<u>"</u>	<u>1320</u>				
				<u>31440</u>				



NOTE:
 THE COMPLETE SYSTEM IS TO HAVE A
 WATER SPRAY SYSTEM TO PREVENT
 TEMPERATURE RISE OF PROPELLANT.

REDESIGNED SYSTEM

Figure VI A-2

COST ESTIMATE

MODIFICATIONS
TO WRO SYSTEM

PROJECT NAVAL PRO. STA.

BLDG _____

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH.

JOB NO E-2278 DATE 8-17-83 T.O. BY: WU CK. BY: _____

EST BY: WU CK. BY: _____

PAGE 1 OF 8

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>1) STEAM GENERATION (BOILER)</u>								
CHECK CONTROLS	16	HR	30	480				
ADD CV IN LINE PWS	4	"	"	120		50		
ADD CV TO CHEM ROOM	4	"	"	120		50		
ADD STRAINER ON HEAD TANK	6	"	"	180		35		
ADD PRV ON HD TANK	4	"	"	120		25		
REMOVE GLOBE V ON MAIN ST. LINE	2	"	"	60		5		
CHECK COMPLETE SYSTEM	48	"	"	1440		200		
TOTAL	84	"	"	2520		365		
<u>2) PROCESS HEAT EXCHANGER</u>								
COAT INTERNAL OF EXCHANGER	72	HR	30	2160		6000		
ELIMINATE SCURRY PIPE ACTING AS TRAP.	24	"	"	720		100		

COST ESTIMATE

MODIFICATIONS

PROJECT NAVAL ORD. STA.

BLDG TO WAD SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH.

JOB NO E-2278 DATE 8-17-83 T.O. BY: WR CK. BY: _____

EST. BY: WR CK. BY: _____

PAGE 2 OF 8

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
INSTALL AUTO TRAPS EACH LEG OF EXCHANGER	24	HR	30	720		400		
INSTALL STRAINER	8	"	11	240		150		
INSTALL NEW V. PRIOR TO CONTR. V.	8	"	11	240		200		
CHECK SYSTEM	24	"	11	720		450		
<u>TOTAL</u>	<u>160</u>			<u>4800</u>		<u>7300</u>		
<u>3) SOLVENT SYSTEM</u>								
ADD. BACKFLOW PREVENTER IN COOL'G H ₂ O HDR.	24	HR		720		150		
TIE WIRE 4 VALVES	2	"	11	60		5		
<u>TOTAL</u>	<u>26</u>			<u>780</u>		<u>155</u>		

COST ESTIMATE

MODIFICATIONS

PROJECT NAVAL ORD. STA.

BLDG TO WAO SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH

JOB NO E-2278 DATE 8-17-83 T.O. BY: UW CK. BY: _____

EST BY: UW CK. BY: _____

PAGE 3 OF 8

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>4) SCURRY SYSTEM - WAO PROCESS</u>								
<u>INSTALL 2 TV MONITORING CAMERAS</u>	<u>72</u>	<u>HR</u>	<u>30</u>	<u>2160</u>		<u>11000</u>		
<u>REPLACE VALVE W/ DIFFERENT TYPE</u>	<u>8</u>	<u>"</u>	<u>"</u>	<u>240</u>		<u>350</u>		
<u>REPLACE 70 VALVES WITH SOFT SEAT VALVES</u>	<u>160</u>	<u>"</u>	<u>"</u>	<u>4800</u>	<u>280 FA</u>	<u>5600</u>		
<u>TIE WIRE 8 VALVES IN OPER. POS.</u>	<u>8</u>	<u>"</u>	<u>"</u>	<u>240</u>		<u>5</u>		
<u>ADD CV IN COOL'G WATER CW-8 LINE</u>	<u>4</u>	<u>"</u>	<u>"</u>	<u>120</u>		<u>50</u>		
<u>MODIFY PRESS SW. MAKE COMPATIBLE</u>	<u>6</u>	<u>"</u>	<u>"</u>	<u>180</u>		<u>80</u>		
<u>CHECK COMPLETE SYSTEM</u>	<u>48</u>	<u>"</u>	<u>"</u>	<u>1440</u>		<u>200</u>		
<u>TOTAL</u>	<u>306</u>	<u>"</u>	<u>"</u>	<u>9180</u>		<u>17285</u>		

COST ESTIMATE

MODIFICATIONS

PROJECT NAVAL ORD. STA.

BLDG. TO WAD SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH.

JOB NO. E-2278 DATE 8-17-82 BY: WW CK. BY: _____

EST. BY: WW CK. BY: _____

PAGE 4 OF 8

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>5) PROCESS PLANT AIR.</u>								
<u>INSTALL REMOTE AUTO OILERS ON COMPRESSOR</u>	<u>16</u>	<u>HR</u>	<u>30</u>	<u>480</u>		<u>250</u>		
<u>DISASSEMBLE & OVERHAUL COMP.</u>	<u>32</u>	<u>"</u>	<u>"</u>	<u>960</u>		<u>300</u>		
<u>COMPLETELY CHECK SYSTEM.</u>	<u>24</u>	<u>"</u>	<u>"</u>	<u>720</u>		<u>100</u>		
<u>TOTAL</u>	<u>72</u>	<u>"</u>	<u>"</u>	<u>2160</u>		<u>650</u>		
<u>4) ELECTRICAL SYSTEM</u>								
<u>CONTROL STEAM HEAT INPUT TO REACTOR.</u>	<u>16</u>	<u>HR</u>	<u>30</u>	<u>480</u>		<u>1500</u>		
<u>TEMP. INTERLOCK</u>	<u>8</u>	<u>"</u>	<u>"</u>	<u>240</u>		<u>1000</u>		
<u>ASSEMBLE 5 FLOW INDICATORS IN SYSTEM</u>	<u>20</u>	<u>"</u>	<u>"</u>	<u>600</u>		<u>2500</u>		
<u>TWO VALVES PCV1 & PCV2</u>	<u>16</u>	<u>"</u>	<u>"</u>	<u>480</u>		<u>3000</u>		

COST ESTIMATE

(MODIFICATIONS TO WAO SYSTEM)

PROJECT NAVAL ORD. STA

BLDG INDIAN HEAD, MD.

INDIAN HEAD, MD.

BLDG NO. _____ DISCIPLINE Mech.

JOB NO E-2278 DATE 8-18-88 BY: WW CK. BY: _____

EST. BY: WW CK. BY: _____ PAGE 5 OF 8

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
Air Flow Control To Reactor	16	HR	30	480		1500		
Level Indicator In Separation Tank	16	"	"	480		1000		
Control Panel Modifications & Check Out	72	"	"	2160		5000		
TOTAL	164			2920		15500		
7) SLURRY COOLER								
Add Gate Valve On CW-6 Prior To CV-208	8	HR	30	240		150		
TOTAL	8			240		150		
8) PROCESS CONTROL VALVE (SLURRY)								
Check Out	2	HR	30	60				
9) HIGH PRESSURE WATER PUMP								
Add Inline Filter To Inlet	8	HR	30	240		150		

PROJECT NAVAL ORD. STA. BLDG TO WAO SYSTEM **MODIFICATIONS**

INDIAN HEAD, MD. BLDG NO. _____ DISCIPLINE _____

JOB NO. E-2278 DATE 8-29-87 CK. BY: WW EST. BY: WW CK. BY: _____ PAGE 7 OF 8

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
<u>RECAP</u>							
1) STEAM GENERATION (BOILER)				2520		365	
2) PROCESS HEAT EXCHANGER				4800		7300	
3) SOLVENT SYSTEM				780		155	
4) SLURRY SYSTEM WAO PROCESS				9160		17285	
5) PROCESS PLANT AIR				2160		650	
6) ELECTRICAL SYSTEM				4920		15500	
7) SLURRY COOLER				240		150	
8) PROCESS CONTROL VALVE (SLURRY)				60		—	
9) HIGH PRESSURE WATER PUMP				240		150	
10) SEPARATOR TANK SYSTEM				—		—	
11) AFTER BURNER				720		350	
12) VAPOR SCRUBBER				480		200	
<u>TOTAL</u>				<u>26080</u>		<u>42105</u>	



BOOKER ASSOCIATES
COST ESTIMATE

FINAL PAGE NO. _____

PROJECT NAVAL ORD. STA.

BLDG MODIFICATIONS TO WAO SYSTEM

INDIAN HEAD, MD.

BLDG NO. _____ DISCIPLINE _____

JOB NO. E-2278 DATE 8-24-87 BY: WU

EST. BY: WU CK. BY: _____ PAGE 8 OF 8

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>SUMMARY</u>								
<u>TOTAL</u>				<u>26080</u>		<u>42105</u>		
<u>LABOR INS. 15% - SALES TAX 5%</u>				<u>3912</u>		<u>2105</u>		
<u>GENERAL CONDITION</u>				<u>29992</u>		<u>44210</u>		
				<u>2999</u>		<u>4421</u>		
<u>CONTRACTOR MARK-UP 25%</u>				<u>32991</u>		<u>48631</u>		
				<u>8248</u>		<u>12158</u>		
<u>CONTINGENCIES 25%</u>				<u>41239</u>		<u>60789</u>		
				<u>10310</u>		<u>15197</u>		
				<u>51549</u>		<u>75986</u>		<u>127,535</u>
								<u>Say \$127,500⁰⁰</u>

ESTIMATE OF DEVELOPMENT, MODIFICATION AND PROVE OUT OF FBI

PROJECT ORDNANCE DISPOSAL

BLDG _____

NOS

BLDG NO. _____ DISCIPLINE _____

JOB NO. E-2278 DATE 3/27/83 T.O. CK. BY: GED BY: _____

EST. CK. BY: _____ PAGE _____ OF _____

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
<u>ENGINEERING TECHNOLOGY DEVELOPMENT.</u>							
<u>ASSUME 2 ENGINEERS AND 2 TECHNICIANS OVER FOUR YEAR PERIOD</u>							
<u>4 X 2000 = 8320 HRS EACH</u>							
<u>2 ENGRS = 16640</u>							
<u>ENGINEERING HOURS,</u>							
<u>1 TECHNICIAN/HOURS</u>							
	<u>16640</u>	<u>HRS</u>	<u>40</u>	<u>665,600</u>			<u>665,600</u>
	<u>16640</u>	<u>HRS</u>	<u>30</u>	<u>499,200</u>			<u>499,200</u>
<u>MISC MATERIAL</u>	<u>1</u>	<u>LS</u>				<u>100,000</u>	<u>100,000</u>
<u>COST OF CONSTRUCTING REDESIGNED FBI SYSTEMS - ALUMINA FEED, MAINTAINABILITY, BED REDSIGN TO ELIMINATE BRD CARRYOVER, ETC</u>	<u>1</u>	<u>LS</u>		<u>250,000</u>		<u>750,000</u>	<u>750,000</u>
<u>STARTUP & TESTING</u>							
<u>1 ENGR, 2 TECHS, LMO.</u>							
	<u>1040</u>	<u>HRS</u>	<u>40</u>	<u>41,600</u>			<u>41,600</u>
	<u>2080</u>	<u>HRS</u>	<u>30</u>	<u>62,400</u>			<u>62,400</u>

Total This Page 2,118,800

SAY \$2,200,000



BOOKER ASSOCIATES
COST ESTIMATE

FINAL PAGE NO. _____

PROJECT CRONANCE DISPOSAL STUDY BLDG WASTE WATER TREATMENT
INDIAN HEAD BLDG NO. _____ DISCIPLINE _____
 JOB NO E-2278 DATE 10-11-83 T.O. _____ CK. _____ EST. _____ CK. _____
 BY: WW BY: _____ BY: _____ PAGE _____ OF _____

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST	
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
SUMMARY - RECOMMENDED								
MODIFICATIONS INCREMENT I								
Pg 1				10080		16200		
Pg 2				11280		13900		
				TOTAL		30100		
LABOR INS. 15% - SALES TAX 5%				3204		1505		
				<u>24564</u>		<u>31605</u>		
GENERAL CONDITIONS				2456		3161		
				<u>27020</u>		<u>34766</u>		
CONTRACTOR MARK-UP 25%				6755		8692		
				<u>33775</u>		<u>43458</u>		
CONTINGENCIES 25%				8444		10865		
				<u>42219</u>		<u>54323</u>	<u>96542</u>	
				TOTAL \$96500⁰⁰				
SUMMARY - RECOMMENDED								
MODIFICATIONS INCREMENT II								
Pg 3				12000		8500		
LABOR INS. 15% - SALES TAX 5%				1800		425		
				<u>13800</u>		<u>8925</u>		
GENERAL CONDITIONS				1380		893		
				<u>15180</u>		<u>9818</u>		
CONTRACTOR MARK-UP 25%				3795		2455		
				<u>18975</u>		<u>12273</u>		
CONTINGENCIES 25%				4744		3068		
				<u>23719</u>		<u>15341</u>	<u>39060</u>	
				TOTAL \$39100⁰⁰				
COMPLETE TOTAL				\$135,600⁰⁰				

PROJECT ORDNANCE DISPOSAL STUDY BLDG WASTE WATER TREATMENT
INDIAN HEAD BLDG NO. _____ DISCIPLINE _____
 JOB NO E-2278 DATE 10-11-83 ST.O. CK. EST. CK.
 BY: BY: BY: BY: PAGE _____ OF _____

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
SUMMARY - ESSENTIAL MODIFICATIONS INCREMENT I							
Pg 1				7680		11850	
Pg 2				11280		13900	
TOTAL				18960		25750	
LABOR INS. 15% - SALES TAX 5%				2844		1288	
				21804		27038	
GENERAL CONDITIONS				2180		2704	
				23984		29742	
CONTRACTOR MARK-UP 25%				5996		7436	
				29980		37178	
CONTINGENCIES 25%				7495		9295	
				37475		46473	83948
TOTAL SAY \$83900 ⁰⁰							
SUMMARY - ESSENTIAL MODIFICATIONS INCREMENT II							
Pg 3				7920		2500	
LABOR INS. 15% - SALES TAX 5%				1188		125	
				9108		2625	
GENERAL CONDITIONS				911		263	
				10019		2888	
CONTRACTOR MARK-UP 25%				2505		722	
				12524		3610	
CONTINGENCIES 25%				3131		903	
				15655		4513	20168
TOTAL SAY \$20200 ⁰⁰							
COMPLETE TOTAL \$104,100 ⁰⁰							

PROJECT ORDNANCE DISPOSAL STUDY

BLDG WASTEWATER TREATMENT

INDIAN HEAD

BLDG NO. 1574

DISCIPLINE ALL

JOB NO. E-2278 DATE 8/15/83 T.O. CK. BY: GPA BY: _____

EST. CK. BY: GEB BY: _____ PAGE 1 OF _____

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
INCREMENT I MODIFICATIONS							
LOW LEVEL INSTRUMENT FOR TANKS T 1A, B, C	1	LS		INSTR 1000		3000	
AUTOMATIC SHUTOFF FOR PUMPS P 2A, B	3			SW PUMP 200		600	
WATER FILL LINE FOR TANK T 2 - 1" x WITH VALVING & TIE INS	64	Hr	30	1920			
WATER FILL LINE FOR TANK T 3 - 1" x WITH VALVING & TIE IN	1	LS					
DISCHARGE PRESSURE GAGE AND ROTAMETER FOR FICHE PUMP P-4	48	Hr	30	1440		450	
SLUDGE RECEIVING EQUIPMENT FOR VACUUM FILT	1	LS			GAGE 400		
500 GAL SURGE TANK AHEAD OF P-6 W LEVEL INSTR & TRANSMITTER	16	Hr	30	480	ROTO 350		
REDUNDANT PUMP FOR P-6 11 GPM, 20 PSIG WITH LOW LEVEL SHUTOFF	1	LS				8000	
TOTAL	96	Hr	30	2880			
	1	EA				1800	
	24	Hr	30	720			
	8	"	30	240		500	
	1	EA			PUMP 500		
	24		30	720			
	8	Hr	30	240		150	
TOTAL				10080		16200	

TOTAL ESSENTIAL MODIFICATIONS 7680

Total This Page 16850

PROJECT ORDNANCE DISPOSAL STUDY BLDG WASTEWATER TREATMENT
INDIAN HEAD BLDG NO. 1574 DISCIPLINE ALL
 T.O. CK. EST. CK.
 JOB NO. E-2278 DATE 8/15/83 BY: CRD BY: GEB BY: GEB PAGE 2 OF

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
MODIFY TEMP CONTROLS AT FEED HEATER E-3 TO LOWER TEMP	1	LS					
	1/6	HR	30	480		200	
INCREASE SLUDGE LINE FROM T-8 TO P-9 FROM 1" TO 3"	1	LS				3900	
	7 1/2	HR	30	2160			
ADD PRESSURE RELIEF TO P-9 DISCH -ROUTE DISCH TO T-8.	24	HR	30	720	TR	350	
					TRPG	500	
ADD CLEAN WATER TANK AS SOURCE OF BACKWASH FOR SAND FILTER 1000 GAL	1	EA			TANK	2800	
	9/6	HR	30	2880	TRPG	600	
BACKWASH PUMP 100 GPM @ 50 FT	1	EA				1800	
	48	HR	30	1440			
BACKWASH HOLDING TANK 1000 GAL	48	HR	30	1440	TANK	2800	
TRANSFER PUMP TO VACUUM FILTER 10 GPM - 20 FT	1	EA			PUMP	500	
	24	HR	30	720			
MISC BACKWASH PIPING AND VALVING-	1	LS					
	48	HR	30	1440		450	
TOTAL				11280		13900	

ALL ESSENTIAL

Total This Page

COST ESTIMATE

PROJECT ORDNANCE DISPOSAL STUDY BLDG WASTEWATER TREATMENT
INDIAN HEAD BLDG NO. 1574 DISCIPLINE ALL
 T.O. CK. EST. CK.
 JOB NO. E2278 DATE 8/15/83 BY: CEB BY: CEB BY: CEB BY: CEB PAGE 3 OF 9

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
<u>INCREMENT II MODIFICATIONS</u>							
<u>LOW LEVEL INSTRUMENT</u>	<u>1</u>	<u>LS</u>			<u>1000</u>	<u>3000</u>	
<u>FOR TANKS T 401 A,B,C</u>					<u>200</u>	<u>600</u>	
<u>AUTOMATIC SHUTOFF</u>	<u>1</u>	<u>HR</u>	<u>30</u>	<u>1920</u>			
<u>FOR P 402 A,B</u>							
<u>DUST HOOD AND SMALL</u>	<u>1</u>	<u>LS</u>			<u>2400</u>	<u>2400</u>	
<u>DUST COLLECTOR AT</u>	<u>72</u>	<u>HR</u>	<u>30</u>	<u>2160</u>			
<u>SODA ASH BAG STATION</u>							
<u>REPLACE PUMP P 409</u>	<u>1</u>	<u>EA</u>			<u>1500</u>	<u>1500</u>	
<u>SLUDGE TRANSFER</u>	<u>24</u>	<u>HR</u>	<u>30</u>	<u>720</u>			
<u>CENTRIFUGAL WITH</u>							
<u>POSITIVE DISPLACEMENT</u>							
<u>15 GPM</u>							
<u>MISCL. ELECT.</u>	<u>80</u>	<u>HR</u>	<u>30</u>	<u>2400</u>		<u>1000</u>	
<u>SYSTEM CHECK</u>	<u>160</u>	<u>HR</u>	<u>30</u>	<u>4800</u>			
<u>PIPING ELECTRICAL</u>							
<u>EQUIPMENT (NOT</u>							
<u>START-UP REQUIRE-</u>							
<u>MENTS FOR START</u>							
<u>UP.)</u>							
<u>TOTAL</u>				<u>12000</u>		<u>8500</u>	
<u>TOTAL ESSENTIAL</u>							
<u>MODIFICATIONS</u>				<u>7920</u>		<u>2500</u>	

COST ESTIMATE

PROJECT NAVAL ORD. STP
INDIAN HEAD, MD.

BLDG ALTERNATE WASTE WATER TREATMENT FACILITY

BLDG NO. _____ DISCIPLINE _____

JOB NO. E-2278 DATE 10-27-83

CK. BY: _____ EST BY: WW CK. BY: _____

PAGE _____ OF _____

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>RECAP.</u>								
TOTAL				87360		141,365		
LABOR/MS. 15% - SALES TAX 5%				13104		7068		
GENERAL COND.				100464		148433		
				10046		14843		
CONTRACTOR MARK-UP 25%				110510		163276		
				27628		40819		
CONTINGENCIES 25%				138138		204095		
				34535		51024		
TOTAL				172673		255119		427792
				SAY \$427,800 ⁰⁰				



BOOKER ASSOCIATES

FINAL PAGE NO. _____

COST ESTIMATE

PROJECT NAVAL ORD. STA.
INDIAN HEAD, MD.

BLDG ALTERNATE WASTE WATER TREATMENT FACILITY

BLDG NO. _____ DISCIPLINE _____

JOB NO. E-2278 DATE 10-27-83 T.O. BY: _____

CK. BY: _____ EST BY: WJL CK. BY: _____ PAGE 1 OF _____

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>PUMPS RELOCATED & REUSED</u>								
PUMP P-9 (FROM LIME SLURRY TK.)	32	HR	30	960		25		
PUMP P-4 (FROM FERRIC SULFATE TK.)	32	"	30	960		25		
PUMP P-2A (FROM CLEAR WELL)	32	"	30	960		25		
PUMP P-3 (FROM CAUSTIC TK.)	32	"	30	960		25		
PUMP P-2B (FROM NEUTRALIZATION TK.)	32	"	30	960		25		
<u>TANKS RELOCATED & REUSED</u>								
TANK T-8 & MIXER A-4 (FOR LIME SLURRY)	24	HR	30	720		15		
TANK T-3 & MIXER A-2 (FOR FERRIC SULFATE)	24	"	30	720		15		
TANK T-1A (BACKWASH WATER TANK)	28	"	30	840		20		
TANK T-1B (NEUTRALIZATION TANK)	28	"	30	840		20		
				7920		195		

Total This Page

COST ESTIMATE

ALTERNATE WASTE
WATER TREATMENT FACILITY

PROJECT NAVAL ORD. STA
INDIAN HEAD, MD.

BLDG NO. _____ DISCIPLINE _____

JOB NO E-2278 DATE 10-27-83 T.O. CK. BY: _____

EST BY WW CK. BY: _____ PAGE 2 OF _____

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
<u>TANKS RELOCATED & REUSED (CONTINUED)</u>							
<u>TANK T-12 (CAUSTIC TANK)</u>	<u>29</u>	<u>HR</u>	<u>30</u>	<u>720</u>		<u>20</u>	
<u>EXIST PRECOAT FILTER & ASSOC. EQUIPMENT.</u>							
<u>PRECOAT FILTER H-2</u>	<u>60</u>	<u>HR</u>	<u>30</u>	<u>1800</u>		<u>75</u>	
<u>PUMP P-7</u>	<u>24</u>	<u>"</u>	<u>30</u>	<u>720</u>		<u>15</u>	
<u>TANK T-4</u>	<u>28</u>	<u>"</u>	<u>30</u>	<u>840</u>		<u>30</u>	
<u>TANK T-5</u>	<u>28</u>	<u>"</u>	<u>30</u>	<u>840</u>		<u>30</u>	
<u>NEW EQUIPMENT.</u>							
<u>FOUNDATION WORK (ALL)</u>	<u>64.0</u>	<u>HR</u>	<u>30</u>	<u>19200</u>		<u>20,000</u>	
<u>CLARIFIER</u>	<u>340</u>	<u>HR</u>	<u>30</u>	<u>10200</u>		<u>33000</u>	
<u>FILTERS (2)</u>	<u>340</u>	<u>"</u>	<u>30</u>	<u>10200</u>	<u>19000</u>	<u>39,000</u>	
<u>CLEAR WALK</u>	<u>80</u>	<u>"</u>	<u>30</u>	<u>2400</u>		<u>2000</u>	
<u>CATION EXCHANGE UNITS (2)</u>	<u>160</u>	<u>"</u>	<u>30</u>	<u>4800</u>	<u>4000</u>	<u>8000</u>	
<u>HCL TANK</u>	<u>60</u>	<u>"</u>	<u>30</u>	<u>1800</u>		<u>1000</u>	
				<u>53520</u>		<u>94170</u>	

COST ESTIMATE

ALTERNATE WASTE WATER TREATMENT FACILITY

PROJECT NAVAL ORD. STA. INDIAN HEAD, MD.

BLDG WATER TREATMENT FACILITY
BLDG NO. _____ DISCIPLINE _____

JOB NO. E-2278 DATE 10-27-83 T.O. BY: _____ CK. BY: _____

EST BY: WLL CK. BY: _____ PAGE 3 OF _____

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
<u>NEW EQUIPMENT (CONT.)</u>								
HCL PUMP.	32"	30	960			1500		
PROCESS PUMP	32"	30	960			1500		
VALVES (30)	1/2"	30	3600		200	6000		
PIPING	3/4"	30	10200			18000		
ELECTRICAL (CONTROLS ETC)	1/4"	30	10,200			20,000		
TOTAL				25920		47000		
Pg. 1				7920		195		
Pg. 2				53520		94170		
TOTAL				87360		141365		
TOTAL SAY								\$228,700 ⁰⁰

Client: Indian Head, NOS

Proj. No: E-2278

Prel. Pg. No: 1

Location: Indian Head, Md.

Calc: LMS

Date: 10/10/83

Subject: ~~Indian Head~~ Waste Treatment

Chkd: WNV

Date: 10/24/80

ALTERNATE

Bkchkd:

Date:

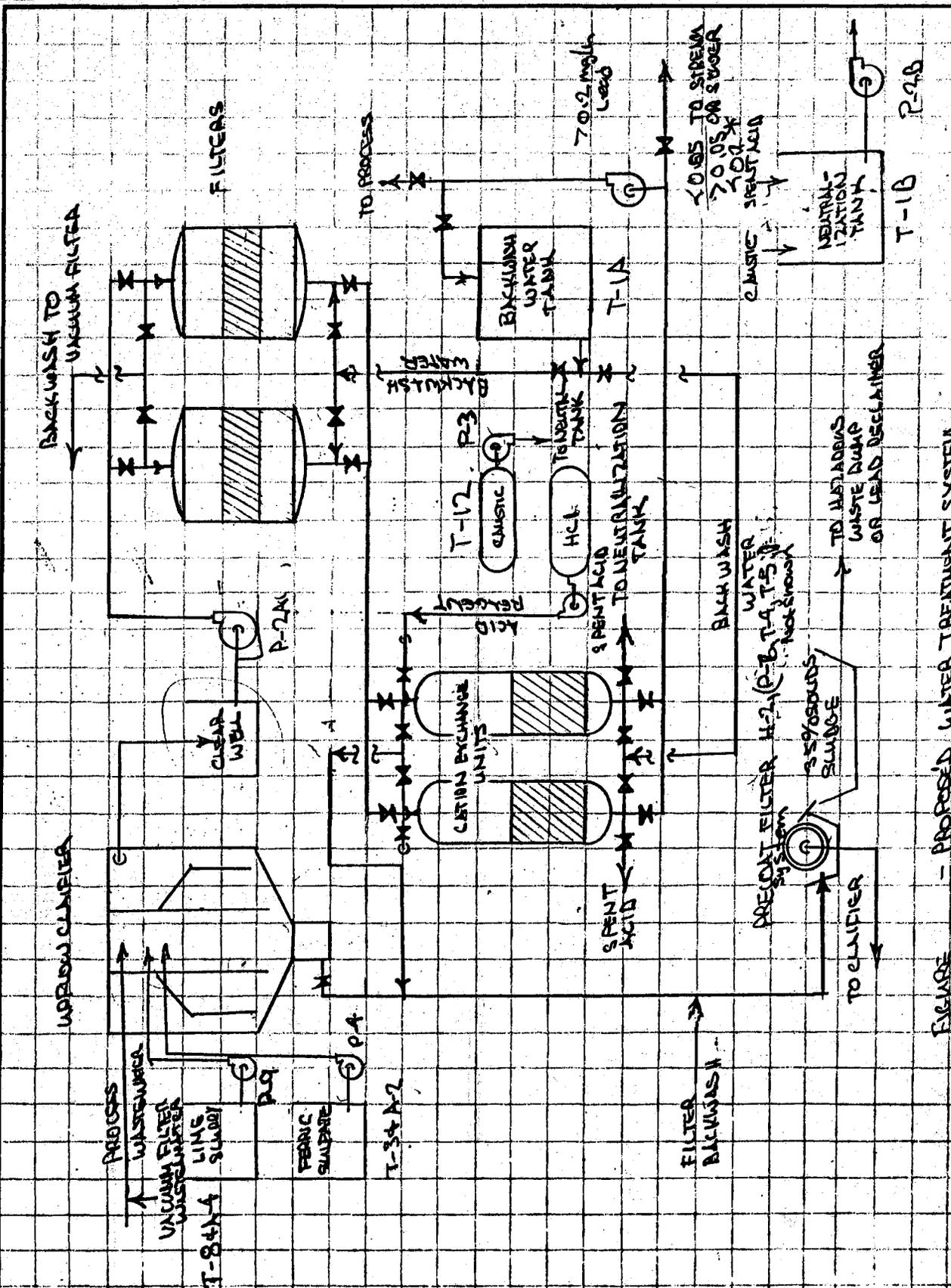


FIGURE - PROPOSED WATER TREATMENT SYSTEM

(INCREMENT 1)

* HSD MASS ALLOWABLE

VIII. Miscellaneous Calculations

NOS WAO UNIT CALCULATIONS

AFTER BURNER - HEAT CAPACITY, RESIDENCE
TIME, PRESSURE DROP

WET SCRUBBER EVALUATION

Client: CHESDIN

Proj. No: E-2278

Prel. Pg. No: 1 of

Location: INNANHEAD Md.

Calc: J. CLAYSON

Date: 4-23-83

Subject: AFTERBURNER

Chkd: GEB

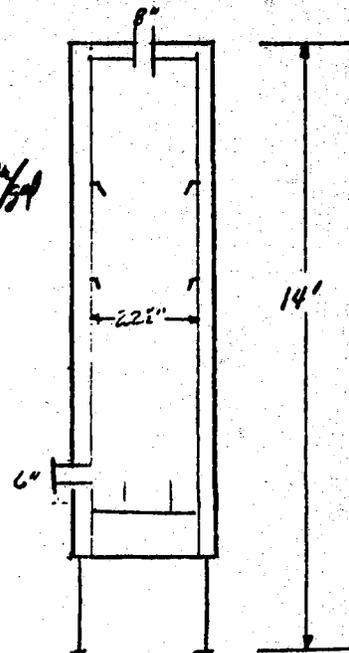
Date: 10/27/83

Bkchkd:

Date:

- Afterburner interior volume $\approx 27.6 \text{ ft}^3$
- burner capacity = 2.56-7.0 gph
- AVAILABLE HEAT #2 fuel oil at an exhaust of 1200° = 97,000 Btu/gal

BASED ON PRELIMINARY TEST DATA FROM THE PROPELLANT RUN VAPORS AT 10 gph would be approximately 375 SCFM. Size at 500 SCFM to give safety factor.



HEAT REQUIRED TO RAISE EXHAUST TO 1200°F

$$q = \dot{m} (h_{1200} - h_{70})$$

$$q = \left(500 \frac{\text{ft}^3}{\text{min}} \times 0.75 \frac{\text{lb}}{\text{ft}^3} \times \frac{60 \text{ min}}{\text{hr}} \right) (412.1 - 126.7) \frac{\text{Btu}}{\text{lb}_m}$$

$$q = \underline{642,150 \text{ Btu/hr.}}$$

FUEL REQUIREMENTS TO MEET THIS DEMAND

$$\dot{m}_f = \frac{642,150 \text{ Btu/hr.}}{97,000 \text{ Btu/gal}}$$

$$\dot{m}_f = \underline{6.6 \text{ gal/hr.}} \quad (7.0 \text{ gal/hr is available})$$

This is considered acceptable. Therefore the afterburner appears to have adequate capacity for this application.

Client: CHESDIV

Proj. No: E-2270

Prel. Pg. No: 2 of

Location: INDIAN HEAD

Calc: J CLAYSON

Date: 4-23-83

Subject: AFTERBURNER

Chkd: GRD

Date: 10/27/83

Bkchkd:

Date:

DETERMINE RESIDENCE TIME.

DENSITY OF GAS AT 1200°F and elevation < 100'

$$\rho = \frac{1.325 \times 29.9}{(1200 + 460)}$$

$$\rho = .0239 \text{ lb/ft}^3$$

$$Q = 500 \times \frac{075}{.0239}$$

$$Q = 1571 \text{ ACFM}$$

$$Q = 26.2 \text{ ft}^3/\text{sec}$$

$$\text{RESIDENCE TIME} = \frac{\text{Volume}}{Q}$$

$$T = \frac{27.6 \text{ ft}^3}{26.2 \text{ ft}^3/\text{sec}}$$

$$T = 1.05 \text{ sec}$$

The 1.05 second RESIDENCE TIME AT 1200°F WILL BE ADEQUATE TO DESTROY THE CO. NO_x FORMATION SHOULD NOT BE A PROBLEM AT THIS TEMPERATURE.

The SIZE AND CAPACITY OF THE AFTERBURNER APPEAR ACCEPTABLE.

Client: CHESDI

Proj. No: E-2270

Prel. Pg. No: 3d

Location: INDIAN HEAD

Calc: J CLAYSON

Date: 4-23-83

Subject: AFTERBURNER

Chkd: GEB

Date: 10/27/83

Bkchkd:

Date:

ANALYZE DUCTING SIZE.

INLET DUCT IS 6" DIA.

THE INLET GAS CONDITIONS ARE ESSENTIALLY AT STANDARD CONDITIONS

$$V = \frac{Q}{A}$$

$$V = \frac{500 \text{ ft}^3/\text{min}}{\left(\frac{6}{12}\right)^2 \frac{\pi}{4} \text{ ft}^2}$$

$$V = 2546 \text{ ft/min}$$

velocity pressure.

$$V = 1096.2 \sqrt{\frac{UP}{\rho}}$$

$$UP = \left(\frac{V}{1096.2}\right)^2 \rho$$

$$UP = \left(\frac{2546}{1096.2}\right)^2 \times 0.075$$

$$UP = .405 \text{ in H}_2\text{O}$$

Assume entrance loss = 1.0 UP

$$\Delta P = .405 \text{ in H}_2\text{O}$$

For 6" duct at 500 CFM $\Delta P/100' \approx 1.6 \text{ in}/100'$

approx 50' EQUIVALENT LENGTH $\Rightarrow 0.8"$

EXIT LOSSES (GAS AT 1200°F, 1571 ACFM, $\rho_a = 0.239 \text{ lb/ft}^3$)

$$V = \frac{Q}{A}$$

$$V = \frac{1571 \text{ ft}^3/\text{min}}{\left(\frac{6}{12}\right)^2 \frac{\pi}{4}}$$

$$V = 4498 \text{ ft/min}$$

Client: CHESDIN

Proj. No: E-2278

Prel. Pg. No: 4 of

Location: INDIAN HEAD

Calc: J. CLAYSON

Date: 4-23-83

Subject: AFTERBURNER

Chkd: GRB

Date: 10/27/83

Bkchkd:

Date:

$$VP = \left(\frac{V}{1096.2} \right)^2 P$$

$$VP = \left(\frac{4498}{1096} \right)^2 \times 0.239$$

$$VP = .402 \text{ in H}_2\text{O}$$

$$\text{exit loss} \approx .5 VP \Rightarrow .2 \text{ in H}_2\text{O}$$

DUCT loss at 4498 ft/min & 8" DIA \approx 3.7 in/100ft

$$\text{DUCT} < 10' \Rightarrow .37''$$

The entire / exit sizing appear adequate. No problems anticipated. Total loss ON AFTERBURNER SIDE OF BLOWER estimated to be less than $2\frac{1}{2}$ in H₂O

EXHAUST STACK

The EXHAUST STACK FOR THE AFTERBURNER AS DEPICTED IN DRAWING I-18-D-511 SHOWS A WEATHER CAP OR HOOD. PER THE ATTACHED SHEETS TAKEN FROM THE SMACNA "INDUSTRIAL VENTILATION" THIS IS NOT RECOMMENDED IT WILL NOT ALLOW THE EMISSIONS TO PROPERLY DISPERSE IN THE ATMOSPHERE SINCE THEY DEFLECT THE DISCHARGE DOWNWARDS.

INDUSTRIAL VENTILATION

A Manual of Recommended Practice

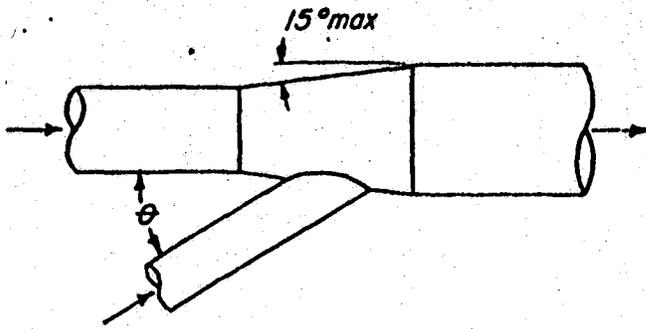
17th Edition

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS



Endorsed by the

**SHEET METAL AND AIR CONDITIONING CONTRACTORS'
NATIONAL ASSOCIATION, INC.**

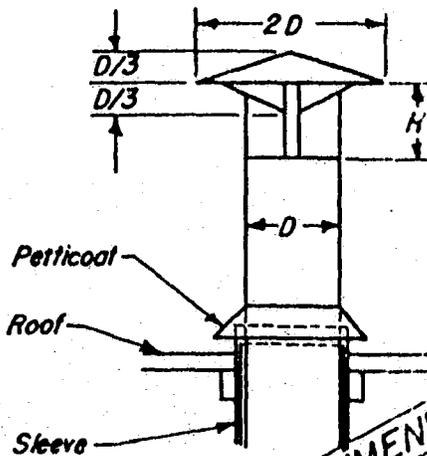


Angle θ Degrees	Loss Fraction of VP in Branch
10	0.06
15	0.09
20	0.12
25	0.15
30	0.18
35	0.21
40	0.25
45	0.28
50	0.32
60	0.44
90	1.00

Note: Branch entry loss assumed to occur in branch and is so calculated.

Do not include an enlargement regain calculation for branch entry enlargements.

BRANCH ENTRY LOSSES



NOT RECOMMENDED

WEATHER CAP LOSSES

H, No. of Diameters	Loss Fraction of VP
1.0 D	0.10
0.75 D	0.18
0.70 D	0.22
0.65 D	0.30
0.60 D	0.41
0.55 D	0.56
0.50 D	0.73
0.45 D	1.0

See Fig. 6-24

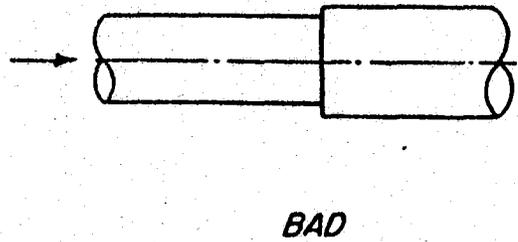
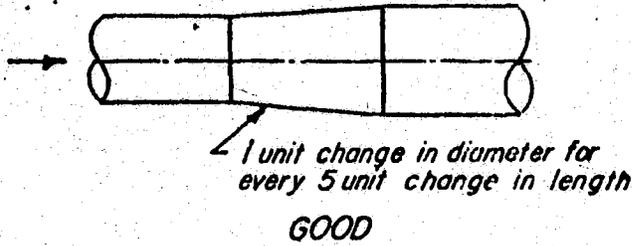
AMERICAN CONFERENCE OF
GOVERNMENTAL INDUSTRIAL HYGIENISTS

DUCTWORK DESIGN DATA

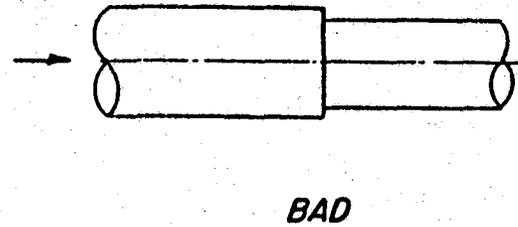
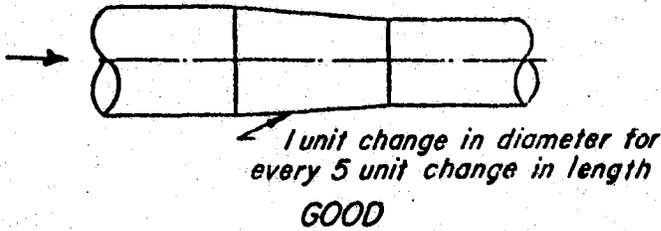
DATE 1-76

Fig. 6-13

DUCT ENLARGEMENT

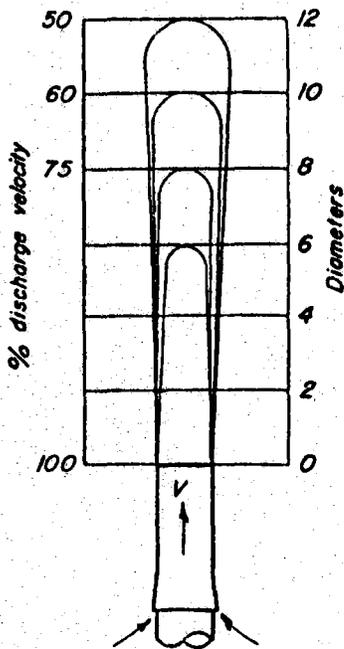


DUCT CONTRACTION



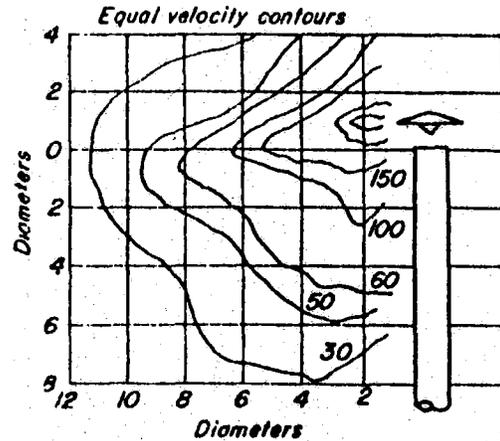
See Fig 6-6

STACKHEAD



Vertical discharge cap throws upward where dilution will take place.

WEATHER CAP



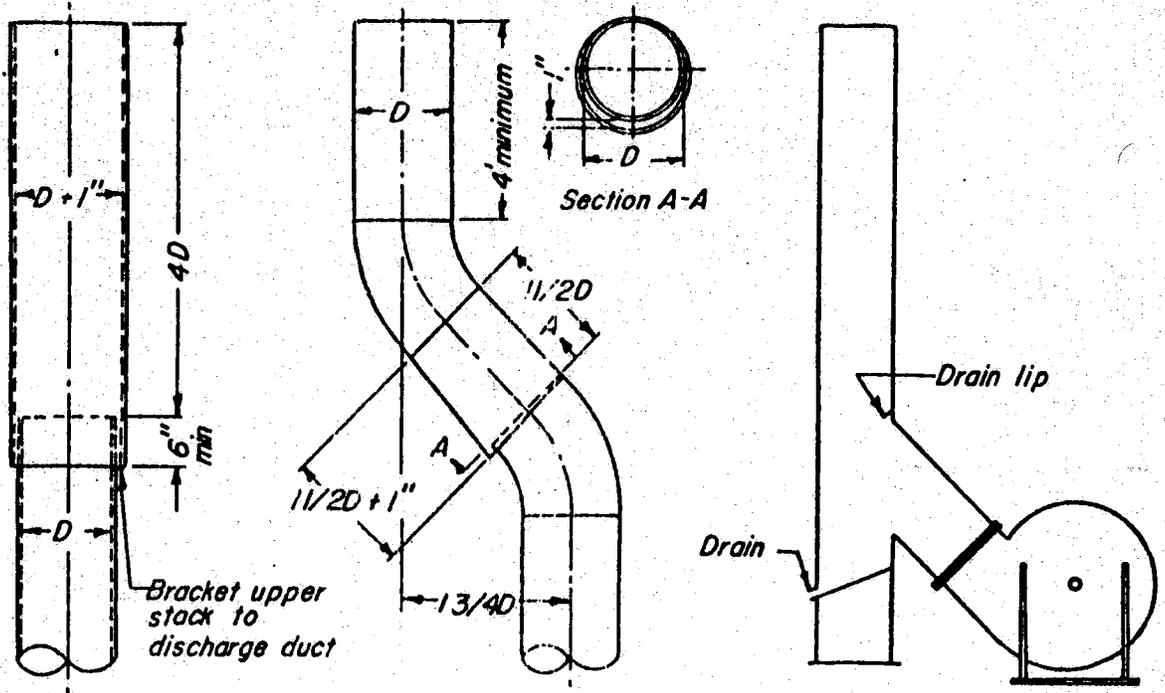
Deflecting weather cap discharges downward.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

PRINCIPLES OF DUCT DESIGN

DATE 1-82

Fig. 6-22



VERTICAL DISCHARGE ⁽⁸⁷⁾⁽¹¹⁶⁾

No loss

OFFSET ELBOWS ⁽¹⁰⁶⁾

Calculate losses due to elbows

OFFSET STACK ⁽¹⁰⁶⁾

1. Rain protection characteristics of these caps are superior to a deflecting cap located 0.75D from top of stack.
2. The length of upper stack is related to rain protection. Excessive additional distance may cause "Blowout" of effluent at the gap between upper and lower sections. ⁽⁸⁶⁾

AMERICAN CONFERENCE OF
GOVERNMENTAL INDUSTRIAL HYGIENISTS

STACKHEAD DESIGNS

DATE 1-76

Fig. 6-24

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No: 1 of

Location: INDIAN HEAD

Calc: J CLAYSON

Date: 12 May 83

Subject: SCRUBBER EVALUATION

Chkd: GEB

Date: 10/27/83

Bkchkd:

Date:

GIVEN - RACKED WET SCRUBBER

INSIDE DIAMETER = 12"

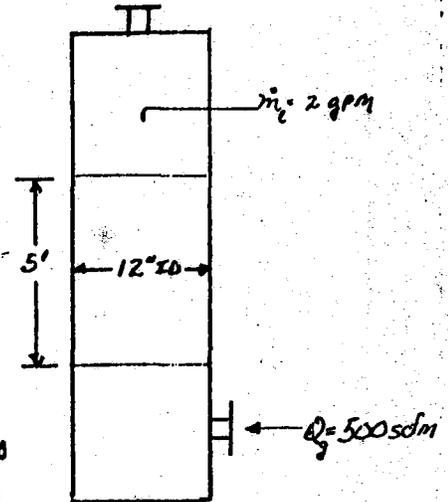
BED HEIGHT = 5'

LIQUID FLOW = 2 gpm

PACKING MATERIAL - CERAMIC

BASED ON A GAS FLOW OF 500 SCFM at 200°F into the scrubber and a liquid flow of 2.0 gpm determine if the 12" ID is acceptable.

FLUID FLOW - DETERMINE weight of liquid PER SQUARE FOOT of tower cross-section (800 lb/hr ft² is desirable as minimum)



$$m_l = \frac{2 \frac{\text{gal}}{\text{min}} \times 8.31 \frac{\text{lb}}{\text{gal}} \times 60 \frac{\text{min}}{\text{hr}}}{\frac{12^2}{4} \text{ ft}^2}$$

$$m_l = 1270 \text{ lb/hr ft}^2$$

∴ fluid flow is acceptable.

$$\frac{L'}{V'} \left(\frac{\rho_g}{\rho_L} \right)^{0.5}$$

$$L' (\text{liquid flow rate}) = 2 \frac{\text{gal}}{\text{min}} \times 8.31 \frac{\text{lb}}{\text{gal}} \times 60 \frac{\text{min}}{\text{hr}} = 997 \text{ lb/hr}$$

$$V' (\text{gas flow rate}) = 500 \frac{\text{ft}^3}{\text{min}} \times 0.75 \frac{\text{lb}}{\text{ft}^3} \times 60 \frac{\text{min}}{\text{hr}} = 2250 \text{ lb/hr}$$

$$\rho_g (\text{density of gas}) = 0.60 \text{ lb/ft}^3 \text{ (at sea level } \& 200^\circ\text{F)}$$

$$\rho_L (\text{density of liquid}) = 62.3 \text{ lb/ft}^3$$

Client: CHASDI

Proj. No: E-227B

Preli. Pg. No: 2 of

Location: INDIAN HEAD

Calc: J. CLAYSON

Date: 12 MAY 83

Subject: SCRUBBER EVALUATION

Chkd: GRB

Date: 10/27/83

Bkchkd:

Date:

$$\frac{L'}{V'} \left(\frac{P_g}{P_L} \right)^{0.5} = \frac{997}{2250} \left(\frac{0.60}{62.3} \right)^{0.5}$$

$$= 0.0137$$

BASED ON ABOVE VALUE, THE FOLLOWING VALUE IS TAKEN FOR Figure 145 of "Air Pollution Engineering Manual" Published by the US Environmental Protection Agency.

$$\frac{G^2 \left(\frac{a}{g_c} \right) \mu^2}{g_c P_g P_L} = 0.25$$

where: G (gas flow rate lb/sec-ft²) =

a/g_c (packing factor) = 175 (BASED ON 1" RASCHIG RINGS)

μ (liquid viscosity) = 1.0 centipoises at 68°F

g_c (gravitational const) 32.2 ft/sec

$$G = \left(\frac{0.25 g_c P_g P_L}{\left(\frac{a}{g_c} \right) \mu^2} \right)^{1/2}$$

$$G = \left(\frac{0.25 \times 32.2 \times 0.06 \times 62.3}{175 \times 1.0^2} \right)^{1/2}$$

$$G = .415 \text{ lb/sec ft}^2$$

$$D = \left(\frac{4V'}{G \cdot f \cdot \pi \cdot 3600} \right)^{1/2}$$

D (INSIDE TOWER DIAMETER)

f (flooding fraction) = .55 (40-70% is standard)

Client: CHESDI

Proj. No: E-2278

Prel. Pg. No: 3 of

Location: INDIAN HEAD

Calc: J. CLAYSON

Date: 12 MAY 83

Subject: SCRUBBER EVALUATION

Chkd: GED

Date: 10/27/83

Bkchkd:

Date:

$$D = \left[\frac{4 \times 2250 \frac{\text{ft}^3}{\text{hr}}}{.415 \frac{\text{ft}^3}{\text{sec}} \times .55 \times \pi \times 3600 \frac{\text{sec}}{\text{hr}}} \right]$$

$$D = \underline{\underline{1.87 \text{ ft} = 22.4 \text{''}}}$$

- o. Under the stated conditions the tower's inside diameter should be 22.4 inches.

CONCLUSION: The existing wet scrubber is too small. BACK CALCULATIONS yield that the existing 12 inch inside diameter scrubber is sized for APPROXIMATELY 110 SCFM.

NOS FBI ENTRAINMENT CALCULATIONS

Client: CHSDIV

Proj. No: E-2278

Prel. Pg. No: 1

Location: INDIAN HEAD

Calc: B CRIST

Date: 6/9/83

Subject: FBE ENTERTAINMENT

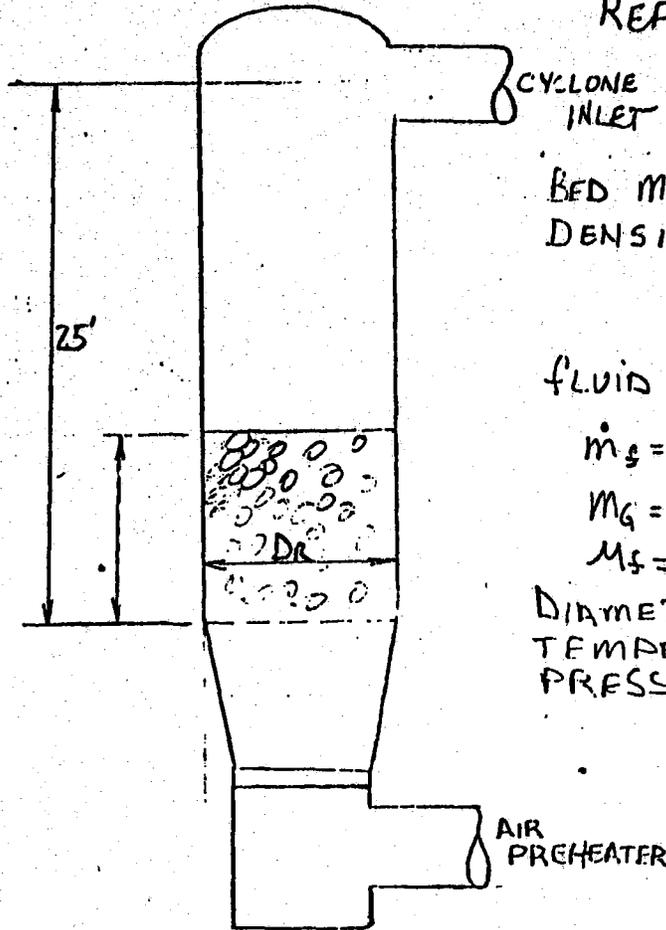
Chkd: GRB

Date: 10/27/83

Bkchkd:

Date:

PROPERTIES GIVEN



REF: FLUID BED REACTORS,
AMERICAN INSTITUTE OF
CYCLONE INLET CHEMICAL ENGINEERS

BED MATERIAL - ALUMINA
DENSITY PARTICLE = $\rho_p = 24.9 \frac{\text{lbs}}{\text{ft}^3}$

FLUID

$$\dot{m}_s = 11362 \frac{\text{lb}}{\text{hr}}$$

$$M_G = 24.9 \frac{\text{lb}}{\text{lb-mole}}$$

$$M_s = 3.09 \times 10^{-5} \frac{\text{lb}}{\text{foot}^2 \text{ sec}}$$

$$\text{DIAMETER REACTOR} = D_R = 6' 2\frac{1}{2}'' = 74.5$$

$$\text{TEMPERATURE} = 1650^\circ\text{F} = 2110^\circ\text{R}$$

$$\text{PRESSURE} = 1.5 \text{ psig} = 16.2 \text{ psia}$$

SOLVING FOR ρ_f

$$PV = RT \quad V = m_g \cdot N$$

$$v_g = \frac{1}{\rho_g}$$

$$\frac{P m_g}{\rho_g} = RT \quad \therefore \rho_g = \frac{m_g P}{RT}$$

$$R = 1545 \frac{\text{ft} \cdot \text{lb}}{\text{lb mole} \cdot ^\circ\text{R}}$$

$$\rho_f = \frac{m_g P}{RT} = \frac{(24.9 \frac{\text{lb}}{\text{lb mole}}) (16.2 \frac{\text{lb}}{\text{in}^2}) (\frac{144 \text{ in}^2}{\text{ft}^2})}{1545 \frac{\text{ft} \cdot \text{lb}}{\text{lb mole} \cdot ^\circ\text{R}} (2110^\circ\text{R})} = 0.0178 \frac{\text{lbs}}{\text{ft}^3}$$

SUPERFICIAL GAS VELOCITY

SINCE $Q = VA =$

$$A = \frac{\pi D^2}{4}$$

$$Q = \frac{\dot{m}}{\rho} = \frac{\dot{m} \frac{\text{lbs}}{\text{hr}}}{\rho \frac{\text{lbs}}{\text{ft}^3}}$$

$$V \left(\frac{\pi D^2}{4} \right) = \frac{\dot{m}_s}{\rho_s}$$

Client: CHESDIN

Proj. No: E-2778

Prel. Pg. No: 2

Location: INDIAN HEAD

Calc: B CRIST

Date: 6/9/83

Subject: FBI ENTRAINMENT

Chkd: GRB

Date: 10/27/83

Bkchkd:

Date:

SOLVING FOR V_e

$$V_e = \frac{m_s / \rho_s}{\frac{\pi D R^2}{4}} = \frac{\left(\frac{11362 \frac{\text{lbs}}{\text{hr}} \cdot \frac{\text{hr}}{3600 \text{ sec}}}{0.0178 \frac{\text{lbs}}{\text{ft}^3}} \right)}{\frac{\pi (74.5)^2 \text{ in}^2 \left(\frac{\text{ft}^2}{144 \cdot \text{in}^2} \right)}{4}} = \boxed{5.86 \frac{\text{ft}}{\text{sec}}}$$

FROM DATA SOURCE.

INCIPIENT FLUIDIZATION VELOCITY $V_{mb} = 1.4 \frac{\text{ft}}{\text{sec}}$

$$V - V_{mb} = 5.86 - 1.4 = 4.46$$

FROM FIGURE 16

$$\boxed{TDH = 280''}$$

FROM THE CENTER OF INLET TO CYCLONE TO THE GRID $\Rightarrow 25'$

THE EXPANDED BED HEIGHT = $14'$

DISENGAGEMENT HEIGHT = $DH = 25' - 14' = 11' = 132''$

FROM FIGURE 18

$$\frac{DH}{TDH} = \frac{132}{280} = 0.47$$

$$\frac{V_e}{V} = 1.27$$

THE EFFECTIVE ENTRAINING VELOCITY

$$V_e = 1.27 (5.86) \frac{\text{ft}}{\text{sec}} = 7.5 \frac{\text{ft}}{\text{sec}}$$

Client: CHSDIY

Proj. No: E-2278

Prel. Pg. No: 3

Location: INDIAN HEAD

Calc: B. CRIST

Date: 6/9/83

Subject: FBI ENTRAINMENT

Chkd: GRB

Date: 10/27/80

Bkchkd:

Date:

FROM FIGURE 5D

$$\begin{aligned} \mu_g &= \mu_f \\ \rho_g &= \rho_f \end{aligned}$$

$$w = \frac{4g \mu_g (\rho_f - \rho_g)^{1/3}}{3 \rho_g}$$

$$w = \left[\frac{4(32.2 \frac{ft}{sec^2})(3.09 \times 10^{-5} \frac{lb}{ft \cdot sec})(24.9 - 0.0178) \frac{lb}{ft^3}}{3(0.0178 \frac{lb}{ft^3})^2} \right]^{1/3} = 10.14 \frac{ft}{sec}$$

$$\Delta = \left(\frac{3 \mu_g^2}{4g \rho_g (\rho_f - \rho_g)} \right)^{1/3}$$

$$\Delta = \left(\frac{3(3.09 \times 10^{-5} \frac{lb}{ft \cdot sec})^2}{4(32.2 \frac{ft}{sec^2})(0.0178 \frac{lb}{ft^3})(24.9 - 0.0178) \frac{lb}{ft^3}} \right)^{1/3}$$

$$\Delta = 1.71 \times 10^{-4} ft$$

$$\frac{D_p}{\Delta} = 5.4$$

$$D_p = (5.4)(1.71 \times 10^{-4}) ft = 9.24 \times 10^{-4} ft$$

$$D_p = 280 \text{ MICRONS}$$

Client: CHESDI

Proj. No: E-2278

Prel. Pg. No: 4

Location: INDIAN HEAD

Calc: B CRIST

Date: 6/9/83

Subject: FBI ENTRAINMENT

Chkd: GBB

Date: 10/27/83

Bkchkd:

Date:

FROM PARTICLE SIZE DISTRIBUTION CURVE

WEIGHT FRACTION ENTRAINABLE $W_e = 0.11$

W/50% WT % MEAN OF ENTRAINED MATERIAL

$$D_p \approx 140 \text{ MICRON} \\ = 4.60 \times 10^{-4} \text{ ft}$$

DILUTE PHASE ENTRAINMENT

FROM FIGURE 17

$$\frac{V_e^2}{g D_p P^2} = \frac{(7.15)^2 \frac{\text{ft}^2}{\text{sec}^2}}{32.2 \frac{\text{ft}}{\text{sec}^2} (4.60 \times 10^{-4} \text{ ft}) (249 \frac{\text{lbs}}{\text{ft}^3})^2} = 0.0613$$

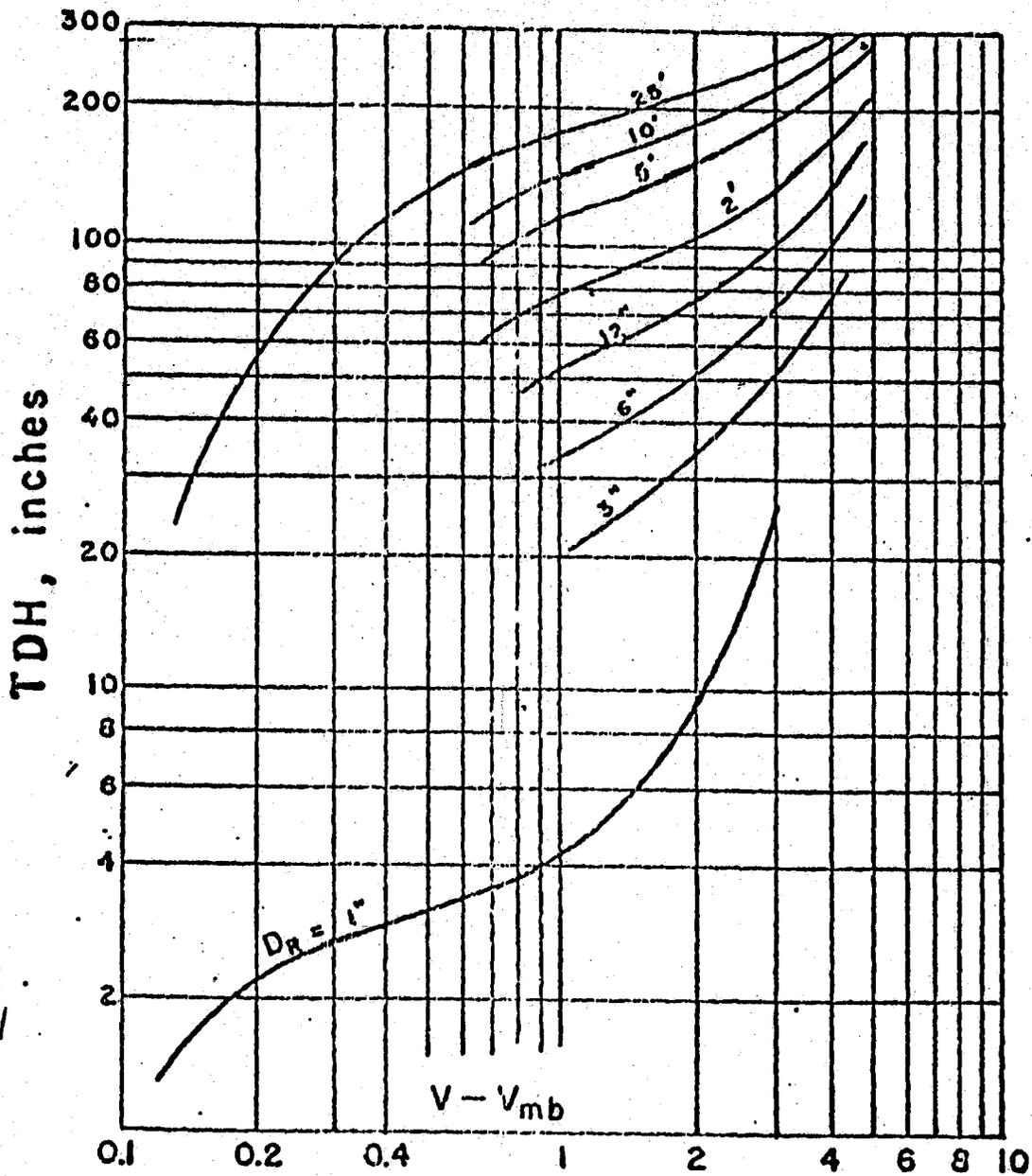
$$\frac{e_s}{\rho_a} = 1.7 \quad e_s = 1.7(0.0178) = 0.0303 \frac{\text{lbs}}{\text{ft}^3}$$

$$e = e_s W_e = (0.11)(0.0303) = 0.0033 \frac{\text{lb SOLIDS}}{\text{ft}^3 \text{ GAS}}$$

$$W = e \dot{m}_g / \rho_g = \frac{(0.0033)(11362)}{0.0178} = \boxed{2124.69 \frac{\text{lb-SO}}{\text{HR}}}$$

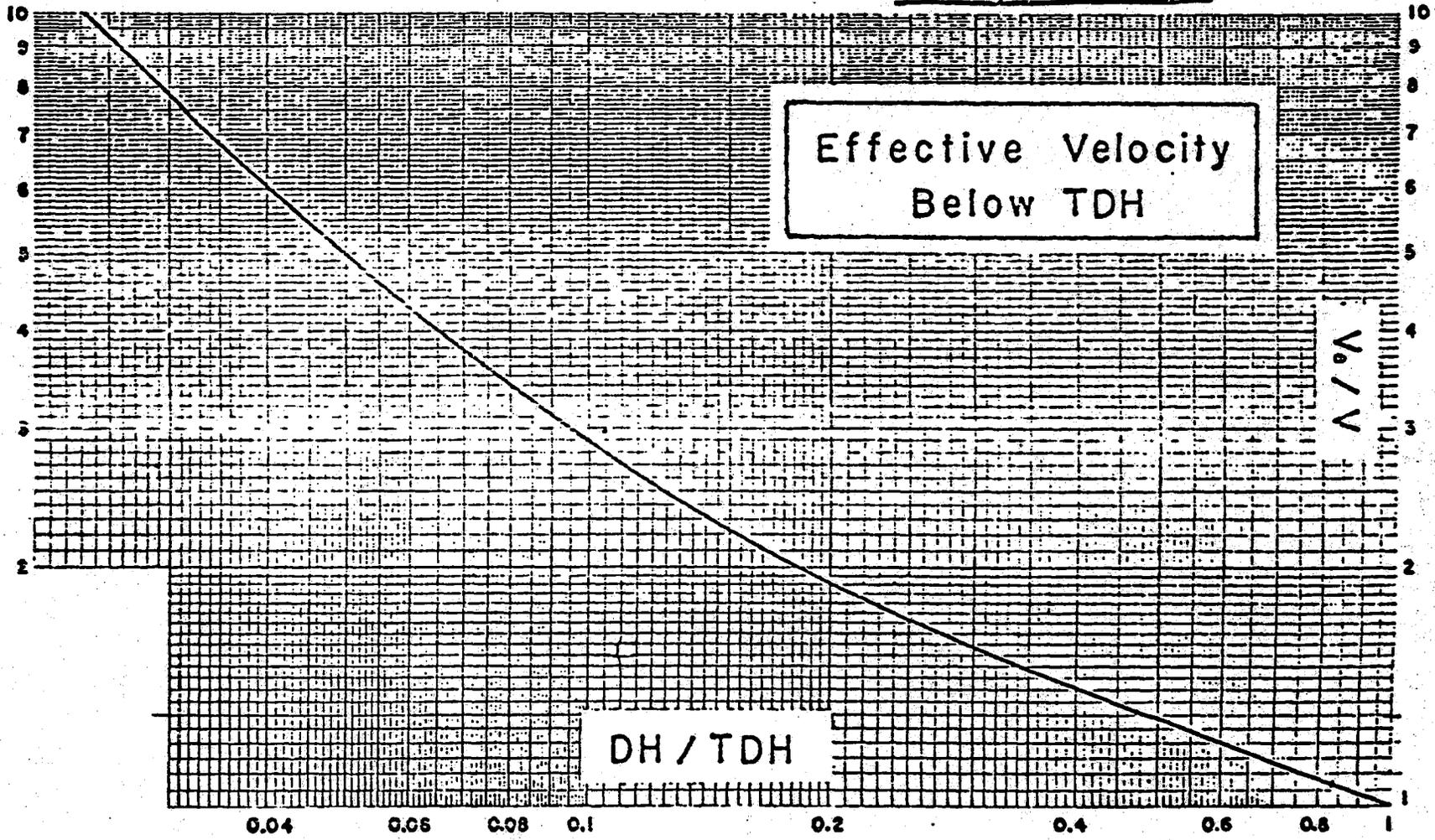
Figure 16

TDH Above Bubbling Fluid Beds

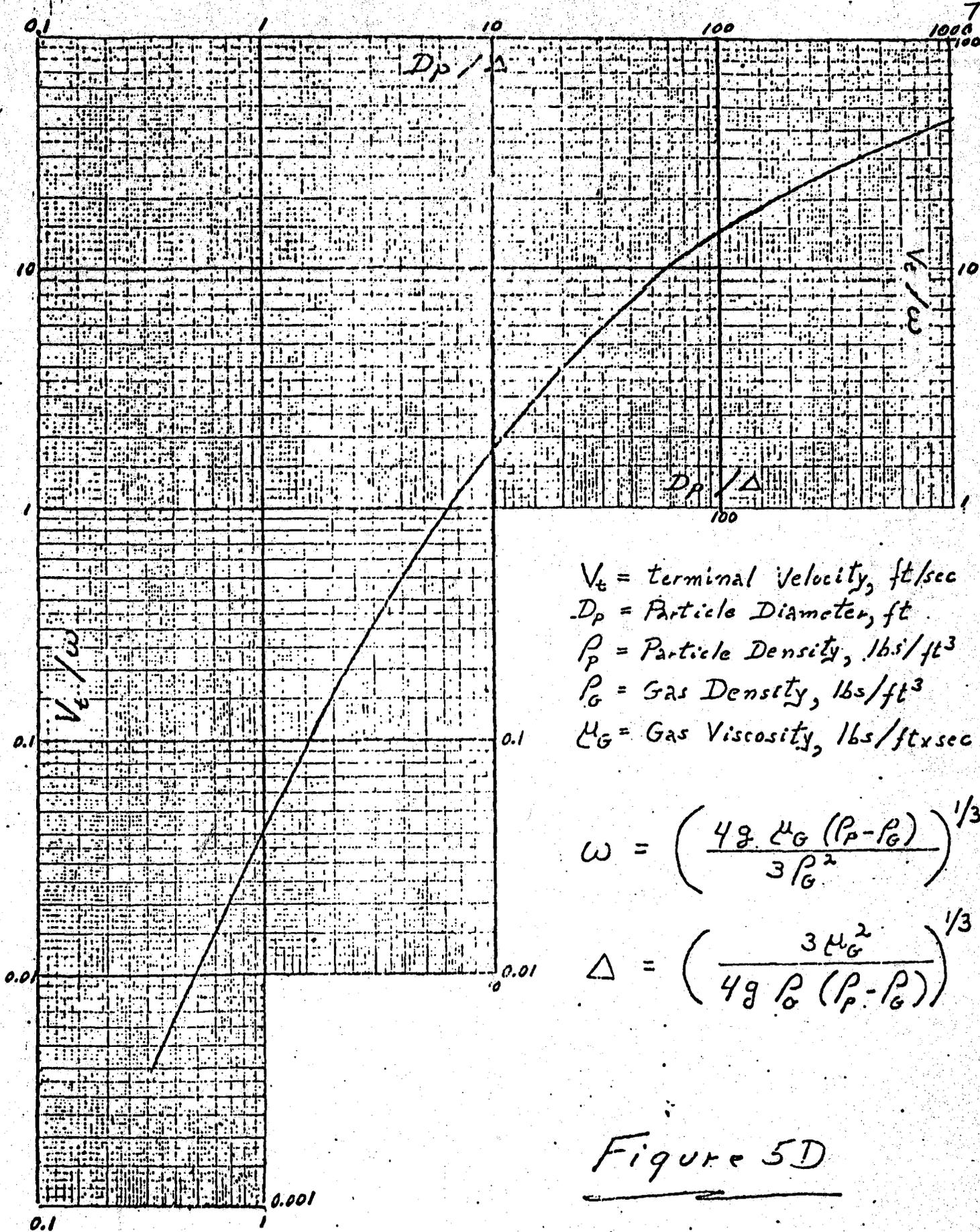


V = superficial gas velocity (CFS/free area), ft/sec
 V_{mb} = superficial bed surface velocity at onset of bubbling, ft/sec
 $(V - V_{mb})$ = CFS of bubble gas/sq.ft. of free cross section
 D_p = Vessel diameter at bed surface

Figure 18



- V_e = Effective entraining velocity, ft/sec (see Chart M-302.01)
- V = Superficial velocity, ft/sec ; (CFS/free area)
- DH = Disengaging Height, (height above bed)
- TDH = see Chart M-301.02



V_t = terminal velocity, ft/sec
 D_p = Particle Diameter, ft
 ρ_p = Particle Density, lbs/ft³
 ρ_g = Gas Density, lbs/ft³
 μ_g = Gas Viscosity, lbs/ft x sec

$$\omega = \left(\frac{4g \mu_g (\rho_p - \rho_g)}{3 \rho_g^2} \right)^{1/3}$$

$$\Delta = \left(\frac{3 \mu_g^2}{4g \rho_g (\rho_p - \rho_g)} \right)^{1/3}$$

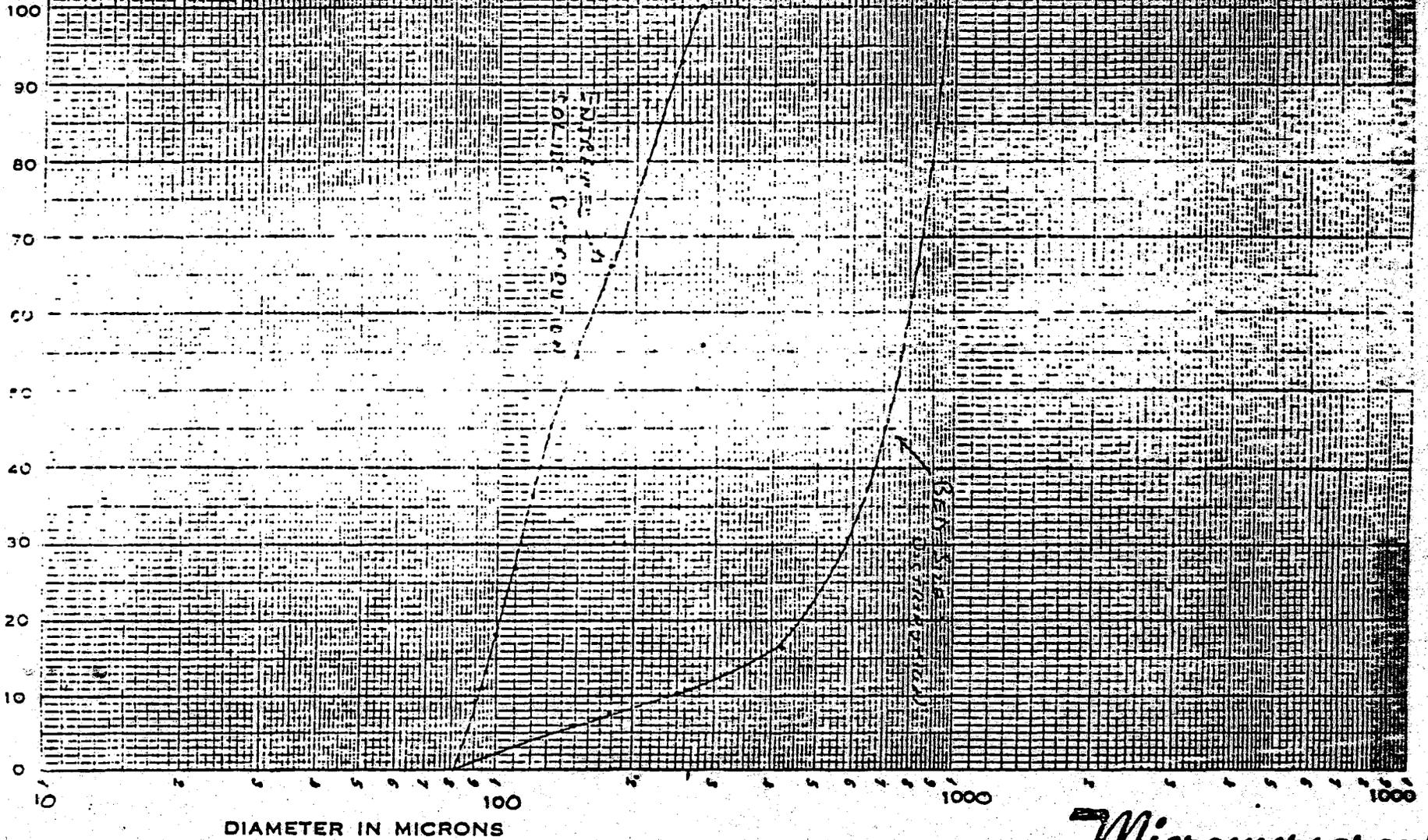
Figure 5D

EQUAL OPPORTUNITY EMPLOYER

PERCENTAGE OF PARTICLES WITH EQUAL OR SMALLER DIAMETER

COMMENT

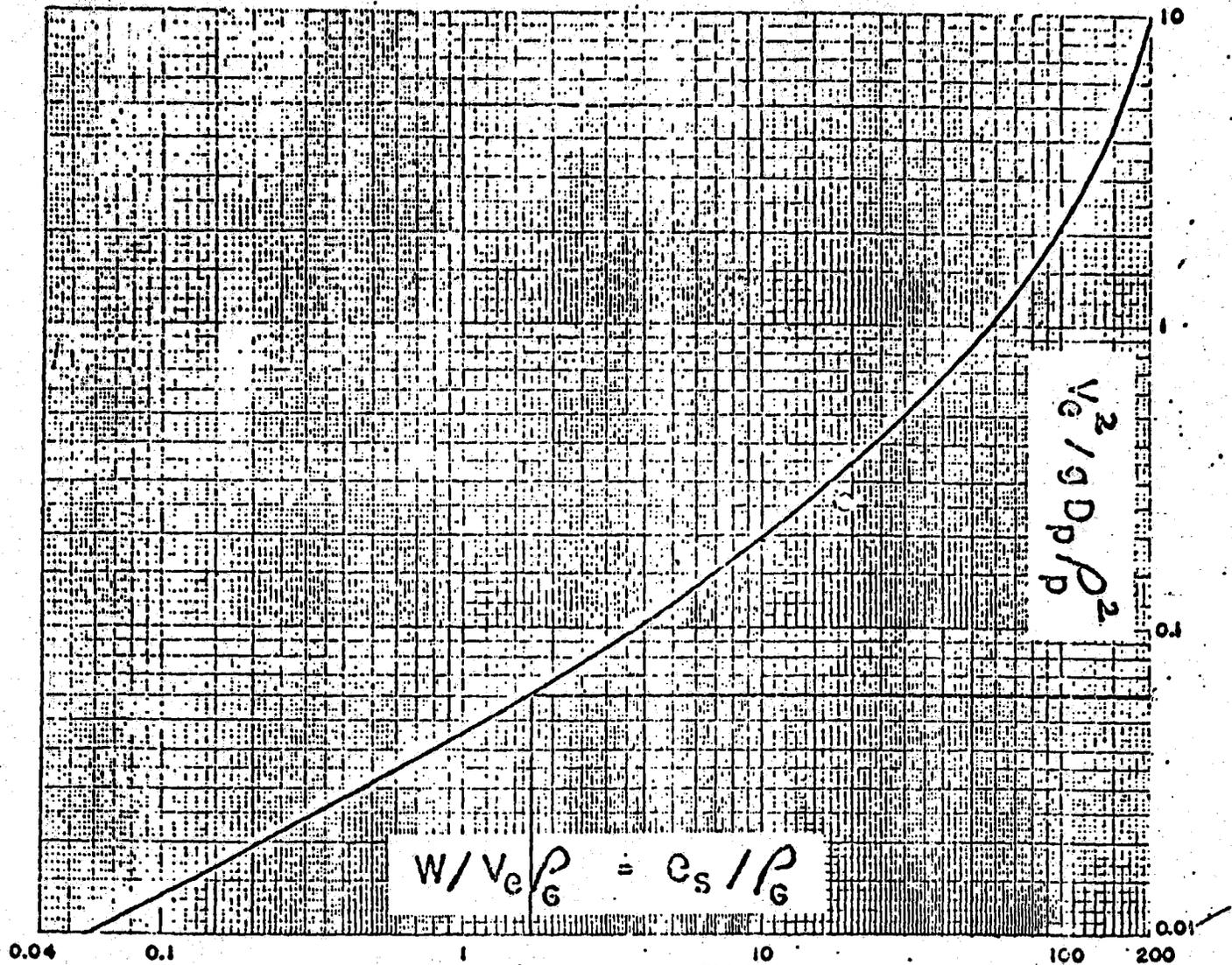
PARTICLE SIZE DISTRIBUTION ANALYSIS



Micrographs

Figure 17

Maximum Dilute Phase Entrainment
in Vertical Gas-Solids Upflow.



- e_s = max. entrainable lbs of solids/ft³ of gas
- V_e = effective gas velocity, ft/sec
- D_p = particle diameter, feet
- ρ_p = " density, lbs/ft³
- ρ_g = gas " " "
- W_s = lbs of solids/sec. x ft²
- $g = 32.2$

ENERGY RECOVERY - COST ESTIMATES AND PAYBACK ANALYSES

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No: 1

Location: INDIAN HEAD MARYLAND

Calc: AJY

Date: Aug 31, 1983

Subject: ENERGY RECOVERY ANALYSIS

Chkd: GSB

Date: 10/19/83

APPENDIX

Bkchkd:

Date:

This appendix contains calculations for the analysis of energy recovery equipment for the propellant disposal facility. Included in this appendix are the calculations used to calculate temperatures and mass flow rates etc. Also included are prices supplied by heat exchanger manufacturers. Cost estimates and payback calculations are shown last.

Client: PDI

Proj. No: E2278

Prel. Pg. No: 2

Location: INDIAN HEAD MARYLAND

Calc: AJY

Date: AUG 26, 1983

Subject: HEAT OF COMBUSTION OF
PROPELLANT

Chkd: GEB

Date: 10/19/83

Bkchkd:

Date:

HEAT OF REACTION OF DOUBLE BASE PROPELLANT
FROM THE ZIMMER PROPELLANT DISPOSAL
DEMONSTRATION REPORT IS 3600 BTU/LBM TO
4080 BTU/LBM.

HEAT OF REACTION OF SINGLE BASE PROPELLANT
RANGES FROM 2500 TO 3000 CAL/GRAM.
THIS IS EQUAL TO 4500 TO 5400 BTU/LBM

AVERAGE IS

$$(3600 + 4080 + 4500 + 5400) / 4 = 4395$$

AVERAGE OF HEATS FOR BOTH DOUBLE AND SINGLE BASED PROPELLANTS
IS $(3600 + 5400) / 2 = 4500$ BTU/LBM.

SO USE 4450 BTU/LBM AS GOOD APPROXIMATION.

Client: KHES DIV

Proj. No: E-2278

Prel. Pg. No: _____

Location: INDIAN HEAD, MD.

Calc: ASY

Date: OCT 13, 1983

Subject: GAS TEMP TO FBI

Chkd: GEB

Date: 10/19/83

Bkchkd: _____

Date: _____

CALLULATE THE ACTUAL AIR TEMP ENTERING THE FLUIDIZED BED,

AIR MASS FLOW $161 / 0.075 = 2150$ SCFM

14.7 PSIA TO 24.2 PSIA

FOR REVERSIBLE ADIABATIC COMPRESSION

$$\frac{P_1}{P_2} = \left(\frac{T_2}{T_1} \right)^{k/(1-k)}$$

$$14.7/24.2 = (T_2 / 530)^{(1.4/1.4)}$$

$$T_2 = 611^\circ R = 152^\circ F$$

$\therefore 152^\circ F$ IS THE LOWEST POSSIBLE TEMPERATURE

THEORETICAL WORK

$$W = MR(T_2 - T_1) / (1 - k) = (161) 53.34 (611 - 530) / (1 - 1.4)$$

$$= -1,739 \text{ EG FT-LBF/MIN} = -52.70 \text{ HP}$$

AN ACTUAL BLOWER

WILL PRODUCE

2027 SCFM @ 10 PSIA

WITH BHP = 111.2

$$\text{THEORETICAL HP} = (152 - 53.34) 53.34 (615 - 530) / (1 - 1.4) = 52.217$$

\therefore THEREFORE EXPECT EFFICIENCY OF ABOUT

$$\eta = \frac{52.217}{111.2} = .4696$$

$$\text{ACTUAL HP REQD} = 52.7 / .47 = 112.1 \text{ HP}$$

$$112.1 - 52.7 = 59.42 \text{ HP} = 1.96 \text{ EG FT-LBF/MIN}$$

Client: CHESDIV

Proj. No: E-2278

Prel. Pg. No: _____

Location: INDIAN HEAD, MD.

Calc: AJY

Date: OCT 13, 1983

Subject: GAS TEMP TO FBI

Chkd: GBB

Date: 10/19/83

Bkchkd: _____

Date: _____

1.96 EG FT LBF / MIN IS NOT BECAUSE OF
INEFFICIENCY. THIS TRANSLATES INTO A
TEMPERATURE RISE OF

$$1.96 \text{ EG } (1.286 \text{ F}^3) \text{ BTU} / (\text{F} \cdot \text{LBF}) = 2521 \text{ BTU} / \text{MIN}$$

$$\Delta T = q / (m \cdot C_p) = 2521 / (1161 \cdot 0.240) = 65.24$$

TEMP. LEAVING BLOWER WILL BE

$$152^\circ \text{F} + 65.24^\circ \text{F} = 217.24^\circ \text{F}$$

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No: _____

Location: INDIAN HEAD MARYLAND

Calc: AJY

Date: JULY 20, 1983

Subject: HEAT RECOVERY FROM FBI

Chkd: GEB

Date: 10/19/83

Bkchkd: _____

Date: _____

THE FOLLOWING IS AN ENERGY AND MASS BALANCE OF MATERIALS ENTERING THE FLUIDIZED BED INCINERATOR. THE MATERIALS ARE:

AIR - $V = 1479$ ACFM
 $T = 600^{\circ}R^*$
 $P = 24.2$ PSIA = 34.85 PSFA
 $R = 53.34$ FT LBF / (LBM²R)

$V = RTP = 9.18$ ft³/LBM

$\dot{m} = 1479 / 9.18 = 161$ LBM/MIN.

*TEMP. STATED IN FLOW DIAGRAM ACTUAL TEMP IS 217°F

SLURRY: 25% PROPELLANT 75% WATER

$\dot{m} = 66.67$ LBM/MIN

$\dot{m}_{\text{PROPELLANT}} = 16.67$ LBM/MIN.

$\dot{m}_{\text{WATER}} = 50.00$ LBM/MIN.

$H_{\text{PROPELLANT}} = 4450$ BTU/LBM.

No. 2 Oil: $d = 7.38$ LBM/GAL

$h_c = 138,000$ BTU/GAL

$\dot{m} = .5 \times 7.38 = 3.69$ LBM/MIN

$h = 136,620$ BTU/MIN

PRODUCTS OF COMBUSTION OF FUEL OIL, FUEL OIL

85% CARBON BY MASS.

$\dot{m}_{\text{CO}_2} = (3.69) .85 (44.01/12.01) = 11.49$ LBM/MIN

$\dot{m}_{\text{H}_2\text{O}} = (3.69) .15 (18.01/2.02) = 4.93$ LBM/MIN

$\dot{m}_{\text{O}_2} = 11.49 + 4.93 - 3.69 = 12.73$ LBM/MIN (CONSUMED)

TOTAL $\dot{m} = 161 + 66.67 + 3.69 = 231.36$ LBM/MIN

Client: CHESDIV

Proj. No: E-2278

Prel. Pg. No: _____

Location: INDIAN HEAD MARYLAND

Calc: AJY

Date: Oct 17, 1983

Subject: HEAT RECOVERY FROM FBI

Chkd: GAB

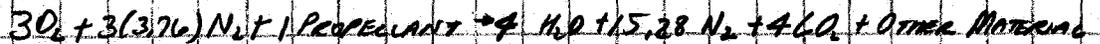
Date: 10/19/83

Bkchkd: _____

Date: _____

APPROXIMATE COMPOSITION OF EXHAUST

FROM THE WAO ANALYSIS COMPUTER PROGRAM (SEE 1974 PROPULSION MEETING VOL. I PART II) WE KNOW THE PROPELLANT OXIDATION EQUATION IS



THE MOLECULAR WEIGHT OF THE PROPELLANT IS 296,

THE MASS FLOW RATES ARE:

$$H_2O = 4.05 \text{ LBM/MIN}$$

$$N_2 = 24.09 \text{ LBM/MIN}$$

$$CO_2 = 9.91 \text{ LBM/MIN}$$

THE TOTAL MATERIAL FLOW RATE IS

		MASS PERCENT
H ₂ O	43.82 LBM/MIN	24.9
N ₂	147.39 LBM/MIN	57.5
CO ₂	32.68 LBM/MIN	12.7
O ₂	12.28 LBM/MIN	4.8
TOTAL	256.17 LBM/MIN	

FROM THIS WE CAN FIND

$$C_p = .289 \text{ BTU/(}^\circ\text{F/LBM)}$$

$$R = 59.84 \text{ ft}^2\text{LBF/(LBM}^\circ\text{K)}$$

THE ANALYSIS OF GASES ENTERING THE QUENCHER AS GIVEN IN THE QUENCHER AND SCRUBBER SPECIFICATION IS

	MASS PERCENT
H ₂ O	31.5
N ₂	50.8
CO ₂	10.8
O ₂	4.9
HCL	1.9

$$C_p = .302 \text{ BTU/(LBM}^\circ\text{F)}$$

$$R = 61.99 \text{ ft}^2\text{LBF/(LBM}^\circ\text{R)}$$

Client: CHESDIV

Proj. No: E-2278

Prel. Pg. No: _____

Location: INDIAN HEAD M.D.

Calc: AJY

Date: Oct 17, 1983

Subject: HEAT RECOVERY FROM FB1

Chkd: GAB

Date: 10/19/87

Bkchkd: _____

Date: _____

AT THE TEMPERATURE, PRESSURE AND FLOW RATE GIVEN
IN THE FLOW DIAGRAM THE MASS FLOW RATE IS FOUND

$$T = 459 + 1650 = 2109^{\circ}R$$

$$P = (14.7 + 1)144 = 2260.8 \text{ LBF/FT}^2$$

$$V = 61.99(2109)/2261 = 57.82 \text{ FT}^3/\text{LBM}$$

$$\rho = .0173 \text{ LBM/FT}^3$$

WITH 9982 ACFM

$$\dot{M} = 9982(.0173) = 173 \text{ LBM/MIN}$$

THESE TWO SETS OF FIGURE AGREE CLOSELY IN EVERY
THING BUT MASS FLOW RATE. FOR SELECTION OF EQUIPMENT
THE FIRST SET OF NUMBERS WERE USED.

Client: CHESDIN

Proj. No: E-2278

Prel. Pg. No: _____

Location: INDIAN HEAD MD.

Calc: ASY

Date: Oct 27, 1983

Subject: HEAT RECOVERY FROM FB1

Chkd: GRB

Date: 10/19/83

Bkchkd: _____

Date: _____

HEAT EXCHANGER SELECTION:

THE HEAT EXCHANGER REQUIREMENTS WERE GIVEN TO SMITH ENGINEERING AND ENVIRONMENTAL CORPORATION THE UNIT THEY RECOMMEND IS

HOT SIDE

INLET - 3840 SCFM @ 1650°F & 9.5 PSIG
OUTLET 1184°F
ΔP = 2.74 IN. WATER

COLD SIDE

INLET - 2150 SCFM @ 217°F
OUTLET - 1100°F
ΔP = 1.34 IN. WATER

APPROX. SIZE 3½' X 3½' X 5'

APPROX. UNIT COST 22,000

THIS SAVES

$$(1100 - 217) \cdot 240 (161) = 34500 \text{ BTU/MIN}$$
$$34500 / 13800 = .25 \text{ GPM}$$

YEARLY SAVINGS WITH 960 HOURS PER YEAR OF OPERATION.

$$.25 (60) 960 = 14400 \text{ GALLONS / YEAR}$$

COST SAVINGS

$$14400 (1.96) = \$13820$$

Client: CHESDIV

Proj. No: E-2278

Prel. Pg. No: 2-1 a

Location: INDIAN HEAD INO

Calc: AJY

Date: May 31, 1983

Subject: HEAT RECOVERY FROM

Chkd: GBB

Date: 10/19/83

CATALYTIC OXIDATION UNIT

Bkchkd:

Date:

COMPOSITION OF EXHAUST GAS AT CATALYTIC OXIDATION UNIT AS GIVEN IN TABLE 12 OF THE PROPELLANT DISPOSAL FACILITY TECHNO/ECONOMIC STUDY.

H ₂ O	139.2 Lbm/min	43.6%	.563
N ₂	138.8 Lbm/min	43.4%	.361
CO ₂	30.0 Lbm/min	9.3%	.491
O ₂	11.7 Lbm/min	3.7%	.270

$$C_p = .486(1.45) + .434(1.248) + .093(1.203) + .037(1.214) = .329$$

$$R = .486(85.76) + .434(55.15) + .093(35.10) + .037(48.28) = 66.37$$

$$V = RT/P$$

$$P = 15.2(144) = 2189 \text{ LBF/ft}^2$$

$$T = 459 + 850 = 1309^\circ\text{F}$$

$$\therefore V = 39.69 \text{ ft}^3/\text{LBM}$$

$$12,050 / 39.69 = 303.60 \text{ LBM/min}$$

APPROXIMATELY AGREES WITH FIGURES ABOVE.

HEAT RECOVERY

850°F

517.5



517.5

185°F

$$(517.5 - 185) 303.6(1.329) = 33,212 \text{ BTU/min}$$

$$(33,212 / 138,000)(60) = 14.44 \text{ GPM}$$

$$14.44(720) = 10,396$$

$$10,396(1.86) / 1.83 = 12,024$$

Client: CHESDIU

Proj. No: E-2278

Prel. Pg. No: 3-1

Location: INDIAN HEAD

Calc: AJY

Date: MAY 25 1983

Subject: HEAT RECOVERY FROM

Chkd: GWB

Date: 10/19/83

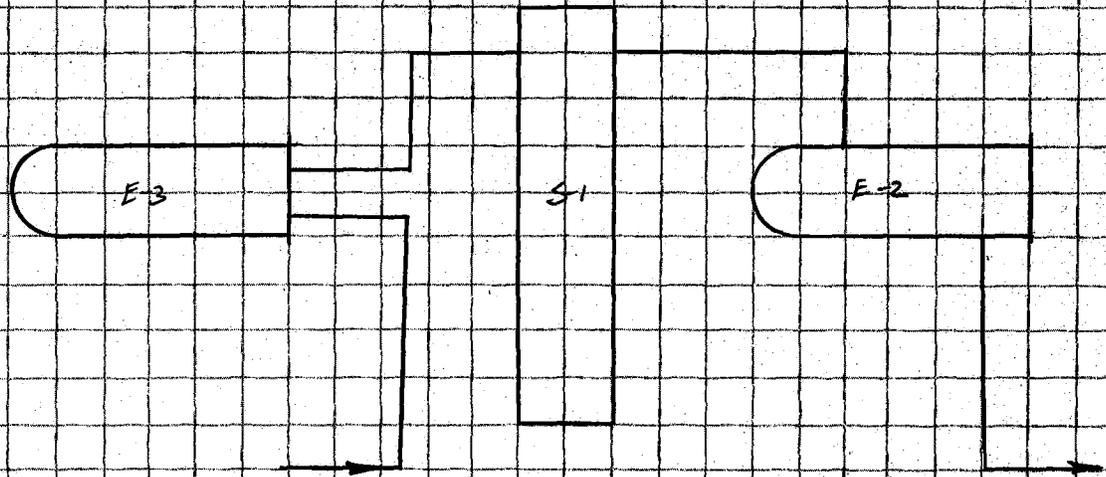
EVAPORATOR CONDENSOR

Bkchkd:

Date:

USE HEAT REJECTED AT E-2 TO PREHEAT SLURRY

THE PRESENT SYSTEM IS:



E-3 DUTY: .7 MM BTU/HR.
SLURRY INLET CONDITION: 105°F
SLURRY OUTLET CONDITION: 240°F @ 10 PSIG
FLOW RATE: 10.31 GPM
STEAM: 780 LBM/HR @ 100 PSIG

E-2 DUTY: 5.4 MM BTU/HR.
INLET CONDITION: STEAM 240°F @ 2 PSIG
OUTLET CONDITION: WATER 120°F @ 0 PSIG
FLOW RATE: 4940 LBM/HR

THERE IS SUFFICIENT HEAT REJECTED AT E-2. HOWEVER THE HEAT IS IDE TOO LOW A QUALITY MAKE IT ECONOMICALLY FEASIBLE TO DO ANY THING BUT PRE HEAT SLURRY COMING INTO E-3.

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No: A-1

Location: INDIAN HEAD MD.

Calc: AJY

Date: MAY 25, 1983

Subject: WAO AFTER BURNER

Chkd: GBO

Date: 10/19/83

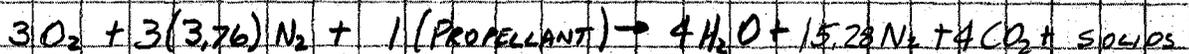
HEAT RECOVERY

Bkchkd:

Date:

INVESTIGATE POSSIBILITY OF USING AFTERBURNER EXHAUST AS HEAT SOURCE:

THE COMPUTER PROGRAM FOR CALCULATION OF NET OXIDATION TEMPERATURES IN THE 1974 JANNAF PROPULSION MEETING VOL I PART II GIVES THE PROPELLANT MOLECULAR WEIGHT AS 296. OXIDATION OF ONE MOLE OF PROPELLANT REQUIRES 3 MOLES OF OXYGEN, AND PRODUCES 4 MOLES OF WATER, 4 MOLES OF NITROGEN AND 4 MOLES OF CARBON DIOXIDE. A CHEMICAL EQUATION CAN BE WRITTEN:



GIVEN A PROPELLANT FLOW RATE OF 500 LBM/HR OR 8.33 LBM/MIN IN MOLE THIS IS

$$8.33 / 296 = .02814 \text{ LB MOLES / MIN}$$

THE MASS OF THE GASES IS:

			MASS PERCENT	MOLE FRACT
H ₂ O	4(.02814)	18.01 = 2.027	10.6	.172
N ₂	15.28(.02814)	28.01 = 12.044	63.6	.656
CO ₂	4(.02814)	44.01 = 4.954	26.0	.172
C _p				
			10.6(.445) + .636(.248) + .260(.203) = .238	Btu/(Lbm °F)
R			10.6(.8576) + .636(.5515) + .260(.3510) = 53.29	Ft Lbf/(Lbm °R)

THE REMAINING SOLIDS MASS IS

$$[3(32) + 3(3.76)(28.01) + 296(.02814) - [2.027 + 12.044 + 4.954]] = 18.968 \text{ LBM / MIN}$$

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No: 14-3

Location: INDIAN HEAD MD.

Calc: ASY

Date: MAY 25, 1983

Subject: WAO AFTER BURNER
HEAT RECOVERY

Chkd: GEB

Date: 10/19/87

Bkchkd:

Date:

IS

COMPOSITION OF AFTER BURNER EXHAUST GASES

		MASS (LBM/MIN)	PERCENT
H ₂ O	2.027 + 1.536 =	2.56	8.3
N ₂	12.044 + 8.599 =	20.64	66.9
CO ₂	4.954 + 1.37 =	6.32	20.5
O ₂	1.30 =	1.30	4.2

THIS IS CLOSE TO THE NUMBERS GIVEN IN TABLE 6 OF THE PROPELLANT DISPOSAL FACILITY TECHNO/ECONOMIC STUDY, THE NUMBER FROM TABLE 6 ARE:

	MASS (LBM/MIN)	PERCENT
H ₂ O	2.29	5
N ₂	34.37	73
CO ₂	6.26	13
O ₂	4.16	9

Client: CHESDIV

Proj. No: E-2278

Prel. Pg. No: 4-4

Location: INDIAN HEAD MD

Calc: AJY

Date: May 25, 1983

Subject: WAO AFTERBURNER

Chkd: GBB

Date: 10/19/83

HEAT RECOVERY

Bkchkd:

Date:

THE ADIABATIC FLAME TEMPERATURE WITH FUEL OIL HAVING A HEAT OF COMBUSTION OF 18700 BTU/LBM IS FOUND FROM

$$18700 (.369) = \Delta T [2.56(.445) + 20.59(1.248) + 6.32(1.203) + 1.30(2.19)]$$

$$\Delta T = 66.5^\circ\text{F}$$

WITH 80°F AIR FEED TEMP

$$\text{STACK TEMP} = 66.5 + 80 = 745^\circ\text{F}$$

SPECIFIC HEAT OF EXHAUST GAS

$$C_{p0} = [2.56(.445) + 20.59(1.248) + 6.32(1.203) + 1.30(2.19)] / 30.77$$

$$= 2.54 \text{ BTU/LBM}^\circ\text{F}$$

MAXIMUM HEAT RECOVERY POSSIBLE

$$q = 2.54(30.77)(745 - T_{e2}) = 2.54(19.28)(T_{i1} - 120)$$

$$(745 - T_{e2}) / (745 - 120) = 19.28 / (19.28 + 30.77)$$

$$T_{e2} = T_{i1} = 509.24^\circ\text{F}$$

$$q = 1981 \text{ BTU/MIN} = 112900 \text{ BTU/HR}$$

FOR THE EXHAUST GAS

$$R = .083(85.76) + .669(55.15) + .205(35.10) + .042(48.28) = 53.24$$

Client: CHES DIV Proj. No: E-2278 Prel. Pg. No: _____
Location: INDIAN HEAD MARYLAND Calc: ASJ Date: JULY 19, 1983
Subject: HEAT EXCHANGER Chkd: GRD Date: 10/19/83
EQUIPMENT: Bkchkd: _____ Date: _____

FROM SMITH HEAT EXCHANGERS
ALL UNITS - 2 PASS

HEAT EXCHANGER #1

3840 SCFM HOT SIDE
2150 SCFM COLD SIDE
WEIGHT OF UNIT ABOUT 500 #
 ΔP HOT SIDE 2.74" WATER
 ΔP COLD SIDE 1.34" WATER
1650°F → 1184°F
217°F → 1100°F
3 1/2 x 3 1/2 x 5 FEET
COST \$22,000

HEAT EXCHANGER #2

50%
5312 SCFM BOTH SIDES
 ΔP HOT SIDE 2.76" WG
 ΔP COLD SIDE 3.06" WG
850°F → 612°F
185°F → 591°F
4 1/2 x 4 x 7
COST \$26,000

60%
 ΔP HOT SIDE 2.75" WG
 ΔP COLD SIDE 2.60" WG
850°F → 545°F
599°F → 185°F
4 1/2 x 4 x 9
COST \$31,000

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No:

Location: INDIAN HEAD MARYLAND

Calc: ASY

Date: July 19, 1983

Subject: HEAT EXCHANGER
EQUIPMENT

Chkd: GRD

Date: 10/19/83

Bkchkd:

Date:

70%
70%

ΔP HOT SIDE = 2.89" WG

ΔP COLD SIDE = 2.77" WG

850°F → 476°F

185°F → 661°F

4 1/2' x 4 1/2' x 14'

\$ 40,000

DESIGN SPECIFICATIONS

TUBE MATERIAL	-	ALUMINUM ALLOY 6063T832
TUBE SPECIFICATION	--	ASTM B-483
TUBE SIZE (O.D.)	--	1.125 IN.
TUBE WALL THICKNESS	--	0.035 IN.
DESIGN PRESSURE (TUBE)	--	20 PSIG
DESIGN PRESSURE (SHELL)	--	12 IN. W.C.
DESIGN TEMPERATURE	--	500°F
SHELL CASING MATERIAL	--	0.125" AL
TEFLON COVERING	--	0.010 IN. (ON TUBE O.D.)
	--	0.040 IN. (ON GAS SIDE OF SHE
FLOW DIAGRAM	-	81002-F

SUPPLEMENTARY INFORMATION

The factory startup service rate is \$450/day + travel and living expenses. This service is required in order to determine SYSTEM PERFORMANCE and to evaluate SYSTEM OPERATION. Additionally, installation supervision is available and at times required. Consult the factory for details.

Shipment is approximately 12 weeks after receipt of approved drawings. All prices are quoted F.O.B., Warnerville, NY, and are firm for 60 days. The Design Conditions and Expected Performance contained herein are collectively considered EXHIBIT A as may be referred to elsewhere.

Thank you for allowing us the opportunity to quote this CHX System for Energy Recovery. Please call if you have any questions regarding this proposal or if you desire additional information.

INDUSTRIAL DESIGN & ECONOMICS PROGRAM - 821130

CATALYTIC OXIDATION UNIT

INPUT VALUES

EXHAUST FLOW ENT(SCFM) =	5310.	EXH HUMIDITY RATIO =	.3500
EXHAUST TEMP ENT =	850.0	STD SUPPLY FLOW(CFM) =	5310.
DRY AIR MASS FLOW RATIO =	1.35	STD FACE VEL(FPM) =	0.
SUPPLY TEMP WINT =	12.0	SUPPLY TEMP SUMMER =	94.0
SUPPLY TEMP AVRG =	57.0	ALTITUDE(FT) =	10.
NUMBER OF ROWS =	3	ELEC COST(\$/KWH) =	.0600
OPER HOURS/YR =	6240.	ENERGY COST(\$/MIL BTU) =	7.27
ENERGY EFFICIENCY =	1.00	MAX PRESS DROP =	0.00

PART = T SERIES = T COAT = F PLAIN FIN = T
ENERGY SOURCE = OIL
FLOW TYPE = COUNTERFLOW

RESULTS

HUMIDITY RATIO EXH ENT = .3500
STANDARD FLOW EXH(SCFM) = 5310.
STANDARD FLOW SUP(SCFM) = 5310.

THERMAL RECOVERY UNIT DESCRIPTION

TYPE SP - STEEL 1 INCH O.D. TUBES WITH PLAIN STEEL FINNS

TWO SETS OF UNITS IN SERIES; EACH SET CONSISTS OF:

1 UNIT WITH 3 ROWS, 5 FPI ON EXHAUST SIDE, 8 FPI ON SUP SIDE

UNIT 1 = 47.0 INCHES HIGH, 72. INCHES LONG

SUPPLY LENGTH(INCHES) =	36.0	STD SUP VELOCITY(FPM) =	452.
EXHAUST LENGTH(INCHES) =	36.0	STD EXH VELOCITY(FPM) =	452.

CATALYTIC OXIDATION UNIT

WINTER CONDITIONS

INITIAL TEMP DIFF =	838.0		
RECOVERY FACTOR SUP DRY =	.4907		
TEMP SUPPLY ENT =	12.0	TEMP SUPPLY LEAV =	423.2
TEMP EXHAUST ENT =	850.0	TEMP EXHAUST LEAV =	514.8
ENTHALPY SUPPLY ENT =	2.9	ENTHALPY SUPPLY LEAV =	101.6
ENTHALPY EXHAUST ENT =	709.2	ENTHALPY EXHAUST LEAV =	576.0
MOIST COND OUT(LBS/MIN) =	0.0	HUMID RATIO EXH LEAV =	.3500
PRESS DROP SUP(INCHES WTR) =	.84	DEW POINT TEMP EXHAUST =	164.6
PRESS DROP EXH(INCHES WTR) =	1.66	HEAT SAVED(BTU/HR) =	2358185.

CAPACITY LIMITED AT 10% TILT

SUMMER CONDITIONS

INITIAL TEMP DIFF =	756.0		
RECOVERY FACTOR SUP DRY =	.4907		
TEMP SUPPLY ENT =	94.0	TEMP SUPPLY LEAV =	465.0
TEMP EXHAUST ENT =	850.0	TEMP EXHAUST LEAV =	547.6
ENTHALPY SUPPLY ENT =	22.6	ENTHALPY SUPPLY LEAV =	111.6
ENTHALPY EXHAUST ENT =	709.2	ENTHALPY EXHAUST LEAV =	589.0
MOIST COND OUT(LBS/MIN) =	0.0	HUMID RATIO EXH LEAV =	.3500
PRESS DROP SUP(INCHES WTR) =	.91	DEW POINT TEMP EXHAUST =	164.6
PRESS DROP EXH(INCHES WTR) =	1.69	HEAT SAVED(BTU/HR) =	2127431.

AVERAGE CONDITIONS

INITIAL TEMP DIFF =	793.0		
RECOVERY FACTOR SUP DRY =	.4907		
TEMP SUPPLY ENT =	57.0	TEMP SUPPLY LEAV =	446.1
TEMP EXHAUST ENT =	850.0	TEMP EXHAUST LEAV =	532.8
ENTHALPY SUPPLY ENT =	13.7	ENTHALPY SUPPLY LEAV =	107.1
ENTHALPY EXHAUST ENT =	709.2	ENTHALPY EXHAUST LEAV =	583.1
MOIST COND OUT(LBS/MIN) =	0.0	HUMID RATIO EXH LEAV =	.3500
PRESS DROP SUP(INCHES WTR) =	.88	DEW POINT TEMP EXHAUST =	164.6
PRESS DROP EXH(INCHES WTR) =	1.68	HEAT SAVED(BTU/HR) =	2231552.

BTUS SAVED PER YEAR =	13924.88	MILLION
ENERGY COST SAVINGS =	101233.87	\$/YR
INCREASE IN FAN HP =	2.83	HP
INCR FAN OPER COST =	877.36	\$/YR
NET OPER SAVINGS =	100356.50	\$/YR

Q-DOT CORPORATION
701 NORTH FIRST STREET
GARLAND, TX 75040

DATE : 22/JUL/1983
TIME : 8:52:54

INDUSTRIAL DESIGN & ECONOMICS PROGRAM - 821130

AFTERBURNER

INPUT VALUES

EXHAUST FLOW ENT(SCFM) =	865.	EXH HUMIDITY RATIO =	.0450
EXHAUST TEMP ENT =	900.0	STD SUPPLY FLOW(CFM) =	630.
DRY AIR MASS FLOW RATIO =	.76	STD FACE VEL(FPM) =	0.
SUPPLY TEMP WINT =	12.0	SUPPLY TEMP SUMMER =	94.0
SUPPLY TEMP AVRG =	57.0	ALTITUDE(FT) =	10.
NUMBER OF ROWS =	3	ELEC COST(\$/KWH) =	.0600
OPER HOURS/YR =	6240.	ENERGY COST(\$/MIL BTU) =	7.27
ENERGY EFFICIENCY =	1.00	MAX PRESS DROP =	0.00

PART = F SERIES = T COAT = F PLAIN FIN = T
ENERGY SOURCE = OIL
FLOW TYPE = COUNTERFLOW

RESULTS

HUMIDITY RATIO EXH ENT = .0450
STANDARD FLOW EXH(SCFM) = 865.
STANDARD FLOW SUP(SCFM) = 630.

THERMAL RECOVERY UNIT DESCRIPTION

TYPE SP - STEEL 1 INCH O.D. TUBES WITH PLAIN STEEL FINS

TWO SETS OF UNITS IN SERIES; EACH SET CONSISTS OF:

1 UNIT WITH 3 ROWS, 5 FPI ON EXHAUST SIDE, 8 FPI ON SUP SIDE

UNIT 1 = 13.0 INCHES HIGH, 36. INCHES LONG

SUPPLY LENGTH(INCHES) =	15.0	STD SUP VELOCITY(FPM) =	460.
EXHAUST LENGTH(INCHES) =	21.0	STD EXH VELOCITY(FPM) =	460.

Q-DOT CORPORATION
701 NORTH FIRST STREET
GARLAND, TX 75040

DATE : 22/JUL/1983
TIME : 8:52:56

AFTERBURNER

WINTER CONDITIONS

INITIAL TEMP DIFF =	888.0		
RECOVERY FACTOR SUP DRY =	.5193		
TEMP SUPPLY ENT =	12.0	TEMP SUPPLY LEAV =	473.1
TEMP EXHAUST ENT =	900.0	TEMP EXHAUST LEAV =	576.3
ENTHALPY SUPPLY ENT =	2.9	ENTHALPY SUPPLY LEAV =	113.6
ENTHALPY EXHAUST ENT =	282.0	ENTHALPY EXHAUST LEAV =	197.7
MOIST COND OUT(LBS/MIN) =	0.0	HUMID RATIO EXH LEAV =	.0450
PRESS DROP SUP(INCHES WTR) =	.89	DEW POINT TEMP EXHAUST =	101.4
PRESS DROP EXH(INCHES WTR) =	1.23	HEAT SAVED(BTU/HR) =	313751.

SUMMER CONDITIONS

INITIAL TEMP DIFF =	806.0		
RECOVERY FACTOR SUP DRY =	.5193		
TEMP SUPPLY ENT =	94.0	TEMP SUPPLY LEAV =	512.5
TEMP EXHAUST ENT =	900.0	TEMP EXHAUST LEAV =	606.2
ENTHALPY SUPPLY ENT =	22.6	ENTHALPY SUPPLY LEAV =	123.0
ENTHALPY EXHAUST ENT =	282.0	ENTHALPY EXHAUST LEAV =	205.5
MOIST COND OUT(LBS/MIN) =	0.0	HUMID RATIO EXH LEAV =	.0450
PRESS DROP SUP(INCHES WTR) =	.97	DEW POINT TEMP EXHAUST =	101.4
PRESS DROP EXH(INCHES WTR) =	1.25	HEAT SAVED(BTU/HR) =	284779.

AVERAGE CONDITIONS

INITIAL TEMP DIFF =	843.0		
RECOVERY FACTOR SUP DRY =	.5193		
TEMP SUPPLY ENT =	57.0	TEMP SUPPLY LEAV =	494.8
TEMP EXHAUST ENT =	900.0	TEMP EXHAUST LEAV =	592.7
ENTHALPY SUPPLY ENT =	13.7	ENTHALPY SUPPLY LEAV =	118.7
ENTHALPY EXHAUST ENT =	282.0	ENTHALPY EXHAUST LEAV =	202.0
MOIST COND OUT(LBS/MIN) =	0.0	HUMID RATIO EXH LEAV =	.0450
PRESS DROP SUP(INCHES WTR) =	.93	DEW POINT TEMP EXHAUST =	101.4
PRESS DROP EXH(INCHES WTR) =	1.24	HEAT SAVED(BTU/HR) =	297852.

BTUS SAVED PER YEAR =	1858.59	MILLION
ENERGY COST SAVINGS =	13511.98	\$/YR
INCREASE IN FAN HP =	.35	HP
INCR FAN OPER COST =	107.43	\$/YR
NET OPER SAVINGS =	13404.55	\$/YR

PROJECT INSTALL HEAT EXCHANGER BLDG _____
FOR FBI UNIT BLDG NO. _____ DISCIPLINE MECH.
 T.O. CK. EST. CK.
 JOB NO. EZZ78 DATE AUG 24, 1983 BY: AJY BY: _____ BY: AJY BY: _____ PAGE 1 OF _____

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
HEAT EXCHANGER FOR FBI UNIT	1	EA		4400		22,000	26400
INSULATE HEAT EXCHANGER	1	LS		1530		444	1974
10" PIPE	26	LF	6.15	160	49	1274	1434
10" GATE VALVES	2	EA	215	430	2250	4500	4930
10" WELD NECKS	4	EA	81	324	1185	740	1064
10" 90° ELBOWS	3	EA	67	201	335	1005	1206
10" 20° ELBOWS	2	EA	67	134	360	720	854
INSULATE 20' OF 10" PIPE	1	LS		848		244	1092
TOTAL				8027		30927	38954
DESIGN (6%)				482		1056	2338
TAX (5%)						1546	1546
LABOR INS (15%)				1204			1204
				9713		34329	44042
GENERAL CONDITIONS (10%)				971		3433	4404
				10684		37762	48446
CONTRACTOR'S MARK-UP (25%)				2671		9441	12112
				13355		47203	60558
CONTINGENCIES (25%)				3339		11801	15140
				16694		59004	75698

Total This Page _____

Client: PDF

Proj. No: E-2278

Prel. Pg. No: 1

Location: INDIAN HEAD MD.

Calc: AJY

Date: AUG 24, 1983

Subject: PAYBACK CALCULATION

Chkd: GEB

Date: 10/22/83

Bkchkd:

Date:

FOR A 10 YEAR PROJECT LIFE THE
PRESENT VALUE OF \$1.00 IN A CUMULATIVE UNIFORM
SERIES WITH A 10% DISCOUNT RATE IS 6.447.
THE SAVINGS INVESTMENT RATIO (SIR) IS:

$$SIR = 6.447 \text{ ANNUAL SAVINGS} / \text{INVESTMENT}$$

1. FLUIDIZED BED.

$$SIR = 6.447 (13820) / 95698 = 1.17$$

PAYBACK FROM TABLE C APPENDIX E OF NAUFAL
P-442 IS 7.84 YEARS.

2. CATALYTIC OXIDATION UNIT

$$SIR = 6.447 (12024) / 77002 = 1.01$$

PAYBACK IS 10 YEARS

3. WATER TREATMENT

$$SIR = 6.447 (2520) / 17094 = .950$$

THIS WILL NOT PAYBACK IN THE LIFE
OF THE PROJECT.

4. ONE BOILER

$$SIR = 6.447 (4336) / 23052 = 1.21$$

PAYBACK IS 7.53 YEARS.

Client: PDF

Proj. No: E-2278

Prel. Pg. No: 2

Location: INDIAN HEAD MO.

Calc: AJY

Date: Aug. 24, 1983

Subject: PAYBACK CALCULATIONS,

Chkd: GEG

Date: 10/22/87

Bkchkd:

Date:

5 AFTER BURNER

$$SIR = 6,447(758) / 16,152 = 302$$

THIS WILL NOT PAYBACK IN THE
LIFE OF THE PROJECT.

ECONOMIC ANALYSIS - EIGHT WASTE DISPOSAL OPTIONS

Client: CHESDIN

Proj. No: E-2778

Prel. Pg. No: _____

Location: NDS

Calc: AJY

Date: OCT 26, 1973

Subject: ECONOMICS

Chkd: GEB

Date: OCT 27, 1973

Bkchkd: _____

Date: _____

THE FOLLOWING CALCULATIONS PRESENT ECONOMIC
ANALYSES OF THE FEASIBLE OPTIONS FOR 100 PERCENT
DISPOSAL OF NDS GENERATED WASTE

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No: 1

Location: INDIAN HEAD MD.

Calc: ASY

Date: OCT. 26, 1983

Subject:

Chkd: GRB

Date: 10/27/83

Bkchkd:

Date:

METHOD OF CALCULATING EQUIVALENT UNIFORM ANNUAL COST AND NET PRESENT VALUE

INFORMATION NEEDED:

1. ANNUAL OPERATING COSTS
2. INITIAL CAPITAL INVESTMENT COST.
3. PROJECT LIFE EXPECTENCY
4. SALVAGE VALUE.

Items 1 & 2 WERE OBTAINED FROM OPERATING & CONSTRUCTION COST ESTIMATES.

Item 3 WAS OBTAINED FROM PG. 14 OF NAVFAC P-442 "ECONOMIC ANALYSIS HANDBOOK". THIS GIVES THE ECONOMIC LIFE OF OPERATING EQUIPMENT AS 10 YEARS.

Item 4 SALVAGE VALUE WAS ASSUMED TO BE 5% OF INITIAL COST.

THE NET PRESENT VALUE (NPV)

1. PROJECT CAPITAL INVESTMENT COST
2. ANNUAL OPERATING COST TIMES PRESENT VALUE OF 1 DOLLAR CUMULATIVE UNIFORM SERIES OF 10 YEARS (TABLE B PG E-2 NAVFAC P-442)
3. THE SALVAGE VALUE TIMES THE NEGATIVE PRESENT VALUE OF 1 DOLLAR OVER 10 YEARS, (TABLE A PG E-2 NAVFAC P-442)

NOTE: P-442 USES A DISCOUNT RATE OF 10%.

Client: CHES DIV

Proj. No: E-2778

Prel. Pg. No: 2

Location: INDIAN HEAD, MD.

Calc: AJV

Date: OCT 26, 1983

Subject:

Chkd: GEB

Date: 10/27/83

Bkchkd:

Date:

THE UNIFORM ANNUAL COST WAS CALCULATED
FROM THE FORMULA

$$C = NPU / p_n$$

WHERE

C = UNIFORM ANNUAL COST

p_n = PRESENT VALUE OF 1 DOLLAR
CUMULATIVE UNIFORM SERIES OF
10 YEARS

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No: 3

Location: INDIAN HEAD MD.

Calc: ASY

Date: Oct. 25, 1983

Subject:

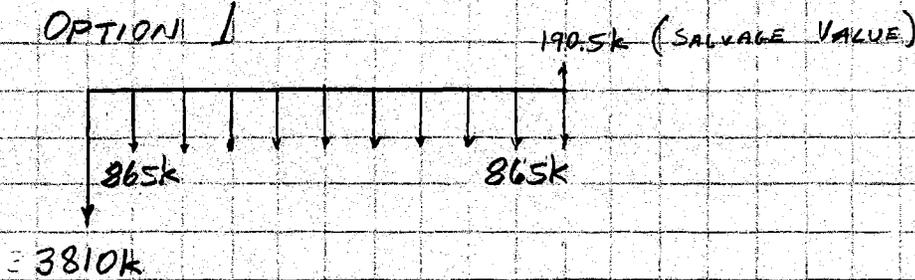
Chkd: GEB

Date: 10/27/83

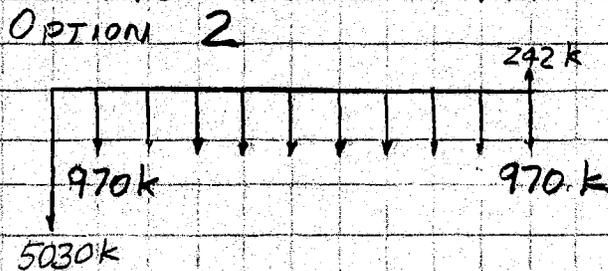
Bkchkd:

Date:

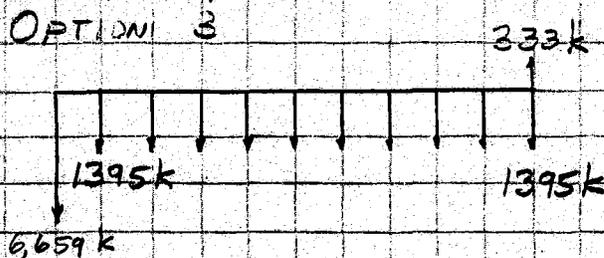
OPTION 0 $99920 + 4548 = 54468$
 Total NPV Cost = $6.447(54.5)$
 $= 351 \text{ k}$
 $C = 54.5 \text{ k}$



Total NPV Cost = $3810 + 6.447(865) - .405(190.5)$
 $= 9310 \text{ k}$
 $C = 9310 / 6.447 = 1444 \text{ k}$



Total NPV Cost = $5030 + 6.447(970) - .405(242)$
 $= 11186$
 $C = 11186 / 6.447 = 1735 \text{ k}$



Total NPV Cost = $6659 + 6.447(1395) - .405(333) = 15518 \text{ k}$
 $C = 15518 / 6.447 = 2407 \text{ k}$

Client: CHESDIV

Proj. No: E-2278

Prel. Pg. No: 4

Location: INDIAN HEAD MD.

Calc: ASJ

Date: Oct. 25, 1983

Subject: _____

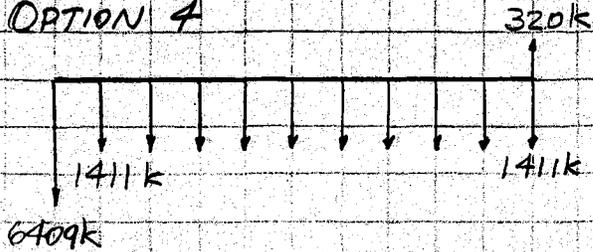
Chkd: GEB

Date: 10/27/83

Bkchkd: _____

Date: _____

OPTION 4

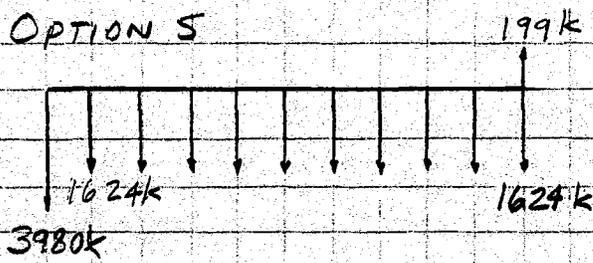


$$\text{Total NPV Cost} = 6409 + 6.447(1411) - .405(320)$$

$$= 15376 \text{ k}$$

$$C = 15376 / 6.447 = 2385 \text{ k}$$

OPTION 5

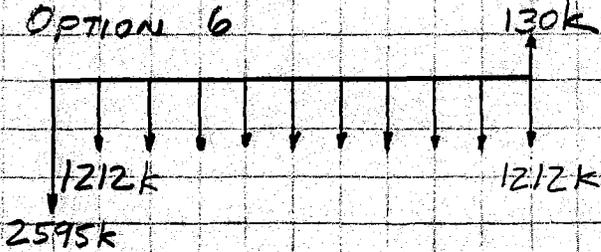


$$\text{Total NPV Cost} = 3980 + 6.447(1624) - .405(199)$$

$$= 14369 \text{ k}$$

$$C = 14369 / 6.447 = 2229 \text{ k}$$

OPTION 6



$$\text{Total NPV Cost} = 2595 + 6.447(1212) - .405(130)$$

$$= 10401 \text{ k}$$

$$C = 10401 / 6.447 = 1613 \text{ k}$$

Client: CAES DIV

Proj. No: E-2272

Prel. Pg. No: 5

Location: INDIAN HEAD MD.

Calc: ASY

Date: Oct 25, 1983

Subject:

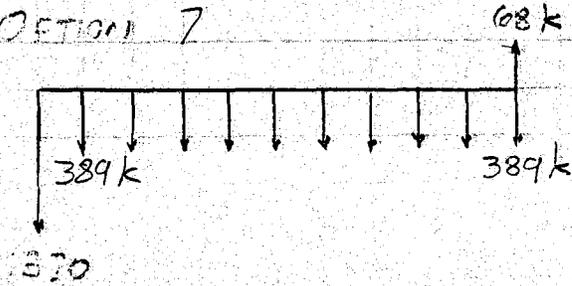
Chkd: GEB

Date: 10/27/83

Bkchkd:

Date:

SECTION 7



$$\text{TOTAL NPV COST} = 1370 + 6.447(389) + 7405(68)$$
$$= 3850 \text{ k}$$

$$L = 3850 / 6.447 = 597 \text{ k}$$

COST ESTIMATE *OPERATING COST*

PROJECT NAVAL ORD. STA.

BLDG CONTAMINATED WASTE PROCESSOR

INDIAN HEAD, MD.

BLDG NO. _____ DISCIPLINE MECH.

JOB NO. E-2278 DATE 10-17-83 T.O. 1 CK. WU BY: GEO

EST. WU CK. _____ BY: _____ PAGE 1 OF 1

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
<i>COST FOR 1-DAY</i>							
FUEL OIL	416	GAL.	1.10		1.10	458	
PERSONNEL (4 REQ'D)	96	Hr	30	2880			
MAINT. COST \$40,000 YR./365	1				1 Day	110	
WATER					1 Day	5	
ELECTRICITY	216	KW			.10	216	
DISPOSAL OF ASHES ETC.	1	Day		100			
	TOTAL			2980		789	3769
<i>\$3769⁰⁰/DAY</i>							
<i>A SINGLE SHIFT = \$1,256⁰⁰/DAY</i>							
<i>ASSUME SINGLE SHIFT WOULD OPERATE 10 MONTHS PER YR.</i>							
<i>10 x 30 x 1256 = \$376,800⁰⁰</i>							

PROJECT NAVAL ORD. STA.

OPERATING COST.
BLDG EXPLOSIVE WASTE INCINERATOR

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE MECH.

JOB NO E-2278 DATE 10-17-83 BY: WU

EST. BY: WU CK. BY: _____

PAGE 1 OF 1

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
			Cost 1 Day				
FUEL OIL	504	Gal			1.10	554	
PERSONNEL (4-REQ'D.)	96	Hr	30	2880			
MAINT. COST \$80,000/YR / 365	1				Day	220	
WATER	1				Day	15	
ELECTRICITY	2160	KWh			.10	216	
DISPOSAL OF ASHES ETC	1	Day		100			
TOTAL				2980		1005	3985
				\$3985 ⁰⁰	Day		
A SINGLE SHIFT = \$1,328 ⁰⁰							
ASSUME SINGLE SHIFT WOULD OPERATE 10 MONTHS PER YR.							
10 x 30 x 1170 = \$398,400 ⁰⁰							

Total This Page _____

Client: NAV. ORP. STA.

Proj. No: E-2278

Prel. Pg. No: 1-1

Location: INDIAN HEAD, MD.

Calc: W.W.W.

Date: 10-25-83

Subject: RECAP - OPER. COST

Chkd:

Date:

WAO & FBI UNITS

Bkchkd:

Date:

COST OF OPERATION

RECAP

WAO UNIT (INCREMENT I)

PREPARATION - $60,000\# \times \$1.00 = \$60,000.00$
PER 1, 5 DAY RUN.
 $\$60,000.00 \times 6 \text{ RUNS PER YR} = \$360,000.00 \text{ YR.}$

ASSUME PREP. COST $\$.10 \text{ LB}$ OR $\$200.00 \text{ TON}$

DISPOSAL - $60,000\# = \$60,643.00$ PER 1, 5 DAY RUN.
 $\$60,643.00 / 60,000 =$
 $\$.01 \text{ LB}$ OR $\$2040.00 \text{ TON.}$

$\$60,643.00 \times 6 \text{ RUNS PER YR} = \$363,900.00 \text{ YR.}$

TOTAL PREP. & DISP. = $\$400,000 = \$.11 \text{ LB.}$

FBI UNIT (INCREMENT II)

PREPARATION - $120,000\# \times \$1.00 = \$120,000.00$
PER 1, 5 DAY RUN
 $\$120,000.00 \times 6 \text{ RUNS PER YR} = \$720,000.00 \text{ YR.}$

DISPOSAL - $120,000\# = \$101,934.00$ PER 1, 5 DAY RUN.
 $\$101,934.00 / 120,000 =$
 $\$.85 \text{ LB}$ OR $\$1,700.00 \text{ TON.}$

$\$101,934.00 \times 6 \text{ RUNS PER YR} = \$611,600.00 \text{ YR.}$

TOTAL PREP & DISP. = $\$683,600.00 = .95 \text{ LB.}$

Client: NAV. ORD. STA Proj. No: E-2278 Prel. Pg. No: 1 OF 3
 Location: INDIAN HEAD, MD. Calc: WWW. Date: 10-25-83
 Subject: OPERATING COST Chkd: _____ Date: _____
WAO UNIT. Bkchkd: _____ Date: _____

OPERATING COST
 BASED UPON 24 HRS PER DAY
 FOR 5 DAYS.
 COMPLETE TOTAL BASED UPON
 6 - 5 DAY OPERATIONS PER YEAR.
WAO UNIT (INCREMENT I)

- 1) PREPARATION - 500#/HR
 DISPOSAL AMOUNT = 6000# @ \$.10 = \$6000⁰⁰
- 2) MATERIAL TO SITE; 1000# PER
 LOAD = 60 LOADS @ 1 HR. EA. =
 \$40.00 HR x 60 (INCLUDES LABOR & EQUIP) = \$2400⁰⁰
- 3) MAINTENANCE PREPARATORY TO
OPERATION (INCLUDES LABOR & MAT'L)
 4 - MEN 1 WEEK = 160 HRS. x \$40.00 = \$6400⁰⁰
- 4) OPERATING PERSONNEL FOR RUN
 (INCLUDES LABOR, CONT. MAINT. & SLURRY PREP) \$
 4 - MEN x 120 HRS x \$40.00 = \$19,200⁰⁰
- 5) ELECTRICAL POWER (SHREDDER & CONVEY.
SYSTEM) ASSUME 6 - 7.5HP & 1 - 50HP.
 MOTORS = 95HP x .746 x 120 = 8505 KWH x \$.10 = \$850⁰⁰
- 6) ELECTRICAL POWER FOR CONTINUOUS
OPERATION OF SLURRY STG. BLDG.
 60 HP x .746 x 192 HRS = 8594 KWH x \$.10 = \$860⁰⁰

Client: NAV. ORD. STA.

Proj. No: E-2278

Prel. Pg. No: 2 OF 3

Location: INDIAN HEAD, MD.

Calc: W.W.W.

Date: 10-25-83

Subject: OPERATING COST
WAO UNIT.

Chkd:

Date:

Bkchkd:

Date:

7) OPERATION OF BOILER (1-300HP)
 FUEL OIL @ 89 GPH. SAY 144 HRS X
 $89 \times \$1.10 \text{ GAL} = \$14100^{00} + \$200^{00} \text{ CHEM.} = \$14,300^{00}$

8) WATER - ASSUME \$100⁰⁰ PER WK. = \$500⁰⁰

9) OPERATION OF SLURRY SYSTEM

ELECTRICAL
 $120 \text{ HP} \times .746 \times 120 = 10742 \text{ KWH} \times \$10 = 1074^{00}$

10) SLURRY SYSTEM CONTINUOUS MAINT. \$
 1-MAN 60 HRS X \$40.00 (1/2 OPER. TIME) = 2400⁰⁰

11) OPERATION OF WAO SYSTEM ELECTRICAL

ASSUME 2-20HP, 2-10HP, & 4-5HP
 MOTORS = $80 \text{ HP} \times .746 \times 120 = 7162 \text{ KWH} \times \$10 = 716^{00}$

12) WAO BOILER OPERATION (1/2 OPER. TIME)
 $20 \text{ GPH} \times 60 \text{ HR.} \times 1.10 = \1320^{00}

13) WAO AFTER BURNER OPERATION \$
 $3 \text{ GPH} \times 120 \text{ HRS} \times 1.10 = 396^{00}$

14) WAO CONTINUOUS MAINT. (1/2 OPER. TIME) \$
 1-MAN 60 HRS X \$40⁰⁰ = 2400⁰⁰

15) WATER TREATMENT ELECTRICAL

ASSUME 4-20HP, 4-10HP, & 5-5HP
 MOTORS + 20 MISC. HP = 165HP =
 $165 \times .746 \times 120 \text{ HRS} = 14770 \text{ KWH} \times \$10 = 1477^{00}$

16) WATER TREATMENT CHEMICALS

\$100.00 PER WK = \$500⁰⁰

Client: NAV. ORD. STA.

Proj. No: E-2278

Prel. Pg. No: 3 OF 3

Location: INDIAN HEAD, MD.

Calc: WWW.

Date: 10-25-83

Subject: OPERATING COST
WAO UNIT.

Chkd:

Date:

Bkchkd:

Date:

17) WATER TREATMENT CONTINUOUS
MAINT. 1-MAN 60 HRS (1/2 OPER. TIME) * \$
340⁰⁰ = \$2400⁰⁰

18) WATER \$50 PER WK = \$250⁰⁰

19) SHUTDOWN TO STANDBY

2-MEN, 1 WEEK = 80 HR * \$40⁰⁰ = \$3200⁰⁰

TOTAL \$66,643⁰⁰

\$66,643⁰⁰ * 6 = SAY \$400,000⁰⁰ YR.

Client: NAV. ORD. STA.

Proj. No: E-2278

Prel. Pg. No: 1 OF 3

Location: INDIAN HEAD MD.

Calc: WUW

Date: 10-25-83

Subject: OPERATING COST
FBI UNIT.

Chkd:

Date:

Bkchkd:

Date:

OPERATING COST
BASED UPON 24 HRS., PER DAY
FOR 5 DAYS.
COMPLETE TOTAL BASED UPON
6-5 DAY OPERATIONS PER YEAR
FBI UNIT (INCREMENT II)

- 1) PREPARATION - 1000#/HR
DISPOSAL AMOUNT 120,000#@\$.10 = \$12000⁰⁰
- 2) MATERIAL TO SITE 1000# PER LOAD
120 LOADS x \$40.00 HR (LABOR & EQUIP.) = \$4800⁰⁰
- 3) MAINTENANCE PREPARATORY TO
OPERATION - SAME AS WAO = \$6400⁰⁰
- 4) OPERATING PERSONNEL FOR RUN
SAME AS WAO = \$19200⁰⁰
- 5) ELECTRICAL POWER (SHREDDER & CONVEY
SYSTEM) SAME AS WAO = \$850⁰⁰
- 6) ELECTRICAL POWER FOR CONTINUOUS
OPERATION OF SLURRY STG. BLDG.
SAME AS WAO = \$860⁰⁰
- 7) OPERATION OF BOILER (1-300 HP)
SAME AS WAO = \$14,300⁰⁰
- 8) WATER SAME AS WAO = \$500⁰⁰
- 9) OPERATION OF SLURRY SYSTEM -
ELECTRICAL - SAME AS WAO = \$1074⁰⁰

Client: NAY. ORD. STA.

Proj. No: E-2278

Prel. Pg. No: 2 OF 3

Location: INDIAN HEAD MD.

Calc: W.W.W.

Date: 10-25-83

Subject: OPERATING COST
F. B. I. UNIT

Chkd:

Date:

Bkchkd:

Date:

10) SLURRY SYSTEM CONTINUOUS MAINT. \$ 2400⁰⁰
SAME AS WAO =

11) OPERATION OF F. B. I. ELECTRICAL \$ 1343⁰⁰
ASSUME 150HP x .746 x 120 = 13428 KWH x \$.10 =

12) F. B. I. OPERATION \$ 7920⁰⁰
ASSUME 60 GPH x 120 HR x 1.10 =

13) OPERATION OF CATALYTIC OXIDIZER \$ 3960⁰⁰
ASSUME 30 GPH x 120 HR x 1.10 =

14) F. B. I. MAINTENANCE \$ 4800⁰⁰
2-MEN 120 HRS x \$40.00 (1/2 OPER. TIME) =

15) HANDLING OF F. B. I. BED MATERIAL \$ 9600⁰⁰
INSTALLATION AND REMOVAL
2-MEN 240 HRS x \$40⁰⁰ =

16) LOSS OF F. B. I. BED MATERIAL \$ 10,500⁰⁰
LOSS 500#/HR @ \$350⁰⁰ PER TON =
500 x 120 / 2000 x 350 =

17) DISPOSAL OF WASTES 60 LOADS \$ 2400⁰⁰
@ 1 HR EA = 60 x \$40⁰⁰ =
(INCLUDES LABOR & EQUIP.)

18) WATER TREATMENT ELECTRICAL \$ 1477⁰⁰
SAME AS WAO =

19) WATER TREATMENT CHEMICALS \$ 500⁰⁰
SAME AS WAO =

Client: NAV. ORD. STA.

Proj. No: E-2278

Prel. Pg. No: 3 OF 3

Location: INDIAN HEAD, MD.

Calc: WUW

Date: 10-25-83

Subject: OPERATING COST
F. B. I. UNIT.

Chkd:

Date:

Bkchkd:

Date:

20) WATER TREATMENT CONTINUOUS \$
MAINTENANCE - SAME AS WAO = \$2400⁰⁰

21) WATER - SAME AS WAO = \$250⁰⁰

22) SHUTDOWN TO STANDBY
SAME AS WAO = \$3200⁰⁰

TOTAL \$113,934⁰⁰

\$113,934⁰⁰ x 6 = SAY \$683,600⁰⁰

Client: CHESDIVProj. No: E-2278

Prel. Pg. No: _____

Location: INDIAN HEAD M.D.Calc: AJYDate: OCT. 24, 1983Subject: SHIPPING COSTSChkd: GEBDate: 10/27/83

Bkchkd: _____

Date: _____

SHIPPING COSTS					
ORT.	LB/WR.	CODE NO.	PACKING ¹ COST	SHIPPING ² COST	TOTAL
4	25,000	8	21,250	1488	22738
5	25,000	8	21,250	1488	22738
6	126,400	3	107,100	7520	114620
	3000	4	2550	188	2728
	515200	5	437,920	30654	468574
	108,800	6	92,480	6474	98954
	25,000	8	21,250	1488	22738
7	25,000	8	21,250	1488	22738
TODLA	5000	7	4250	298	4548
1	SEE PG.	XI-17	, \$85 / LB		
2	SEE PG.	XI-18	, \$119 / TON		

ALTERNATE FACILITY USES - COST ESTIMATES AND PAYBACK ANALYSES

Client: CHESDIY

Proj. No: E-2278

Prel. Pg. No: 1

Location: INDIAN HEAD, MD. Calc: DAO

Date: 8/30/83

Subject: ALTERNATE USES
WAO

Chkd: GBB

Date: 10/27/83

Bkchkd:

Date:

I. ECONOMIC PAYBACK ANALYSIS FOR WAO FACILITY ALTERNATE USAGE

A.

SILVER RECOVERY FROM PHOTOGRAPHIC FILM AND
DEVELOPER

FACTORS IN SAVINGS - INVESTMENT RATIO
EQUATION:

A = COST OF NEW EQUIPMENT

B = COST OF OPERATING WAO FACILITY

C = SELLING PRICE OF SILVER

D = PRESENT FILM PURCHASE CREDIT FROM
RECOVERY CARTRIDGE HANDLER

E = PROJECT YEAR DISCOUNT FACTOR (CUMULATIVE
UNIFORM SERIES) FOR 10 YR. EQUIPMENT LIFE

F = COST OF REFINING SILVER SLUDGE PRODUCED BY
WAO UNIT

$$SIR = [C - (B + D + F)] E / A$$

REFERENCE (6.)

AMOUNT OF PHOTOGRAPHIC AND X-RAY FILM
CONSUMED ON BASE IS APPROXIMATELY 200,000 SQ. FT.
PER YEAR

THE REFINING COST OF OBTAINING SILVER FROM
SILVER SLUDGE AS PRODUCED BY THE WAO UNIT
IS \$0.70 PER 100 SQ. FT. FILM PLUS FIXER REQUIRED TO
DEVELOP THAT AMOUNT.

$$\begin{aligned} \text{THE COST OF REFINING SLUDGE FROM} \\ 200,000 \text{ SQ. FT. FILM} &= 200,000 \text{ SQ. FT.} \times \frac{\$0.70}{100 \text{ SQ. FT.}} \\ &= \$1400.00 \end{aligned}$$

Client: CHES DIV

Proj. No: E-2278

Prel. Pg. No: 2

Location: INDIANHEAD, MD.

Calc: DAO

Date: 8/30/83

Subject:

Chkd: GBB

Date: 10/27/83

Bkchkd:

Date:

COST OF NEW EQUIPMENT = \$194,200.00

COST OF OPERATING WAO FACILITY FROM
REFERENCE (a) = \$0.60 PER POUND OF SOLID
MATERIAL. 20,000 LB SOLID MATL. X 0.60 = \$12,000.00

CURRENT SELLING PRICE OF SILVER TAKEN AT
\$12.00/OZ.

PRESENT CREDIT FOR WASTE FILM AND FIXER = 0.88/SILVER
200,000 SQ. FT. FILM X 2 OZ. SILVER PER 100 SQ. FT. FILM X \$0.88 = \$3520.00
100 SQ. FT. FILM OZ. SILVER

VALUE OF RECOVERED SILVER RETURNED TO BASE;

= 200,000 SQ. FT. FILM X 2 OZ. SILVER PER 100 SQ. FT. FILM
X \$12.00 PER OZ. SILVER
= \$48,000.00

SIR = $\left[\frac{48,000 - (12,000 + 3,520 + 1,400)}{194,200} \right] 6.447$

SIR = 1.03

PAYBACK = 10 YEARS

Client: CHESDI

Proj. No: E-2278

Prel. Pg. No: 3

Location: INDIANHEAD, MD.

Calc: DAO

Date: 8/30/83

Subject: ALTERNATE USES

Chkd: GEB

Date: 10/27/83

Bkchkd:

Date:

B. SEWAGE SLUDGE DISPOSAL

THE AMOUNT OF SLUDGE GENERATED ON BASE IS 150 CUBIC YARDS PER YEAR

THE COST OF OXIDIZING THIS AMOUNT OF SLUDGE IN THE WAO UNIT IS ESTIMATED AS (REF. C);

$$150 \text{ CU. YDS.} \times \frac{27 \text{ FT}^3}{\text{CU. YD.}} \times 62.4 \left(\frac{\text{LB SLUDGE}}{\text{FT}^3} \right) \times \frac{\$ 0.60}{\text{LB SLUDGE}} = \$ 45,490.00 \text{ PER YEAR}$$

THE PRESENT SLUDGE HAULING CONTRACT IS

$$\$ 5,000.00 \text{ PER YEAR}$$

IMPROVEMENTS TO THE WAO FACILITY TO PERMIT SLUDGE HANDLING WERE ACCOUNTED FOR IN THE SILVER RECOVERY PAYBACK ANALYSIS.

FOR SLUDGE DISPOSAL THE SAVINGS/INVESTMENT RATIO IS NEGATIVE SINCE THE COST IS GREATER THAN THE SAVINGS.

Client: CHESDI V

Proj. No: E-2278

Prel. Pg. No: 4

Location: INDIAN HEAD, MD.

Calc: DAO

Date: 8/30/83

Subject: ALTERNATE USES FBI

Chkd: GEB

Date: 10/27/83

Bkchkd:

Date:

II. ECONOMIC PAYBACK ANALYSIS FOR FBI FACILITY ALTERNATE USAGE

A. DISPOSAL OF NON-HAZARDOUS TRASH

THE COST OF OPERATING THE FBI FACILITY FOR DESTROYING DOUBLE BASE PROPELLANTS IS \$0.64 PER POUND FROM REFERENCE (A). DESTRUCTION OF TRASH WOULD HAVE A LOWER OPERATING COST IF THE FOLLOWING CONDITIONS EXISTED;

1. THE USE OF GROUND MATERIAL WETTED ONLY SUFFICIENTLY TO PERMIT TRANSFER BY A MOYNO PUMP. FUEL COSTS WOULD BE REDUCED BY THE LOWER WATER VAPORIZATION ENERGY REQUIREMENT
2. LABOR COST REDUCED BY IMPROVED HANDLING TECHNIQUES FOR NEW AND SPENT BED MATERIAL AS DISCUSSED IN REFERENCE (A).

REVISED FBI OPERATING COST PER 1000 LB. SOLIDS	
\$648.86	PROPELLANT DESTRUCTION
- \$ 60.00	FUEL OIL SAVINGS WITH TRASH
- \$ 172.38	BED MATERIAL HANDLING IMPROVEMENTS (TABLE 16, REF. A)
<u>\$408.48</u>	FBI OPERATING COST FOR TRASH

COST IS TAKEN AS \$0.41 PER POUND

THE AMOUNT OF NON-HAZARDOUS TRASH GENERATED ON BASE REQUIRES EMPTYING 154 DUMPSTERS TWICE WEEKLY. THE DENSITY OF HOUSEHOLD TRASH WAS ESTIMATED AT 4 LBS. PER CUBIC FOOT.

Client: CHESDIV

Proj. No: E-2278

Prel. Pg. No: 5

Location: INDIANHEAD, MD.

Calc: DAO

Date: 8/30/83

Subject: ALTERNATE USES FBI

Chkd: GEB

Date: 10/27/83

Bkchkd:

Date:

THE COST OF DESTROYING BASE GENERATED
NON-HAZARDOUS TRASH IN THE FBI FACILITY IS
ESTIMATED AS;

$$\begin{aligned} &154 \text{ DUMPSTERS} \times 5 \text{ CU. YD. PER DUMPSTER} \\ &\times 50 \text{ PERCENT FILLING FACTOR} \times 27 \text{ FT}^3/\text{CU. YD.} \\ &\times 4 \text{ LB/FT}^3 \text{ TRASH DENSITY} \times 2 \text{ EMPRIES PER WK} \\ &\times 52 \text{ WK. PER YR.} \times \$0.41 \text{ PER POUND OPERATING COST} \\ &= \$1,772,971 \text{ PER YEAR} \end{aligned}$$

THE PRESENT TRASH HAULING CONTRACT IS

$$\$110,000 \text{ PER YEAR}$$

IMPROVEMENTS TO THE FBI FACILITY TO
PERMIT TRASH DESTRUCTION IS COSTED AT

$$\$244,300$$

THE SAVINGS/INVESTMENT RATIO IS NEGATIVE
SINCE THE COST IS GREATER THAN THE SAVINGS.



COST ESTIMATE

ALTERNATE USE FOR
WAO SYSTEM.

PROJECT NAVAL ORD. STA.

BLDG _____

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE _____

JOB NO. E-2278 DATE 8-29-83 T.O. BY: WU CK. BY: _____

EST. BY: WU CK. BY: _____

PAGE 1 OF 2

DESCRIPTION	QUANTITY		LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
<u>EQUIPMENT</u>							
<u>HOPPER</u>	<u>72</u>	<u>HR</u>	<u>30</u>	<u>2160</u>		<u>5000</u>	
<u>GRINDER</u>	<u>48</u>	<u>"</u>	<u>30</u>	<u>1440</u>		<u>15000</u>	
<u>WEIGH FEEDER</u>	<u>60</u>	<u>"</u>	<u>30</u>	<u>1800</u>		<u>5000</u>	
<u>CONVEYOR</u>	<u>96</u>	<u>"</u>	<u>30</u>	<u>2880</u>		<u>3800</u>	
<u>SLURRY PUMP</u>	<u>96</u>	<u>"</u>	<u>30</u>	<u>2880</u>		<u>1500</u>	
<u>SLURRY TANK</u>	<u>32</u>	<u>"</u>	<u>30</u>	<u>960</u>		<u>4800</u>	
<u>SLURRY TANK AGITATOR</u>	<u>8</u>	<u>"</u>	<u>30</u>	<u>240</u>		<u>2000</u>	
<u>ELECTRICAL & INSTRUMENTATION.</u>	<u>160</u>	<u>"</u>	<u>30</u>	<u>4800</u>		<u>10000</u>	
<u>PIPING</u>	<u>240</u>		<u>30</u>	<u>7200</u>		<u>5000</u>	
<u>COST FOR START-UP</u>	<u>480</u>		<u>30</u>	<u>14400</u>		<u>2000</u>	
<u>TOTAL</u>	<u>1388</u>			<u>38760</u>		<u>54100</u>	

Total This Page

COST ESTIMATE

ALTERNATE USE
FOR F.B.I. SYSTEM

PROJECT NAVAL ORD. STA.

BLDG _____

INDIAN HEAD, MD.

BLDG NO. _____

DISCIPLINE _____

JOB NO. E-2278 DATE 8-29-83 T.O. BY: WW CK. BY: _____

EST. BY: WW CK. BY: _____

PAGE 1 OF 2

DESCRIPTION	QUANTITY			LABOR		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL		
ALL BASED UPON ASSUMPTION F.B.I. UNIT INSTALLED.								
HOPPER	72	HR	30	2160		7000		
GRINDER	48	"	30	1440		7000		
WEIGH FEEDER	60	"	30	1800		5000		
CONVEYOR	96	"	30	2880		4800		
SLURRY PUMP	96	"	30	2880		1500		
SLURRY TANK	32	"	30	960		4800		
SLURRY TANK AGITATOR	8	"	30	240		2000		
ELECTRICAL & INSTRUMENTATION	160	"	30	4800		15000		
PIPING	240	"	30	7200		6000		
COST FOR START UP	480		30	14400		2000		
TOTAL	1292			38760		68100		

Total This Page

IX. Miscellaneous Communications

GPB

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE 10-5-83 8:00 AM

SUBJECT: Disposal of Waste Propellant

ORGANIZATION: Radford

CITY, STATE: _____

PERSON/TITLE: JOHN HORVATH 703-639-8641 (RIF FTS)

INITIATED / ~~RECEIVED~~ CALL: W.W. WASSMUND

ITEMS OF CONVERSATION / ACTION TO BE TAKEN: at Radford
the material fed to the grinder
(MITTS and Merrill) is in approx
max 2 inch size and
the grinder reduces this to 1/8"
or less in one pass. At
Radford they saw the propellant
into these smaller sizes so
the grinder will accept it,
rather than have two
grinders. Mr. Horvath said
the grinding operation causing
into these small pieces was
not detrimental.

BY W.W. Wassmund

GB

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE 10-5-83 - 11:10 AM
SUBJECT: MITT & MERRILL (FLYING KNIFE GRINDERS)
ORGANIZATION: MITT & MERRILL INC.
CITY, STATE: SABINAW, MICH. (517-752-6191)
PERSON/TITLE: BILL McMAHON
INITIATED / RECEIVED CALL: W. W. WASSMUND

ITEMS OF CONVERSATION / ACTION TO BE TAKEN: DISCUSSED
THEIR GRINDING EQUIP. ACCORDING TO MR.
McMAHON THEIR FLYING KNIFE GRINDERS ARE
CAPABLE OF REDUCING 8" SIZE MATERIAL TO 1/8" OR
LESS IN ONE PASS. REQUESTED CATALOG AND
ANY TECHNICAL DATA AVAILABLE PERTAINING
TO THEIR GRINDING EQUIPMENT. WE SHOULD
RECEIVE THIS SHORTLY.

ALSO McMAHON STATED THEY HAVE
TWO GRINDERS AT TADFORD AND AT
LEAST ONE AT HAWTHORN.

BY W. W. WASSMUND.

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE 3^{30 PM} / 8-26-83

SUBJECT: ALTERNATE USE OF PROPELLANT DISPOSAL FACILITY

ORGANIZATION: INDIANHEAD NAVAL ORDNANCE STATION

CITY, STATE: INDIANHEAD, MD.

PERSON/TITLE: MR. A. J. PERK (301) 743-4495

INITIATED / RECEIVED CALL: MR. PERK / D. OSBORNE

ITEMS OF CONVERSATION / ACTION TO BE TAKEN: _____

1. 165,000 FT² OF X-RAY FILM IS UTILIZED PER YEAR BY THE PRODUCTION O/C X-RAY FACILITY. AN ADDITIONAL LESSER AMOUNT OF FILM PER YEAR IS UTILIZED AT OTHER FACILITIES THROUGHOUT THE BASE. THIS INFO. OBTAINED FROM THE PROPERTY DISPOSAL OFFICER.
2. THE REMOVAL OF 150 CU. YDS. OF SEWAGE SLUDGE TO AN OFF-SITE LANDFILL COSTS \$5000/YR. AND IS PART OF A \$160,000/YR CONTRACT FOR SITE MAINTENANCE WITH A HANDICAPPED PERSONNEL ORGANIZATION
3. TRASH/GARBAGE CONTRACT WITH LOCAL HAULER IS FOR \$110,000/YR.
4. THERE ARE NO SIGNIFICANT NON-ORDNANCE WASTE CHEMICALS PRODUCED ON BASE EXCEPT FOR A SMALL AMOUNT OF WASTE OIL.

BY D. A. OSBORNE

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE 1:45 PM - 8-5-83
SUBJECT: Belt lift conveyors
ORGANIZATION: Sell Equipment Co 839-0230
CITY, STATE: Floresant, Mo
PERSON/TITLE: Cliff Sell
INITIATED / ~~RECEIVED~~ CALL: W.W. Wassman

ITEMS OF CONVERSATION / ACTION TO BE TAKEN:

Discussed "Hapman Belt Lift Conveyor" for handling powders or explosive materials of any kind. He did recall use of a competitor's belt of this type for explosives, but knows of no specific applications where the Hapman belt was used.

The belt by other name can be made of any material the customer might specify. Examples being Rubber, Neoprene, nylon, reinforced nylons etc. Also belt can be food grade, with no charging etc.

BY W.W. Wassman

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE 8/23/83
SUBJECT: Latest Regulations on Open Burning
ORGANIZATION: US EPA
CITY, STATE: Wash DC
PERSON/TITLE: Mark Surgen (202-382-4761)
INITIATED / ~~RECEIVED~~ CALL: NE Burger

ITEMS OF CONVERSATION / ~~ACTION TO BE TAKEN~~: At the suggestion of Frank Peters I called to try to determine what the latest likely amendments to regulations governing open burning of explosive wastes might be.

According to Mark, NOS (and everyone else) is operating under Interim Status Standards which allow open burning at existing sites where no other feasible means of disposal exist. EPA cannot legally approve new sites. However, they might "look the other way" if a state or locality wanted to establish a new open burning ground and nobody on the state or local level were opposed.

The latest amendments were expected to be released in June or July but are "hung up" somewhere. The new draft Federal Regs will

BY YEB

be issued as Subpart X of 40 CFR part 264. Subpart X will deal with one of a kind or special facilities which would encompass things like open burning of propellants and explosives. The proposed regulations will be very general generic environmental goals.

They will say things like - open burning shall not have a detrimental effect on ground water or adjacent water. The actual requirements will be negotiated separately for each site and will be left largely up to the State or Region to establish allowable limits and write permits.

To summarize, these new amendments do not appear that they will alter the status quo at NOS greatly in the immediate future.

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE 1:30 PM 8-23-83
SUBJECT: Disposal of Waste Propellant
ORGANIZATION: Radford
CITY, STATE: _____
PERSON/TITLE: LARRY COLLIE 703-639-8482 ENGR
JOHN HORVATH 703-639-8641 CHIEF ENGR
INITIATED / RECEIVED CALL: W. W. WASSMUND

ITEMS OF CONVERSATION / ACTION TO BE TAKEN: Discussed
the rotary Kiln disposal system. What
type of conveyors, grinders etc.
Basic system:- Hopper, to grinder,
grinder to surge tank, then by
pneumatic conveying water & Propellant
into Kiln. Hopper & grinder have
water spray. Rotary Kiln is brick
lined and oil fired making the
system workable but expensive.
Grinder is a MITTS and MERRILL
Flying Knife Type. If we want detailed
info on system we will have to get it
through the Navy because "Hercules"
operating Contractor has several patents on system
and information is proprietary.

BY

W. W. Wassmund

EL DORADO ENGINEERING INC.

HAZARDOUS WASTE SPECIALISTS

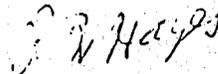
June 22, 1983

Mr. Herman Baren (DRSAR-MAD)
U.S. Army Armament Materiel Readiness Command
Rock Island Arsenal
Rock Island, Illinois 61201

Dear Mr. Baren:

El Dorado Engineering is currently performing as a subcontractor to Booker and Associates to provide a study to the Navy addressing their propellant and explosive disposal facilities. Part of this contract provides for our investigating off-site disposal services within other government agencies. Are you aware of any facilities which you believe could provide a disposal service for the propellant and explosive wastes currently generated at Indianhead? If there is significant interest, we would gladly provide details as to the type and quantities of material for which disposal services may be desired.

Sincerely,



RALPH W. HAYES
President

RWH/gh

EL DORADO ENGINEERING INC.

HAZARDOUS WASTE SPECIALISTS

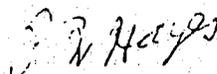
June 22, 1983

Mr. Jerry Gregg
Department of the Army
Huntsville Division Corps of Engineers
P.O. Box 1600 West Station
Huntsville, AL 35807

Dear Mr. Gregg:

El Dorado Engineering is currently performing as a subcontractor to Booker and Associates to provide a study to the Navy addressing their propellant and explosive disposal facilities. Part of this contract provides for our investigating off-site disposal services within other government agencies. Are you aware of any facilities which you believe could provide a disposal service for the propellant and explosive wastes currently generated at Indianhead? If there is significant interest, we would gladly provide details as to the type and quantities of material for which disposal services may be desired.

Sincerely,



RALPH W. HAYES
President

RWH/gh

INDIANHEAD

Appendix 3: "Explosive Waste Incinerator" taken from ammunition Equipment Office Report 19-79 "Design Analysis for Explosive Waste Incinerator" dated June, 1979 and prepared by D. B. Hill.

Appendix 4: "Contaminated Waste Processor" was prepared Mr. J.R. Clayson of EDE with excerpts from the Contaminated Waste Process design specifications authored by the Ammunition Equipment Office, Tooele Army Depot. Approximate date 1980.

TELEPHONE LOG

Project No: E-2278

Date: JULY 12, 1983

Project Name: ORDNANCE DISPOSAL STUDY

Time: 10:30 AM/PM

From/To Company: SCA SERVICES

City, State: BOSTON, MASS.

Individual's Name: MR. BOYLAND

Phone No. (area code): (617)-367-8300 EXT 605

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:
MR. BOYLAND SAID THAT SCA SERVICES WOULD UTILIZE
ITS CHICAGO INCINERATOR FOR POSSIBLE DISPOSAL OF
WASTE PROPELLANTS FROM INDIAN HEAD. HE REITERATED
THAT SCA WOULD HAVE TO HAVE SAMPLES AND AN
ANALYSIS OF EACH TYPE OF PROPELLANT PRIOR TO THE TRIAL
BURN. THE POSSIBILITY EXISTS THAT SOME OF THE COMPOSITE
PROPELLANTS MIGHT DAMAGE THE REFRACTORY LINING OF THE
ROTARY KILN INCINERATOR. HE REITERATED THAT SCA SERVICES
WOULD BE VERY HAPPY TO MEET WITH BOOKER AND THE
NAVY AT INDIAN HEAD TO FURTHER DISCUSS THE MATTER AND INVITED
BOOKER AND THE NAVY TO INSPECT SCA SERVICES' CHICAGO INCINERATOR.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Wmoff

Note: Please complete each item on this form.

TELEPHONE LOG

Project No: E-2278 Date: JULY 7, 1983
Project Name: ORDNANCE DISPOSAL STUDY Time: 1:30 AM/PM
From/To Company: ROLLINS ENVIRONMENTAL SERVICES, INC.
City, State: WILMINGTON, DEL.
Individual's Name: MR. BRYAN TRAYNOR
Phone No. (area code): (302)-429-2700

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:
MR. TRAYNOR SAID THAT HIS COMPANY COULD POSSIBLY
DISPOSE OF WASTES FROM INDIAN HEAD. THEY HAVE THREE
ROTARY KILN INCINERATORS LOCATED IN BATON ROUGE, LA.,
HOUSTON, TEXAS, AND BRIDGEPORT, N. J. BEFORE PRECEDING
ANY FURTHER, THEY WOULD REQUIRE A COMPLETE DESCRIPTION
AND CHEMICAL ANALYSIS OF ALL THE MATERIALS FROM THE
NAVY. HE SAID THAT HE WOULD SEND ME A COPY OF
THE QUESTIONNAIRE THAT WOULD HAVE TO BE FILLED OUT.
HE ACKNOWLEDGED THAT SCA SERVICES AT THEIR CHICAGO INCINERATOR
AND ENSCO AT THEIR LITTLE ROCK, ARK INCINERATOR COULD ALSO
POTENTIALLY HANDLE THE HAZARDOUS WASTE FROM INDIAN HEAD.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Knoff

Note: Please complete each item on this form.

June 20, 1983

Combustion Kinetics Corp.
1416 South Big Bend Blvd.
St. Louis, Missouri 63117

Attention: Mr. Ed Schmidt

Re: Heat Recovery Study for
Propellant Disposal Facility
Naval Ordnance Station
Indian Head, Maryland
Chesapeake Division, Naval Facilities
Engineering Command
Contract No. N62477-80-C-0441
Booker Project No. E-2278

Dear Mr. Schmidt:

Enclosed is information on possible heat recovery systems for the Indian Head Propellant Disposal Facility. As we discussed, we are in need of information on the cost of heat recovery equipment as well as potential energy savings of economically sized equipment. Information on equipment size for general layout and equipment specifications would also be helpful.

Your continued assistance on this project is appreciated. If you have any questions, please feel free to contact this office.

Very truly yours,

BOOKER ASSOCIATES, INC.



A. Joseph Younger
Mechanical Engineering Department

AJY/dlk

Enclosure

bcc: General Job File
Reading File
M-E File

TELEPHONE LOG

Project No: E-2278

Date: JUNE 15, 1983

Project Name: ORDNANCE DISPOSAL STUDY

Time: 9:30 AM/~~PM~~

From/To Company: SCA SERVICES

City, State: BOSTON, MASS.

Individual's Name: MR. BOYLAND

Phone No. (area code): (617)-367-8300 EXT 605

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:
MR. BOYLAND SAID THAT THE TECHNOLOGY EXISTS AND THAT HIS COMPANY
AND TWO OTHERS (EMSCO LOCATED AT LITTLE ROCK, ARK AND ROLLINS
LOCATED IN DEL) POTENTIALLY COULD DISPOSE OF WASTES FROM INDIAN
HEAD. HOWEVER, ONE OF THE COMPANIES WOULD FIRST HAVE TO CONDUCT A
TRIAL BURN, AT THE NAVY'S EXPENSE, IN ORDER TO OBTAIN THE NECESSARY DATA
FOR BIDDING ON A YEARLY DISPOSAL CHARGE. THE WASTE PROPELLANT WOULD HAVE
TO BE PACKAGED IN COMBUSTIBLE CONTAINERS THAT WOULD BE FED INTO THE
INCINERATORS. TRIAL BURN WOULD HAVE TO BE FULLY INSTRUMENTED AND
WITNESSED BY AN INDEPENDENT INSPECTION TEAM. THE NAVY WOULD HAVE TO
PROVIDE SAMPLES AND AN ANALYSIS OF EACH TYPE OF PROPELLANT PRIOR TO THE TRIAL
BURN. PERMANENT DISPOSAL WOULD PROBABLY REQUIRE A BUNKER AT THE SITE.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Knoff

Note: Please complete each item on this form.

TELEPHONE LOG

Project No: E-2278

Date: JUNE 9, 1983

Project Name: ORDNANCE DISPOSAL STUDY

Time: 1:45 ~~AM~~/PM

From/To Company: BROWNING FERRIS

City, State: PORT ARTHUR, TEXAS

Individual's Name: CLIFF HARDY

Phone No. (area code): (409)-722-4388

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:

MR. HARDY SAID THAT BROWNING FERRIS HAD A CONTRACT
WITH ENSCO THAT ALLOWED BROWNING FERRIS TO USE
ENSCO'S EL DERADO INCINERATOR. UTILIZING THIS ARRANGEMENT,
HE FELT THAT BROWNING FERRIS WOULD BE ABLE TO
DISPOSE OF WASTES FROM INDIAN HEAD. HE STATED THAT
HE WOULD LIKE SAMPLES AND MORE INFORMATION ON EACH
TYPE OF WASTE PROPELLANT BEFORE PRECEDING FURTHER.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Knoll
RD

Note: Please complete each item on this form.

TELEPHONE LOG

Project No: E-2278 Date: JUNE 7, 1983

Project Name: ORDNANCE DISPOSAL STUDY Time: 10:30 AM/PM

From/To Company: U.S. DEPARTMENT OF TRANSPORTATION

City, State: JEFFERSON CITY, MO.

Individual's Name: BARBRA 'SPESSARD

Phone No. (area code): (314) 636-7104

Subject Discussed: D.O.T. REGULATIONS GOVERNING TRANSPORTATION
OF HAZARDOUS WASTES FROM INDIAN HEAD ORDNANCE
FOR OFF BASE DISPOSAL — 49 CFR
PARTS 100-199 GOVERN. THE NAVY SHOULD
IDENTIFY WHERE THE VARIOUS WASTES FALL
IN TABLE 172.101 OF SECTION 172 OF
49 CFR SINCE THEY ARE FORMULATED WITH THE
VARIOUS CHEMICAL COMPOSITIONS, THIS WOULD THEN
GOVERN HOW THEY WOULD HAVE TO BE TRANSPORTED.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Knapp

Note: Please complete each item on this form.



Booker Associates, Inc.
1139 Olive Street
St. Louis, Missouri 63101

Cables: Bookconeng
(314)421-1476

June 7, 1983

Rollie Johnson, Inc.
180 Weidman Road
Suite 225
Manchester, MO 63011

Attention: Mr. Dan Plank

Re: Heat Recovery Study for
Propellant Disposal Facility
Naval Ordnance Station
Indian Head, Maryland
Chesapeake Division, Naval Facilities
Engineering Command
Contract No. N62477-80-C-0441
Booker Project No. E-2278

Dear Mr. Plank:

Enclosed are completed data forms on possible heat recovery systems for the Indian Head Propellant Disposal Facility. As we discussed, we are in need of information on the cost of heat recovery equipment as well as potential energy savings. Information on equipment size for general layout and equipment specifications would also be helpful.

Your continued assistance on this project is appreciated. If you have any questions, please feel free to contact this office.

Very truly yours,

BOOKER ASSOCIATES, INC.

A. Joseph Younger
Mechanical Engineering Department

AJY/atw

Enclosure

bcc: General Job File
Reading File
M-E File



Jeffrey Manufacturing Division Dresser Industries, Inc.
P. O. Box 3080 Greenville, South Carolina 29602

Please Reply To:
ST. LOUIS DISTRICT OFFICE
3555 Sunset Office Drive
Grandel Building, Suite 209
St. Louis, Missouri 63127
Telephone: (314) 822-7117 — 822-7118

June 6, 1983

Booker Associates
1139 Olive Street
St. Louis, Missouri 63101

Attention: Mr. Bill Wassmund

Dear Bill:

Confirming our conversation, the unknown nature of this material makes it impossible to give any recommendations. Hammermills are used on a wide variety of materials, and it is likely they would do this job.

Hammermills can be run anywhere from 500 RPM to 1800 RPM (depending on the job and material) and are often used with a water wash. Hammermills are capable of reducing many materials from 8" to 1/16" in a single pass.

A common arrangement is to have the mill set up with 1/4" screen bars, run the material over a wet screen and recycle the oversize back to the mill.

Please call if I may be of service.

Yours truly,

Bill Graessle
William S. Graessle *hh*
Branch Manager
St. Louis District

WSG/bk
Enclosures

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE June 3, 1983 AM

SUBJECT: Alternate Uses for Facility

ORGANIZATION: Naval Ord Sta

CITY, STATE: India Wood, Md

PERSON/TITLE: Tommy Woo 301-743-4534

INITIATED / ~~RECEIVED~~ CALL: HE Beggs

ITEMS OF CONVERSATION / ACTION TO BE TAKEN:

I called to generally discuss some of the alternate uses for the facility I proposed to study to see if Mr Woo felt there would be any use for the alternatives.

The possible alternates I asked about were:

1. Silver recovery from x-ray film
2. Metal decarbonization
3. Steam
4. Sludge disposal
5. Classified document or film disposal

Mr Woo said the need for x-ray film disposal and silver recovery depends upon workload. X-rays are taken during "type and life" studies and for quality control purposes. This item seems to merit further study.

Mr Woo knew nothing about metal decarbonization.

BY HEB

and neither do I. This alternate use was picked up from a previous report. Unless more is discovered about a possible need for this it will be dropped.

There is no apparent need for the steam which could be generated in the disposal facility elsewhere on base. There is currently plenty of steam from central steam plant.

Sludge digestion would appear to be an attractive alternate. Currently a minimum of 150 cubic yards of sewage sludge is generated yearly. Now drying beds are used. Perhaps vacuum filter could be used for dewatering prior to beds, or FBI or WHO units for incineration. Studies are underway on centralized sewage treatment for base as well as industrial wastewater treatment which could result in additional sludge. This alternative needs further study.

Regarding destruction of classified material: Mr Woo said there would be no need for this. They currently have an incinerator and are currently building a second.

Additional alternate uses suggested, for which there might be a need are disposal of hazardous waste - both solid and liquid such as Endbrook, fiber drums, organic solvents, acetone, chlorinated hydrocarbons etc, and household trash generated

by the 2000 dependants on base. There are currently 154 dumpsters around the base which are emptied twice weekly.

Mr. Wood also indicated that EPA R;D is currently thinking about acquiring the WAD unit for sludge disposal. They are currently running tests on a pilot unit. The contact is Jim Bricillero at the Washington, D.C. office.

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE June 3, 1983 Am
SUBJECT: Water Treatment Water Balance
ORGANIZATION: Naval Ordnance Station
CITY, STATE: Dulles Head Maryland
PERSON/TITLE: Walt Seruskie
INITIATED / ~~RECEIVED CALL:~~ Y E Buzyn

ITEMS OF CONVERSATION / ACTION TO BE TAKEN: _____

I called Wale to generally discuss water balance for WWT bldg to make sure I wasn't missing something. CHESOV seemed concerned about this aspect of project, but my investigations thus far do not reveal any great inefficiencies in water system. Wale says a number of models were written regarding water system and this is what probably accounted for concerns. He agreed that although quite a bit of water is used for initial tank filling the actual operations are pretty good. It appears about 85 percent of WAO water is recovered for reuse. The FBI evaporates all of the slurry water so this would appear to be the best potential area for recovery.

BY Y E Buzyn

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE MAY 31, 1983
SUBJECT: ADDITIONAL REQUESTS FOR DOCUMENTS
ORGANIZATION: CHESDIV
CITY, STATE: WASHINGTON DC
PERSON/TITLE: FRANK PETERS 202-433-3760
INITIATED / RECEIVED CALL: GE BERGEN

ITEMS OF CONVERSATION / ACTION TO BE TAKEN: I CALLED WITH THE FOLLOWING QUESTIONS:

- 1) IS THERE A NAVY DOCUMENT WITH GROUNDRULES FOR ECONOMIC STUDIES? ANSWER - YES - FRANK WILL COPY PERTINENT PARTS AND SEND.
- 2) HAS HE HAD ANY LUCK GETTING COPY OF NAVY SAFETY MANUAL? ANSWER - NO - STILL TRYING HE HAS SENT A COPY OF INDIAN HEAD SAFETY MANUAL BUT IT WON'T BE AS HELPFUL.

OTHER COMMENTS:

- 1) FRANK DOESN'T THINK HE WILL BE ABLE TO OBTAIN A COPY OF ABL HAZARDS ANALYSIS REQUESTED BY R. BOSSARD ON MAY 4, 1983.
- 2) FRANK ASKED ABOUT ANOTHER FIELD TRIP. I TOLD HIM MY INTENTION WAS TO WAIT UNTIL FIRST DRAFT OF REPORT IS SUBMITTED AND PERHAPS COMMENTS ARE RECEIVED.
- 3) FRANK IS STILL TRYING TO GET A COPY OF INCREMENT I FUNDED MODS TO SEND US.

BY MEYER

TELEPHONE LOG

Project No: E-2278 Date: MAY 31, 1983

Project Name: ORDNANCE DISPOSAL STUDY Time: 2:15 ~~AM~~ PM

From/To Company: MITRE CORP

City, State: MC LEAN, VA.

Individual's Name: GREG VOGEL

Phone No. (area code): (703)-827-6000

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:
MR. VOGEL SAID THAT THE TECHNOLOGY EXISTS FOR THE
INCINERATION OF WASTE PROPELLANTS FROM INDIAN HEAD,
BUT HE FELT THAT IT WOULDN'T BE PRACTICAL TO
DISPOSE OF THEM OFF BASE. TRANSPORTATION FOR
OFF BASE DISPOSAL IN ACCORDANCE WITH D.O.T.
REGULATIONS WOULD BE VERY EXPENSIVE. IN ADDITION,
HE FELT THAT IT WOULD BE POLITICALLY UNTENABLE
TO TRANSPORT THE MATERIAL FOR OFF BASE DISPOSAL.
TRANSPORTATION OF THE MATERIAL WOULD BE MORE
HAZARDOUS THAN CONTINUING TO OPEN BURN IT.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. Knoff

Note: Please complete each item on this form.

TELEPHONE LOG

Project No: E-2278 Date: MAY 27, 1983
Project Name: ORDNANCE DISPOSAL STUDY Time: 11:00 AM/PM
From/To Company: JOHN ZINC
City, State: TULSA, OKLAHOMA
Individual's Name: DR. JOHN CEGIELSKI
Phone No. (area code): (918)-777-1371

Subject Discussed: DISPOSAL OF HAZARDOUS WASTE FROM INDIAN HEAD
ORDNANCE STATION OFF BASE AT PRIVATE INDUSTRY SITES:
DR. CEGIELSKI SAID THAT THE TECHNOLOGY PRESENTLY
EXISTS FOR THE INCINERATION OF WASTE PROPELLANTS
FROM INDIAN HEAD. HE POINTED OUT THAT THE ROTARY
KILN INCINERATOR WOULD BE THE BEST WAY TO
ACHIEVE THIS. HOWEVER, HE WENT ON TO POINT OUT THAT
HE FELT TRANSPORTATION PROBLEMS WOULD PRECLUDE
OFF BASE DISPOSAL. TRANSPORTATION IN ACCORDANCE WITH
D.O.T. REGULATIONS WOULD BE VERY EXPENSIVE. FURTHERMORE,
HE FELT THAT IT WOULD BE POLITICALLY UNTENABLE
TO TRANSPORT THE MATERIAL FOR OFF BASE DISPOSAL.

Is Action Req'd By: Booker _____ Party Above _____ Other _____

What Action Req'd: _____

BY: Richard C. King

Note: Please complete each item on this form.

Key personnel:
 Gene Crumpler (EPA)
 Marc Turgeon (EPA)
 Ivan Tominack (OES)
 Linda Lay, Pam Clements (OESO)

CODE (S)

PHONE NO (S)

ORGANIZATION VISITED - ADDRESS

Environmental Protection Agency
 Washington, D.C.

DATE (S) OF VISIT

3/23/81

PURPOSE (S)

- I. Open Burning Ordnance Waste
- II. Lithium Battery Incineration
- III. OESO Advice/Consultation to EPA

SUMMARY (Information obtained, evaluations made, conclusions reached, decisions made, commitments given, and/or action required.)

This OESO/EPA meeting was also designed to reestablish liaison developed during the open burning effort of some 18 months ago.

I. Background. The allowance for the open burning of ordnance waste under RCRA relieved some of the pressure for immediate installation of controlled incinerators. Some concern was expressed by Navy planners as to determining the expected life of the allowance.

Both EPA representatives indicated that the ordnance waste open burning issue had very low priority in EPA and unless some unexpected public outcry developed it would remain a low priority. Given the present administration posture very little new regulation is expected and then only after a thorough cost benefit analysis was conducted. Also, now that open burning is an approved method, it would be incumbent on the EPA to propose a proven alternate method. Given the present state-of-the-art available to both DoD and EPA, the development of a proven alternate method will be hard to come by.

Crumpler indicated that one of the major reasons for granting the allowance was the property damage likely to accrue the size reduction of large grains. (We toured them through the Building 720 saw bay that was severely damaged with the burning of a 110# grain and compared it to what might happen if a 4000 pound grain caught fire.)

Both Crumpler and Turgeon thought that similiar contacts as OESO/EPA needed to be made at the state level.

In summary, the working level at EPA thinks that the open burning allowance is likely to continue for at least five years.

SIGNATURE (Division Head)
 I. L. TOMINACK

DATE

APPROVAL (Division Head)

DATE

DISTRIBUTION

A/B, PM/TD, EN

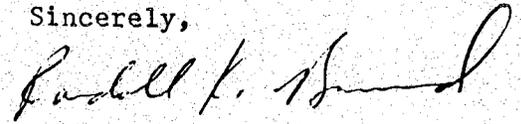
NAVSEA (641, 04H(Holter))
 NSWC/WO (Mueller, Fauth)

NEESA (Kneeling)

information to:

Booker Associates, Inc.
1139 Olive Street
St. Louis, MO 63101
Attn: Mr. George Bergen

Sincerely,



RANDALL K. BOSSARD, P.E.
Mechanical Engineer

RKB/gh

Enclosure

cc: Mr. Frank Peters, Chesdiv Code 114
Mr. George Bergen, Booker Associates

POHLKOTTE ENGINEERING CO., INC.

P. O. BOX 458
BALLWIN, MO 63011-0458
(314) 391-8992

May 17, 1983

Mr. Bill Wassmund
Booker & Associates
1139 Olive St.
St. Louis, Mo. 63101

RE: LITERATURE ON SERPENTIX CONVEYOR

Dear Mr. Wassmund,

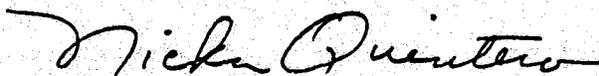
Per your request, I am enclosing several items that would be of interest to you regarding the Serpentix conveyor systems.

We are sending you several flyers on actual installations, a list of benefits, information on how Serpentix systems are being used in coal mining and a brochure with more detailed information. Please refer to page 18 for technical data.

After reviewing these enclosures, you may want to call Ken Ressler, with our firm for further input. If you have a specific application in mind, we would be happy to have Serpentix draw it up for you.

Sincerely;

POHLKOTTE ENGINEERING CO., INC.



Nicka Quintero
Customer Service

Hapman Conveyor Co.

6002 E. Kilgore Road
Kalamazoo, Michigan 49003
(616) 343-1675
Telex: 224468

May 16, 1983

Mr. Bill Wassmond
Booker Associates
1139 Olive
St. Louis, MO 63101

Dear Mr. Wassmond:

Thank you for your interest in Hapman mechanical conveyors.
The literature you requested is enclosed.

Hapman offers you a broad choice of mechanical conveyors and conveyor systems to handle a variety of flowable materials in the chemical, pharmaceutical, food processing and plastics industries. We have been engineering and manufacturing conveyors for four decades and offer you experience in selecting the conveyor best suited to your application.

We include the name and address of the Hapman agent in your territory below. Call him if you have an immediate need.

We appreciate your interest in Hapman Conveyors and look forward to working with you.

Sincerely,

Carl Corless

Carl Corless
Sales Administrator

/kls

Enclosure: ISA #99

CC: Sell Equipment Co.
100 S. Francois Street
Florissant, MO 63031
314-839-0230
Cliff Sell

R. L. Sutton, Hapman



Booker Associates, Inc.
1139 Olive Street
St. Louis, Missouri 63101

Cables: Bookconeng
(314) 421-1476

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE 9:00 AM May 13, 1988

SUBJECT: Serpentine Concrete

ORGANIZATION: Pohlkotte Eng. Co

CITY, STATE: Ballwin Mo

PERSON/TITLE: Nucka Christens And. Soc.

INITIATED / ~~RECEIVED CALL~~: W. W. Wassmann

ITEMS OF CONVERSATION / ACTION TO BE TAKEN: _____

Discussed use of Serpentine
Concrete for churning
exhibits and requested
literature
used in Lone Star Amusement
plant in Texas

BY W. W. Wassmann

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2278 TIME/DATE 10:00 AM 5-13-1983
SUBJECT: Hopman Conveyor Equip.
ORGANIZATION: Hopman Conveyors Co.
CITY, STATE: Ann Arbor, Mich
PERSON/TITLE: Carl Cobless, Sales admin.
INITIATED / RECEIVED CALL: W.W. Wassmann

ITEMS OF CONVERSATION / ACTION TO BE TAKEN:
Requested literature and
discussed explosive handling
by Hopman equipment
know of no specific application
where equipment used to handle
explosives.

BY W.W. Wassmann

for those wastes which cannot be handled by the Propellant Disposal Facility, first and second increments. We have an undated listing of these materials by name, but we need much more detail to be able to propose demil approaches. We need such information on size, shape, material composition, whether cased or not, etc. Drawings of the munitions, motors, metal parts, etc., would be of great benefit to us.

4. Mr. Seroskie told me that he thought Allegheny Ballistic Laboratory had conducted a safety evaluation of increments 1 and 2. If a report on this is available, we would like to receive a copy, to assist us in our WAO and FBI evaluation.

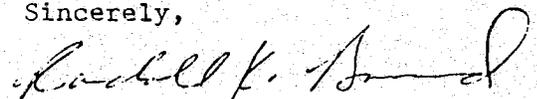
5. During our current evaluation in the WAO area, very specific questions have arisen on certain devices and equipment currently installed. The information needed includes such items as model numbers, how an item is mounted, whether grounded or not, etc. It is information which we require for our evaluation, but which does not show on the drawings.

It would be of significant benefit to the job if we could be put in contact with someone at Indianhead who could get answers to these detailed questions for us, for both WAO and FBI systems.

6. Our list of equipment requiring decontamination burning shows about 500,000 lbs. generated annually. Is this total equipment weight? Also we need information regarding the expected physical sizes to be encountered.

The above constitutes our present information request. We hope that you will be able to help us, and we expect that receipt of the information requested will enable us to complete our evaluation in a professional and timely manner.

Sincerely,



RANDALL K. BOSSARD, P.E.
Mechanical Engineer

RKB/gh

cc: Mr. George Bergen, Booker Associates

May 16, 1983

Booker Associates
1139 Olive
St. Louis, MO 63101

Attention: Mr. Bill Wassmund

Gentlemen:

Thank you for your recent telephone call concerning Teledyne Readco cooling belts.

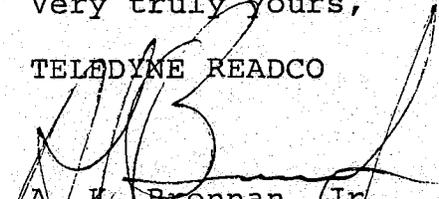
These units are stainless steel belts equipped with sprays for cooling the undersides of the belt for cooling of materials such as molten plastics, waxes, etc.

We are enclosing a copy of our brochure which describes these units. Also find a copy of our catalog which shows the general line of processing equipment we manufacture.

Our local representative in your area is Floyd Gilliam Associates, whose address and phone number appear below. By copy of this letter, we are asking them to contact you to discuss your application in detail.

Very truly yours,

TELEDYNE READCO


A. K. Brennan, Jr.
Vice President
Processing and Mixing
Equipment Division

AKBJr:jk
Enclosures

cc: Floyd Gilliam Associates, Inc.
1760 S. Brentwood Blvd.
St. Louis, MO 63144
Phone: 314-961-5555



Booker Associates, Inc.
1139 Olive Street
St. Louis, Missouri 63101

Cables: Bookconeng
(314) 421-1476

TELEPHONE CONVERSATION LOG

PROJECT NO. E-2287 TIME/DATE 4/18/83

SUBJECT: NAVORDSTA, INDIAN HEAD, MD.

ORGANIZATION: "REXNORD" 502-969-3171

CITY, STATE: Louisville, Ky

PERSON/TITLE: E. J. Anderson, Mgr. Eng. Projects

INITIATED / RECEIVED CALL W. W. Dammund

ITEMS OF CONVERSATION / ACTION TO BE TAKEN: Talked about conveyor decision and was there only suggested modifications.

Reminded the fact that a revised conveyor system was in the works when project was cancelled.

No drawings actually completed.

BY Bill Dammund



BOSSERT GLEASON COMPANY

Manufacturers' Agents Since 1971

MATERIAL HANDLING AND PROCESS EQUIPMENT

P.O. BOX 24568

ST. LOUIS, MISSOURI 63141

April 15, 1983

TELEPHONE
314/432-5240

TELEX
44-2576

Mr. W.W. Wassmund
Booker Associates
1139 Olive Street
St. Louis, Missouri 63101



Reference: Rexnord Vibrating Equipment Division
Conveying Equipment

Dear Mr. Wassmund:

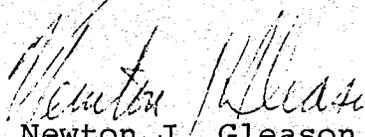
In accordance with your request during our recent phone discussion concerning your study, we are pleased to enclose the general bulletin covering the Rexnord conveying equipment.

As discussed, if you develop questions concerning our equipment during your study, we would be pleased to discuss our capabilities and to further define our technical capabilities with this equipment.

We look forward to hearing from you in the near future.

Sincerely,

BOSSERT GLEASON COMPANY
Representing
REXNORD, INC.
VIBRATING EQUIPMENT DIVISION


Newton J. Gleason

NJG/ksc
cc: Mr. Paul Poling
Encl.