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19 pages,

NITRIC ACID RECOVERY AND AMMONIA REMOVAL -
MODIFICATIONS TO THE REDOX DISSOLVER OFF-GAS SYSTEMS

Prepared by

D. J. Stoker

October 1, 1954

Process Engineering Sub-Section
Design Section
Engineering Department

General Electric Company - Hanford Atomic Products Operation

CLASSIFICATION CHANGED TO

DATE

H. F. Cancele

Chief, Declassification Branch

This document has been reviewed and approved by the appropriate members of the Process Engineering Sub-Section as a scope basis for nitric acid recovery and ammonia removal facilities in the Redox off-gas systems.

AEC RESEARCH AND DEVELOPMENT REPORT

Chas. A. Rohmann
Separations Design and Development

W. M. Harty
Head, Separations Design and Development

J. H. Shaw
Manager, Process Engineering Sub-Section

CLASSIFICATION CANCELLED
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BY J. F. Davis S.E. Gydensen 2-6-90
DATE 1-23-91
W. C. Crawford 1-23-91

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HW-33266

Page 3

**NITRIC ACID RECOVERY AND AMMONIA REMOVAL -
MODIFICATIONS TO THE REDOX DISSOLVER OFF-GAS SYSTEMS**

INTRODUCTION

Project CG-588 authorized the design and construction of dissolver and waste neutralizer off-gas scrubbers to remove the ammonia given off during coating removal and waste neutralization steps of the Redox operation. It has always been recognized that the nitrogen oxides in the dissolver off-gases, resulting from the dissolution of bare uranium slugs, could also be absorbed in water under proper conditions to give re-useable nitric acid. Consequently it appeared feasible to provide facilities which would combine these ammonia removal and nitric acid recovery operations.

PURPOSE

The purpose of this report is to present a scope design for the economical recovery of nitric acid from the Redox dissolver off-gases in addition to the removal of ammonia. It is recognized that acceptance of this scope for project execution would make unnecessary the ammonia scrubbers for the dissolver off-gases of Project CG-588.

SUMMARY

The most economical method of recovering nitric acid and removing ammonia from the Redox dissolver off-gas systems is by the use of absorber units which will alternately absorb ammonia and nitrogen oxides. The specific features of this scope design are summarized as follows:

1. These units will give an overall mole ratio of 2.2 moles of nitric acid consumed per mole of uranium dissolved (0.58 pounds of nitric acid per pound of uranium). The present Redox up-draft condensers are yielding a mole ratio of 5.0 (1.32 pounds of nitric acid) and the Purex down-draft condensers are expected to give a mole ratio of 3.0 (0.79 pounds of nitric acid).
2. These units will reduce the ammonia content of the air from 0.1 to less than 0.001 moles ammonia/mole air (.0005 lb. ammonia per lb. of air).
3. An absorber unit consisting of a gas cooler and condenser, bubble-cap-tray absorber tower, an ammonia catch tank, and associated jumpers will be required for each dissolver cell.
4. The ammonia absorber previously designed for the waste neutralizer in D-cell will still be required.
5. The estimated project cost for design, construction and installation of the dual purpose absorption system plus spares is \$483,000 greater than the presently designed dissolver off-gas ammonia scrubbers. Included in this difference is a sum of \$35,000 for additional waste water cribbing facilities, in the event that the additional water load of this project might shorten the life of present facilities or exceed their capacity.

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SUMMARY (Cont'd)

Excluded from consideration in these economic figures are costs which may result from plant down time during the installation of these facilities. Such costs were not required in the CG-588 project.

6. The above additional investment would be paid back when 9430 tons of uranium had been processed in Redox using dual purpose absorption. This given a payout period of 3.23 years at 240 tons/month production or 3.88 years at 200 tons/month production. These production figures represent 120% and 100%, respectively, of the nominal Phase II design rate. It is estimated that completion time for this project would be 18 months after authorization.

RECOMMENDATIONS

It is recommended that dual purpose absorber units be considered for installation in the Redox dissolver cells in place of the proposed ammonia scrubbers as per the attached scope. Specifically this should include:

1. Design and fabrication of four, six-tray, bubble-cap, absorber towers with cooling coils on the trays (SK-2-5851).
2. Design and fabrication of four gas coolers and condensers (SK-2-5850).
3. Design and fabrication of four 3 ft. O.D. x 5 ft. ammonia catch tanks.
4. Design and fabrication of the necessary process and service jumpers as shown on Equipment Arrangement Drawings (SK-2-5841 and SK-2-5844).
5. Design for and installation of new instrumentation and gallery piping as shown on Engineering Flow Diagram SK-2-5841.
6. Design and construction of a proportional sampler in the existing line from the 241-S diversion box to the 216-S crib to monitor the waste liquor (SK-2-5844). This is already included in Project CG-588.

DISCUSSIONPart A - Development of the Problem

The occasional emission from the Redox stack of large masses of ammonium nitrate carrying a significant amount of radioactivity has caused serious contamination problems around the Redox Plant. Ammonium nitrate was apparently formed in the stack by the combination of ammonia and nitrogen oxide gases. Ammonia is liberated during the coating removal operation in the dissolvers, and during neutralization in the waste neutralizer. Nitrogen oxides are released from the dissolvers during uranium dissolution. The ammonium nitrate formed in the stack and breaching by the combination of these gases apparently deposited on the liner, adsorbed radioactive material, then later broke off, were blown out of the stack and fell to the ground in the surrounding area.

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Part A - Development of the Problem (Cont'd)

When the seriousness of this situation became evident studies were initiated to correct the problem as quickly as possible. The most immediate solution to the problem was the proposal to install ammonia scrubbers in the off-gas lines which would effect the removal of ammonia from the vessel vent and dissolver off-gas systems (HW-30935)⁽¹⁾. This proposal was accepted as a project (CG-588) which is now in the final stages of detailed design.

Concurrent with this design effort, laboratory studies have been progressing on the mercury - catalyzed acid dissolution of coatings. Manufacturing personnel also have initiated a program of scheduling the dissolving and coating removal operations. Laboratory work has shown that neither ammonia nor hazardous quantities of hydrogen are given off during certain acid, catalyzed coating removal processes.⁽²⁾ To date, this recent development work has not been demonstrated by plant test. The use of scheduled dissolving in which the coating removal and uranium dissolution steps are not carried on simultaneously in the various dissolvers, has substantially reduced the quantities of ammonium nitrate formed.⁽³⁾

Part B - Alternatives Studied

Following the initial ammonia absorber proposal a more extensive study, prompted by the prospect of large chemical savings, was made concerning the recovery of nitric acid in the dissolver off-gases. The two alternatives studied were (1) the dual purpose absorber unit as described in this report, and (2) the use of a down-draft Purex type condenser tower to recover acid in combination with the CG-588 facilities to remove ammonia.

An economic study was made for each of the alternatives (see Appendix A). There was substantially no difference in the payout period for the two alternatives, but the dual purpose proposal showed a 40 percent greater economic gain after the payout period. For this reason the dual purpose proposal was chosen. The main disadvantage to dual purpose absorption would be the delay in the installation of equipment required for ammonia removal. However, this is not considered as serious a deterrent now as it might have been several months ago. The successful scheduling of dissolver operations at initial Phase II rates has reduced the urgency for installation of ammonia scrubbers.⁽³⁾ The additional months delay would be compensated for by the subsequent major savings in operating costs.

- (1) HW-30935 - "Facilities Required For Correction of Ammonium Nitrate Emission Problem at Redox", by L. L. Zahn, March 17, 1954.
- (2) HW-32823 - "Proposed Alternate Dissolving Flowsheets for the Redox Plant", by M. H. Curtis and M. K. Harmon, August 13, 1954.
- (3) "Combination Ammonia Absorber and Down-draft Condenser", by V. R. Cooper, July 22, 1954.

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Part C - Scope of Dual Purpose Absorption

The proposed arrangement is shown on the attached flow diagrams, drawings SK-2-5839 and SK-2-5841. During coating removal, the gas from the dissolver is routed through the gas condenser where it is cooled and the water vapor condensed. The condensate is used in the tower as reflux to scrub the ammonia from the non-condensable gas which is fed to the bottom of the tower. Additional reflux water, as needed, is fed into the top of the tower. The non-condensable gas goes to the heater, silver reactor and filter, and from that point the gas is jetted through the ventilation port into the air tunnel. The bottoms from the tower flow to the ammonia catch tank and are jetted into the spare 3-inch waste-storage, cascade header. From there the liquor flows to the 240-S diversion box from which it is diverted to the 241-S diversion box, and thence to the 216-S crib via a proportional sampler. Make-up water can be added to the dissolver via the chemical addition lines.

During uranium dissolution, the gas from the dissolver is routed through the condenser where the acid vapor is condensed and fed to the tower as reflux. Oxygen in the form of air is bled into the cooled condenser off-gas and this mixture is fed to the bottom of the tower, where in passing countercurrently to the reflux the gas is oxidized to NO_2 and absorbed. The non-condensable gas from the top of the tower goes to the heater, silver reactor, filter and is then jetted into the air tunnel. The reflux out of the bottom of the tower flows back into the dissolver and, thus, the cycle is complete. In the early stages of uranium dissolution, before sufficient water vapor is given off, reflux water is added to the top of the tower to absorb the nitrogen oxides being evolved. Once boiling has begun in the dissolver the additional reflux would be stopped.

The recovery of nitric acid is due to both absorption and chemical reaction. The absorption being the physical diffusion of the reacting oxides from gas to liquid phase and the chemical reactions being basically the following:

The lower the temperature the faster the reaction of NO to NO_2 and the greater the equilibrium is displaced towards HNO_3 in the liquid phase reaction. For further, more detailed discussions of reaction rates and equilibrium constants pertaining to the above reactions, the reader is referred to Bibliography references (4), (5), (6) and (7).

Maximum dissolution rates for coating removal were taken from HW-30935⁽¹⁾. Maximum dissolution rates for uranium dissolution were obtained from the Separations Technology Sub-Section⁽⁸⁾. All of these rates correspond to a processing rate of 240 tons of uranium per month with three dissolvers in operation.

- (1) HW-30935, "Facilities Require for Correction of Ammonium Nitrate Emission Problem at Redox", by L. L. Zahn, March 17, 1954.
- (4) "Absorption and Extraction", by Thomas K. Sherwood and Robert L. Pigford, McGraw-Hill, 1952, pg. 368-383.
- (5) HW-19140, "Uranium Recovery Technical Manual", November 19, 1951, pg. 902-904.
- (6) Wourtsel, Comptes Rendus etc., Vol. 169, 1919, pg. 1397.
- (7) "Systematic Inorganic Chemistry", D. M. Yost and H. Russell, Prentice-Hall Inc., 1946, pg. 22-31, and pg. 78-79.
- (8) Letter, E. R. Irish to C. A. Rohrmann, August 10, 1954, "Project CG-588: Ammonia Absorber (and Down-draft Nitric Recovery Tower)".

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Part C - Scope of Dual Purpose Absorption (Cont'd)

At the maximum instantaneous design rate of 1,000 lb/hr. of uranium dissolved, the gases discharged from the absorption tower will contain approximately 0.5 moles of acid per mole of uranium dissolved (equivalent to a mole ratio of 2.5). Under controlled operation the dissolution will seldom exceed this 1,000 lb/hr. rate and will usually be substantially below it resulting in better recovery. During the latter part of the dissolving cycle, the rate continually diminishes and percent recovery will increase. Therefore, the overall consumption of nitric acid during any one complete dissolution cycle was estimated to be 2.2 moles acid per mole of uranium dissolved.

The gas condenser (SK-2-5850) is elliptical shaped with two shell passes and eight tube passes. Its placement in the cell is dictated by its size and by the fact that, for simplicity, it was desired to have gravity flow for the reflux to the tower. The Y-pads and the feet of the dissolver rinse tanks provide the anchorage for the condenser dunnage. The dissolver lid hangers will have to be removed from the wall and new hangers provided on the condenser dunnage. These original hangers were mounted by contact methods and will have to be either torn or burned off by remote methods. The condenser not only condenses the acid vapor and cools the gases but it also acts as one equilibrium stage and thus removes a sizeable quantity of reaction heat. The choice of fin tubes for a portion of the bottom section of the condenser was dictated by the fact that the condenser will act as one equilibrium stage, if reaction surface and gas cooling surface are provided. The calculated pressure drop across the condenser at maximum instantaneous rates is 10 inches of water.

The six tray bubble cap tower (SK-2-5851) is located atop the dissolver by means of a transition piece and an oversize flange. The transition piece acts as the deflector in routing the off-gases from the dissolver tank to the condenser. The absorption and formation of acid takes place on the trays and the oxidation of NO takes place between the trays. A Murphee Tray Efficiency of 60% was assumed for the tower. Gas hold-up times of two to three minutes are provided between the trays and liquid hold-up times of six to seven minutes are provided on trays. Cooling coils placed on the trays remove the heat of reaction from the liquid and thus keep the temperature favorable to increased equilibrium and reaction rates. At maximum instantaneous rates the calculated total pressure drop across the tower is 10 inches of water.

Series flow through the tower and subsequently the condenser is provided for the cooling water. The maximum flow of 200 gal./min./cell will be approximately 150 gal./min./cell greater than is now being used during dissolution operations. Because of the inadequate water disposal facilities now being used by Redox it is questionable as to whether present facilities will handle this additional water load. If tests on newly constructed water disposal facilities prove they are also similarly inadequate they will have to be enlarged to accommodate this flow. A lump sum of \$35,000 was included in the economic calculations for additions to future water disposal facilities should such expansion be required.

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Part C - Scope of Dual Purpose Absorption (Cont'd)

The combined pressure drop across the condenser, tower, silver reactor, filter and connecting piping will be approximately 45 inches of water at maximum instantaneous rates. In order to maintain a vacuum in the dissolver pot at this pressure drop it will be necessary to replace the present jet with a larger jet. Contamination prevents the changing of jets in the jet pit, so a new method of disposing of the off-gases had to be used. This method involves the jetting of the gases from the filter into the ventilation tunnel via ports located near the bottom of the cell. The gases then travel through the sand filter and thence to the stack.

The ammonia catch tank is simply the lower section of the proposed ammonia scrubber with a head placed on it⁽¹⁾. Tentative nozzle locations are shown in SK-2-5840. Because no vent lines are located in the dissolver cell the tank is vented to the tower.

The neutralizer vent gas ammonia scrubber for Cell D is the same unit as originally scoped in HW-30935⁽¹⁾.

Part D - Cost of Installing Dual Purpose Absorption

The estimated cost of installing Dual Purpose Absorption is shown in Appendix B, to be \$613,000*. This includes all jumpers, piping, instrumentation, vessel fabrication and design necessary for installing one dual purpose absorption unit in each dissolver cell and one neutralizer vent gas scrubber in the waste cell. In addition this includes the fabrication of one spare waste neutralizer gas scrubber, one spare ammonia catch tank, one spare gas cooler and condenser, and one spare bubble cap absorption tower. In the economic calculations (Appendix A) a sum of \$35,000 has been added to the estimated project cost for possible future expansion of waste water disposal facilities.

- (1) HW-30935, "Facilities Required for Correction of Ammonium Nitrate Emission Problem at Redox", by L. L. Zahn, March 17, 1954.

*Includes \$103,500 for direct spare equipment cost, plus additional fixed overhead costs and contingencies necessitated by the fabrication of spares.

D J Stoker
Separations Design & Development
Design Section
ENGINEERING DEPARTMENT

DJ Stoker/baj

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REFERENCES

- (1) HW-30935, "Facilities Required for Correction of Ammonium Nitrate Emission Problem at Redox", by L. L. Zahn, March 17, 1954.
- (2) HW-32823, "Proposed Alternate Dissolving Flowsheets for the Redox Plant", by M. H. Curtis and M. K. Harmon, August 13, 1954.
- (3) "Combination Ammonia Absorber and Down-draft Condenser", by V. R. Cooper, July 22, 1954.
- (4) "Absorption and Extraction", by Thomas K. Sherwood and Robert L. Pigford, McGraw-Hill, 1952, pg. 368-383.
- (5) HW-19140, "Uranium Recovery Technical Manual", November 10, 1951, pg. 902-904.
- (6) Wourtsel, Comptes Rendus etc., Vol. 169, 1919, pg. 1397.
- (7) "Systematic Inorganic Chemistry", D. M. Yost and H. Russell, Prentice - Hall Inc., 1946, pg. 22-31, and pg. 78-79.
- (8) Letter, E. R. Irish to C. A. Rohrmann, August 10, 1954, "Project CG-588: Ammonia Absorber (and Down-draft Nitric Recovery Tower)".

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ECONOMIC CONSIDERATIONSAPPENDIX A

	<u>DUAL PURPOSE</u>	<u>DOWNDRAFT / CG-588 (NH₃ Removal)</u>
Total Project Cost.	\$648,000 (a)	\$540,000 (c)
Cost of CG-588.		175,000
Funds recoverable from CG-588.	165,000 (b)	0
Net cost of nitric acid recovery.	483,000 (a)	365,000 (c)
Annual value of recovered nitric acid.	149,400 (e) 124,500 (f)	106,700 (e) 88,900 (f)
Payout period for additional investment - years.	3.23 (d) (e) 3.88 (d) (f)	3.42 (d) (e) 4.10 (d) (f)

- (a) Includes \$19,000 for D cell ammonia removal and \$103,500 for spares plus overhead costs and contingencies for fabrication of the spares, plus \$35,000 for future water disposal facilities.
- (b) \$10,000 of the \$175,000 CG-588 project have already been spent on design and are not assumed recoverable.
- (c) Includes \$60,000 for spares plus additional fixed overhead costs and contingencies for fabrication of the spares, plus \$35,000 for future water disposal facilities.
- (d) Includes payout for spare equipment which 224-U Building experience shows should not fail during payout period.
- (e) At production rate of 240 tons/month.
- (f) At production rate of 200 tons/month.

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APPENDIX B - PART I

PROJECT DESIGN ESTIMATE
GENERAL ELECTRIC COMPANY
HANFORD ATOMIC PRODUCTS OPERATION

HW-33266

Page 11

PROJECT		TYPE OF ESTIMATE	
Redox Dissolver Off-Gas Absorber		(A) ☐ STUDY STAGE	
DATE PREPARED 9/8/54	ESTIMATED BY D. O. Webb	(B) ☒ DESIGN SCOPE	% COMPLETE
		(C) ☐ FINAL DESIGN	% COMPLETE

ENGINEERING, INCLUDING SCOPING, DETAILED DESIGN, AND DESIGN SERVICES IN THE FIELD

ENGINEERING DESIGN	10,700
DRAFTING	5,800
PROJECT MANAGEMENT	1,900

ARCHITECT ENGINEERS

ENGINEERING ASSISTANCE TO HANFORD, INCLUDING CONSULTANTS, ENGINEERING ASSISTANCE CONTRACTORS, KAPL, GEL, ETC.

ENGINEERING SERVICES (HANFORD)

TRAVEL AND LIVING	
REPRODUCTION	300
ESTIMATING	400
LAYOUT AND SURVEY	
OTHER	
SUB-TOTAL	700

TEST MATERIALS AND EXPERIMENTAL TESTS

CONTINGENCIES

TOTAL	1,900
	21,000

DISTRIBUTION BY DESIGN STAGE

DESIGN SCOPE	1,500
DETAILED DESIGN	17,150
DESIGN SERVICES IN THE FIELD	450
CONTINGENCIES	1,900
TOTAL	21,000

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PROJECT NO. D.O. 100941		CONSTRUCTION BY Plant Forces, M.C.-Off Site		PROJECT MANAGED BY ☒ G. E. ☐ HOO, AEC		GENERAL ELECTRIC COMP PROJECT COS	
ESTIMATED BY Estimating Unit/JMacG		DATE PREPARED 10/11/54		TITLE KEDOX DIAL PURPOSE ABSORBER		CELL A,B,C	
PROPERTY ACCOUNTS		WORK PERFORMED BY: Minor Construction				WORK PERFORMED BY: Plant	
DESCRIPTION	NO.	LABOR	MATERIAL	EQUIP.	TOTAL	LABOR	MATERIAL
Sampler on crib line		3.100	5,450	300	8,850		
Cells A,B,C							
Mechanical						21,750	20,650
Instrumentation						6,000	27,000
Off-Site Fabrication of							
Vessels			400,000		400,000		
Neutralizer Vent Gas							
scrubber, fabrication							
and installation, incl							
jumpers piping &							
instrumentation						2,200	11,100
Spare							3,500
SUB-TOTAL DIRECT CONST. COSTS		3,100	405,450	300	408,850	29,950	62,250
(A) OTHER DIRECT COSTS 5-36-5 (46 % OF LABOR - ITEM 1)		155	1,115	155	1,425		
2 (B) PAYROLL BURDEN (5 % OF LABOR - ITEMS 1 & 2A)		163			163		
(C) CLOSE OUT RESERVE (% OF LABOR - ITEMS 1 & 2A)							
3 TOTAL DIRECT CONST. COSTS		3,418	406,565	455	410,438	29,950	62,250

PROJECT COST ESTIMATE

(A) ☐ STUDY STAGE
(B) ☒ FULLY SCOPE
(C) ☐ FINAL (DESIGN % COMP.)

3E ABSORBER CELL A,B,C
APPENDIX B, PART II
HW-33266, Page 12

Construction		WORK PERFORMED BY: Plant Forces				JOB TOTALS			
	TOTAL	LABOR	MATERIAL	EQUIP.	TOTAL	LABOR	MATERIAL	EQUIP.	TOTAL
00	8,850								8,850
		21,750	20,650		42,400				42,400
		6,000	27,000		33,000				33,000
	400,000								400,000
		2,200	11,100		13,300				13,300
			3,500		3,500				3,500
10	408,850	29,950	62,250		92,200				
5	1,425								
	163								
5	410,438	29,950	62,250		92,200				502,638

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PROJECT NO.		TITLE					
D.O. 100941		REDOX DUAL PURPOSE ABSORBER - CELLS A,B,C					
		WORK PERFORMED BY: Minor Construction				WORK PERFORMED BY:	
		LABOR	MATERIAL	EQUIP.	TOTAL	LABOR	MAT
3	TOTAL DIRECT CONSTRUCTION COSTS	3,418	406,565	455	410,438	29,950	62
4	(A) CPFF SUB-CONTRACTOR INDIRECT COSTS (0 % OF LABOR - ITEM 3)						
	(B) G. E. CONSTRUCTION DEPT. INDIRECT COSTS (19 % OF LABOR - ITEM 3)				650		
	(C) G. E. FORCES INDIRECT COSTS (110 % OF LABOR - ITEM 3)						
5	(A) FEE FOR CPFF SUB-CONTRACTOR						
	(B) FEE FOR LABOR SERVICE GROUP (4 % OF LABOR - ITEM 3)				137		
6	CONSTRUCTION FIELD SUPV. AND INSPECTION (0.00 % OF ITEM 3) Fixed Amount				2,000		
7	SUB - TOTALS				413,225		
8	GENERAL OVERHEAD (2 1/2 % OF ITEM 7)				10,330		
9	OPERATION AND MAINT. OF NO. RICHLAND CAMP (1 % OF ITEM 7)				2,065		
10	START UP COSTS						
11	MISC. LLANEOUS WORK ORDERS						
12	CONSTRUCTION CONTINGENCY (10 % OF ITEM 3)				41,044		
13	TOTAL CONSTRUCTION COST				466,664		
14	ADJUSTED TOTAL CONSTRUCTION COST				467,000		
15	ADJUSTED TOTAL DESIGN - ENG. COST (FORM F-1569 -G)				21,000		
16	ADJUSTED TOTAL PROJECT COST				488,000		
APPROVED (ENGINEERING)		DATE		APPROVED (ESTIMATING)		DATE	
Chas. A. Rohmann		10/12/54		W. J. Carlson			

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APPENDIX B, PART II HW-33266, Page 13						DATE PREPARED 10/11/54			
1. ABSORBER - CELLS A,B,C		WORK PERFORMED BY: Plant Forces				JOB TOTALS			
EQUIP.	TOTAL	LABOR	MATERIAL	EQUIP.	TOTAL	LABOR	MATERIAL	EQUIP.	TOTAL
455	410,438	29,950	62,250		92,200				502,638
	650								650
					32,945				32,945
	137								137
	2,000								2,000
	413,225				125,145				538,370
	10,330								10,330
	2,065								2,065
	41,044								41,044
	466,664				125,145				591,809
	467,000				125,000				592,000
	21,000								21,000
	488,000				125,000				613,000

APPROVED (ESTIMATING) <i>W.D. Carlson</i>	DATE 10/11/54	APPROVED (ACCOUNTING)	DATE
--	------------------	-----------------------	------

LEGEND

- (T) TEMPERATURE INSTRUMENT
- (TC) TEMPERATURE CONTROLLER
- (P) PRESSURE INSTRUMENT
- (F) FLOW INSTRUMENT
- (W) WEIGHT FACTOR ALARM AND CONTROLLER
- (S) PROPORTIONAL SMELTER

MATERIAL BALANCE

NITRIC ACID RECOVERY (BASE 1000°/HR MAXIMUM DISSOLUTION RATE)

STREAM	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr	Component Conc./hr
TEMPERATURE °F	87	87	87	87	87	87	87	87	87	87	87	87	87
DENSITY g/cc	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
PHASE	VAPOR	VAPOR	LIQUID	VAPOR	VAPOR	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
COMPONENTS %													
AMMONIA													
NITROGEN	370	370		310	680								
OXYGEN	110	110		97	47								
NITROGEN DIOXIDE	110	110		97	47								
NITRIC ACID													
WATER	447		1380			1870		10000	10000	10000	10000		
TOTAL	1070	1070	1380	407	830	1870		10000	10000	10000	10000		
SCFM	307	17	21	92	178			300	300	300	301		

AMMONIA REMOVAL (BASE 225°/HR MAXIMUM DISSOLUTION RATE)

TEMPERATURE °F	87	87	87	87	87	87	87	87	87	87	87	87	87
DENSITY g/cc	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
PHASE	VAPOR	VAPOR	LIQUID	VAPOR	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
COMPONENTS %													
AMMONIA	37	37	3	04			24.6						
NITROGEN	370	370		370									
OXYGEN	110	110		110									
NITROGEN													
NITROGEN DIOXIDE													
NITRIC ACID													
WATER	1040		1340		1440		2700	20000	20000	20000	20000	20000	1840
TOTAL	2070	2070	1340	484	1440		2700	20000	20000	20000	20000	20000	1840
SCFM	630	100	21	100	29		40	40	40	40	40	41	20

200 CFM AT 100°/HR
To SAND FILTER
VIA AIR TUNNEL

APPROVED
FOR DESIGN
NOT FOR CONSTRUCTION

REVISION DATA
DATE: 11/10/54
BY: [Signature]
CHECKED: [Signature]
APPROVED: [Signature]

REVISIONS

NO.	DESCRIPTION	DATE	BY	CHKD	APPD
1	AS SHOWN	11/10/54	[Signature]	[Signature]	[Signature]

SCALE: NONE

DESIGNED BY: [Signature]
CHECKED BY: [Signature]
APPROVED BY: [Signature]

U.S. ARMY CORP. ENGINEERING
HAWKINS ARMY RESEARCH CENTER
GENERAL ELECTRIC
DISSOLVER OFF-GAS ABSORBER
CELLS NO. 1-4
Process Flow Diagram

UNCLASSIFIED

2

UNCLASSIFIED

APPROVED
FOR DESIGN
NOT FOR CONSTRUCTION

REVISIONS		DATE	BY	APP
1. REVISED		10/1/81	W. J. B.	
2. REVISED		10/1/81	W. J. B.	
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99. REVISED		10/1/81	W. J. B.	
100. REVISED		10/1/81	W. J. B.	

DISCOVER OFF GAS AMMONIA
CELLS A B & C
ENGINEERING FLOW DIAGRAM

NOTE
 1. FOR EXISTING JUMPER SEE H-2-9346/47
 2. ONLY PROPOSED NEW JUMPER ARE SHOWN. JUMPER SHOWN
 3. EXISTING JET JUMPER H-2-9346 WILL HAVE TO BE REDESIGNED
 AND REPLACED.

UNCLASSIFIED

PROPOSED NEW JUMPER
 PROPOSED NEW JUMPER
 PROPOSED NEW JUMPER

APPROVED
 FOR DESIGN
 FOR CONSTRUCTION

NO. 58754	DATE 11-1-54	BY 11-1-54	FOR 11-1-54
DISOLVER OFF GAS ABSORBER CELLS A B & C EQUIPMENT AREA PLAN

[illegible]

APPROVED
FOR DESIGN
NOT FOR CONSTRUCTION

[illegible]

Print

~~FOR NO. 2, A ORIENTATION 54-200~~

SECTION A

TRAN #	1	2	3	4	5	6
NA 92 PRIMA CON	0	2	0	0	2	2
NA 92 PRIMA CON	0	2	4	4	2	2
NA 92 PRIMA CON	0	2	4	4	2	2

CONFIDENTIAL

TYPICAL BUSINESS GAP ANALYSIS

~~RECORD FLAMES ARE NECESSARY TO
KEEP FLAMES ALIVE ON THE
NORRIS 72 718 RECORDS~~

SECTION 501

~~2. REPORTS FROM DEATH
WITNESSES, AFTER A SEARCH~~

SECTION D-D

CONFIDENTIAL

FOR THE 1982-83
B-117A 1982-83
FOR THE 1982-83
B-117A 1982-83

Answer: 100%

TYPICAL BATTLE ARMY

THOMAS, CAROL ANN DOB: 1960
2540 N. 10TH ST APT 101
2540 N. 10TH ST APT 101
2540 N. 10TH ST APT 101
2540 N. 10TH ST APT 101
2540 N. 10TH ST APT 101

TOTAL GUN ARMY INC.
TOTAL 1910 ALL PIPES 1.500000
2 PER PIPES ROAD FOR YEAR 1
4 PER PIPES ROAD FOR YEARS 2-9
AS SHOWN

GENERAL NOTES

1. ALL CONSTRUCTION WORK ARRANGEMENTS SHOWN ARE TENTATIVE AND MAY BE
CHANGED TO MEET HIGHER LEVEL REQUIREMENTS.
2. MINIMUM FOUNDATION NOTED ON DRAWING SHALL BE STAINLESS STEEL
PIPE PILING IN ACCORDANCE WITH AREA HW-3002 LATEST REVISION AND
HW-3003, Pgs. 2 Pgs. 3.
3. MINIMUM PILING TO BE TIE BARS IN ACCORDANCE WITH HWS-3708
4. FOUNDATION SHALL BE IN ACCORDANCE WITH AREA HWS-1306.
5. OPERATING PRESSURE SHALL BE 30" H₂O OR
" THEREABOUTS " 30 P
6. FORWARD SURVIVABLE LIFTING BEARS ON TOWER.
7. ALL TOWER TO BE LEAK TIGHT AND FREE FROM RETENTION PRESSURE.
8. CAPN TO BE LEVEL WITHIN 2".
9. TOWER TO BE LEVEL WITHIN 2"
10. FORWARD GROUND TO BE PILING AND SOIL CLIM ANALYSTS.

CLASSIFICATION		NO. OF PAGES	DATE	FILE	CLASS
SUBJECTS					
DATE FILE SK2-5851		SEARCHED INDEXED SERIALIZED FILED		MAR 1964 FBI - NEW YORK	
ORIGIN NONU		APPROVAL SPECIAL AGENT IN CHARGE REDA			
SUMMARY REDA		REASON FOR REFUSAL REDA			
DISPOSITION REDA		ACTION REDA			
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DATE FILMED

03 / 20 / 91