AD/A-003 847

REVIEW OF MAGNESIUM NITRATE AS A DEHYDRATING AGENT FOR USE IN THE MANUFACTURE OF NITROCELLULOSE

Martin Netzler, Jr.

Army Armament Command
Rock Island, Illinois

December 1974

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

A recent GAO review of the production base modernization program for the manufacture of nitrocellulose (NC) resulted in a recommendation that further modernization be deferred until a new nitration process employing magnesium nitrate has been evaluated. Consequently, this analysis was undertaken to access the validity of the pollution abatement assertions, the projected cost benefits, and the chance for success of the new process to meet military requirements. Included is a description and analysis of the implications involved in selecting a competing process.

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1. BACKGROUND

The US Army Armament Command (ARMCOM) is currently modernizing obsolete production facilities which are used for the manufacture of nitrocellulose (NC). Projects for three new continuous mixed acid (CMA) nitrocellulose lines were to be initiated in FY74. Each line was designed to produce 4 million pounds of nitrocellulose per month. One each was scheduled to be built at Badger (BAAP), Radford (RAAP), and Sunflower Army Ammunition Plant (SAAP), respectively. Although a number of such projects are underway, the Government Accounting Office (GAO) has challenged these three projects because of a concurrent project which investigates a salt-acid process employing magnesium nitrate as the dehydrating agent in the manufacture of nitrocellulose.

Consequently, on 26 November 1973, the House Appropriations Committee recommended that modernization of the batch nitrocellulose lines be deferred until the proposed salt-acid process has been evaluated. The Deputy Commanding General of ARMCOM requested (Appendix A) that the Systems Analysis Office review the proposed use of magnesium nitrate as a dehydrating agent for use in the manufacture of nitrocellulose because of the GAO challenge.

2. DEFINITION OF PROBLEM

The problem is to select a course of action from one of the following:

a. Protest the House Appropriations Committee's deferment of the modernization program of batch mixed acid (BMA) nitrocellulose facilities by the implementation of the continuous mixed acid (CMA) process.

b. Concur with the delay of further modernization by the CMA process until the salt-acid process has been fully evaluated.

The purpose of analyzing this problem is to determine the probability of developing, within a reasonable timeframe, a continuous salt-acid (CSA) process for manufacture of the nitrocellulose.

3. ALTERNATIVES

Alternatives to the GAO proposal are:

a. Modernize the batch nitrocellulose manufacturing facilities by using a continuous mixed acid process. This alternative has the possibility of later retrofitting the modernized facility to accommodate other dehydrating methods.

b. Hold all modernization projects of batch nitrocellulose manufacturing facilities until the pilot plant employing magnesium nitrate has been evaluated.

4. ASSUMPTIONS

The following assumptions have been made:

a. This review will have general application for all Army Ammunition Plants which have batch nitrocellulose facilities.

b. The operating capacity of one modernized line will be four million pounds of nitrocellulose per month. All calculations and estimates used throughout this review are based upon this capacity.

c. The nitrocellulose produced by the continuous process is acceptable.

d. The Environmental Protection Agency (EPA) standards for the Commonwealth of Virginia are the goals for pollution abatement at RAAP and every practical effort will be made to meet these standards by 1977.

5. DISCUSSION

a. Batch Mixed Acid - Cellulose occurs in nature as wood fiber, cell wall and the structural material of all plants. Cotton fiber is pure cellulose. It is used principally in the production of blasting explosives, smokeless powder and propellants (single, double and triple base). At present, nitrocellulose is manufactured by the batch mixed acid process which has been used by the US Government for the past 30 years. It is referred to as a mixed acid process because nitric acid and sulfuric acid are mixed before dumping them into the nitration tank. A flow diagram of this process is shown in Figure 1.

The manufacture of nitrocellulose is divided into three operational phases: (1) preparation of the cellulose and nitrating acid mixture, (2) nitration of the cellulose to produce either high grade or low grade nitrocellulose, and (3) the purification/blending of the wet nitrocellulose to the desired percent nitrogen.

The following chemical equation describes the nitration of the cellulose.

$$C_6H_{10}O_5 + XHNO_3 \longrightarrow C_6H_{(10-X)}O_{(5+2X)}N_X + XH_2O$$

(CELLULOSE) (NITRIC ACID) (NITROCELLULOSE) (WATER)

where $1 \geq X \geq 3$

Dry shredded cellulose is immersed in the concentrated nitric/sulfuric acid mixture. As nitration progresses, water molecules are formed resulting in dilution of the acid and the need for these water molecules

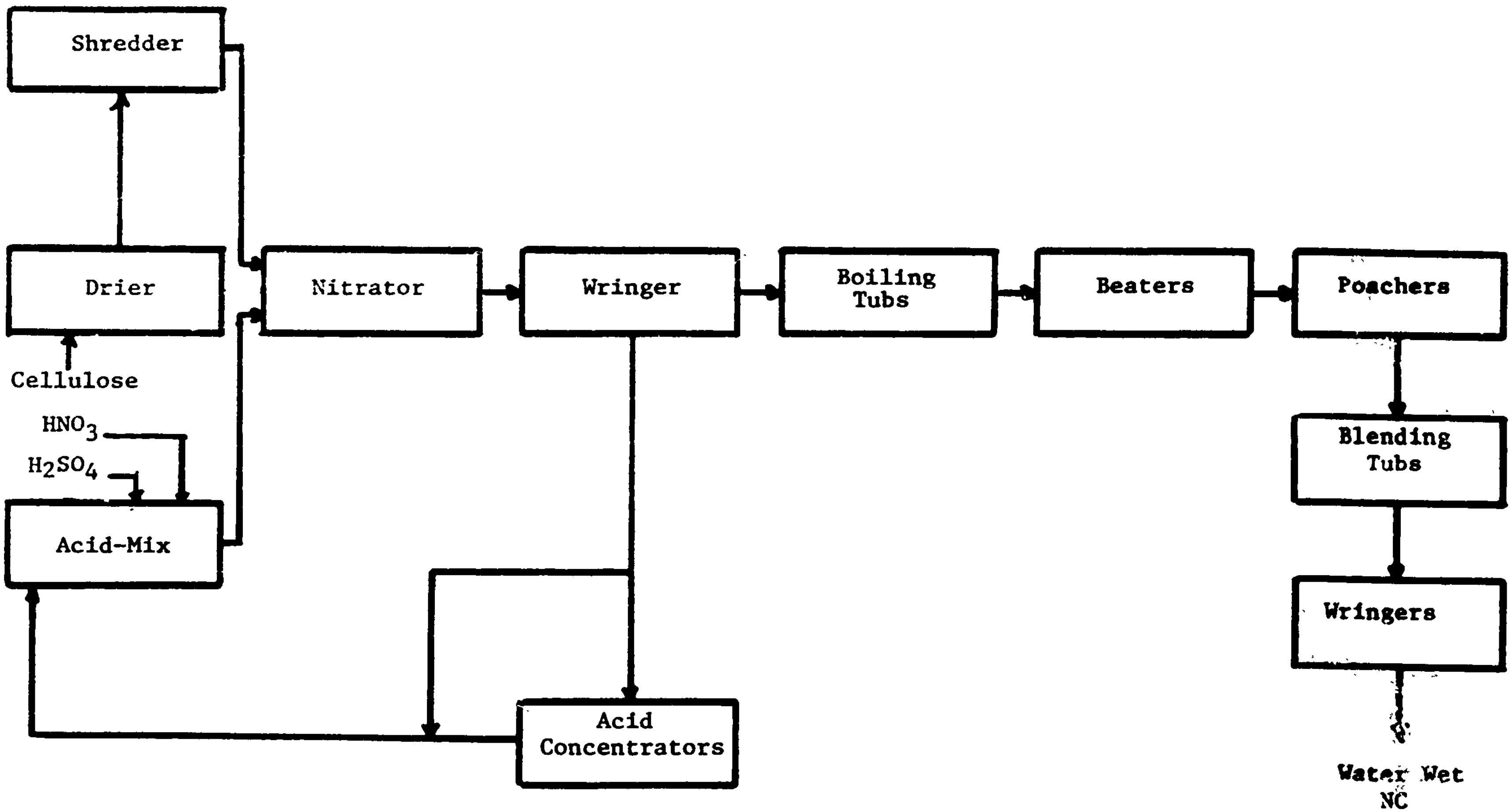

Figure 1. Nitrocellulose Manufacture (Mixed Acid)

to be absorbed in order for the reaction to proceed. Historically, oleum or excess SO_3, dissolved in highly concentrated (100%) sulfuric acid, has always been used as the dehydrating agent. As water molecules form, they react with the SO_3 to form sulfuric acid.

The resulting product is a polymer whose degree of nitration is a function of the concentration of the acid mix. Cellulose containing 12.0 percent nitrogen by weight (low grade) and 13.5 percent nitrogen by weight (high grade) are produced separately and blended to the desired viscosity, solubility and nitrogen content during the purification/ blending phase.

The percent weight of nitrogen designation occurs in the polymer's repeat chemical structure, $C_6H_{(10-X)}\ O_5(ONO)_X$ (where $1 \geq X \geq 3$). Theoretically, the greatest number of (ONO) groups which can be attached to every six carbon atoms is three, thereby producing the high grade nitrocellulose.

The Kaiser Study labeled the batch process as obsolete, inefficient, hazardous, and a pollution source. Severe pollution occurs because of the remaining sulfates, nitrates, and nitrocellulose fines. It is expected that abatement of these pollutants can be eliminated via molecular sieves and/or bio-degradable holding ponds, but the exact approach for RAAP has not been developed yet.

The batch mixed acid process requires an enormous amount of labor, particularly during nitration. The need for all this manual labor is one of the main reasons why the construction of new continuous facilities was undertaken. Drums are filled with cellulose, weighed, and dumped manually into the nitrating vessels. After nitration, the wringer tubs are unloaded by hand, and the caked nitrocellulose is scraped off the wringer walls into a vat of water. Further, this operation is hazardous because the nitrocellulose with its entrapped acid is highly flammable until it is immersed in water. Nevertheless the quality of the product produced in this manner is acceptable.

b. <u>Continuous Mixed Acid</u> - The continuous mixed acid process is continuous only in the nitration phase (see Figure 1). All other processing steps remain the same as in the batch process. After the nitration phase, a Baker-Perkins centrifuge is used for acid washings while the nitrated cellulose is wrung out. The centrifuge reduces the level of entrapped acid within the nitrocellulose fibers and recovers the mixed acid for further use, thereby reducing the pollution abatement problem. The Baker-Perkins centrifuge has been used in industry for several years and is considered to be highly reliable. Little performance risk for this equipment is evident although the use of this centrifuge increases the possibility of a nonacceptable product compared to that produced by the batch process.

The continuous process technology was developed by Hercules, Inc. at their Parlin, New Jersey plant. It is proprietary and the US Army has signed an agreement with Hercules for the purchase of the process technology necessary to design, construct, and operate a continuous mixed acid nitration facility. Hercules, Inc. estimates that this process will reduce the sulfate pollution by 93.5 percent, the nitrate pollution by 12.5 percent, and the amount of water to be processed by 24.5 percent. Table 1 summarizes this comparison for four million pounds of nitrocellulose per month.

TABLE 1. POLLUTANT REDUC[illegible]ION

Process Pollutant	Batch Mixed Acid	Continuous Mixed Acid
Sulfates (lbs)	2,227,000	150,000
% reduction	N/A	93.5%
Nitrates (lbs)	945,000	827,000
% reduction	N/A	[illegible]
Water ($\bar{M}$ gal)	82	[illegible]
% reduction	N/A	[illegible]

Even if these Hercules estimates for th [illegible]
tants are not achieved totally, the po[illegible]
aggravated.

Further, this process reduces the [illegible] or a[illegible]
eliminating 72 people and the hazard [illegible] people
exposed during the removal of moist ce[illegible]er.

The nitrocellulose produced by this [illegible] he
the batch produced product and may cause [illegible]ance
of the propellant. This problem is not w[illegible]eview
and will not be considered.

There are no other unresolved problems. Equipment to be used has been proven suitable within the chemical industry and its use in the continuous process introduces no appreciable risk. Although the batch line employs Jordan Beaters to pulverize the nitrocellulose, they will not be used in any future nitrocellulose lines because they are obsolete, repair parts are difficult to obtain and the maintenance frequency is increasing. Attrition mills perform the same function and are expected to replace the Jordan Beaters. Their location in the line has not yet been determined, but, regardless of their location, their cost should not be attributed to the modernized nitration phase.

Hercules, Inc. has accepted the first continuous manufacturing line at RAAP. Property transfer between Hercules and the Corps of Engineers occurred on July 26, 1974. Hercules has no reservations about the CMA manufacturing process or the prototype line at RAAP. They are fully confident in its meeting stated design characteristics.

c. Salt-Acid Process - Since the continuous process changes the nitration phase only, the problem of developing a pollution free nitrocellulose manufacturing process still exists. Picatinny Arsenal proposed that magnesium nitrate rather than sulfuric acid be used as the dehydrating agent during the nitration phase to eliminate all sulfate pollution and to reduce nitrates and nitrocellulose fines. The feasibility of this process was demonstrated by Hercules who manufactured nitrocellulose samples which were tested at Aberdeen Proving Ground. No significant difference in performance was found between this NC and the NC produced by the batch process.

Magnesium nitrate is a crystalline solid which has zero to six water molecules of hydration attached. During nitration, the mix of nitric acid and magnesium nitrate with its two water molecules of hydration reacts with the shredded cellulose forming additional water molecules which attach themselves to the magnesium nitrate. Consequently, dehydration is accomplished because the number of water molecules of hydration increases from two to five or six. Throughout the process, the chemical structure of the magnesium nitrate molecule itself remains the same. Figure 2 depicts the elements of the continuous salt-acid process.

An ion exchange system to recover magnesium nitrate is needed in the purification area, and is readily available as a commercial system. The costs to convert a continuous mixed acid process to a continuous salt-acid process was estimated by Hercules, Inc. in November 1973 and is included in Appendix B. A cost summary is shown in Table 2.

TABLE 2. RETROFIT COSTS (1974 DOLLARS)

	Contract Cost	Corps of Eng Costs	Total
Convert nitrator bldg & Process equipment	\$ 341,300	\$ 250,600	\$ 591,900
Auxiliary equipment to support	\$ 671,800	\$ 493,400	\$1,165,200
Treatment area for pollution abatement	\$2,070,600	\$1,520,700	\$3,591,300
Total	\$3,083,700	\$2,264,700	\$5,348,400

It is important to note that overhead and profit (26.5%), contingency

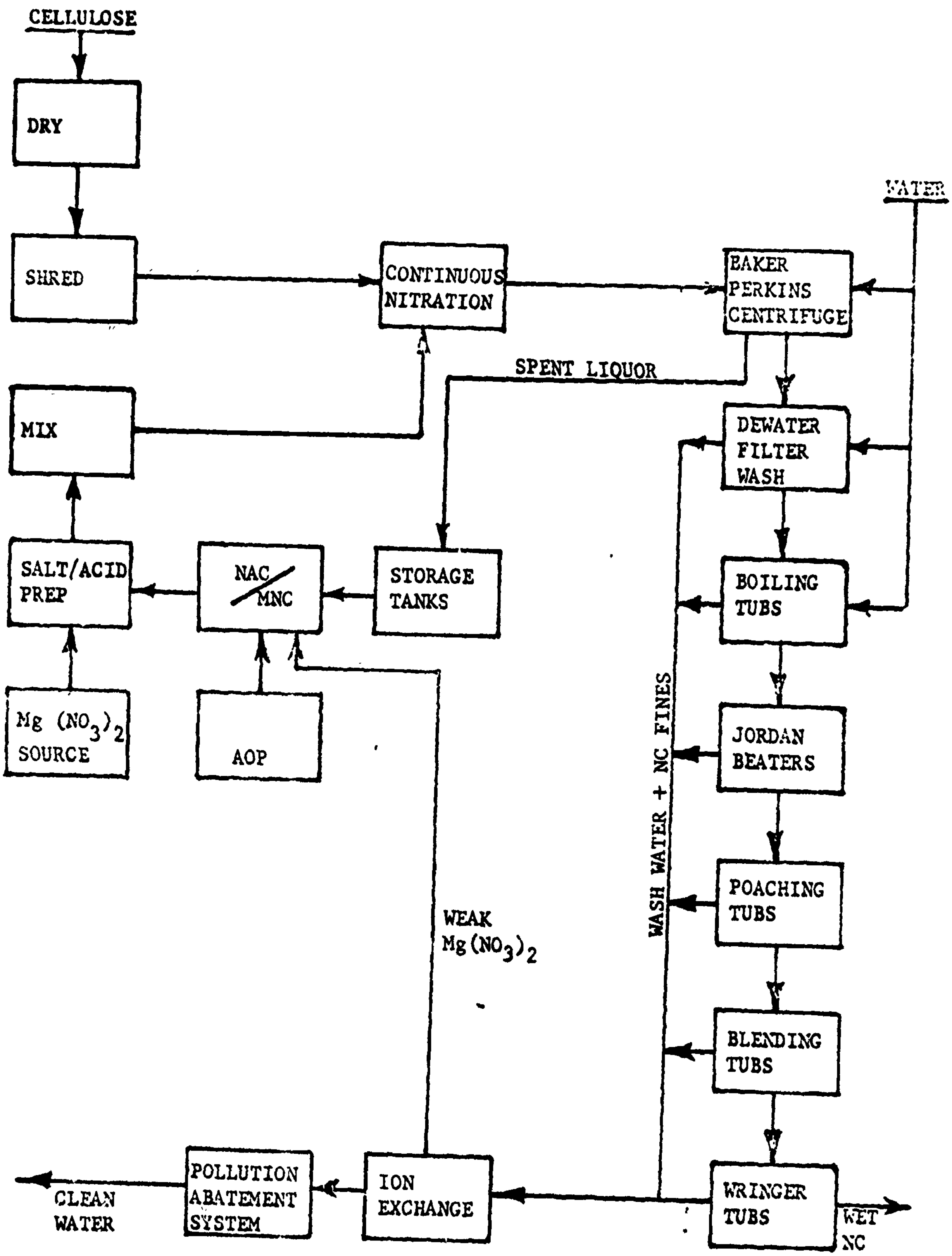

FIGURE 2 - Continuous Salt-Acid Nitrocellulose Process

fees (10%), architectual/engineering fees (3.5%) and supervision/administration fees (5%) have been included within these estimates. Continuous salt-acid employs equipment similar to that used in the continuous mixed acid process. For example, it uses the Baker-Perkins centifuge. However, Hercules, Inc. estimates that the use of magnesium nitrate will reduce the nitrate pollution by 83.6 percent, and the amount of water to be processed by 80 percent. Table 3 summarizes this comparison for a line producing four million pounds per month of nitrocellulose.

TABLE 3. POLLUTANT REDUCTION

Process Pollutant	Batch Mixed Acid	Salt Acid Magnesium Nitrate Process
Sulfates (lbs)	2,227,000	
% reduction	N/A	N/A
Nitrates (lbs)	945,000	155,000
% reduction	N/A	83.6%
Water ($\bar{M}$ gal)	82	16
% reduction	N/A	80%

6. ANALYSIS

Conducting a formal uncertainty analysis was discarded because of the low risks involved.

The batch mixed acid process has no uncertainty. It has been used by the US Government for the past thirty years. The continuous mixed acid method is a variation from the batch method only in the nitration area. It uses a commercial centrifuge (Baker-Perkins). No change in the sequence of the manufacturing steps has occurred. Hence the success of this method of manufacture approaches certainty.

Changing the dehydrating agent from sulfuric acid to magnesium nitrate introduces some uncertainty. However, the ion-exchange is an off-the-shelf item. No major unresolved problems were encountered at Hercules' Parlin Plant. If unforeseen problems occur, it is very likely that they can be overcome in the debugging of the system by slight process changes, such as adjusting the temperature of the chilled acid. Further engineering changes can be made during debugging based on the salt-acid pilot line results.

The nitrocellulose produced at Parlin, NJ possessed "horny" characteristics but met military specifications. The chance of the product being unacceptable is very small because no difference in performance was detected during firing tests.

The attrition mill's location has not yet been determined. Location prior to nitration increases the surface area of the cellulose and may result in more occluded acid. If this happens, its location could be changed to within the poaching operations.

7. FINDINGS

There is little risk involved with either method for manufacturing nitrocellulose. Both the continuous salt-acid process and the continuous mixed acid process are within the current state-of-the-art. However, the salt-acid process introduces a slightly greater risk than the more conventional mixed acid process.

The actual process to be selected depends upon external factors other than the implications associated with a given process. These factors will determine whether the US Army Armament Command should delay its modernization program for nitrocellulose by waiting for the evaluation of the salt-acid pilot plant operation or proceed with the modernization by the continuous mixed acid process. Some of these external factors to be considered are:

a. Nature of present and future site interface

b. Direct support facilities from acid areas

c. Availability of concentrators

d. Costs of new acid concentrators

e. Escalated construction costs because projects are delayed

f. EPA effects on the DOD Five Year Defense Plan

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DEPARTMENT OF THE ARMY
UNITED STATES ARMY MATERIEL COMMAND
OFFICE OF THE PROJECT MANAGER
FOR
MUNITION PRODUCTION BASE MODERNIZATION
DOVER, NEW JERSEY 07801

AMCPM-PBM 11 December 1973

Brigadier General L. E. Van Buskirk
Deputy Commander
HQ, US Army Armament Command
Rock Island, Illinois 61201

Dear General Van Buskirk:

Reference is made to your telephone call concerning the possible deferment of the FY 74 projects for Single Base Propellant and Nitrocellulose. I am inclosing the rationale we prepared as a hasty attempt to provide justification for the retention of these projects and a copy of a rough transcript of some of the House testimony.

I fully agree with you that a formal decision risk analysis which would lay out the complete picture would be of great benefit to us both for these 74 projects and the possible impact on the 70-71 Nitrocellulose projects. We would be happy to assist you in any way in the conduct of this analysis.

Sincerely,

ROBERT J. MALLEY
Brigadier General, USA
Project Manager

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as

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17 December 1973

MEMORANDUM TO: AMSAR-SA

SUBJECT: An Analysis of Our Modernization Program for Single Base Propellant and Nitrocellulose Production

1. In the FY 70 and 71 modernization projects, we have developed a process for the continuous production of nitrocellulose and single base propellant following basically the same chemical process as our current batch process. There has been considerable MMT effort with prototype equipment being developed to produce these items on a continuous process. Our FY 74 program calls for three continuous nitrocellulose lines and one single base propellant continuous line. At the same time, Picatinny Arsenal has been developing a different chemical process for the production of propellants. This is a magnesium nitrate process which was initially conceived to reduce our waste disposal problem for our current process. It was also to have been less expensive in terms of operating cost as well as capital investment. This process has been under development at Picatinny for several years, and at various times we have had very optimistic projections as to when it could be incorporated into the modernization program. Recently the GAO challenged us and Congressional committees have questioned whether we should proceed with our current program to automate our lines and build for continuous production under the current chemical process when we have the magnesium nitrate process almost ready for implementation. The program that we are currently following says to build using the current chemical process and then retrofit the lines for the magnesium nitrate process when it becomes available.

2. Request that you prepare a decision risk analysis to view the two courses of action. First, hold all modernization projects for nitrocellulose and for single base propellant until the magnesium nitrate process is proven and available for incorporation into the projects. This is the GAO recommended approach. Second, modernize a portion of the lines with our current chemical process and retrofit those to the magnesium nitrate process when that process is available. Also, modernize the balance of the lines directly with the magnesium nitrate process, the splitting point to be determined by the availability of the magnesium nitrate process. This analysis should take into consideration the cost of the alternatives and the risks involved in these alternatives, and should give the manager the information to make a decision on the best course of action and the cost differential on the two courses of action. The results of this study should be available then to the Modernization Project Manager, this headquarters, AMC and DCSLOG, to support the decision on modernizing our propellant capability. Personnel from the Manufacturing Technology Directorate, Picatinny Arsenal and the Modernization Project Manager's Office will be made available to support you in this study.

L. E. VAN BUSKIRK
Brigadier General, USA
Deputy Commanding General

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AMCPM-PBM Ltr dtd 11 Dec 73

CF:
AMSAR-PP
AMSAR-OP

APPENDIX B - ESTIMATED COST OF CONVERSION

DEPARTMENT OF THE ARMY
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA 24141

20 DEC 1973

SARRA-IE

SUBJECT: ROM Cost Estimate for Retrofit of Continuous Nitration NC Mixed-Acid Facilities to the Magnesium Nitrate Process

Commander
U. S. Army Armament Command
ATTN: AMSAR-MT, COL D. J. Benefiel
Rock Island, Illinois 61201

As requested, a copy of Hercules Incorporated letter, dated 19 November 1973, subject as above, is forwarded for your information. This letter was previously transmitted to the office of Mr. E. Hann, Picatinny Arsenal, on 20 November 1973.

1 Incl
as

RONALD E. SNYDER
LTC, OrdC
Commanding

HERCULES INCORPORATED

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA 24141

November 19, 1973

cc: H. R. Davies
E. H. Carroll
L. O. Randolph
W. T. Bolleter
J. W. Bolejack
PE File (PE-293)

Contracting Officer's Representative
Radford Army Ammunition Plant
Radford, Virginia

Reference: COR letter SARRA-IE dated 11/9/73.

Dear Sir:

ROM Cost Estimate for Retrofit of Continuous Nitration
NC Mixed Acid Facilities to the Magnesium Nitrate Process

In compliance with your request of November 9, 1973, we submit the attached cost estimate for the conversion of one 4 x 10^6 pounds per month continuous NC mixed acid line to the subject process. Included in this estimate are descriptions of changes to processing equipment, building modifications and projected funding required to effect these items based on the following ground rules.

1. Equipment and process modifications are based entirely on bench-scale work performed under PE-274 and pilot plant design criteria developed from this work.

2. No pilot plant operations have been conducted to date.

3. No equipment modifications or equipment removal have been included that would preclude the operation of the facility as either continuous mixed acid or magnesium nitrate.

4. No consideration has been given herein to continuous purification.

5. No consideration has been given to the conversion of the NAC-SAC facilities to magnesium nitrate-nitric acid concentration since this information is unavailable to us at this time. It is suggested that Chemical Construction Company be contacted for availability of conversion costs.

6. The changes delineated in the purification section apply in the interest for reducing stream pollution and are not necessary for process conversion.

7. All cost estimates are FY-74 and based on rough-order-of-magnitude costs obtained from current purchase orders, vendor contacts and best engineering judgement for labor and contingencies.

8. Completion of design criteria as shown on the attached schedule is dependent upon completion of design by Chemico and installation of the pilot acid concentrator as shown.

Very truly yours,

Original signed by
H. R. DAVIES

H. R. DAVIES
MANAGER

TKDANIEL/meq

Attachments - 3

ATTACHMENT I

I. Changes to Processing Equipment

A. Cellulose Preparation and Feed

No change.

B. Nitrator Building

1. Add attrition mills to the process flow and divert cellulose feed to the mills.

2. Provide surge tanks, pumps, and pipe, to return attrition mill discharge slurry to the nitrators.

3. Heat and insulate acid lines, and spent acid receivers.

4. Insulate nitrators.

5. May require finer mesh screen in centrifuges.

C. Auxiliary Equipment to Support Nitration

1. Provide storage tank for molten magnesium nitrate.

2. Provide molten magnesium nitrate transfer pump.

3. Install steam jacketed magnesium nitrate line from concentrator area.

4. Replace carbon steel spent acid tanks with stainless steel tanks.

5. Provide agitation for mixed acid /spent acid storage tanks, weigh tanks, and mixed acid feed tanks.

6. Heat and insulate mixed acid and spent acid storage tanks, weigh tanks, and mixed acid feed tanks.

D. Purification

These changes all involve installation of pollution abatement equipment. Existing purification equipment is satisfactory for the processing of NC by the magnesium nitrate process. Bench-scale studies indicate that some existing purification equipment may be eliminated; however, no pilot plant operation has been conducted to confirm this.

1. Add dewatering filters with attendant equipment and piping.

2. Add ion exchange units with attendant equipment and piping.

E. NAC/SAC Conversion

No information is available concerning this operation. It is suggested that Chemical Construction Company be approached for these details; however, the pilot plant magnesium nitrate/nitric acid concentrator design is not scheduled for completion until March 1974.

II. Building Modifications

A. Cellulose Preparation and Feed

No change.

B Convert Nitrator Building

The only changes involved in the Nitrator Building are the installation of support foundations for the four attrition mills with attendant surge tanks and pumps.

C Auxiliary Equipment to Support Nitration

No modifications.

D. Purification

Construct a building or remove tanks in the existing Tub House or Poacher House to house the dewatering filters and ion exchange units. This will be determined by the pilot plant work.

E. NAC/SAC Facilities

Modifications required are not known at this time.

ATTACHMENT II

'onvert one line continuous mixed acid nitrocellulose area to magnesium nitrate process to produce 4 x 10^6 pounds per month. The line is to have the capability of producing two types of nitrocellulose simultaneously.

			FY-74 Estimated Cost
A. Cel .ulose Preparation and Feed:			
No :hange.			
B. Con 'ert Nitrator Building and Process Equipment:			
1. Add 4 attrition mills.			$ 105,400
2. Add 2 attrition mill feeders.			9,000
3. Add 2 surge tanks.			10,300
4. Add surge tank agitators.			7,200
5. Add 4 pumps.			10,400
6. Change 2 centrifuge screens.			10,600
7. Pipe and valves.			8,400
8. Controls.			8,800
9. Heat and insulate 2 spent acid storage tanks.			16,000
10. Insulate nitrators.			8,000
11. Trace and insulate acid lines.			10,000
12. Install attrition mill foundations.			8,000
13. Install added fume removal piping.			5,000
		Subtotal Material	$ 217,100
Labor @ 31% Material		$67,300	
20% Contingency		13,500	43,400
	Subtotal	$80,800	$ 260,500
Corps of Engineers Extension			
4% Labor & 18% Material		3,200	46,900
	Subtotal	$84,000	$ 307,400
		Combined Subtotals	$ 391,400
Overhead & Profit @ 26 1/2%			103,700
		Subtotal	$ 495,100
Contingency @ 10%			49,500
		Subtotal	$ 544,600
Architectural & Engineering @ 3.5%			19,100
		Subtotal	$ 563,700
Supervision & Administrative @ 5%			28,200
		TOTAL	$ 591,900

		FY-74 Estimated Cost
C. Auxiliary Equipment to Support Nitration:		
1. Magnesium Nitrate storage tank.		$ 38,700
2. Magnesium Nitrate pump.		2,600
3. Magnesium Nitrate transfer line.		48,000
4. Heat and insulate 3 weigh tanks.		24,000
5. Heat and insulate 4 mixed acid make-up tanks.		32,000
6. Heat and insulate 2 feed tanks.		16,000
7. Heat and insulate 7 spent acid storage tanks.		56,000
8. Provide agitation for mix and spent acid storage, and feed and weigh tanks.		46,700
9. Controls.		45,800
10. Replace 7 carbon steel spent acid tanks with stainless steel tanks.		117,500
	Subtotal Material	$ 427,300
Labor @ 31% Material	$132,500	
20% Contingency	26,500	85,500
Subtotal	$159,000	$ 512,800
Corps of Engineers Extension		
4% Labor & 18% Material	6,400	92,300
Subtotal	$165,400	$ 605,100
	Combined Subtotals	$ 770,500
Overhead & Profit @ 26 1/2%		204,200
	Subtotal	$ 974,700
Contingency @ 10%		97,500
	Subtotal	$1,072,200
Architectural & Engineering @ 3.5%		37,500
	Subtotal	$1,109,700
Supervision & Administrative @ 5%		55,500
	TOTAL	$1,165,200

D. Addition to Purification for Pollution Abatement:*

			FY-74 Estimated Cost
1.	Construct building (site preparation, access roads, utilities).		$ 169,000
2.	Install 2 dewatering filters.		640,000
3.	Added controls.		38,000
4.	Install 6 NC fines strainers.		18,100
5.	Install 2 slurry water accumulator tanks.		18,500
6.	Install 2 NC fines tanks.		5,200
7.	Install 2 fines tank agitators.		7,200
8.	Install 12 pumps.		36,600
9.	Pipe and valves.		44,000
10.	Install ion exchange units.		220,000
11.	Install 1 weak nitric acid tank.		13,800
12.	Install 1 weak magnesium nitrate tank.		13,800
13.	Install 1 ammonium hydroxide tank.		13,800
14.	Install 1 deionized water storage tank.		75,000
15.	Install 400 ft slurry line.		4,800
		Subtotal Material	$1,317,800
	Labor @ 31% Material	$408,500	
	20% Contingency	81,700	263,600
	Subtotal	$489,200	$1,581,400
	Corps of Engineers Extension		
	4% Labor & 18% Material	19,600	284,700
	Subtotal	$508,800	$1,866,100
		Combined Subtotals	$2,374,900
	Overhead & Profit @ 26 1/2%		629,300
		Subtotal	$3,004,200
	Contingency @ 10%		300,400
		Subtotal	$3,304,600
	Architectural & Engineering @ 3.5%		115,700
		Subtotal	$3,420,300
	Supervision & Administrative @ 5%		171,000
		TOTAL	$3,591,300

*To close the loop on the continuous NC mixed acid process would require similar pollution abatement equipment.

E. Summary of Costs for Conversion of One Line of Continuous Nitrocellulose Manufacture to Magnesium Nitrate Process

Item	FY-74 Costs Contract Cost	Corps of Engineers Extension	Total
A	N/A	N/A	
B	$ 341,300	$ 250,600	$ 591,900
C	671,800	493,400	1,165,200
D	2,070,600	1,520,700	3,591,300
TOTAL	$3,083,700	$2,264,700	$5,348,400

ATTACHMENT III