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Group II

Development Document for Interim Final Effluent Limitations Guidelines and Proposed New Source Performance Standards for the

EXPLOSIVES MANUFACTURING

Point Source Category

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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DEVELOPMENT DOCUMENT
for
INTERIM FINAL
EFFLUENT LIMITATIONS, GUIDELINES AND PROPOSED NEW SOURCE PERFORMANCE STANDARDS

for the

EXPLOSIVES MANUFACTURING POINT SOURCE CATEGORY

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ABSTRACT

This document presents the findings of a study of the explosives manufacturing point source category for the purpose of developing effluent limitations and guidelines for existing point sources and standards of performance and pretreatment standards for new and existing point sources, to implement Sections 301(b), 301(c), 304(b), 304(c), 306(b), 306(c), 307(b) and 307(c) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251, 1311, 1314(b) and (c), 1316(b) and 1317(b) and (c), 86 Stat. 816 et. seq., P.L. 92-500 (the "Act").

Effluent limitations and guidelines contained herein set forth the degree of effluent reduction attainable through the application of the Best Practicable Control Technology Currently Available (BPT) and the degree of effluent reduction attainable through the application of the Best Available Technology Economically Achievable (BAT) which must be achieved by existing point sources by July 1, 1977, and July 1, 1983, respectively. The standards of performance and pretreatment standards for existing and new sources contained herein set forth the degree of effluent reduction which is achievable through the application of the Best Available Demonstrated Control Technology (BADCT), processes, operating methods, or other alternatives.

The development of data and recommendations in this document relate to explosives manufacturing, which is one of eight industrial segments of the miscellaneous chemicals point source category. Effluent limitations were developed for each explosives manufacturing subcategory on the basis of the level of raw waste load as well as on the degree of treatment achievable. Appropriate technology to achieve these limitations includes biological and physical/chemical treatment systems and systems for reduction in pollutant loads. Various combinations of in-plant and end-of-pipe technologies are considered for explosives manufacturing plants.

Supporting data and rationale for development of the proposed effluent limitations, guidelines and standards of performance are contained in this report.

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SECTION I

CONCLUSIONS

General

The miscellaneous chemicals point source category encompasses eight segments grouped together for administrative purposes. This document provides background information for the explosives manufacturing point source category and represents a revision of a portion of the initial contractor's draft document issued in February, 1975.

In that document it was pointed out that the explosives manufacturing point source category differs from the others in raw materials, manufacturing processes, and final products. Water usage and subsequent wastewater discharges also vary considerably from segment to segment. Consequently, for the purpose of the development of the effluent limitations and guidelines for corresponding BPCTCA (Best Practicable Control Technology Currently Available), BADCT (Best Available Demonstrated Control Technology) for new sources, and BATEA (Best Available Technology Economically Achievable) requirements, each point source category is treated independently.

It should be emphasized that the proposed treatment model technology will be used only as a guideline and may not be the most appropriate in every case. The cost models for BPCTCA, BATEA, and BADCT were developed to facilitate the economic analysis and should not be construed as the only technology capable of meeting the effluent limitations, guidelines and standards of performance presented in this development document. There are many alternative systems which, taken either singly or in combination, are capable of attaining the effluent limitations, guidelines and standards of performance recommended in this development document. These alternative choices include:

1. Various types of end-of-pipe wastewater treatment.
2. Various in-plant modifications and installation of at-source pollution control equipment.
3. Various combinations of end-of-pipe and in-plant technologies.

It is the intent of this document to identify the technology that can be used to meet the regulations. This information also will allow the individual plant to make the choice of which specific combination of pollution control measures is best suited to its situation in complying with the limitations and standards of performance presented in this development document for the explosives manufacturing point source category.

Explosives

For the purpose of developing effluent limitations, guidelines and standards of performance, the explosives segment has been subcategorized as follows:

A. Manufacture of Explosives. Examples of explosives are dynamite, nitroglycerin, cyclotrimethylene trinitramine (RDX), cyclotetramethylene tetranitramine (HMX), trinitrotoluene (TNT) and nitroguanidine.
B. Manufacture of Propellants. Examples of propellants are rolled powder, high-energy ball powder, and nitrocellulose (NC). Propellants can be single-based, double-based, or triple-based.
C. Load, Assemble and Pack Operations. Includes plants which blend explosives and market a final product, and plants that fill shells and blasting caps. Examples of such installations would be plants manufacturing ammonium nitrate and fuel oil (ANFO), nitrocarbonitrate (NCN), slurries, water gels, and shells.
D. Manufacture of Initiating Compounds. Initiating compounds are highly-sensitive explosives used for detonation. Examples are pentaerythritol tetranitrate (PETN), lead styphnate, tetryl, mercury fulminate, lead azide, nitromannite (HMN), and isosorbide dinitrate.

The criteria used for establishing the above subcategorization included the impact of the following factors on the above groupings:

1. Production processes.
2. Product types and yields.
3. Raw material sources.
4. Wastewater quantities, characteristics, control and treatment.

The wastewater parameters of significance in explosives manufacturing are BOD_5, COD, TOC, TSS, NO_3-N, SO_4, TKN, oil and grease and trace quantities of explosives. In addition, lead and sometimes mercury were found to be significant in the wastewaters of subcategory D. The characterization of the wastewaters are in terms of these parameters and their concentrations are variable.

In explosives manufacturing, a portion of the pollution load comes from the manufacture, concentration, recovery, and purification of sulfuric, nitric, acetic, and other acids. The wastes associated with this portion of explosives manufacturing are not addressed in this document, since these are covered by CFR 414, 415 and 418 manufacturing point source categories (organic, inorganic and fertilizer, respectively).

End-of-pipe treatment for the 1977 standard, i.e., Best Practicable Control Technology Currently Available (BPCTCA) for subcategories A, B and D, is defined as biological treatment as typified by equalization, neutralization and activated sludge with pre-clarification. These systems may require pH control and equalization in order to control variable waste loads, and phosphorus nutrient addition to ensure maintenance of an activated sludge with desirable performance and handling characteristics. These systems do not preclude the use of equivalent chemical/physical systems, nor do they preclude the use of in-process controls applicable for the control of those pollutants which may be inhibitory to the biological waste treatment system. End-of-pipe treatment for 1977 standards, that is BPCTCA for subcategory C, is defined as equivalent to extended aeration packaged plant which includes biological treatment, clarification with skimming and chlorination.

Wastewater treatment technology for new sources utilizing the Best Available Demonstrated Control Technology (BADCT) for subcategories A, B and D is defined as equivalent BPCTCA with suspended solids removal by filtration. In case of subcategory C, the BADCT is defined as BPCTCA with further suspended solids and oil removal by a packaged dual-media filtration system. In addition, exemplary in-plant controls are applicable, particularly where biologically inhibitory pollutants must be controlled.

Best Available Technology Economically Achievable (BATEA), is based upon treatment equivalent to the addition of filtration and activated carbon to BPCTCA treatment for subcategories A, B and D. The BATEA treatment for subcategory C is based upon the addition of chemical coagulation and filtration to BPCTCA treatment. This technology is based upon the need for substantial reductions of dissolved organics which tend to be biorefractory, as well as those which are biodegradable.

TABLE 1-1

Summary Table
Explosives Manufacturing

Subcategories	Contaminants of Interest	Flow l/kkg Product (gal/1,000 lbs)	Raw Waste Loads (RWL)					Treatment Technology	BPCTCA (1977) Long-Term Average Daily Effluent					
			BOD5		COD		TSS		BOD5		COD		TSS	O&G
			kg/kkg Product	mg/L	kg/kkg Product	mg/L	mg/L		kg/kkg[1] Product	mg/L	kg/kkg[1] Product	mg/L	mg/L	mg/L
Subcategory A Manufacture of Explosives	BOD_5, COD, TOC, TSS, NO_3, SO_4, TKN, Trace Explosives (TNT, NG, RDX, HMX)	1,680 (201)	1.46	871	3.87	2,310	690	Biological Treatment and Sludge Disposal	0.10	61	1.08	647	**	*
Subcategory B Manufacture of Propellants	BOD_5, COD, TOC, TSS, NO_3, SO_4, TKN, Trace Explosives	267,000 (32,000)	63.4	237	118	442	242	Biological Treatment and Sludge Disposal	4.44	17	33	124	**	*
Subcategory C Load and Pack Operations	BOD_5, COD, TOC, TSS, NO_3, SO_4, TKN, Trace Explosives	1,760 (211)	.0005	less than 1	0.08	45	523	Extended Aeration Packaged Plant with Screening, Clarification, Skimming and Chlorination plus Package Dual-Media Filtration	*	*	*	*	**	**
Subcategory D Manufacture of Initiators	BOD_5, COD, TOC, TSS, NO_3, SO_4, TKN, Trace Explosives	873,000 (105,000)	1,170	1,340	6,290	7,210	56	Biological Treatment and Sludge Disposal	81.9	94	1,760	2,020	**	*

[1] kg/kkg is equivalent to lb/1,000 lbs

*No limitation at this time.

**Due to a limited data base in this category and the achievable level by the proposed cost model, the effluent limitations for TSS and O&G have been established by transfer of technology from the Fertilizer Chemicals and Petroleum Refining Point Source Categories, respectively.

Subcategories		Treatment Technology	BATEA (1983) Long-Term Average Daily Effluent						Treatment Technology	New Source Performance Standard (BADCT) Long-Term Average Daily Effluent					
			BOD5		COD		TSS	O&G		BOD5		COD		TSS	O&G
			kg/kkg Product	mg/L	kg/kkg Product	mg/L	mg/L	mg/L		kg/kkg Product	mg/L	kg/kkg Product	mg/L	mg/L	mg/L
Subcategory A Manufacture of Explosives	BOD_5, COD, TOC, TSS, NO_3, SO_4, TKN, Trace Explosives (TNT, NG, RDX, HMX)	BPCTCA Filtration Activated Carbon	0.028	17	0.23	137	**	*	BPCTCA Filtration	0.092	55	0.94	560	**	*
Subcategory B Manufacture of Propellants	BOD_5, COD, TOC, TSS, NO_3, SO_4, TKN, Trace Explosives	BPCTCA Filtration Activated Carbon	1.24	5	6.90	26	**	*	BPCTCA Filtration	4.08	15	29	108	**	*
Subcategory C Load and Pack Operations	BOD_5, COD, TOC, TSS, NO_3, SO_4, TKN, Trace Explosives	BPCTCA Filtration Activated Carbon	0.00014	less than 1	0.017	10	**	**	BPCTCA Filtration	*	*	*	*	**	**
Subcategory D Manufacture of Initiators	BOD_5, COD, TOC, TSS, NO_3, SO_4, TKN, Trace Explosives	BPCTCA Filtration Activated Carbon	22.9	26	370	424	**	*	BPCTCA Filtration	75.3	86	1,530	1,760	**	*

The effluent limitations are in terms of the maximum for any one day (maximum day limitation) and the maximum average of daily values for any period of thirty consecutive days (maximum thirty day limitation). These limitations are determined using the performance factors developed from long-term operation of exemplary systems evaluated in explosives manufacturing. In the case of TSS (total suspended solids) and O&G (oil and grease), effluent limitations have been established by transfer of technology from the inorganic chemicals, fertilizer chemicals and petroleum refining point source categories, respectively.

Table I-1 summarizes the contaminants of interest, raw waste loads, and recommended treatment technologies for BPCTCA, BATEA, and BADCT for each subcategory of the explosives manufacturing point source category.

SECTION II

RECOMMENDATIONS

General

The recommendations for effluent limitations and guidelines commensurate with the BPCTCA, BATEA and BADCT are given in this text for the explosives manufacturing point source category. A discussion of in-plant and end-of-pipe control technology required to achieve the recommended effluent limitations, guidelines and new source performance standards are included.

Explosives

The BPCTCA treatment technology recommended for subcategories A, B and D of explosives manufacturing is an activated sludge system with influent equalization and neutralization. The BPCTCA treatment technology recommended for subcategory C is equivalent to an extended aeration packaged plant which includes screening, biotreatment, clarification with skimming and chlorination. These treatment systems are designed to attain the BPCTCA effluent limitations and guidelines presented in Table II-1.

BATEA treatment technology for subcategories A, B and D is defined as filtration and activated carbon added to the BPCTCA treatment system. For subcategory C, the BATEA treatment technology is defined as chemical coagulation and filtration added to the BPCTCA treatment system. This treatment system is designed to attain the BATEA effluent limitations and guidelines presented in Table II-2.

New source performance standards (BADCT) for subcategories A, B and D can be achieved by filtration added to the BPCTCA treatment system. BADCT standards for subcategory C can be achieved by a packaged dual-media filtration system added to the BPCTCA treatment system. Effluent limitations and guidelines for BADCT are shown in Table II-3. The effluent limitations are based on the maximum day limitation and the maximum thirty day limitation. These effluent limitation values are developed using the performance factors for the treatment plant operation as discussed in Section XIII of this document.

It is recommended that wastewater from explosives manufacturing plants be treated on site. If municipal

TABLE II -1

BPCTCA Effluent Limitations

Explosives Manufacturing

Subcategory	Effluent Characteristic	Effluent Limitations: Average of Daily Values for 30 Consecutive Days Shall Not Exceed kg/kkg[1]	mg/L	Maximum for Any One Day kg/kkg	mg/L
A	BOD_5	.24		0.72	
	COD	2.59		7.77	
	TSS	.084	50	0.25	150
B	BOD_5	10.7		32.1	
	COD	79.2		237.6	
	TSS	13.3	50	40.0	150
C	BOD_5	*		*	
	COD	*		*	
	TSS	0.088	50	0.26	150
	O&G	0.035	20	0.11	60
D	BOD_5	197		591	
	COD	4220		12660	
	TSS	43.8	50	131.0	150

[1] kg/kkg Production is equivalent to lbs/1,000 lbs production

*No limitation has been set

TABLE II -2

BATEA Effluent Limitations

Explosives Manufacturing

Subcategory	Effluent Characteristic	Effluent Limitations: Average of Daily Values for 30 Consecutive Days Shall Not Exceed		Effluent Limitations: Maximum for Any One Day	
		kg/kkg[1]	mg/L	kg/kkg	mg/L
A	BOD_5	.067		0.11	
	COD	.55		0.85	
	TSS	0.017	10	0.034	20
B	BOD_5	2.98		4.71	
	COD	16.6		26.2	
	TSS	2.67	10	5.34	20
C	BOD_5	*		*	
	COD	*		*	
	TSS	.035	20	.070	40
	O&G	.018	10	.035	20
D	BOD_5	55		87	
	COD	838		1410	
	TSS	8.76	10	17.5	20

[1] kg/kkg Production is equivalent to lbs/1,000 lbs production

TABLE II .-3

BADCT Effluent Limitations

Explosives Manufacturing

Subcategory	Effluent Characteristic	Effluent Limitations			
		Average of Daily Values for 30 Consecutive Days Shall Not Exceed		Maximum for Any One Day	
		kg/kkg[1]	mg/L	kg/kkg	mg/L
A	BOD_5	0.22		0.35	
	COD	2.3		3.6	
	TSS	0.034	20	0.067	40
B	BOD_5	9.79		15.5	
	COD	69.9		110	
	TSS	5.34	20	10.7	40
C	BOD_5	*		*	
	COD	*		*	
	TSS	0.035	20	0.07	40
	O&G	0.018	10	0.035	20
D	BOD_5	181		286	
	COD	3670		5810	
	TSS	17.5	20	35	40

[1] kg/kkg Production is equivalent to lbs/1,000 lbs production

*No limitation has been set

treatment is highly advantageous over on-site treatment, a pretreatment system must be designed to remove potentially hazardous explosives wastes. Variability factors for BOD_5 and COD have been computed from historical data where available. Long term TSS data from explosives manufacturing was not available. In this case, the predominant treatment technology is biological and treatment plants in both industries should experience similar suspended solids on the exit side of the biological treatment plant in spite of the complex mix in the influent from the respective types of manufacturing plants.

Due to the lack of a more reliable data base and the similarity of the wastes generated and treatment systems available for use in the pharmaceutical and explosives point source categories the technology has been transferred. Both are generally batch type operations using non-dedicated equipment and generating a wide pH range of effluents. In addition, the treatment technology from the inorganic chemicals manufacturing point source category, the fertilizer manufacturing point source category and the petroleum refining point source category have been transferred to applicable subcategories in this point source category. The wastes from the fertilizer and petroleum manufacturing processes and their treatability are quite similar to treatment in this point source category and the model technologies are therefore used. When a better data base becomes available, this position will be reevaluated.

SECTION III

INTRODUCTION

Purpose and Authority

The Federal Water Pollution Control Act Amendments of 1972 (the Act) made a number of fundamental changes in the approach to achieving clean water. One of the most significant changes was to shift from a reliance on effluent limitations related to water quality to a direct control of effluents through the establishment of technology-based effluent limitations to form an additional basis, as a minimum, for issuance of discharge permits.

The Act requires EPA to establish guidelines for technology-based effluent limitations which must be achieved by point sources of discharges into the navigable waters of the United States. Section 301(b) of the Act requires the achievement by not later than July 1, 1977 of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the BPCTCA as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983 of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the BATEA, resulting in progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) of the Act. Section 306 of the Act requires the achievement by new sources of federal standards of performance providing for the control of the discharge of pollutants, which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the BADCT processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish regulations based on the degree of effluent reduction attainable through the application of the BPCTCA and the best control measures and practices achievable, including treatment techniques, process and procedure innovations, operation methods, and other alternatives. The regulations proposed herein set forth effluent limitations and guidelines pursuant to Section 304(b) of the Act for the explosives manufacturing point source category. Section

304(c) of the Act requires the Administrator to issue information on the processes, procedures, or operating methods which result in the elimination or reduction in the discharge of pollutants to implement standards of performance under Section 306 of the Act. Such information is to include technical and other data, including costs, as are available on alternative methods of elimination or reduction of the discharge of pollutants.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b) (1) (A) of the Act, to propose regulations establishing federal standards of performance for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973 (38 F.R. 1624) a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources.

Furthermore, Section 307(b) provides that:

1. The Administrator shall, from time to time, publish proposed regulations establishing pretreatment standards for introduction of pollutants into treatment works (as defined in Section 212 of this Act) which are publicly owned, for those pollutants which are determined not to be susceptible to treatment by such treatment works or which would interfere with the operation of such treatment works. Not later than ninety days after such publication, and after opportunity for public hearing, the Administrator shall promulgate such pretreatment standards. Pretreatment standards under this subsection shall specify a time for compliance not to exceed three years from the date of promulgation and shall be established to prevent the discharge of any pollutant through treatment works (as defined in Section 212 of this Act) which are publicly owned, which pollutant interferes with, passes through, or otherwise is incompatible with such works.
2. The Administrator shall, from time to time, as control technology, processes, operating methods, or other alternatives change, revise such standards, following the procedure established by this subsection for promulgation of such standards.
3. When proposing or promulgating any pretreatment standard under this section, the Administrator

shall designate the category or categories of sources to which such standard shall apply.

4. Nothing in this subsection shall affect any pretreatment requirement established by any State or local law not in conflict with any pretreatment standard established under this subsection.

In order to insure that any source introducing pollutants into a publicly owned treatment works, which would be a new source subject to Section 306 if it were to discharge pollutants, will not cause a violation of the effluent limitations established for any such treatment works, the Administrator is required to promulgate pretreatment standards for the category of such sources simultaneously with the promulgation of standards of performance under Section 306 for the equivalent category of new sources. Such pretreatment standards shall prevent the discharge into such treatment works of any pollutant which may interfere with, pass through, or otherwise be incompatible with such works.

The Act defines a new source to mean any source the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance. Construction means any placement, assembly, or installation of facilities or equipment (including contractual obligations to purchase such facilities or equipment) at the premises where such equipment will be used, including preparation work at such premises.

Scope of Study and Methods Used for Development of the Effluent Limitations and Standards for Performance

The Standard Industrial Classifications (SIC) list was developed by the United States Department of Commerce and is oriented toward the collection of economic data related to gross production, sales, and unit costs. The SIC list is not related to the nature of the industry in terms of actual plant operations, production, or considerations associated with water pollution control. As such, the list does not provide a realistic or definitive set of boundaries for study of effluent limitations for the explosives manufacturing point source category. The scope of coverage is therefore not based strictly on SIC codes, but on the manufacture of explosives by the commercial and military sector. These include the manufacture of explosives, propellant, the manufacture of initiating compounds and the load, assemble and pack operations.

The effluent limitations and standards of performance proposed in this document were developed in the following manner. The miscellaneous chemicals point source category was first divided into industrial segments, based on type of industry and products manufactured. Determination was then made as to whether further subcategorization would aid in description of the segment. Such determinations were made on the basis of raw materials required, products manufactured, processes employed, and other factors.

The raw waste characteristics for each category and/or subcategory were then identified. This included an analysis of: 1) the source and volume of water used in the process employed and the sources of wastes and wastewaters in the plant; and 2) the constituents of all wastewaters (including toxic constituents) which result in taste, odor, and color in water or could affect aquatic organisms. The constituents of wastewaters which should be subject to effluent limitations, guidelines and standards of performance were identified.

The full range of control and treatment technologies existing within each category and/or subcategory was identified. This included identification of distinct control and treatment technology, including both in-plant and end- of-pipe technologies, which are existent or capable of being designed for each subcategory. It also included an identification of the effluent level resulting from the application of each of the treatment and control technologies, in terms of the amount of constituents and of the chemical, physical, and biological characteristics of pollutants. The problems, limitations, and reliability of each treatment and control technology and the required implementation time were also identified. In addition, the non-water quality environmental impacts (such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, radiation, and noise) were also identified. The energy requirements of each of the control and treatment technologies were identified, as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constituted the BPCTCA, BATEA, and BADCT. In identifying such technologies, factors considered included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impact (including energy requirements), and other factors.

During the initial phases of the study, an assessment was made of the availability, adequacy, and usefulness of all existing data sources. Data on the identity and performance of wastewater treatment systems were known to be included in:

1. NPDES permit applications.

2. Self-reporting discharge data from various states and regions.

3. Surveys conducted by trade associations or by agencies under research and development grants.

A preliminary analysis of these data indicated an obvious need for additional information.

Additional data in the following areas were required: 1) process raw waste load (RWL) related to production; 2) currently practiced or potential in-plant waste control techniques; and 3) the identity and effectiveness of end-of-pipe treatment systems. The best source of information was the manufacturers themselves. Additional information was obtained from direct interviews and sampling visits to production facilities.

Collection of the data necessary for development of RWL and effluent treatment capabilities within dependable confidence limits required analysis of both production and treatment operations. In a few cases, the plant visits were planned so that the production operations of a single plant could be studied in association with an end-of-pipe treatment system which receives only the wastes from that production. The RWL for this plant and associated treatment technology would fall within a single subcategory. However, the wide variety of products manufactured by most of the industrial plants made this situation rare.

In the majority of cases, it was necessary to visit facilities where the products manufactured fell into several subcategories. The end-of-pipe treatment facilities received combined wastewaters associated with several subcategories (several products, processes, or even unrelated manufacturing operations). It was necessary to analyze separately the production (waste-generating) facilities and the effluent (waste treatment) facilities. This approach required establishment of a common basis, the raw waste load (RWL), for common levels of treatment technology for the products within a subcategory and for the translation of treatment technology between categories or subcategories.

The selection of wastewater treatment plants was developed from identifying information available in the NPDES permit applications, state self-reporting discharge data, and contacts within the point source category. Every effort was made to choose facilities where meaningful information on both treatment facilities and manufacturing processes could be obtained.

Survey teams composed of project engineers and scientists conducted the actual plant visits. Information on the identity and performance of wastewater treatment systems was obtained through:

1. Interviews with plant water pollution control personnel or engineering personnel.
2. Examination of treatment plant design and historical operating data (flow rates and analyses of influent and effluent).
3. Treatment plant influent and effluent sampling.

Information on process plant operations and the associated RWL was obtained through:

1. Interviews with plant operating personnel.
2. Examination of plant design and operating data (design specifications, flow sheets, day-to-day material balances around individual process modules or unit operations where possible).
3. Individual process wastewater sampling and analysis.
4. Historical production and wastewater treatment data.

The data base obtained in this manner was then utilized by the methodology previously described to develop recommended effluent limitations and standards of performance for the explosives manufacturing point source category. References utilized are included in Section XV of this report. The data obtained during the field data collection program are included in Supplement B. Cost information is presented in

Table III -1

Explosives Products - SIC 2892

Amatol (explosive)
Azides (explosives)
Blasting powder and blasting caps
Carbohydrates, nitrated (explosives)
Cordeau detonant (explosive)
Cordite (explosive)
Detonating caps for safety fuses
Detonators (explosive compounds)
Dynamite
Explosive cartridges for concussion forming of metal
Explosive compounds
Explosives
Fulminate of mercury (explosive compound)
Fuse powder
Fuses, safety
Gunpowder
High explosives
Lead azide (explosive)
Mercury azide (explosive)
Nitrocellulose powder (explosive)
Nitroglycerin (explosive)
Nitromannitol (explosive)
Nitrostarch (explosive)
Pentolite (explosive)
Permissible explosives
Picric acid (explosive)
Powder: pellet, smokeless and sporting (explosive)
RDX (explosive)
Squibbs, electric
Styphnle acid
Tetryl (explosive)
TNT (trinitrotoluene)
Well shooting torpedoes (explosives)

Supplement A. These documents are available for examination by interested parties at the EPA Public Information Reference Unit, Room 2922 (EPA Library), Waterside Mall, 401 M St. S.W., Washington, D.C. 20460.

The following text describes the scope of the study, technical approach to the development of effluent limitations, guidelines, and the scope of coverage for the data base for explosives manufacturing.

Explosives

The compounds covered by explosives manufacturing as designated in SIC 2892 are shown in Table III-1. For a cross-sectioned view of the commercial explosives sold, see Table III-3.

As stated previously in the conclusions section, inorganic and organic acids such as the sulfuric acid concentration (SAC) and nitric acid concentration (NAC) are not considered as a part of the explosives manufacturing point source category and have been excluded from consideration in this document. Also excluded are off-site ANFO activities at mining or construction locations (point of use) since investigation determined that no point source water related pollution occurred.

In addition, little quantitative information could be gathered for the process of demilitarization of explosives. (Demilitarization normally would occur in the load, assemble and pack subcategory.) This is a process by which the military scours obsolete or defective munitions with steam hoses to remove explosives and propellants from their containers (e.g., projectiles and shell casings). The process is performed so as to save the containers for possible reuse.

The pollution load from the operation of demilitarization can be very high. It is recommended that, until such time when an adequate data base is available, this operation be dealt with on a plant-by-plant basis since investigation determined that no point source water related pollution occurred. This potential source of pollution was not recognized early since it is non-continuous in nature and was not assigned to the contractor.

To help clarify the coverage of this document the following are excluded from the scope of this study.

- Metal parts and finishing

- Toxic chemical agents, except as noted
- Illuminants and incendiaries
- Liquid propellants
- Nuclear explosives
- Demilitarization

Explosives manufacturing can be divided into two broad areas: military and commercial. Military and commercial plants differ in both size, product and type of operation. Ammonium nitrate based explosives, dynamite, and nitroglycerin are considered commercial explosives, while TNT, HMX, and RDX are generally considered military explosives.

The manufacture of explosives in either area can be viewed primarily as the nitration of an organic molecule. Most processes use nitric acid as the nitrate source and employ sulfuric or acetic acid as a dehydrating agent. Therefore, most wastes in the industry are low in pH.

Wastewaters in explosives manufacturing are of concern because of their pollutional nature and, in certain cases, their hazardous character. For example, wastewaters from nitroglycerin manufacture are often saturated with soluble nitroglycerin, which may become a potential explosive hazard if concentrated. Other than military publications, in some cases classified and/or limited distribution, information pertaining to the wastewaters of explosives manufacture and pollution abatement technology applicable to explosives manufacturing is very limited.

Technical Approach to the Development of Effluent Limitations and Guidelines

To prepare effluent limitations and guidelines for explosives manufacturing as stated, it was necessary to develop a comprehensive scope of work. Each EPA regional office was visited, and permit information was gathered. This enabled the contractor to select representative plants to visit and to sample.

Plant visits generally consisted of two phases. The first took place in an office, where pertinent data was exchanged. The second phase consisted of an examination of the plant, viewing each process previously discussed, followed by a detailed examination and/or sampling of processes producing pollutants.

Four commercial and two military explosives plants were visited. Extensive sampling was performed at each of the

Table III-2

Major Operations at Major Ammunition Plants

Plant	Explosive Manufacture	Propellant Manufacture	Initiator Manufacture	Assemble, Load and Pack.
ARMY				
Holston AAP	+			
Radford AAP	+	+		+
Joliet AAP	+		+	+
Badger AAP	+	+		
Lake City		+	+	+
Longhorn AAP				+
Newport AAP	+			
Volunteer AAP	+			
Indiana AAP		+		
Iowa AAP				+
Kansas AAP				+
Louisiana AAP				+
Lone Star AAP				+
Milan AAP				+
Twin Cities AAP			+	+
Sunflower AAP		+		+
Cornhusker AAP				+
NAVY				
NOS Indian Head		+	+	+
NAD Yorktown				+
NAD Crane			+	+
NAD McAlester				+
NAD Hawthorne				+
Navy Magna Plant				+
AIR FORCE				
AF Plant 78				+
COMMERCIAL				
45			+	+
46		+		
47		+		
48	+		+	+
49	+			+
50	+		+	+

TABLE III-3

INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, 1973(1)

Class	Description	Quantity 10^3 metric tons/year	
Fixed High Explosives(2)			
Permissibles	Grades of high explosives approved by the U.S. Bureau of Mines for use, in a prescribed, in underground coal mines.	20	
Other High Explosives	All high explosives except permissibles and those water gels or slurries containing high explosives; includes all formulations packaged in metal containers.	119	
Subtotal			139
Blasting Agents			
Cylindrically-packaged(2)	Ammonium nitrate and fuel mixtures packaged in paper, burlap, or plastic containers having a cylindrical shape.	126	
Water gels and slurries(2)	All water gels or slurries, packaged or in bulk, made by addition of more than 5% water to high explosives or blasting agents.	120	
Other processed blasting(3). agents and unprocessed ammonium nitrate	Ammonium nitrate and fuel mixtures sold in bulk or packed in paper, plastic, burlap bags, or other containers designed for bulk loading; also prilled or grained ammonium nitrate.	865	
Subtotal			1,111
Grand Total		1,250	1,250

(1)"Mineral Industry Surveys", U. S. Department of the Interior, Bureau of Mines, July 23, 1974

(2)Some quantities of this class of explosive or blasting agent are included with "other" processed blasting agents and unprocessed ammonium nitrate to avoid disclosing individual company data.

(3)Includes some quantities of fixed high explosives, cylindrically packaged blasting agents and water gels and slurries (see note (1) above).

commercial plants, while the military plants were visited for conceptualization, visual inspection, and verification of existing data. The data existing for the government-owned, contractor-operated (GOCO) munitions plants were collected and made available by the Army Environmental Hygiene Agency (AEHA).

The Army operates seventeen (17) munitions plants, the Navy operates six (6) plants, and the Air Force one (1). Only the Army is actually engaged in large scale manufacture of explosives. Although there are load, assemble and pack (LAP) operations at various Navy and Air Force installations, no usable data were available from these operations at this time. Since similar load and pack operations are carried out at the Navy and Air Force facilities, the Army data collected is felt to be representative. Hence, the Army was the best source of military effluent quality data at this time. Consequently, it was decided that the focus of the study of the military area of explosives manufacturing would be the Army ammunition plants (AAPs). Excellent representative effluent data for the several AAPs were included in the information provided by AEHA.

Visits with AEHA personnel, investigation of laboratory techniques and equipment, rationalization of the excellent field procedures, and the fact that production processes were similar or identical for particular processes between plants the AEHA reports were used to their fullest extent. Two large AAPs considered the most representative were visited.

When all the explosives manufacturing plant visits were completed and the laboratory analysis of the samples finished, waste load characteristics were compiled, and each process waste stream was characterized by production-based water quality parameters. Subcategorization of the segment was based on raw waste loading calculations. Effluent limitations were determined for each subcategory by reviewing the removal rates of a treatment facility serving a propellant plant. This was necessary since pollution treatment in the explosives manufacturing point source category is uniformly inadequate. Hence, the best information available from manufacturers (both commercial and military) and transfer technology between subcategories within the same point source category were used in developing the effluent limitations, guidelines and new source performance standards.

SECTION IV

INDUSTRIAL CATEGORIZATION

The goal of this study is the development of effluent limitations and guidelines for the explosives manufacturing point source category that will be achieved with different levels of in-plant waste reduction and end-of-pipe pollution control technology. These effluent limitations and guidelines specify the quantity of pollutants which are to be discharged from a specific facility and are related to a common yardstick for the point source category, such as quantity of production.

Explosives

Discussion of the Rationale of Categorization

Manufacturing subcategories were established so as to define those sectors of explosives manufacturing where separate effluent limitations and standards of performance should apply. The distinctions between the subcategories have been based on the production process and product type, its quality, characteristics, and applicability of control and treatment. The following factors were considered in determining whether such subcategorizations are justified:

Raw Material, Production Processes, and Product Type

The general production process for the manufacturing of explosives involves the nitration of an organic molecule. Raw materials used in this process are nitric acid, acting as the nitrate source, and sulfuric or acetic acid, acting as a dehydrating agent. Examples of the organic molecules used are glycerin, toluene, resorcinol, hexamine, and cellulose. After nitration, these organic molecules produce the following products: nitroglycerin and dinitroglycerin; trinitrotoluene and dinitrotoluene; trinitroresorcinol; nitromannite; and nitrocellulose, respectively. Additional production processes involve the formation of highly sensitive initiating compounds with nitrogen salts as a nitrogen source. An example of this product would be lead azide.

A categorization based on product or process is possible. For example, explosives manufacturing could be broken down into four areas: explosives, propellants, LAP plant operations and initiating compounds. Explosives and propellants are manufactured in bulk, while initiating compounds (highly sensitive compounds used to ignite the explosive or propellant) are manufactured in small quantities. Explosives oxidize at an extremely fast rate, giving off large volumes of gas. Propellants burn layer after layer at a much slower rate than explosives.

Propellant manufacturing is highly specialized. Two considerations of density are important in solid propellants-volume efficiency and density of the propellant itself. A propellant of high density is generally desirable so as to contain the maximum possible amount of energy-producing material in the minimum space. Pressure exerted during extrusion or molding frequently increases the density of a propellant. The minimum mechanical strength requirement for solid propellants dictate that the propellant will not undergo deformation under its own weight to change the grain geometry or substantially alter the dimensions of the grain. In addition, the propellant should possess sufficient strength to withstand the stresses imposed during shipping, handling, and firing.

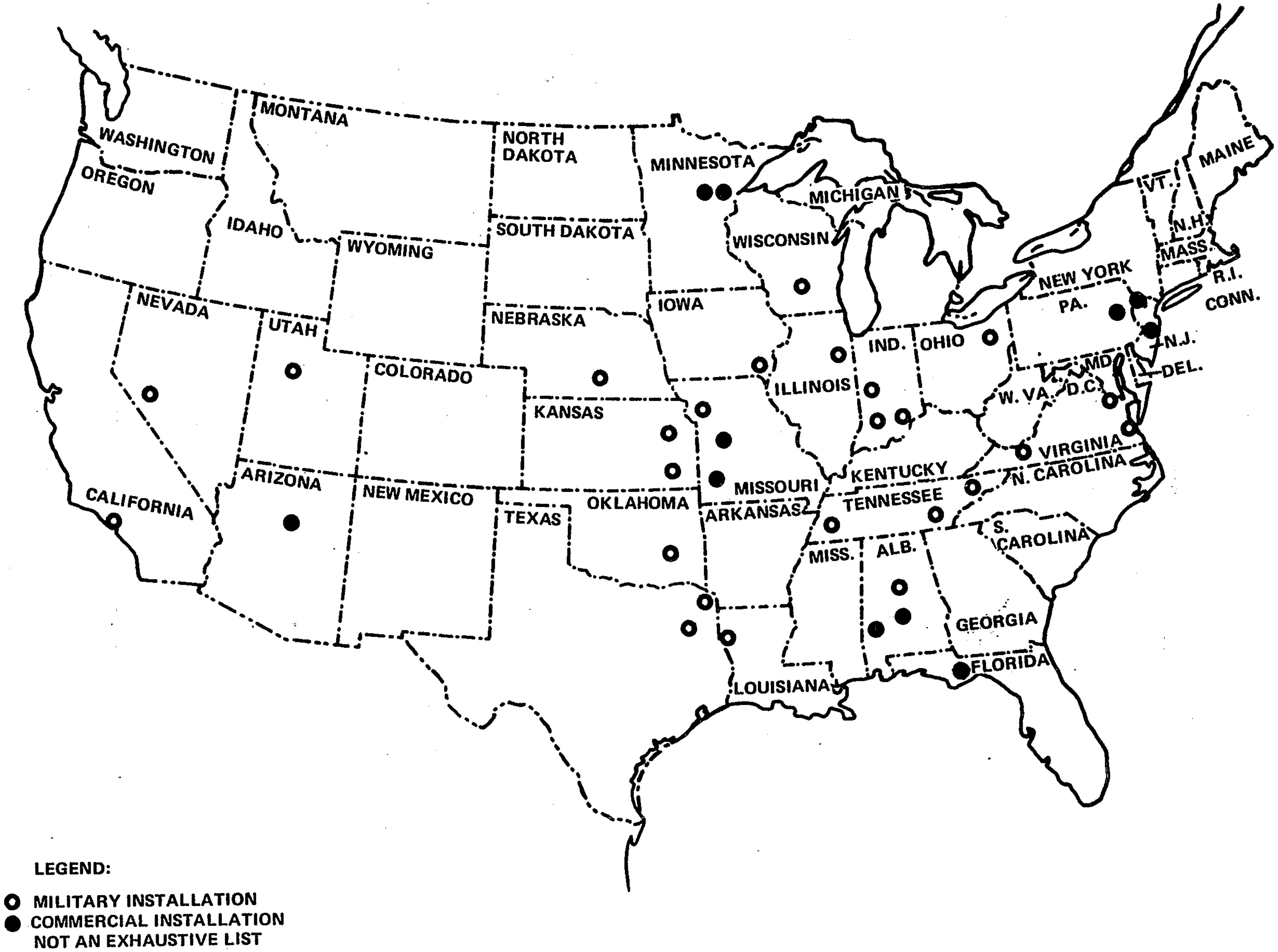
Many compounds used as military high explosives can be used as propellants since the difference between combustion and detonation of a crystalline propellant is merely a difference in reaction rate. Many of these compounds will burn quietly when ignited; they will detonate only under the influence of a mechanical shock much more severe than will be found in a gun or rocket chamber.

Plastic propellants are commonly known as smokeless powders. The first such propellants were made by converting nitrocellulose (NC) into grains with the addition, and later removal of solvents such as ether and alcohol. The next development of smokeless powders involved using nitroglycerin (NG) as a colloiding plasticizer for the nitrocellulose. Such propellants are known as double-base because they contain two explosive ingredients in contrast to single-base propellants which contain only nitrocellulose. Smokeless powders are generally comprised of three principal ingredients: a polymer, usually nitrocellulose; an energetic plasticizer, usually nitroglycerin; and a fuel plasticizer, often diethylphthalate. Other nitrate esters which have been used in place of nitroglycerin are diethylene glycol dinitrate (DEGN), triethylene glycol dinitrate (TEGN), metriol trinitrate, and butanetriol trinitrate. Other fuel plasticizers which have been acceptable include dimethyl and di-n-butyl esters of phthalic acid, triacetin, adipates, sebacates, dinitrotoluene (DNT), and substituted ureas such

MAP IV

EXPLOSIVES INDUSTRY

MAJOR EXPLOSIVES AND PROPELLANT FACILITIES IN THE U.S.



LEGEND:

○ MILITARY INSTALLATION
● COMMERCIAL INSTALLATION
NOT AN EXHAUSTIVE LIST

TABLE IV-8

NUMBER OF EXPLOSIVES MANUFACTURING PLANTS

		Commercial Explosives Plants			Military (GOCO) Plants**		
EPA Region	State	ATF*** Data	Additional Data from TRW*	Commercial Subtotal	Active	Subtotal	Combined Total
4	Alabama	11		11	0	1	12
10	Alaska	0		0	0	0	0
9	Arizona	22	1	23	0	0	23
6	Arkansas	7		7	1	1	8
9	California	43		43	1	2	45
8	Colorado	19		19	0	1	20
1	Connecticut	9		9	0	0	9
3	Delaware	0		0	0	0	0
3	District of Columbia	1		1	0	0	1
4	Florida	11		11	0	0	11
4	Georgia	11		11	0	0	11
9	Hawaii	1		1	0	0	1
10	Idaho	6		6	0	0	6
5	Illinois	23	1	24	1	1	25
5	Indiana	14		14	2	2	16
7	Iowa	17		17	1	2	19
7	Kansas	7		7	1	2	9
4	Kentucky	21		21	0	0	21
6	Louisiana	4		4	1	1	5
1	Maine	2		2	0	0	2
3	Maryland	5		5	1	1	6
1	Massachusetts	2		2	0	0	2
5	Michigan	12		12	0	0	12
5	Minnesota	11		11	0	1	12
4	Mississippi	1		1	0	0	1
7	Missouri	17		17	2	0	19
8	Montana	12		12	0	0	12
7	Nebraska	2		2	0	1	3
9	Nevada	9		9	0	0	9
1	New Hampshire	4		4	0	0	4
2	New Jersey	6	2	8	1	2	10
6	New Mexico	13		13	2	2	15
2	New York	16		16	0	0	16
4	North Carolina	8	1	9	0	0	9
8	North Dakota	0		0	0	0	0
5	Ohio	30	1	31	1	2	33
6	Oklahoma	8	1	9	0	0	9
10	Oregon	3		3	0	0	3
3	Pennsylvania	72		72	0	3	75
2	Puerto Rico	0		0	0	0	0
1	Rhode Island	0		0	0	0	0
4	South Carolina	2		2	0	0	2
8	South Dakota	0		0	0	0	0
4	Tennessee	12		12	3	3	15
6	Texas	35	1	36	3	3	39
8	Utah	9		9	0	0	9
1	Vermont	0	1	1	0	0	1
3	Virginia	7		7	1	1	8
10	Washington	12		12	0	0	12
3	West Virginia	22	1	23	0	0	23
5	Wisconsin	11		11	1	1	12
8	Wyoming	6		6	0	0	6
NATIONAL TOTALS		576	10	586	21	35	621

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* TRW (G. I. Gruber and H. Ghassemi) Contract No. 68-01-2919 Final Report - Assessment of Industrial Hazardous Waste Practices, Organic Chemicals, Pesticides and Explosives Industries

**Includes six AEC plants. One each in Iowa, Texas, California and Ohio, and two in New Mexico, the data on the total number of Army GOCO and GOGO plants (330), And do not include commercial plants in Utah and California manufacturing propellant for the U. S. Air Force.

***ATF is the abbreviation for the Bureau of Alcohol, Tobacco and Firearms, Department of the Treasury as centralites. Hence, propellant manufacturing wastewater varies significantly from bulk explosives manufacturing.

These factors make products a basis for subcategorization. In addition, a separate subcategory is assigned formulation and packing of (military and commercial) explosives and propellants under the LAP plant subcategory.

Plant Size

Plant sizes ranged from a few hundred to several thousand acres. Explosives plants are generally spread out (each area isolated from the other) so that if a serious accident occurs, a chain reaction will be minimized. Plant size had no bearing on waste characteristics.

Plant Age

Most plants visited were old plants, ranging from 20 to 50 years in age. Waste characteristics could not be correlated to age. Most plants do not separate uncontaminated cooling waters, and load, assemble and pack operations use large amounts of water for corrosion control. Plant age is not considered a basis for subcategorization.

Plant Location

Explosives plants generally are evenly distributed in the eastern portions of the United States, away from large population centers (See Figure IV). They are generally located in rural areas or areas that were rural when the plant began operations. A determination of the number of explosives manufacturing plants was made for both the commercial (private) sector and the military sector of this point source category by reviewing records maintained by the Bureau of Alcohol, Tobacco and Firearms, Department of the U.S. Treasury. See Tables IVa and IVb for a complete breakdown by state and EPA region, respectively.

Air Pollution Technology

Air pollution controls were almost non-existent at the plants visited, but most plants had plans for controlling emissions. Wet scrubbers will be used in three areas: demilitarization, sulfate liquor incineration, and sludge incineration. Because of the industry-wide lack of air pollution control equipment and the wide variety of waste to be controlled, air pollution technology is not considered a basis for subcategorization.

TABLE IV-b

NUMBER OF EXPLOSIVES MANUFACTURING PLANTS

By U. S. EPA Regions

	Commercial Explosives Plants			Military (GOCO) Plants		
EPA Region	ATF*** Data	Additional Data from TRW	Commercial Subtotal	Active	Subtotal	Combined Total
1	17	1	18	0	0	18
2	22	2	24	1	2	26
3	107	1	108	2	5	113
4	77	1	78	3	4	82
5	101	2	103	4	7	110
6	67	2	69	7	7	76
7	43		43	3	7	50
8	46		46	0	1	47
9	75	1	76	1	2	78
10	21	—	21	0	0	21
REGION TOTALS	576	10	586	21	35	621

* TRW (G. I. Gruber and M. Ghassemi) Contract No. 68-01-2919 Final Report - Assessment of Industrial Hazardous Waste Practices, Organic Chemicals, Pesticides and Explosives Industries

**Includes six AEC plants. One each in Iowa, Texas, California and Ohio, and two in New Mexico, the data on the total number of Army GOCO and GOGO plants and do not include commercial plants in Utah and California manufacturing propellant for the U. S. Air Force.

***ATF data refers to records from the Bureau of Alcohol, Tobacco and Firearms, Department of the Treasury

Solid Waste

A detailed study performed by TRW Systems and Energy assessed the hazardous solid waste problems associated with the explosives industry. With the information available from that study combined with the Roy F. Weston, Inc. study solid waste generation, other than the imperfect explosives, is not a major problem. At least one plant incinerates its waste in a starved oxygen incinerator. Disposal of the ash can be done by landfilling. The landfill area is generally available on plant site. Therefore, solid waste generation is not considered a basis for subcategorization.

Military vs. Commercial Explosives

Two major sectors of explosives manufacturing are the military and the commercial sectors. Military plants are involved in bulk manufacturing of explosives and propellants. Military plants involved in munitions loading are classified as (LAP) load, assemble and pack plants. Common military explosives are nitroguanidine, trinitrotoluene (TNT), RDX, HMX and Composition B. These are less sensitive explosives and are manufactured in bulk. In addition, the military manufactures sensitive explosives commonly called initiating compounds. Examples of such initiating compounds are mercury fulminate, tetryl, and lead styphnate (lead trinitroresorcinate). The manufacture of tetryl, although not currently manufactured in the United States, is included for completeness.

The commercial sector of explosives manufacturing can also be divided into plants manufacturing bulk explosives, propellants and initiating compounds. Others are designated load, assemble and pack plants. Examples of explosives manufactured commercially are nitroglycerin (NG), dynamites, and gelatin dynamites. Load, assemble and pack plants typically buy the raw materials and blend explosives on site in a recipe operation.

Since both sectors of explosives manufacturing are basically involved with the same production processes, the waste loads on a production basis are similar.. Hence, the military and commercial sectors of segment are considered as one in this study.

Nature of Wastes Generated

Wastewater characteristics in explosives manufacturing have extreme variability. Characteristics are presented for this segment by subcategory in Section V. For this reason, subcategorization of the industry was influenced by wastewater characterization and processes. For the earlier contractor draft document, the industry was divided into three initial subcategories and the first subcategory was further subdivided into two more subcategories:

A. Manufacturing plants
  Subcategory A1 - Manufacture of Explosives
  Subcategory A2 - Manufacture of Propellants
B. Load, assemble and pack plants
C. Manufacture of initiating compounds
  (specialty plants)

Subsequently, the four subcategories were reassigned according to the following designations for this document.

Subcategory A - Manufacture of explosives
Subcategory B - Manufacture of propellants
Subcategory C - Load, assemble and pack plants
Subcategory D - Manufacture of initiating compounds
(Specialty plants)

Description of Subcategories

Subcategories A and B - Manufacturing Plants

Manufacturing plants are those plants that formulate explosives from raw materials by a specific industrial process. Such plants are generally large, complex facilities. Products can be generally classified as explosives or propellants. On the basis of this product difference, the manufacturing plant category was further subdivided into two parts: manufacture of explosives (subcategory A) and manufacture of propellants (subcategory B).

Although there is no sharp boundary between the two areas, there are basic differences between them, including effluent characteristics. Explosives are compounds or mixtures of compounds which, when ignited, decompose rapidly, releasing large volumes of gases and heat. Propellants differ in their mode of decomposition in that they are designed to burn rather than detonate. Burning in a propellant does not proceed through the material as in an explosive but in layers parallel to the surface. plosives are nitroglycerin, dynamite, ammonium nitrate-based explosives, RDX, HMX, and TNT.

The wastewaters associated with the manufacture of explosives are of moderate loading, while wastewaters emanating from the manufacture of propellants contain loadings, in some cases, orders of magnitude higher. For example, the lb COD/ton production for the manufacture of propellant because of the different methods of manufacturing such as liquid transport of propellant from station to station and the use of contact cooling water, was 22.6 times larger than that for the manufacture of explosives. Constantly higher values for other water quality parameters for propellant manufacture necessitated the division of explosives manufacturing into these two subcategories. Within each subcategory, the deviation from the average value is not excessive. For example, the average COD raw waste load for propellant manufacture was 174.8 lb COD/ton production and ranged from 70.7 to 271; for explosives manufacture, it was 7.73 lb COD/ton and ranged from 1.1 to 20.6.

Subcategory C - Load, Assemble and Pack Plants

Load, assemble and pack (LAP) plants are those that may buy all the necessary ingredients from an outside supplier and then mix and pack them as a final product. Examples of this type of manufacturing in the private sector would be small arms plants involved in the filling of shells. Other plants manufacture load and pack ammonium nitrate and fuel oil (ANFO), nitrocarbonitrate (NCN), blasting caps, and water slurry plants. In the military sector, munitions are filled with blends of TNT and other ingredients. The process of filling is preceded by melting in a kettle. These kettles are cleaned after use along with other equipment.

Small rocket motors can be loaded with preshaped propellants that fit snugly into the casing. Pollutant loads from this operation generally come from the preshaping area. The wastes generated from this subcategory are small, coming from sloppy handling, accidental spills and washdowns of floors and equipment.

The load, assemble and pack operations in this definition exclude demilitarization, which is a non-scheduled and discontinuous activity. That is the process by which the military disposes of obsolete and defective munitions by scouring out the shells. Also excluded are off-site ANFO activities at mining or construction locations (point of use).

Subcategory D -Manufacture of Initiating Compounds

Initiating compounds plants are those manufacturing "sensitive" explosives. Examples of these explosives would

Table IV -1

Common Ingredients of Dynamites

Nitroglycerin

Ammonium Nitrate

Sodium Nitrate

Sodium Chloride

Sulfur

Nitrocellulose

Phenolic Resin Beads

Bagasse

Sawdust and Wood Flour

Coal

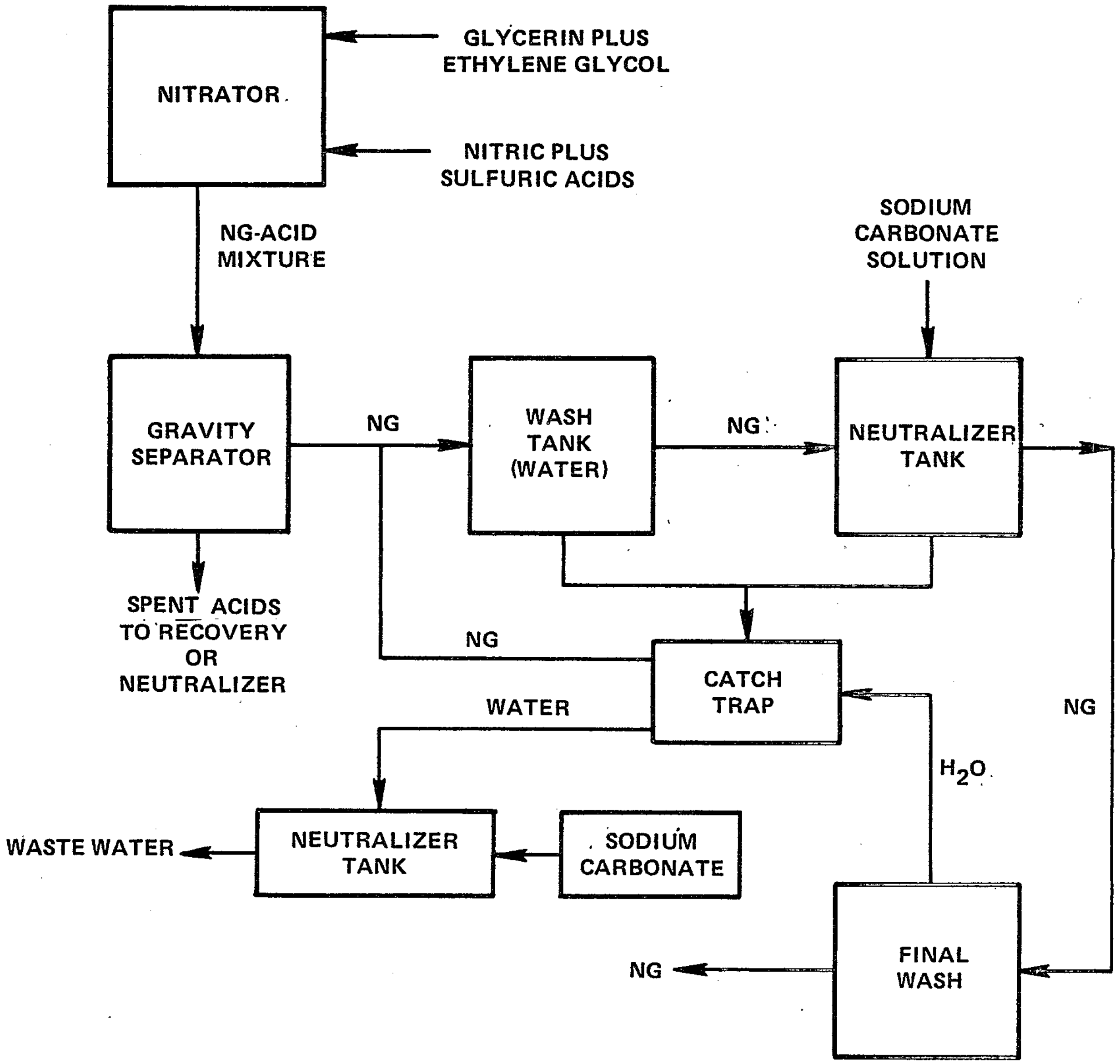
Corn Meal and Corn Starch

Trace Inorganic Salts

Grain and Seed Hulls and Flours

FIGURE IV -1 a

TYPICAL NITROGLYCERIN PRODUCTION SCHEMATIC



be pentaerythritol tetranitrate (PETN), lead azide, lead mononitroresorcinate (LMR), lead styphnate, tetryl, nitromannite (HNM) and isosorbide dinitrate. The waste volume generated is generally small but highly concentrated.

Process Descriptions

Subcategory A - Manufacture of Explosives

Nitroglycerin

Nitroglycerin is commonly manufactured by two different processes. The commercial sector generally employs the older "batch" process, while the military sector uses the Biazzi, or "continuous" process.

Batch Process

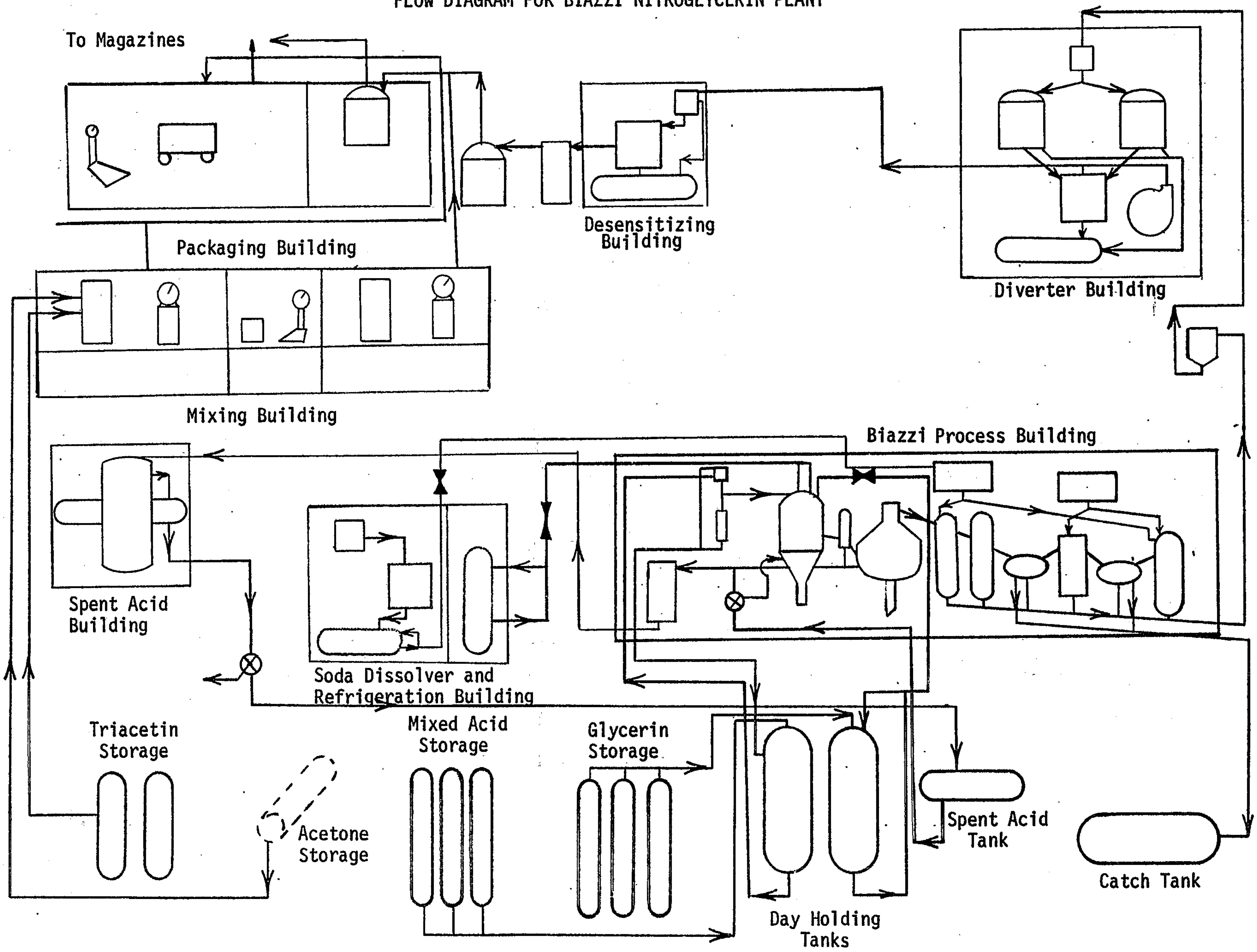
Nitroglycerin (NG) can be synthesized in a batch reactor by a controlled reaction between a concentrated sulfuric acid (dehydrating agent), a concentrated nitric acid solution (nitrate source), and a mixture of ethylene glycol and glycerin. Figure IV-1a shows a typical schematic diagram for the batch manufacture of nitroglycerin. The reactor contains cooling coils through which circulate a cooled brine solution. The reactor is initially charged with the nitrating acid mixture. The glycerin-glycol solution is then added, at a rate that maintains a constant temperature in the reactor. The reacted product (a mixture of NG, ethylene glycol dinitrate, water, and spent sulfuric and nitric acid) passes into a gravity separator tank where the spent acid is drawn from the bottom of the mixture and either discharged or sent on for recovery of nitric and sulfuric acid. The nitroglycerin is then dropped into a prewash tank and mixed with water. The resulting "sour water" is removed from the top and goes to a catch tank. The NG is drained from the catch tank and sent to neutralizer tanks. In the neutralizer tanks the NG is emulsified with a soda water solution. After a final wash with water the NG is taken to the dynamite formulation building. Ethyl acetate, a desensitizing carrier solvent, is sometimes mixed with the NG when it is to be stored for a period of time.

Continuous Process

The Biazzi process for continuous manufacture of nitroglycerin (Figure IV-1b) is one of the safest methods known for the production of this sensitive and unstable compound. It is safe because it is a continuous process and

FIGURE IV-1b

FLOW DIAGRAM FOR BIAZZI NITROGLYCERIN PLANT



very little of the raw nitroglycerin is present in any one place at any one time and because of various safety interlocks and remote-control features which have been incorporated in the design of the line. Despite the small quantities present at any time, a typical plant, when in continuous operation, can produce 2200 pounds per hour. To make nitroglycerin by the Biazzi process the mixed acid circulates through a constant head tank; the required amount of acid flows through a calibrated orifice into the nitrator. Plates with different-size orifices are used to change the flow rate of the acid. A proportioning pump, adjustable to the nearest ounce per minute, regulates the flow of glycerin to the nitrator.

The reaction mass consisting of spent acid and nitroglycerin then flows to the separator. Spent acid is drained off and the raw acid-contaminated NG is sent to the soda water washers. The spent acid is passed through a dilutor which adds water to increase the solubility of any NG which may be present and on to the spent acid storage tanks. Here the acid is retained for displacing NG on shutdown or shipped off station. The NG is passed through the three soda water washers which neutralize the residual acid and into another separator where the spent soda water is removed and sent to a catch tank to be discarded.

The neutralized NG is then passed through two fresh water washers to remove sodium salts formed in the neutralizing step and to a re-emulsifier.

The NG-water emulsion now leaves the nitrating building and flows down a trough to the diverter building. As it leaves the nitrating building the emulsion passes through an interrupter funnel to provide an air gap between NG flow lines so that an explosion in either building is not carried to the other.

In the diverter building the NG-water emulsion is channeled to one of two receiving tanks. The product is sampled remotely and subjected to the Able Heat Test to ensure that it is stable. This sample is also withdrawn completely by remote control while the operator is several hundred yards from the building. The raw NG is then transferred to the jet tank. A water pump boosts the water pressure to 120 lbs and jets the NG, now emulsified by the jet action, to the desensitizing building. The jet transfer technique keeps the NG emulsified with water until it reaches a separator tank. From the separator tank the raw NG is drawn off into portable carts known as angel buggies containing a desensitizer such as acetone, ether, or triacetin, 2-

Table IV -2

Ingredients of Water Gels and Slurries

Typical Ingredients	Optional Ingredients
Ammonium Nitrate	Fuel Oil
Sodium Nitrate	Aluminum Powder
Guar Gum	Smokeless Powder
Water	Nitroglycerin
Gelling Agents	Trinitrotoluene
Fumaric Acid	Proprietary Agents
Ethylene Glycol	Carbon Fuel
Ammonium Sulfamate	

Table IV -3

Ingredients of ANFO Explosives

Ammonium Nitrate	Fuel Oil
Ferrophosphate	Aluminum
Calcium Silicate	Coal
Atticote	Mineral Oils

nitrodiphenylamine as a stabilizer and in some cases, ballistic modifier. From there, the desensitized NG is transported to magazines for storage or other operating areas for use.

Sometimes a graphic control panel is used which realistically portrays each of the tanks and all pipelines and valves of the system. From this graphic control panel the operator can immediately see the position of all valves and know what operations are taking place.

Another safeguard is the use of "dead-man" switches at the four stations where NG is drawn off to prevent a continued flow of NG or solvent should a fire occur and the area have to be abandoned.

Ammonium Nitrate

Ammonium nitrate is used primarily in granular or "prill" form in explosives. Ammonium nitrate explosives have the important advantage of being very safe to handle. Special primers containing TNT are sometimes required to detonate these materials. Anhydrous ammonia and weak nitric acid react to yield ammonium nitrate. This solution is then crystallized. The crystals are ground or crushed and screened. Various additives, including wax to coat the prill and fuller's earth for moisture control are also blended, as shown in Figure IV-2a. Bulk producers of ammonium nitrate are covered by effluent limitations and guidelines issued for the fertilizer industry in the Federal Register, CFR 418.

Dynamite

There are many different formulations of dynamite, although the basic ingredients are nitroglycerin and ammonium nitrate. Ammonium nitrate is first mixed in batches with various minor ingredients. The most common of these are listed in Table IV-1. This mixture forms a "dope", to which the nitroglycerin is added. The proportions of nitroglycerin and ammonium nitrate, and the specific minor ingredients and their proportions, determine the particular properties of the dynamite. Many dynamites are formulated to customer specification. After formulation, the dynamite is transported to a cartridging house for punching out and for packaging into waxed cardboard or plastic tubes, and then shipped or stored in magazines.

Trinitrotoluene (TNT)

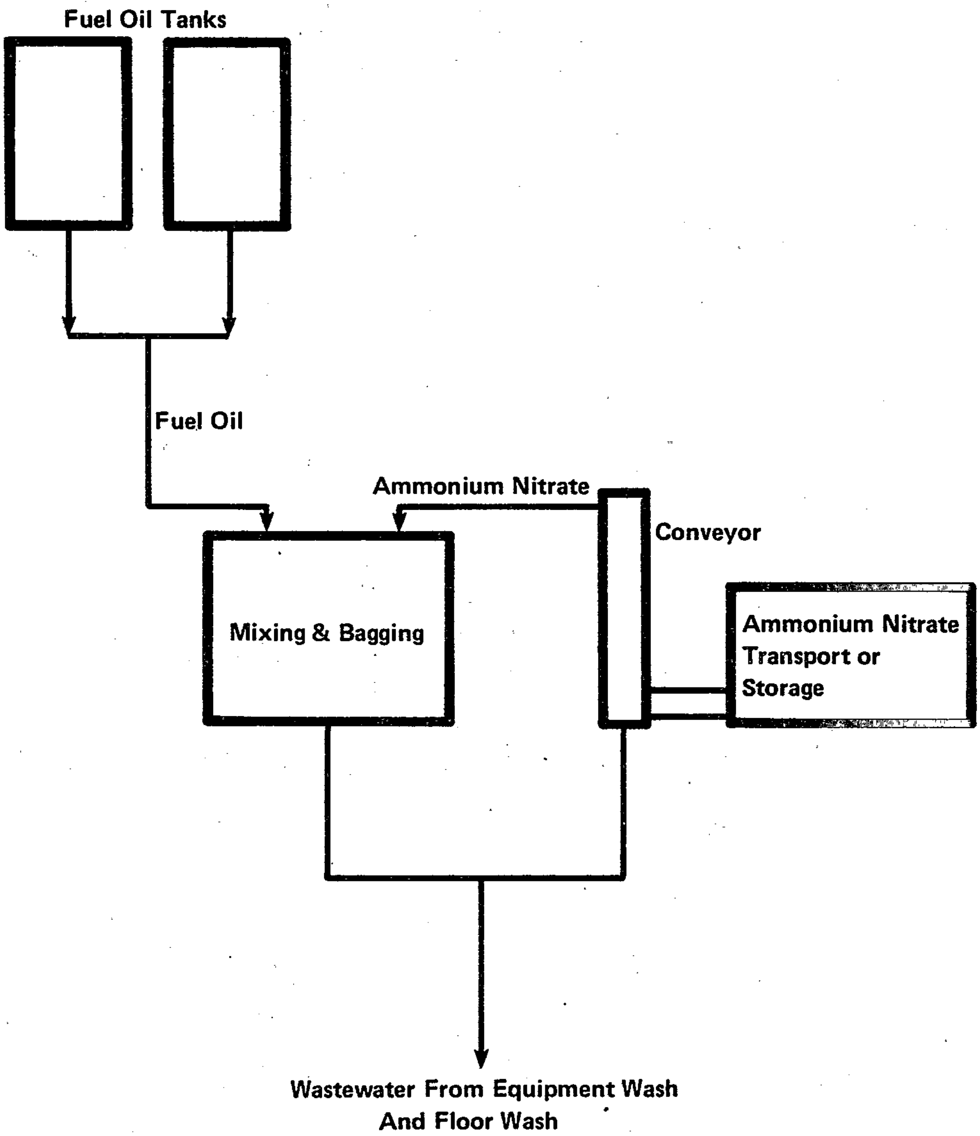
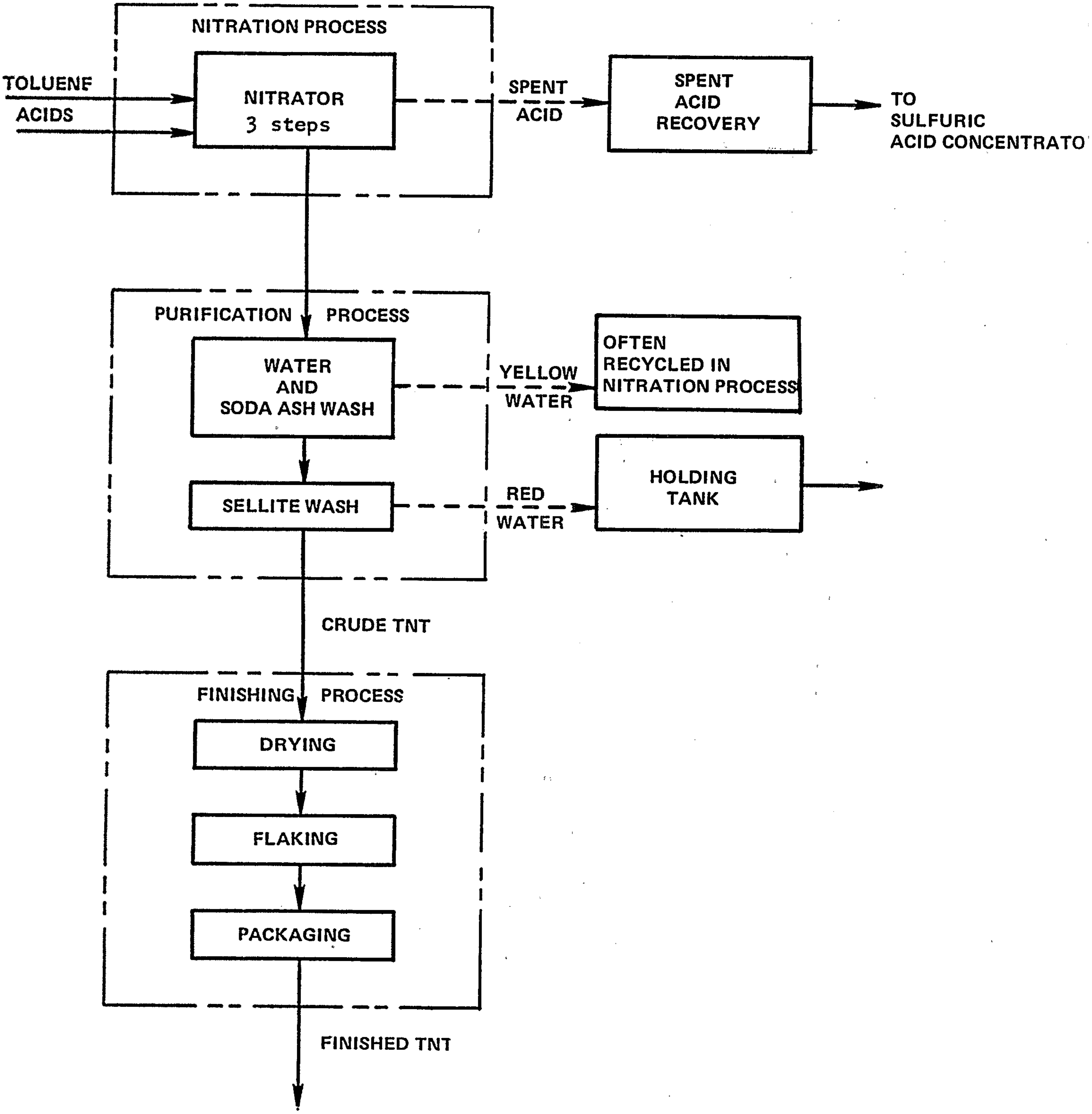


Figure IV-2a Typical Ammonium Nitrate - Fuel Oil Production Schematic

FIGURE IV -3a

Typical Batch TNT PRODUCTION SCHEMATIC



TNT is the most important military high explosive. It exceeds all other explosives in tonnage produced per year. In its finished form it is a light yellow crystal. Figure IV-3aa presents an overall schematic of the batch TNT manufacturing process, which can be divided into two integrated subprocesses, nitration and purification. The continuous process (CIL-Canadian Industries Limited) is being installed at Radford AAP and other AAP's as part of the plant modernization program for the AAP's.

In the nitration process for the batch process, acids (sulfuric and nitric) and toluene are combined in the nitrator to form raw TNT in three steps going from mono-, di- and finally to trinitrotoluene. The TNT is then sent to the purification process. In the purification process, the crude TNT is first subjected to water and soda ash washes which neutralize the excess acid and then to a sellite wash which preferentially removes the isomers of TNT and various oxidation products resulting from the nitration process. The impurities dissolve in the sellite washing operation and produce a wastewater stream commonly called "red water." The crude TNT is then sent to the finishing process.

In the production of TNT by the continuous process, the nitration of toluene is carried out in six nitrator-separator stages with the organic phase (toluene-nitrobody mixture) flowing countercurrent to the acid phase. Nitric acid fortification is provided at intermediate points in the process. The first and third nitration stages have two nitration vessels per separator whereas the remaining four stages have only one nitration vessel per separator. Extensive instrumentation provides for safe operation and automatic process control. If the process temperature in a nitrator vessel exceeds a pre-set level, the feed to the nitrator is automatically shut off and the contents of the nitrator and separator are automatically discharged into drowning tubs to quench the reaction. For TNT purification, the crude TNT first passes through a mixer-settler washer where five separate countercurrent water washes remove the free acids. The acid wash is returned to the second nitrator as acid make up. The TNT then flows through two sellite washers in series where it is neutralized with soda ash and treated with sodium sulfite. Each of the sellite washers is followed by a separator which separates the aqueous phase (red water) from the purified TNT phase. The dilute red water from the second separator is returned to the first separator, and the more concentrated red water from the first separator is sent to the red water treatment plant. The sellite-treated TNT receives final

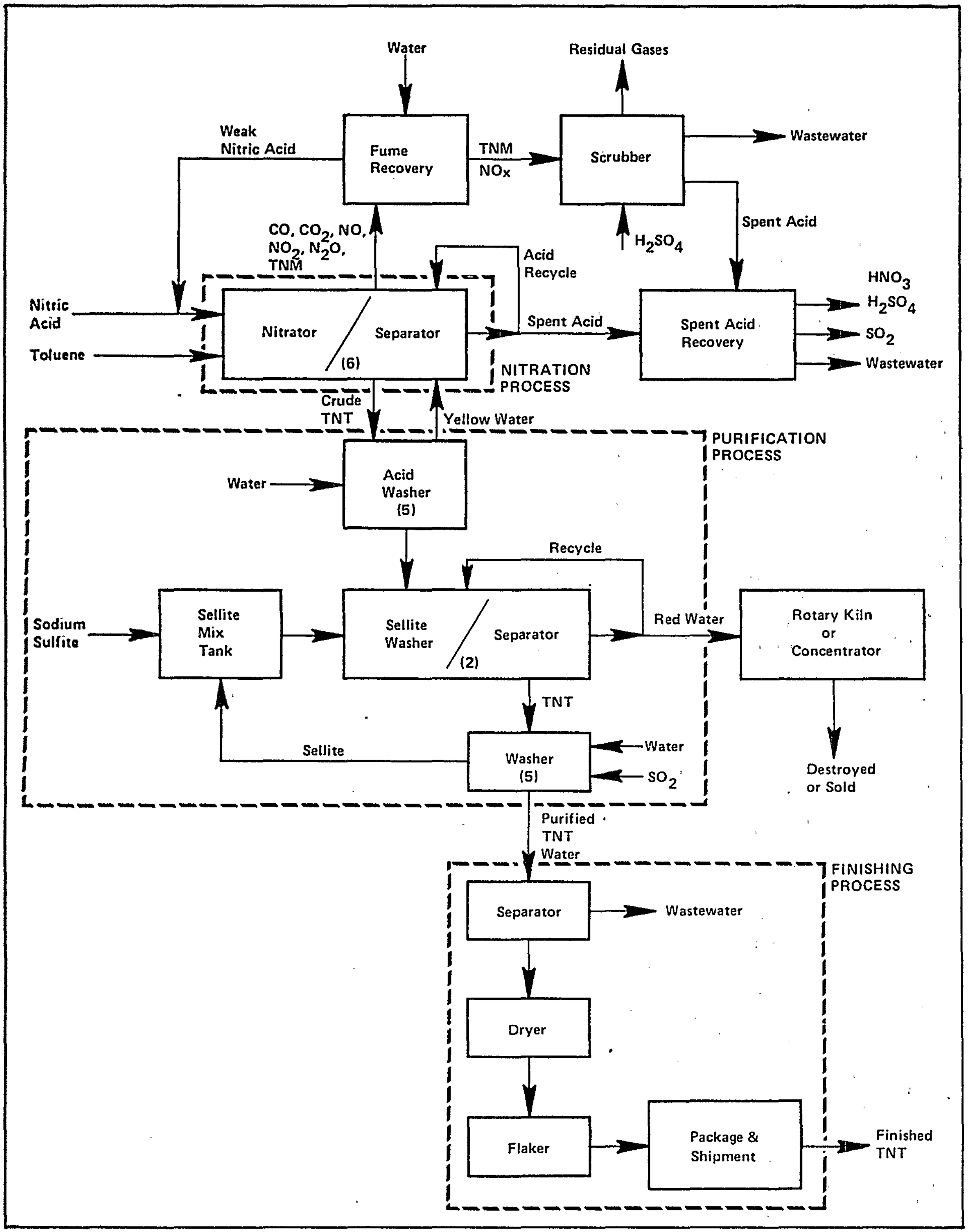


FIGURE IV-3b CONTINUOUS TNT PRODUCTION SCHEMATIC countercurrent water washes and is slurried and pumped to the finishing building for drying, flaking and packaging. The continuous process eliminates the "yellow water" problem.

Three important pollution problems associated with the manufacture of TNT are "red water", "yellow water" and "pink water" shown on Figure IV-3a. Only red water and pink water are problems with the CIL process. TNT in its purification is first washed with water. TNT is soluble in water up to 100 mg/l at ambient conditions. The exposure to sunlight or ultraviolet light causes the formation of highly colored, complex substances similar to dyes. They impart a pink or yellow color to the water. Pink water can also occur in the LAP area by washing down kettles and other machinery. The product stream after the water wash is a mixture of TNT and unwanted by-products (about 4.5 percent). The desired form of TNT is the pure TNT, 2, 4, 6- or alpha TNT. Removal of these materials is through extraction by a sodium sulfite wash (sellite). The waste effluent producted is brick red or almost black color and is commonly called "red water". Currently none of the "red water" in any of the military plants is being discharged. It is either being sold for its sulfate content to paper mills or evaporated and incinerated to destroy the organics.

Cyclotrimethylene Trinitramine (RDX) and Cyclotetramethylene Tetranitramine (HMX)

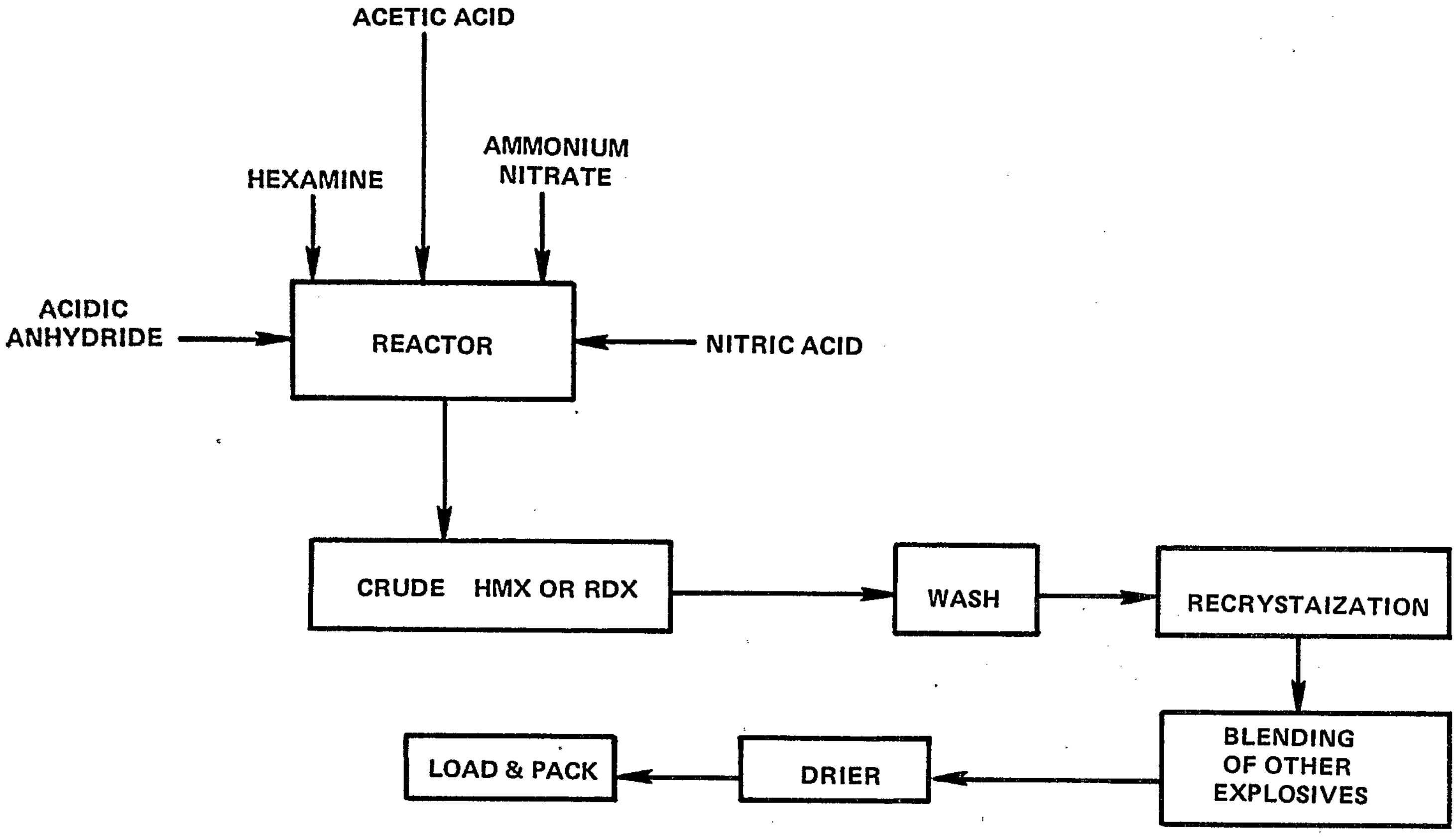
Two of the most powerful explosives, RDX and HMX, are manufactured exclusively by the military sector of the point source category. for manufacturing RDX and HMX are essentially identical, except for the relative amounts of raw materials which are reacted (Figure IV-4). Some HMX is present in commercial grade RDX and vice versa. Acetic acid, hexamine acetic acid, ammonium nitrate, nitric acid, and acetic anhydride are reacted to form crude RDX or HMX. The crude material is then washed, recrystallized to the proper crystal size, filtered, blended with other explosives, and dried. It is then packaged for shipment. Special ingredients like lacquers and waxes are sometimes blended and added.

Nitroguanidine

Nitroguanidine is a guanyl nitramine that is a colorless crystalline compound with the formula $NH_2CNHNHNO_2$ and with a molecular weight of 104.06. It is most frequently manufactured by reacting guanidine (NH_2CNHNH_2) with nitric

FIGURE IV -4

TYPICAL SCHEMATIC FOR RDX HMX PRODUCTION



acid. Pure nitroguanidine melts with decomposition at 232°C.

Nitroguanidine has found extensive use in triple-base propellants. Nitroguanidine is currently not manufactured in the United States but is expected to be produced in the near future. Canada presently supplies the United States with nitroguanidine.

Subcategory B - Manufacture of Propellants

The term "propellants" refers to a broad range of compounds. Propellants are classified as solvent or solventless, according to the use of solvent ingredients in the mixing operation. Solvent propellants are either single-base, double-base, triple-base, or high-energy. Nitrocellulose (NC) is the basic ingredient of single-base propellant which is used as a cannon powder or a casting powder-base. NC and NG are incorporated as the two-bases of double-base cannon or rocket propellants. Nitroguanidine is added to NC and NG to make the triple-base cannon propellant. High-energy is the term applied to certain double-base rocket propellants containing metal particles and special oxidizer ingredients. All solventless propellants are referred to as rolled powders.

Differences in each kind of solvent propellant can be found in the specific chemicals and explosive ingredients added during the mixing operation. Some ingredients act as sensitizers, others as uniform burning rate control agents, others as cross linking agents, and some depress the freezing point of the propellants. Depending on what properties the customer requires, formulation can be blended to meet the specifications. Most propellants use nitrocellulose as a base.

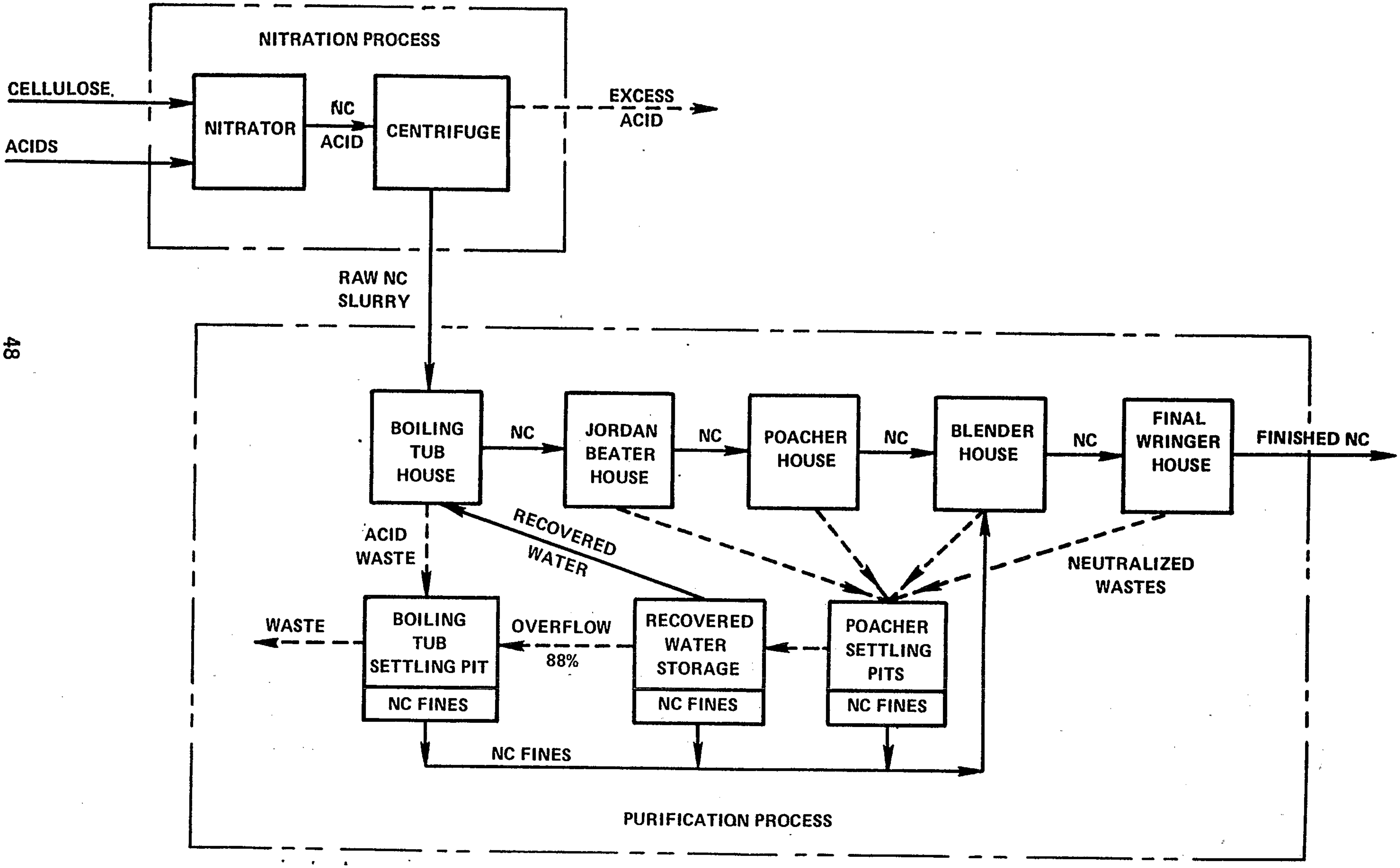
Nitrocellulose Powder

Nitrocellulose powder, first manufactured in 1867, is colloidal nitrocellulose containing about 1 percent diphenyl amine to improve its storage life and a small amount of plasticizer such as dibutyl phthalate. This powder (sometimes called smokeless powder), in its finished form, is the basic material for nearly all types of propellants.

Figure IV-5 presents an overall schematic of the finished NC manufacturing process. The process starts in the cellulose dry house where large bales of pre-purified cotton linters or rolls of dried wood pulp are shredded and dried in an oven to remove excess moisture. Then the processing begins.

FIGURE IV -5

NITROCELLULOSE POWDER PRODUCTION SCHEMATIC



This process is divided into two integrated subprocesses, nitration and purification. Supplemental operations include purification of the fibers by kier boiling, bleaching and drying of cellulose fibers prior to nitration.

In the nitration process, acids (sulfuric and nitric) and cellulose (in the form of loosened fibers) are combined in the nitrator to form raw nitrocellulose (NC). The NC is dewatered and sent to the purification process. Purification is accomplished by boiling, beating and poaching the nitrocotton fibers in acidic and basic aqueous solutions.

Solvent Propellants

Figure IV-6 shows a schematic diagram for the manufacture of solvent propellants. In the manufacture of single-base propellant, finished NC is sent to a mix house where it is mixed with solvents (alcohol and ether) and other chemical ingredients. The raw propellant is then sent to a blocker house where it is screened and pressed into blocks. From the blocker house it is taken to the press and cutting house where it is pressed into strands and then cut to specified lengths. From here it proceeds to solvent recovery and drying and finishing steps.

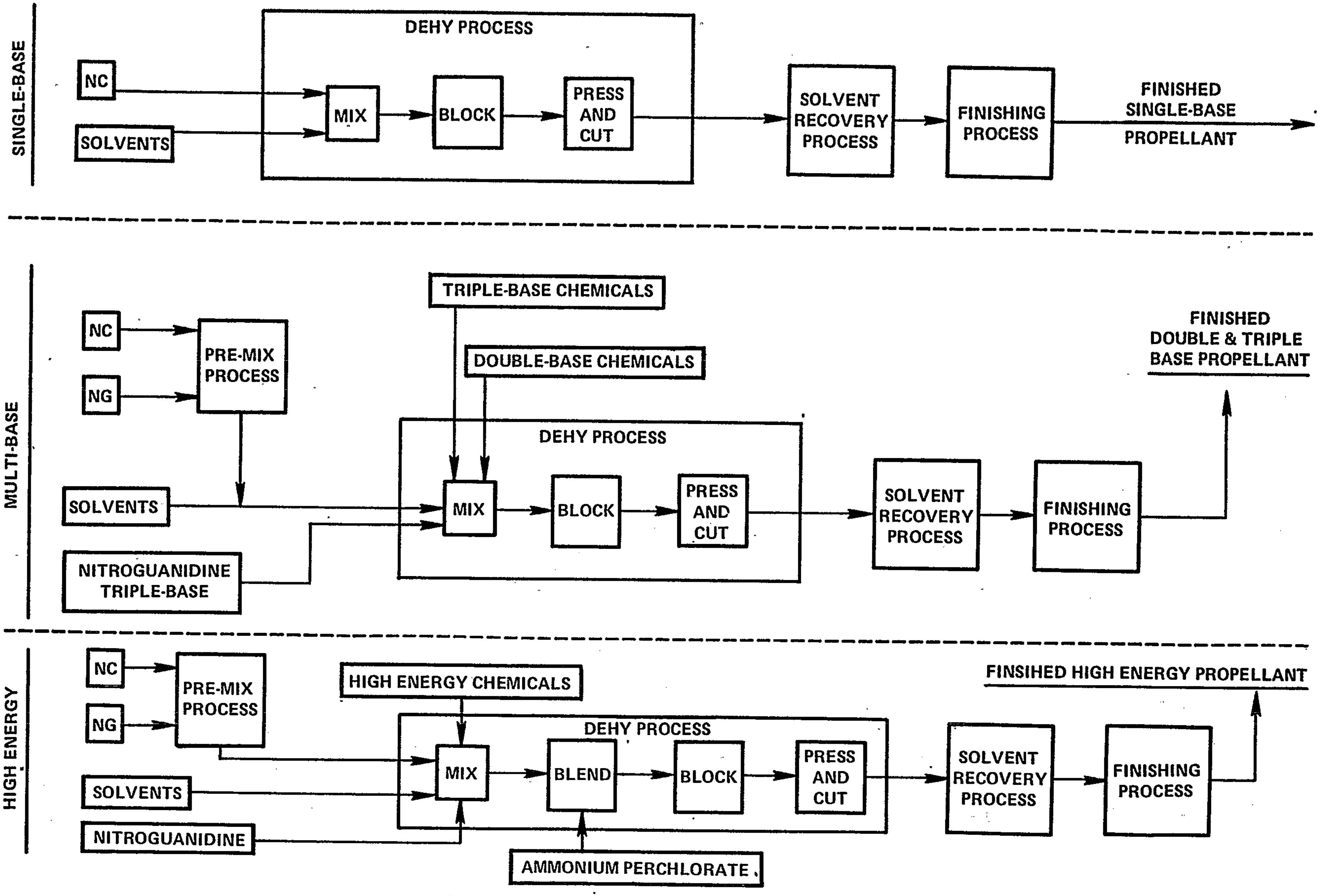
In the manufacture of double- and triple-base propellants, finished NG is combined with finished NC in a pre-mix process and then sent to the "DEHY" process for mixing with solvents and other chemicals. In the mix house, nitroguanidine is combined with the NG-NC mixture, solvents, and other chemicals to form triple-base propellants. High-energy propellants require a separate blending process for the addition of ammonium perchlorate. Solvents used in multi-base and high-energy propellants include acetone and alcohol.

Solventless Propellants

The manufacturing process of solventless propellants (rolled powder) is similar to the process for solvent propellants, but without the addition of solvents in the mix house. Propellants, after the addition of NG, are air-dried, temporarily stored, and then processed through a blender. From the blender, the powder is transported to a pre-roll process and then to a final roll process. The sheets produced from the rolling operations are cut and made into "carpet rolls" or otherwise shaped as desired. These products then undergo final processing preparation.

FIGURE IV -6

SOLVENT PROPELLANT PRODUCTION SCHEMATIC



Subcategory C - Load, Assemble and Pack Plants

Water Gels and Slurries

Water gels and slurries were introduced as industrial explosives in 1960 and have rapidly expanded in use since that time. Water gels and slurries can have an almost infinite number of formulations, but are basically mixtures of an oxidizer and a fuel and sensitizer in an aqueous media.

Water gel and slurry manufacture is a batch process involving mixing of ammonium nitrate, sodium nitrate and other ingredients listed in Table IV-2 to form a semi-solid product in a 7 to 20 percent water slurry. Certain water gel formulations include proprietary supplemental components as explosive boosters. Guar gum is added to provide binding. The product is then bagged or shipped in bulk by truck for on-site injection. A gelling catalyst such as chromate is injected when water gel is used in bulk on site. Bagged products do not incorporate the catalyst. The only wastewater sources from the manufacture of water gels are clean-up of spills, mixing equipment and bulk-transport trucks.

Ammonium Nitrate - Fuel Oil (ANFO) Mixtures

ANFO was introduced as an explosive in the mid-1950's and by 1972 constituted 79.7 percent of the total commercial explosive use. ANFO is a mixture of ammonium nitrate prills and/or grains and fuel oil, to which a variety of other minor ingredients (Table IV-3) may be added. Typical formulation would include less than 94 percent ammonium nitrate, 6 percent No. 2 fuel oil and less than 1 percent minor ingredients. ANFO is formulated by either a batch or continuous dry mixing operation, and the only wastewater source is the clean-up of spills and equipment. Occasionally the fuel oil (#2) is dyed before it is mixed with ammonium nitrate to identify specific formulations. The product is bagged in paper, plastic, or burlap, depending upon its intended use. A typical ANFO mixing plant is shown in Table IV-2a.

Nitrocarbonitrates (NCN)

NCN was first introduced as a blasting agent in 1935 and was primarily used for seismic exploration. These explosive products are similar in composition and manufacture to ANFO. In addition to or in place of fuel oil, the product may also contain mineral oil. Carbonaceous material, aluminum

FIGURE IV -7

TYPICAL PETN PRODUCTION AND ACETONE RECOVERY SCHEMATIC

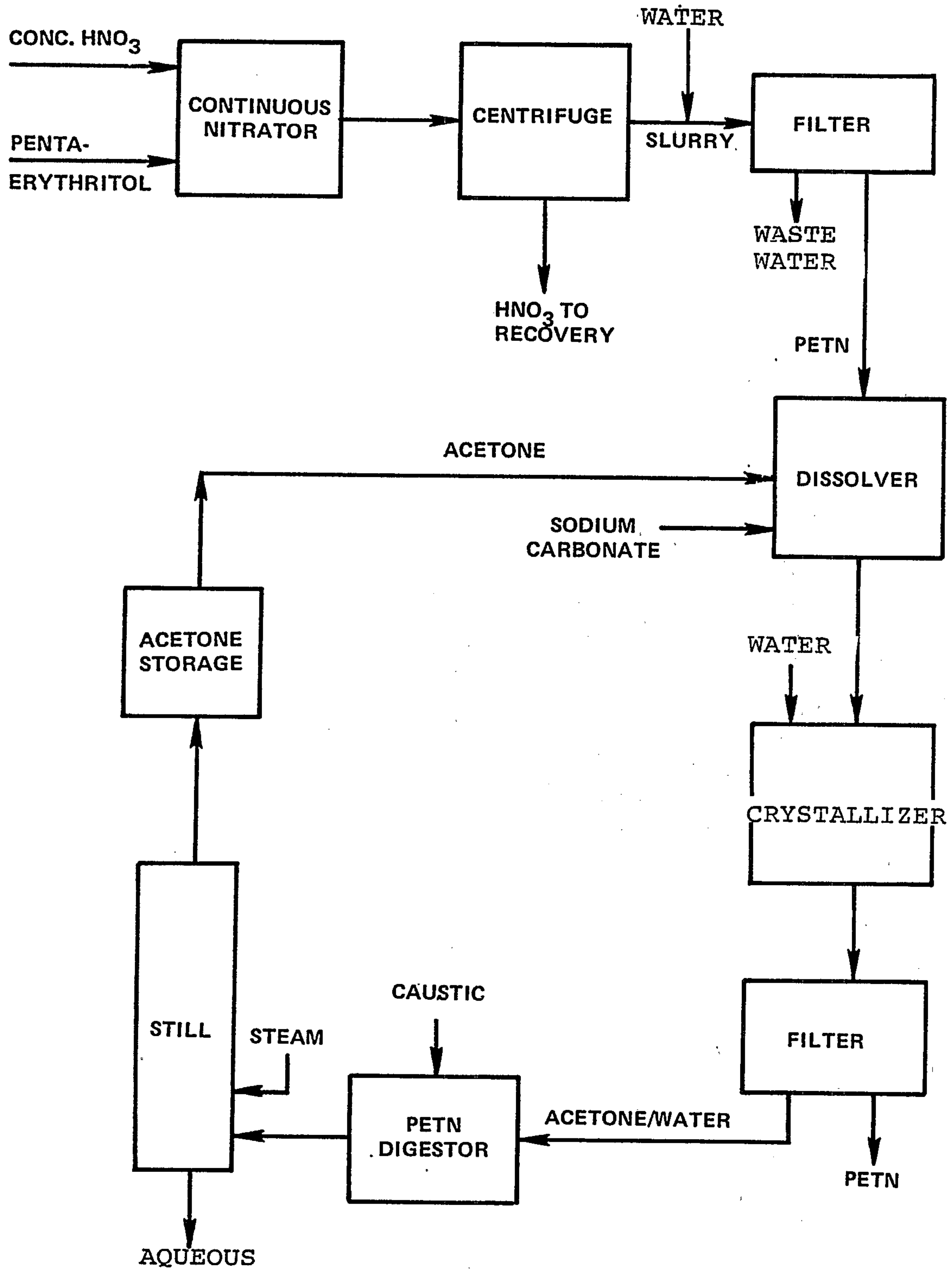
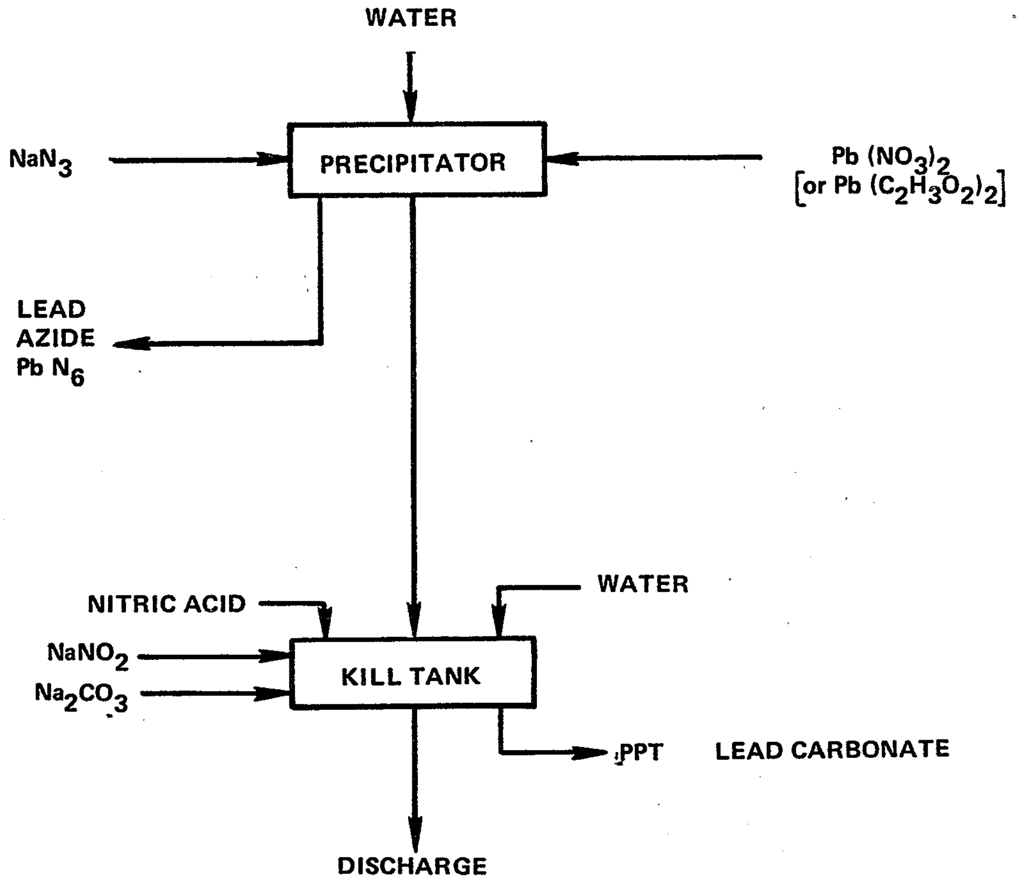


FIGURE IV -8

TYPICAL LEAD AZIDE PRODUCTION SCHEMATIC



powder, and dinitrotoluene (DNT) are also common ingredients. The formulation is a dry batch mix, with wastewater restricted to clean-up of spills and equipment.

Additional Load, Assemble and Pack Processes

Additional load, assemble and pack processes involve filling blasting caps or shells with highly sensitive explosives. In addition, primers use large amounts of water since they are wet when loaded.

Subcategory D - Manufacture of Initiating Compounds

Pentaerythritol Tetranitrate (PETN)

Figure IV-7 provides a schematic of PETN production. The pentaerythritol is nitrated with concentrated nitric acid, and PETN separated in a centrifuge, after which the spent acid is recovered. The PETN cake is mixed with water, and the slurry is filtered to removal residual acid. The crystalline PETN is then dissolved in acetone, with sodium carbonate added to further neutralize residual acidity. After graining with water, the slurry is again filtered, and the granular PETN taken to storage. The acetone-water filtrate is digested with sodium hydroxide at pH 10 to destroy residual PETN, and the acetone is recovered by distillation. Still bottoms are discharged as watery wastes.

Lead Azide

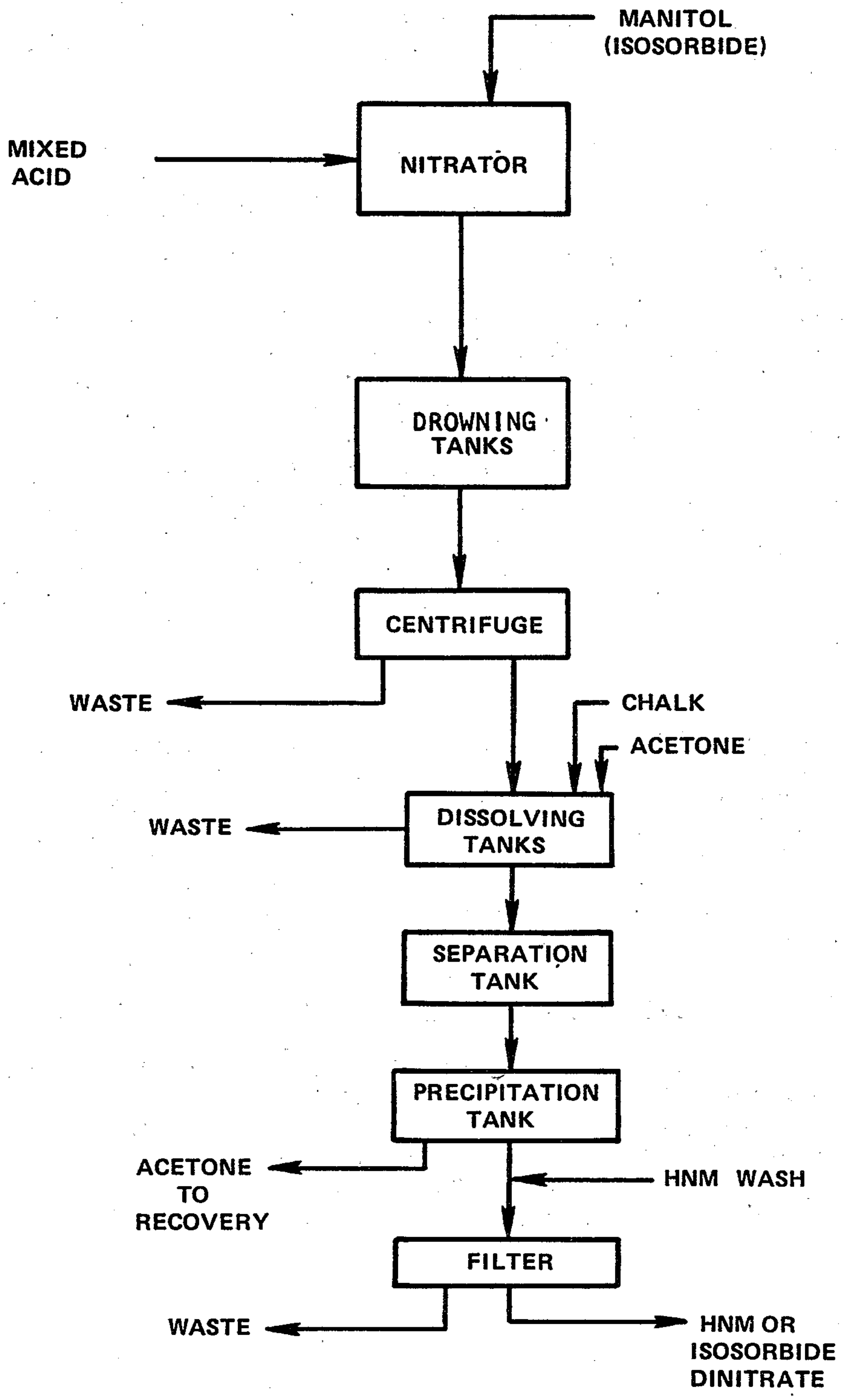
Figure IV-8 provides a schematic of lead azide production. Sodium azide is reacted with lead nitrate or lead acetate and is mixed with water and dextrinate to precipitate lead azide, which is then separated from the wastewater. Frequently, dissolved lead azide in the wastewater will lead to an additional step where nitric acid, sodium nitrite and soda water are added to precipitate any additional lead previously in solution.

Nitromannite (HNM) and Isosorbide Dinitrate

Figure IV-9 provides a schematic of HNM production. Mannitol, a powdered solid, is fed into an agitated mixture of sulfuric and nitric acids in a nitrator. After the nitration phase is completed, the liquid mixture, composed essentially of suspended nitromannite and spent acids, is drawn down into a drowning vessel which contains water.

FIGURE IV -9

TYPICAL NITROMANITE OR ISOSORBIDE DINITRATE PRODUCTION SCHEMATIC



From here the suspension is sent to a centrifuge. The solid material is retained on a cloth filter and is washed free of acid. The spent acid and wash waters pass through a catch tank and are neutralized.

The solid nitromannite from the centrifuge is dissolved in acetone. A small amount of chalk is added to neutralize the solution. It is allowed to separate into layers. The water layer is drawn off through the catch tank described above. The acetone layer is diluted with water in a continuous precipitator to form a slurry which is filtered and then washed. The acetone water mixture and the filtrate wash waters are collected for processing through a still for acetone recovery. Solid material collected at the catch tank is periodically collected and burned.

Isosorbide dinitrate is manufactured by essentially the same process, using different raw materials.

Lead Mononitroresorcinate (LMR)

Figure IV-10 provides a schematic diagram of LMR production. Mononitroresorcinate is reacted in a tub with sodium hydroxide and lead nitrate and allowed to separate. The LMR is drawn off from the bottom and washed first with water, then acetone and then amyl acetate. The first two rinses produce the waste water, while the third rinse (amyl acetate) dissolves some of the explosive and is therefore collected and burned.

Primer Explosives

Several less frequently used types of explosives form the raw materials for primer explosives and are used primarily in small arms ammunitions. Examples of these explosives are lead styphnite and tetracene. They are combined, along with other chemicals, to form the primer explosives.

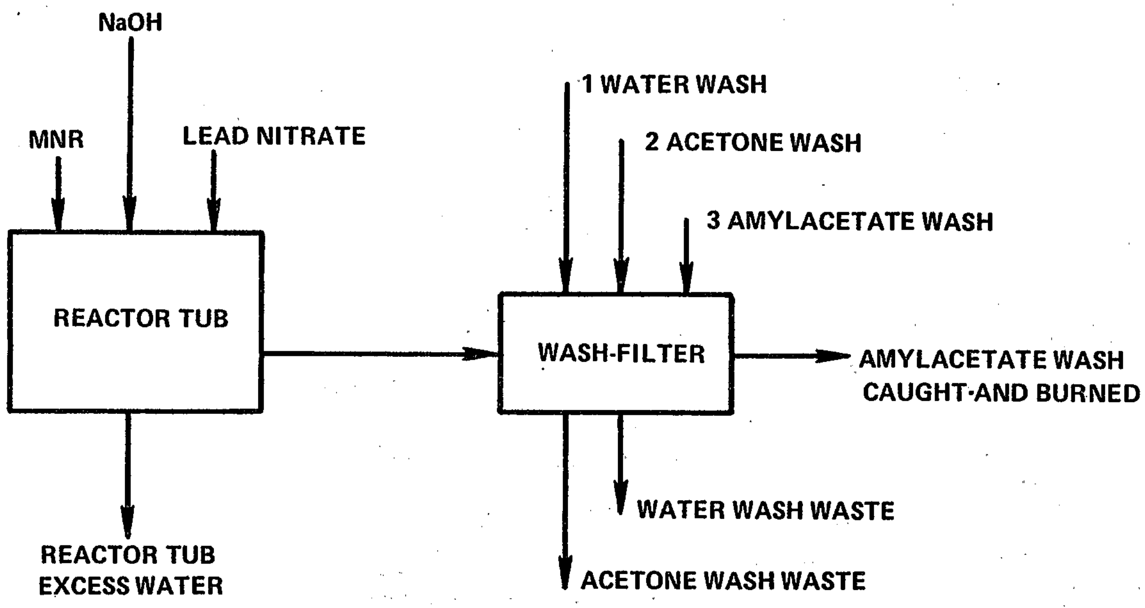
Tetryl

Tetryl (Trinitrophenylmethylnitramine) is chiefly used as a base charge in blasting caps, as the booster explosive in high explosive shells, and as an ingredient of binary explosives. Nitric acid, sulfuric acid, and DMA (dimethylaniline) are the raw materials in its manufacture. The major steps in production are nitration of DMA to tetryl, refining the product, drying, and packaging.

Basis of Assignment of Subcategories

FIGURE IV -10

TYPICAL LEAD MONONITRORESORCINATE PRODUCTION SCHEMATIC



The subcategories chosen are intended to encompass the entire range of explosives manufacturing. They include both military and commercial explosives and propellants. Although there are some differences, both in volume and product, between the military and commercial sectors, their waste loads are equivalent. For example, the load, assemble and pack subcategory in the commercial explosives averaged 0.973 lb COD/ton explosives handled, while the military explosives averaged 0.253 lb COD/ton explosives handled, with a range of 0.727 to 0.003.

Explosive plants sometimes manufacture additional products besides explosives. Fertilizer or raw materials for the manufacture of explosives (such as sulfuric and nitric acid) have been excluded from this subcategorization, since they are covered under other effluent limitations, guidelines and new source performance standards. Considerable effort was spent in segregating these sections to produce an unambiguous set of effluent limitations and guidelines for explosives manufacturing point source category without contradicting any other industrial point source category effluent limitations and guidelines.

It is anticipated that no single plant will fall under only one of the subcategories developed. Plants that fall into more than one subcategory will have to conform to effluent limitations, guidelines and new source performance standards for each subcategory. If a plant chooses to combine its wastes from two subcategory areas in a treatment center, then total plant allowable effluent limitations, guidelines and new source performance standards should be calculated according to the method presented in Section IX using the building block technique.

SECTION V

WASTE CHARACTERIZATION

The wastewater sources associated with each subcategory and ranges for values of selected water quality parameters are presented in the following discussion. The wide variability in the ranges are due in part to the wide variety of products produced, differences between war time and peace time operations, combined commercial and military sector data and combined historical (some which contained cooling water) and surveyed data. These numbers are presented in order to show the ranges of waste that are generated from these subcategories. The numbers of significance are the calculated raw waste load data found in Tables V-1 through V-4.

Subcategory A - Manufacture of Explosives

The following tabulation summarizes the effluent waste load ranges for subcategory A (see Table V-2a).

Parameter	Range (lbs/1,000 lbs product)
BOD5	0.18 - 6.35
COD	0.30 - 10.6
Nitrates	0.31 - 9.00
Sulfates	0.28 - 116.
TOC	0.24 - 4.13
TSS	0.054 - 10.7

The wastes from this subcategory are characteristically high in BOD5, COD, nitrates, sulfates, and TOC.

Highly variable pH is also characteristic of the wastewater from explosives manufacturing.

The manufacture of explosives generally involves the nitrification of organic compounds. Many of the explosives use nitric acid to serve as the nitrate source and sulfuric and acetic acids as dehydrating compounds. Nitrification is followed by product finishing, including washing, refinement, and drying. The major waste loads generally come from the finishing area, where the crude explosive becomes the final product.

The raw materials used in the manufacture of explosives explain some of the wastewater characteristics. The BOD5,

Table V - 1

Raw Waste Loads In Weight Per Unit Weight Of Production
Explosives Manufacturing

Subcategory	Products	Flow/Production		Raw Waste Loads	(kg/kkg Product)[1]					
		L/kkg	gal/1,000 pounds	BOD	COD	TKN	Nitrates	Sulfates	TOC	TSS
A. Manufacture of Explosives	Dynamites, NG, NH_4NO_3,TNT, RDX, HNX	1680	201	1.46	3.87	.82	2.50	6.90	1.63	0.82
B. Manufacture of Propellants	NC, Single, Double, Triple Base Propellants, High Energy Propellants Rolled Powders	267,000	32,000	63.4	118	5.98	38.4	191	43.6	64.5
C. Load, Assemble and Pack Plants	Primers, Fuses, Shells, Blasting Caps, NCN, Water gels, slurries, ANFO	1,760	211	0.0005	0.08	0.021	0.015	0.409	0.004	0.92
D. Manufacture of Initiators	Manufacture of Initiators such as Primer Explosives, Lead Azide, HNM, LMR, PETN, Lead Styphinate, Mercury Fulmenate	873,000	105,000	1170	6290	3.00	5.50	927	851	49.3

---

[1] Equivalent to lb/1000 lbs Product

[2] Prior to 90% reduction in flow

TABLE V-2a

Explosive Manufacturing Raw Waste Loads

Subcategory A

Subcategory A - Explosive Manufacture	Production	Flow		Raw Waste Load (kg/kkg Prod.)[1]						
Plant No.	kkg/day (1,000 lb/day)	kkg/day (mgd)	L/kkg product (gal/1,000 prod)	BOD5	COD	TSS	TOC	NO3-N	SO4	TKN
49	59.4 (131)	0.188 (0.05)	3,190 (382)	0.311	0.921	0.152	0.550	3.35	6.55	0.10
50	145 (320)	0.024 (0.0063)	165 (19.7)	0.181	0.563	0.054	0.24	1.11	0.3	0.60
43[9]	128 (283)	0.67 (0.163)	4,800 (576)	--	--	0.062	0.27	0.31	10.4	0.021
41[9]	45.8 (101)	5.68 (1.50)	124,000 (4,900)	--	--	10.7	4.13	--	116	0.770
44[9]	296 (652)	28.4 (7.50)	95,800 (11,500)	6.04	10.6	1.02	4.05	.35	--	0.343
01[1]	76.8 (169)	(2)	(2)	6.35	10.3	0.90	--	9.0	0.28	5.25
03[1]	339 (745)	(2)	(2)	0.22	3.73	0.550	--	4.83	1.05	--
04[1]	127 (280)	(2)	(2)	1.66	6.99	2.55	--	3.60	26.5	1.0
06[1]	90.9 (200)	(2)	(2)	0.360	1.19	0.53	--	3.34	0.410	2.88
07[1]	58.2 (128)	(2)	(2)	0.085	.300	0.780	--	.92	3.15	0.060
Raw Waste Load[2]	-- --	-- --	1,680 (201)[7]	1.46[3]	3.87[3]	0.82[3]	1.63[3]	2.50[3]	6.90[3]	0.82[3]

[1] Data from Patterson (1974).

[2] Due to coding ambiguities, this individual information was unavailable. However, the average of these numbers was available and use in computing the overall average.

[3] Excludes high and low values.

[4] Propellant operation

[5] Explosive operation

[6] Four-plant average

[7] Average from plants 49, 50 only (49, 50 the only ones visited in this category).

[8] RWL developed from more reliable single source - 47.

[9] Data obtained from Department of Defense

TABLE V-2b

Explosive Manufacturing Raw Waste Loads

Subcategory B

	Production	Flow		Raw Waste Load (kg/kkg Prod.)[1]						
	kkg/day (1,000 lb/day)	kkg/day (mgd)	L/kkg product (gal/1,000 prod)	BOD5	COD	TSS	TOC	NO3-N	SO4	TKN
Subcategory B - Propellant Manufacture										
Plant No										
47	13.1 (28.9)	1.37 (.363)	105,000 (12,600)	63.4	118	74.6	43.6	.236	53.5	13.8
43[9]	22.0 (48.6)	8.29 (2.19)	376,000 (45,000)	--	--	83.5	--	48.4	--	3.51
48[9]	30.3 (66.9)	6.74 (1.78)	222,000 (26,600)	--	35.4	25.7	--	66.5	--	--
42[9]	72.9 (161.0)	26.8 (7.07)	366,000 (43,900)	--	91.0	124.	28.8	--	328	.687
Raw Waste Load	-- --	-- --	267,000 (32,000)	63.4	118[8]	64.5	43.6[8]	38.4	191	5.98

[1] Data from Patterson (1974).
[2] Due to coding ambiguities, this individual information was unavailable. However, the average of these numbers was available and use in computing the overall average.
[3] Excludes high and low values.
[4] Propellant operation
[5] Explosive operation
[6] Four-plant average
[7] Average from plants 49, 50 only (49, 50 the only ones visited in this category).
[8] RWL developed from more reliable single source - 47.
[9] Data obtained from Department of Defense

COD and TOC loads can be attributed to the organic compounds involved. The high nitrate levels can be attributed to acid and organic compounds that contain nitrogen. The sulfate level can be attributed to sulfuric acid, and, in the case of TNT, the sellite wash used in the purification of TNT.

Initially the wastewaters from explosives manufacturing are highly acidic, and pH values of 1.0 are not uncommon. However, prior to discharge, neutralization is practiced and, hence, the pH can be as high as 9.0 at discharge.

Another wastewater problem is the discharge of trace quantities of explosives. Discharges of nitroglycerin as high as 1,000 mg/l have been recorded. TNT is of particular interest since it has been proven to inhibit natural biological processes. Discharges of wastewater containing 100 mg/l of TNT are typical. Concentration of RDX and HMX can be as high as 25 mg/l.

Subcategory B - Manufacture of Propellants

The waste loads associated with the manufacture of propellants are generally higher than those associated with the manufacture of explosives. The following tabulation summarizes the effluent waste load ranges for subcategory B (see Table V-2b).

Parameter	Range (lbs/1,000 lb product)
COD	35.41 - 118
Nitrates	0.237 - 66.5
Sulfates	53.5 - 328
TOC	28.8 - 43.6
TSS	25.7 - 124

Suspended solids are a troublesome problem, specifically in the manufacture of nitrocellulose, where NC fines can produce levels of TSS concentration from 1,000 to 10,000 mg/l. Wide variation in pH is also a problem. The BOD5 value obtained is 63.4 lb/1000 lb product.

High BOD5, COD and TOC levels can be attributed to the organic compounds and solvents (alcohol and ether) involved in the processes. High nitrate levels can be attributed to the use of nitric acids and organic compounds with nitrogen as one of the elements. Similarly, sulfate levels can be attributed to the use of sulfuric acid.

TABLE V-2c
Explosive Manufacturing Raw Waste Loads

Subcategory C

Subcategory C - Load Assemble & Pack Plants Plant No.	Production kkg/day (1,000 lb/day)	Flow kkg/day (mgd)	Flow L/kkg product (gal/1,000 prod)	Raw Waste Load (kg/kkg Prod.)[1] BOD5	COD	TSS	TOC	NO3-N	SO4	TKN
50	44.2 (97.5)	.0004 (.0001)	8.58 (1.03)	.000	.0011	.000	.000	--	--	0.00
01[1]	27.2 (60)	(2)	(2)	.000	.0015	--	--	.025	--	--
02[1]	59 (130)	(2)	(2)	.0015	.0180	.0470	--	.0010	--	.078
03[1]	5.5 (12)	(2)	(2)	--	1.44	5.12	--	.034	--	.079
43[9]	22.1 (48.6)	.037 (.0097)	1,660 (199)	--	.015	.0176	.0065	.00045	--	.0038
48	30.3 (66.9)	.882 (.233)	29,000 (3,480)	--	.364	.37	--	.053	1.22	--
41[9]	45.8 (101)	.023 (.0052)	509 (61.1)	--	--	.0003	.003	--	--	.0010
B[9]	.63 (1.4)	.0057 (.0015)	8,920 (1,070)	--	--	6.25	4.30	--	.0045	--
43[5,9]	128 (283)	.027 (.0071)	209 25.1)	--	.0015	.001	.0025	.0003	.0015	.0001
Raw Waste Load[2]	-- --	-- --	1,760[3,10] (211)[3,10]	.0005	.08[3]	.92[3]	.004[3]	0.015[3]	0.409	.021[3]

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[1] Data from Patterson (1974).

[2] Due to coding ambiguities, this individual information was unavailable. However, the average of these members was available and use in computing the overall average.

[3] Excludes high and low values.

[4] Propellant operation.

[5] Explosive operation

[6] Four-plant average

[7] Average from plants 49, 50 only (49, 50 the only ones visited in this category).

[8] RWL developed from more reliable single source - 47.

[9] Data obtained from Department of Defense.

[10] Average of flows from plants 01, 02, 03, 43, 41 and 43.

Throughout the survey, one fact continued to repeat itself. There was no significant treatment in place except one commercial location. Generally a plant site had only neutralization and in some cases sedimentation.

Subcategory C - Load, Assemble and Pack Plants

Waste loads from subcategory C are the mildest, but most variable, in explosives manufacturing. The following tabulation summarizes the range of effluent waste loads for this subcategory (see Table V-2c).

Parameter	Range (lb/1,000 lbs product)
BCD5	0 - .0015
COD	0.0011 - 1.44
Nitrates	.0003 - .053
Sulfates	0.0015 - 1.22
TOC	0 - 4.3
TSS	0.0003 - 6.25

Subcategory D - Manufacture of Initiating Compounds (Specialty Plants)

The waste loads associated with the manufacture of initiating compounds and other specialty explosives are the highest of any subcategory of explosives manufacturing due to high concentrated waste streams and small volumes of production. The following tabulation summarizes the effluent waste load ranges for subcategory D (see Table V-2d).

Parameter	Range (lbs/1,000 lbs Production)
BOD5	3.46 - 2,210
COD	9.52 - 17,100
Nitrates	0.003 - 5,750
Sulfates	0.06 - 7,180
TOC	101 - 1,520
TSS	0.464 - 174

High TKN waste loads were also observed.

The cause of high waste loads in this subcategory is related to the total quantity of specialty products manufactured. In general, specialty products are sensitive high explosives, used to detonate the more massive but less

Table V-2d

Explosive Manufacturing Raw Waste Loads

Subcategory D

Subcategory D - Manufacture of Initiators

	Production	Flow		Raw Waste Load (kg/kkg Prod.)[1]						
Plant No.	kkg/day (1,000 lb/day)	kkL/day (mgd)	L/kkg product (gal/1,000 prod)	BOD$_5$	COD	TSS	TOC	NO$_3$-N	SO$_4$	TKN
A	.119 (.263)	.0026 (.0007)	22,200 (2,600)	--	--	--	--	5.67	8.36	.590
45	.143 (.315)	.0042 (.0011)	29,100 (3,490)	3.46	9.52	136	39.7	0.003	1.22	1.09
50	.041 (.090)	.019 (.005)	464,000 (55,600)	1,020	17,100	0.464	1,520	.241	7,180	1.48
50	.0011 (.0025)	.0019 (.0005)	1,670,000 200,000)	1,430	2,090	10.0	934	5,750	--	8.85
50 & DIAZO	.023 (.051)	.011 (.003)	1,330,000 (159,000)	2,210	5,960	1.96	1,520	--	--	461
B[9]	.636 (1.400)	.0174 (.0046)	27,400 (3,290)	--	--	174	101	--	0.06	--
A[9]	.150 (.330)	.0026 (.0007)	17,000 (2,120)	--	--	--	--	10.59	2,770	0.53
Raw Waste Load			873,000[6] (105,000)[6]	1,170	6,290	49.3[3]	851[3]	5.50[3]	927[3]	3.00[3]

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[1] Data from Patterson (1974).

[2] Due to coding ambiguities, this individual information was unavailable, however, the average of these numbers was available and used in computing the over-all average.

[3] Excludes high and low values

[4] Propellant operation

[5] Explosive operation

[6] Average of four streams (from plants 45 and 50)

[7] Average from plants 49, 50 only (49, 50 the only ones visited in this category).

[8] RWL developed from more reliable single source - 47.

[9] Data obtained from Department of Defense

sensitive explosives. Therefore, the quantity produced is small when compared with the more widely-used explosives of Subcategory A. Because of the small quantity, batch processes are used, recovery of spent materials is not attempted, and a total lack of treatment prevails. For example, it was observed in the field that a discharge with a pH of 12.0 occured regularly. No treatment facilities were observed at this time and from the best sources available no known treatment presently exists in the point source category.

Table V-1 depicts the raw waste loads (RWL) for explosives manufacturing. Tables V-2a through d and V-3a through d present raw waste load data by plant. As these tables indicate, there are seven parameters whose raw waste loads are significant: BOD5, COD, TOC, TSS, NO3-N, TKN, and SO4.

The mean of this data is very sensitive to the presence or absence of the extremes in the distribution. This is even more pronounced when dealing with a small sample. In a severely skewed distribution, the very high or very low scores can exert a considerable impact on the mean, to the extent that it is no longer a good measure of central tendency. Hence, the statistical technique of discarding the largest and smallest value, where there was no clear or reasonable explanation, was used in determining the raw waste load for each subcategory if there were five or more pieces of data to work with. If there were fewer than five pieces of data, a simple mean was determined, and none of the data were discarded.

OTHER PARAMETERS OF CONSIDERATION

Oil and grease levels as high as 341 mg/l were found in some waste streams of plants manufacturing products in subcategory C, LAP. Because oil and grease can be hazardous to the receiving waters, effluent limitations are being established for this parameter.

A significant waste characteristic not represented in Table V-1 is metals. Information available on heavy metals was not adequate to promulgate effluent limitations; however, they appear significant only in subcategory D. Lead from the production of lead azide and lead styphnate can be found in significant quantities. Quantities of approximately two pounds of lead a day (200 mg/l) were observed being discharged daily at one installation.

Table V-3a

Subcategory A

Explosives Manufacture Raw Waste Loads for Additional Parameters

Plant No.	Raw Waste Load (lbs/ton Product)					
	TDS	Alkalinity	NH_3-N	T-P	Oil	Na
48	19.5	25.4	.133			
50	31.8	6.36	.147			
43	39.4	1.85				
46	616	49.2				
44	41.3	13.4				
01[1]	13.0	--	10.4	--	--	--
02[1]	--	--	--	--	--	--
03[1]	98.5		5.27	--	0.00	--
04[1]	96.8		2.06	--	1.09	--
06[1]	47.0	--	5.28	--	.09	--
07[1]	43.9	--	1.54			
Raw Waste Load	116	19.2	3.55	--	.72	4.71

[1] Data from Patterson's Study

Table V-3b

Subcategory B

Propellant Manufacture Raw Waste Loads for Additional Parameters

	Raw Waste Load (lbs/ton Product)					
Plant No.	TDS	Alkalinity	NH_3-N	T-P	Oil	Na
47	502	63.9	2.75	1.10	2.75	154
43	10,200	--	2.09	.169	--	--
48	--	--	--	--	--	--
42	2,890	--	--	.92	--	--
Raw Waste Load	4,520	63.9	2.42	.730	2.75	154

Table V-3c

Subcategory C

Load, Assemble & Pack Plants Manufacture Raw Waste Loads for Additional Parameters

	Raw Waste Load (lbs/ton Product)					
Plant No.	TDS	Alkalinity	NH_3-N	T-P	Oil	Na
01[1]	--	--	.007	--	--	--
02[1]	.125		--	--	--	--
03[1]	11.9		.129	--	--	--
43 (Propellant)	.263		--	--	--	--
48	14.2	5.38	--	--	--	--
46	.54	.168	--	--	--	--
141	143	83.4	--	--	--	3.19
43 (TNT)	.035	.014	--	--	--	--
50	.000	--	--	--	.01	--
Raw Waste Load	4.5[2]	22.2	.068	--	0.01	3.19

[1] Data from Patterson's Study

[2] Excludes high and low values

Table V-3d

Subcategory D

Initiating Compounds Manufacturing Raw Loads for Addition Parameters

	Raw Waste Load (lbs/ton Product)					
Plant No.	TDS	Alkalinity	NH_3-N	T-P	Oil	Na
142	--	118	--	.057	--	--
45	17,800	18,800	16	31.7	635	17,300
50		--	1.02			
NHN & 150	19,000	440	14	.093	748	8,020
LHR	78,400	12,300	26.2	.334	2,910	15,700
PETN & DIAZO	24,600	668	--	--	5,080	
141	1,390	390	--	--	--	494
142	--			.30	--	--

Another significant waste characteristic not represented in Table V-1 is trace quantities of explosives. The following concentrations of explosives have been reported:

Explosives	Effluent Concentration
NG	1,800 mg/l
TNT	70-350 mg/l
RDX	7.9 mg/l
HMX	2.6 mg/l

In addition to these manufactured explosives in the effluent, there are significant concentrations of unwanted isomers such as DNT (dinitrotoluene) in the wastewater. The possibility of these small concentrations accumulating in the environment and the toxicity of these wastes necessitates adequate treatment prior to discharge.

Ranges of Concentration

A key waste characterization is the range of concentration for significant pollutant parameters. Average concentrations are presented in Table V-4. These concentrations can be very misleading, since non-contact cooling waters cannot be distinguished from process waters in every case.

The following ranges of pollutants based on the survey and a review of the historical data are for subcategory A:

BOD5 - 20.0 to 1,100 mg/l
COD - 60 to 3,500 mg/l
TSS - 8.0 to 1,300 mg/l
TOC - 12.0 to 1,500 mg/l
NO3-N - 20.0 to 6,800 mg/l
TKN - 5.0 to 3,700 mg/l
SO4 - 50 to 2,100 mg/l

The following pollutant concentration ranges generally characterize subcategory B:

COD - 200 to 1,200 mg/l
TSS - 100 to 1,000 mg/l
TOC - 30 to 130 mg/l
NO3-N - 1.0 to 4,000 mg/l
TKN - 1.8 to 60 mg/l
SO4 - 300 to 900 mg/l

The pollutant concentration ranges for subcategory C generally fall into the following ranges:

BOD5 - 0 to 12 mg/l
COD - 8.0 to 220 mg/l
TSS - 1 to 770 mg/l
TOC - 2.0 to 480 mg/l
NO3-N - 0.4 to 12 mg/l
TKN - 2.0 to 6.0 mg/l
SO4 - 50 to 85 mg/l

Table V-4

Concentration of Pollutants

Explosives Industry

Category	BOD_5	COD	TKN	Nitrates	SO_4	TOC	TSS
	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L
A	871	2,310	489	1,490	4,120	972	489
B	237[1]	442[1]	22[2]	144[2]	715[1]	163[2]	242[1]
C	<1	45	12	9	232	2	523
D	1,340	7,210	3	6.0	1,060	975	56

[1] Historical Data, Plant No. 47
[2] Survey Data, Plant No. 47

The above ranges for BOD5, COD and TOC represent different data populations because the complete data for all parameters were not available from each plant.

The pollutant data points generally fall into the following concentration ranges for subcategory D:

BOD5 - 100 to 12,000 mg/l
COD - 300 to 50,000 mg/l
TSS - 1.0 to 60,000 mg/l
TOC - 50 to 15,000 mg/l
NO3-N - 0.5 to 5,000 mg/l
TKN - 4.0 to 1,000 mg/l
SO4 - 5 to 120,000 mg/l

It is evident that the concentrations for subcategory B appear similar to A; however, the amounts of raw pollutant per 1,000 pounds of product differ greatly. Tables V-1 and V-2a through V-2d provide more detailed data to substantiate this observation.

Plants falling in subcategory C appear to be widely scattered with regard to pollutant concentration. It should be noted that the average flow in this category was about 6,800 gpd, even though the concentrations are very small.

Wasteloads from plants in subcategory D appear to be variable in concentration. This is borne out by the nature of this category. For example, if a sample were extracted when the batch process is being dumped, it would have a high concentration. Also, a plant that discharges a specific process effluent once every three weeks was sampled. The result was extremely high concentrations of pollutants on some days, followed by long periods of low concentration.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

General

From review of NPDES permit applications for direct discharge of wastewaters from various explosives manufacturers and examination of related published data, twelve parameters (listed in Table VI-1) were selected and examined for all industrial wastewaters during the field data collection program. In addition, several specific parameters were examined for each of the subcategories. All field sampling data are summarized in Supplement B. Supplement B includes laboratory analytical results, data from plants visited, RWL calculations, historical data, analysis of historical data, computer print-outs (showing flows, production, and pollutants, performance data on treatment technologies and effluent limitations calculations). Supplement A has design calculations, capital cost calculations, and annual cost calculations. Supplements A and B are available at the EPA Public Information Reference Unit, Room 2922 (EPA Library), Waterside Mall, Washington, D.C. 20460.

The degree of impact on the overall environment has been used as a basis for dividing the pollutants into groups as follows:

1. Pollutants of significance.
2. Pollutants of limited significance.
3. Pollutants of specific significance.

The rationale and justification for pollutant categorization within the foregoing groupings, as discussed herein, will indicate the basis for selection of the parameters upon which the actual effluent limitations and guidelines were postulated for each point source. In addition, particular parameters have been discussed in terms of their validity as measures of environmental impact and as sources of analytical insight.

Pollutants observed from the field data that were present in sufficient concentrations so as to interfere with, be incompatible with, or pass with inadequate treatment through publicly owned treatment works are discussed in Section XII of this document.

Pollutants of Significance

Parameters of pollution significance for explosives manufacturing point source category are BOD5, COD, TOC, TDS, TSS, nitrates, sulfates, total Kjeldahl nitrogen, ammonia nitrogen, lead and pH.

BOD5, COD, and TOC have been selected as pollutants of significance because they are the primary measurements of organic pollution. In the survey of the industrial categories, almost all of the effluent data collected from wastewater treatment facilities were based upon BOD5, because almost all the treatment facilities were biological processes. If other processes (such as evaporation, incineration, or activated carbon) are utilized, either COD or TOC may be a more appropriate measure of pollution.

Table VI-1

List of Parameters Examined

- Biochemical Oxygen Demand
- Chemical Oxygen Demand
- Total Organic Carbon
- Total Suspended Solids
- Dissolved Solids
- Lead
- Mercury
- Nitrogen Compounds
- pH, Acidity, Alkalinity
- Sulfates
- Oil and Grease
- Color

BOD

Biochemical oxygen demand (BOD) is usually defined as the amount of oxygen required by microorganisms while stabilizing decomposable organic matter under aerobic conditions. The term "decomposable" may be interpreted as meaning that the organic matter can serve as food for the microorganisms and that energy is derived from this oxidation.

The BOD does not in itself cause direct harm to a water system, but it does exert an indirect effect by depressing the oxygen content of the water. Organic effluents exert a BOD during their processes of decomposition which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are sometimes reached where all of the oxygen is used, and the continuing decay process causes the production of gases, such as hydrogen sulfide. Water with a high BOD indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade the quality and potential use of the water.

Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced DO concentrations that make them less competitive and less capable of sustaining their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in the young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD can kill all aerobic inhabitants of the affected area.

The BOD test (Standard Methods, 1971; Methods of the Chemical Analysis of Water and Wastes, 1971) has been used to gauge the pollutional strength of a wastewater in terms of the oxygen it would demand if discharged into a watercourse. Historically, the BOD test has also been used to evaluate the performance of biological wastewater treatment facilities and to establish effluent limitation values. However, objections to the use of the BOD test have been raised. The major objections are:

1. The standard BOD5 test takes five days before the results are available.

2. At the start of the BOD test, a seed culture of microorganisms is added to the BOD bottle. If the seed culture were not acclimated (i.e., exposed to a similar wastewater in the past), then it may not readily biologically degrade the waste, and a low BOD value may be reported. This situation may occur when dealing with complex industrial wastes.

3. The BOD test is sensitive to toxic materials, as are all biological processes. Therefore, if toxic materials are present in particular wastewater, the reported BOD value may be erroneous. This situation can be remedied by running a microorganism toxicity test, i.e., subsequently diluting the sample until the BOD value reaches a plateau indicating that the material is at a concentration which no longer inhibits biological oxidation.

However, some of the previously cited weaknesses of the BOD test also make it uniquely applicable. It is the only parameter now available which measures the amount of oxygen utilized by microorganisms in metabolizing organics in wastewater.

The use of COD or TOC to monitor the efficiency of BOD removal in biological treatment is possible only if there is a good correlation between COD or TOC and BOD. Under normal circumstances, two correlations would be necessary, one for the raw wastewater and one for the treated effluent. During the field data analysis, varying correlations between COD or TOC and BOD5 were evident between subcategories. In spite of some disadvantages, this industry should continue to use the BOD5 parameter as one of its pollution indicators.

The BOD5 test is essentially a bioassay procedure involving the measurement of oxygen consumed by living organisms while utilizing the organic matter present in a waste under conditions as similar as possible to those that occur in nature. It is extremely important that environmental conditions be suitable for the living organisms to function in an unhindered manner at all times. This requirement means that toxic substances must be absent and that accessory nutrients needed for microbial growth (such as nitrogen, phosphorus, and certain trace elements) must be present. Biological degradation of organic matter under natural conditions is brought about by a diverse group of organisms that carry the oxidation essentially to completion. Therefore, it is important that a mixed group of organisms commonly called "seed" be present in the test. For a few industrial wastes, this "seed" should be allowed to adapt to the particular waste (acclimate) prior to introduction of the culture into the BOD5 bottle.

The BOD5 test may be considered as a wet oxidation procedure in which the living organisms serve as the medium for oxidation of the organic matter to carbon dioxide and water. A quantitative relationship exists between the amount of oxygen required to convert a definite amount of any given organic compound to carbon dioxide and water, which can be represented by a generalized equation. On the basis of this relationship, it is possible to interpret BOD5 data in terms of organic matter that is present as well as in terms of the amount of oxygen used during its oxidation. This concept is fundamental to an understanding of the rate at which BOD5 is exerted.

The oxidative reactions involved in the BOD5 test are the result of biological activity, and the rate at which the reactions proceed is governed to a major extent by the microbial concentration and temperature. Temperature effects are held constant by performing the test at 20°C, which is an approximate median value for natural bodies of water.

The predominant organisms responsible for the stabilization of most organic matter in natural waters are native to the soil. The rate of their metabolic processes at 20°C and under the conditions of the test (total darkness, quiescence, etc.) is such that time must be measured in days. Theoretically, an infinite time is required for complete biological oxidation of organic matter, but for all practical purposes the reaction may be considered to be complete in 20 days. A BOD test conducted over the 20 day period is normally considered a good estimate of the "ultimate" BOD. However, a 20-day period is too long to wait for results in practice. It has been found by experience with domestic sewage that a reasonably large percentage of the total BOD is exerted in five days. Consequently, the test has been developed on the basis of a 5-day incubation period. It should be remembered, therefore, that 5-day BOD values represent only a portion of the total BOD. The exact percentage depends on the character of the "seed" and the nature of the organic matter, and can be determined only by experiment.

COD

The chemical oxygen demand (COD) test represents an alternative to the BOD test, and in many respects it is superior to the BOD test. COD is widely used and allows measurement of a waste in terms of the total quantity of oxygen required for oxidation to carbon dioxide and water under severe chemical and physical conditions. It is based on the fact that all organic compounds, with a few exceptions, can be oxidized by the action of strong oxidizing agents under acid conditions.

During the COD test, organic matter is converted to carbon dioxide and water regardless of the biological assimilability of the substances; for instance, glucose and lignin are both oxidized completely. As a result, COD values are greater than BOD values especially when significant amounts of biologically-resistant organic matter are present.

One drawback of the COD test is that its results give no indication of the rate at which the biologically active material would be stabilized under conditions that exist in nature. High levels of chloride interfere with the analysis. Normally, mercuric sulfate is added to each sample being analyzed for chemical oxygen demand to eliminate the chloride interference.

The major advantage of the COD test is the short time required for evaluation. The determination can be made in about 3 hours rather than 5 days required for the measurement of BOD. Furthermore, the COD test requires less sophisticated equipment, smaller working area, and less investment in laboratory facilities. Another major advantage of the COD test is that there is no seed acclimation problem.

TOC

Total organic carbon (TOC) is a measure of the amount of carbon in the organic material in a wastewater sample. The TOC analyzer withdraws a small volume of sample and thermally oxidizes it at 150°C. The water vapor and carbon dioxide from the combustion chamber (where the water vapor is removed) are condensed and sent to an infrared analyzer, where the carbon dioxide is monitored. This carbon dioxide value corresponds to the total inorganic value. Another portion of the same sample is thermally oxidized at temperatures above 950°C. This latter value corresponds to the total carbon value. TOC is determined by subtracting the inorganic carbon from the total carbon value.

TSS

All undissolved solids in water, unless they have settled to the bottom in one hour, are suspended solids. The fraction of undissolved solids that are settleable is dependent on quiescence, temperature, density, stability, size, flocculation, and many other factors. Suspended solids are a vital and easily determined measure of pollution and also a measure of the material that may settle in tranquil or slow-moving streams.

Suspended solids include both organic and inorganic materials. The inorganic compounds include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, and (animal and vegetable) fats.

Suspended solids in water interfere with many industrial processes, cause foaming in boilers and incrustations on equipment exposed to such water, especially as the temperature rises. They are undesirable in process water used in the manufacture of steel, in the textile industry, in laundries, in dyeing and in cooling systems.

Total suspended solids (TSS) discharged in the biological treatment system effluent consists of biological solids and other suspended solids carried over through the treatment facilities. Total suspended solids, when discharged to a watercourse, settle to the bottom and can blanket spawning grounds and interfere with fish propagation. In addition, the solids which are organic will be metabolized and exert an oxygen demand on the body of water. Total suspended solids, in large concentrations, can impede light transmittance and interfere with aquatic photosynthesis, thereby affecting the oxygen content of a body of water.

Solids in suspension are usually aesthetically displeasing. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat.

In addition to any toxic effect attributable to substances leached out by water, suspended solids may kill fish and shellfish by causing abrasive injuries and by clogging the gills and respiratory passages of various aquatic fauna. Indirectly, suspended solids are inimical to aquatic life because they screen out light, and they promote and maintain the development of noxious conditions through oxygen depletion. This results in the killing of fish and fish food organisms. Suspended solids also reduce the recreational value of the water.

Pollutants of Limited Significance

Dissolved Solids

In natural waters, the dissolved solids are mainly carbonates, chlorides, sulfates, phosphates, and, to a lesser extent, nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances. The summation of all individual dissolved solids is commonly referred to as total dissolved solids.

Many communities in the United States and in other countries use water supplies containing 2,000 to 4,000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4,000 mg/l of total salts are generally considered unfit for human use, although in hot climates such higher salt concentrations can be tolerated. Waters containing 5,000 mg/l or more are reported to be bitter and act as a bladder and intestinal irritant. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, depending on species and prior acclimatization. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with a salt concentration of 15,000 to 20,000 mg/l. Fish can slowly become acclimatized to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil-well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids (TDS) concentrations higher than 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l, water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and can cause interference with cleanliness, color, or taste of many finished products. High concentrations of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of water to convey an electric current. This property is related to the total concentration of ionized substances in water and to the water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

Lead (Pb)

Some natural waters contain lead in solution, as much as 0.4 to 0.8 mg/l where mountain limestone and galena are found. In the U.S.A., lead concentrations in surface and ground waters used for domestic supplies range from traces to 0.04 mg/l, averaging about 0.01 mg/l.

Foreign to the human body, lead tends to be deposited in bone as a cumulative poison. The intake that can be regarded as safe for everyone cannot be stated definitely, because the sensitivity of individuals to lead differs considerably. Lead poisoning usually results from the cumulative toxic effects of lead after continuous consumption over a long period of time, rather than from occasional small doses. Lead is not among the metals considered essential to the nutrition of animals or human beings.

Lead may enter the body through food, air, and tobacco smoke as well as from water and other beverages. The exact level at which the intake of lead by the human body will exceed the amount excreted has not been established, but it probably lies between 0.3 and 1.0 mg per day. The mean daily intake of lead by adults in North America is about 0.33 mg per day, which is derived from water used for cooking and drinking.

Lead in an amount of 0.1 mg ingested daily over a period of years has been reported to cause lead poisoning. On the other hand, one reference considered 0.5 mg per day safe for human beings, and a daily dose of 0.16 mg/l over long periods of time have apparently been non-poisonous. The mandatory limit for lead in the USPHS Drinking Water Standards is 0.05 mg/l. Several countries use 0.1 mg/l as a standard.

Traces of lead in metal-plating baths will affect the smoothness and brightness of deposits. Inorganic lead salts in irrigation water may be toxic to plants and should be investigated further. It is not unusual for cattle to be poisoned by lead in their water. The lead need not necessarily be in solution, but may be in suspension, as, for example, oxycarbonate. Chronic lead poisoning among animals has been caused by 0.18 mg/l of lead in soft water. Most authorities agree that 0.5 mg/l of lead is the maximum safe limit for lead in a potable supply for animals. The toxic concentration of lead for aerobic bacteria is reported to be 1.0 mg/l, and for flagellates and infusoria, 0.5 mg/l. The bacterial decomposition of organic matter is inhibited by 0.1 to 0.5 mg/l of lead.

Studies indicate that in water containing lead salts, a film of coagulated mucus forms, first over the gills, and then over the whole body of the fish, probably as a result of a reaction between lead and an organic constituent of mucus. The death of the fish is caused by suffocation due to this obstructive layer. In soft water, lead may be very toxic; in hard water equivalent concentrations of lead are less toxic. Concentrations of lead as low as 0.1 mg/l have been reported toxic or lethal to fish. Other studies have shown that the toxicity of lead toward rainbow trout increases with a reduction of the dissolved-oxygen concentration of the water.

Mercury (Hg)

Mercury is an elemental metal that is rarely found as a free metal. The most distinguishing feature is that it is a liquid at ambient conditions. Mercury is relatively inert chemically and is insoluble in water. Its salts occur in nature chiefly as the sulfide (HgS) known as cinnabar.

Mercury can be introduced into the body through the skin and the respiratory system. Mercuric salts are highly toxic to humans and can be readily absorbed through the gastrointestinal tracts. Fatal doses can vary from 3 to 30 grams.

Mercuric salts are extremely toxic to fish and other aquatic life. Mercuric chloride is more lethal than copper, hexavalent chromium, zinc, nickel, and lead towards fish and aquatic life. In the food cycle, algae containing mercury up to 100 times the concentration of the surrounding sea water are eaten by fish which further concentrates the mercury and predators that eat the fish in turn concentrate the mercury even further.

Nitrogen Compounds

Ammonia nitrogen (NH_3-N) and total Kjeldahl nitrogen (TKN) are two parameters which have received a substantial amount of interest in the last decade. TKN is the sum of the NH_3-N and organic nitrogen present in the sample. Both NH_3 and TKN are expressed in terms of equivalent nitrogen values in mg/l to facilitate mathematical manipulations of the values.

Organic nitrogen may be converted in the environment to ammonia by saprophytic bacteria under either aerobic or anaerobic conditions. The ammonia nitrogen then becomes the nitrogen and energy source for autotrophic organisms (nitrifiers). The oxidation of ammonia to nitrite and then to nitrate has a stoichiometric oxygen requirement of approximately 4.6 times the concentration of NH_3-N. The nitrification reaction is much slower than the carbonaceous reactions, and, therefore, the dissolved oxygen utilization is observed over a much longer period.

Ammonia is a common product of the decomposition of organic matter. Dead and decaying animals and plants along with human and animal body wastes account for much of the ammonia entering the aquatic ecosystem. Ammonia exists in its non-ionized form only at higher pH levels and is the most toxic in this state. The lower the pH, the more ionized ammonia is formed and its toxicity decreases. Ammonia, in the presence of dissolved oxygen, is converted to nitrate (NO_3) by nitrifying bacteria. Nitrite (NO_2), which is an intermediate product between ammonia and nitrate, sometimes occurs in quantity when depressed oxygen conditions permit. Ammonia can exist in several other chemical combinations, including ammonium chloride and other salts.

Infant methemoglobinemia, a disease characterized by specific blood changes and cyanosis, may be caused by high nitrate concentrations in the water used for preparing feeding formulae. While it is still impossible to state precise concentration limits, it has been widely recommended that water containing more than 10 mg/l of nitrate nitrogen (NO_3-N) should not be used for infants.

Nitrates are also harmful in fermentation processes and can cause disagreeable tastes in beer. In most natural water the pH range is such that ammonium ions (NH_4^+) predominate.

In streams polluted with sewage, up to one-half of the nitrogen in the sewage may be in the form of free ammonia, and sewage may carry up to 35 mg/l of total nitrogen. It has been shown that at a level of 1.0 mg/l non-ionized ammonia, the ability of hemoglobin to combine with oxygen is impaired and may cause fish to suffocate. Evidence indicates that ammonia exerts a considerable toxic effect on all aquatic life within a range of less than 1.0 to 25 mg/l, depending on the pH and dissolved oxygen level present.

Ammonia can add to the problem of eutrophication by supplying nitrogen through its breakdown products. Some lakes in warmer climates, and others that are aging quickly, are sometimes limited by the nitrogen available. Any increase will speed up the plant growth and decay process.

pH, Acidity and Alkalinity

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis, and alkalinity is produced by substances that yield hydroxyl ions. The term "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution.

Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity, while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6 are corrosive to waterwork structures, distribution lines, and household plumbing fixtures, and can thus add such constituents to drinking water as iron, copper, zinc, cadmium, and lead.

The hydrogen ion concentration can affect the taste of water. At a low pH water tastes sour. As pH increases, the bacterial effect of chlorine is weakened, and it is advantageous to keep the pH close to 7.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from acceptable criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7, and a deviation of 0.1 pH unit from the norm may result in eye irritation or severe pain.

Sulfates (SO4)

Sulfates occur naturally in waters, particularly in the western United States, as a result of leachings from gypsum and other common materials. They also occur as the final oxidized state of sulfides, sulfites and thiosulfates. Sulfates may also be present as the oxidized state of organic matter in the sulfur cycle, but they in turn, may serve as sources of energy for sulfate reducing bacteria. Sulfates may also be discharged in numerous industrial wastes, such as those from tanneries, sulfate-pulp mills, textile mills, and other plants that use sulfates or sulfuric acid.

In moderate concentrations, less than 500 mg/l sulfates are not harmful, yet concentrations greater than 1000 mg/l tend to have a laxatives effect on humans. Irrigation concentrations less than 336 mg/l are considered to be good to excellent.

Oil and Grease

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or plankton. Deposition of oil in the bottom sediments can serve to exhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh.

Water-soluble components may be toxic to fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis.

Water-insoluble components damage the coats of water animals and the plumage of waterfowl. Oil and grease in water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water. Oil spills can damage the surface of boats and destroy the aesthetic characteristics of beaches and shorelines.

Color

Color in water may be of natural mineral or vegetable origin, caused by metallic substances, such as iron and manganese compounds, humus material, peat, tannins, algae, weeds, and protozoa. Waters may also be colored by inorganic or organic soluble wastes from many industries including the explosives industry.

Color in the explosives point source category results from the manufacture of TNT; either from the purification steps or the equipment and/or manufacturing area clean-up.

Color is defined as either "true" or "apparent" color. In Standard Methods for the Examination of Water and Wastewater (4), the true color of water is defined as "the color of water from which the turbidity has been removed". Apparent color includes "not only the color due to substances in solution, but also due to suspended matter".

Color bodies interfere with the transmission of light within the visible spectrum which is absorbed and used in the photosynthetic process of microflora. Color will affect the aquarian ecosystem balance by changing the amount of light transmitted and may lead to species turnover.

This is because light intensity at which oxygen production in photosynthesis and oxygen consumption by respiration of the plants concerned are equal is known as the compensation point, and the depth at which the compensation point occurs is called the compensation depth. For a given body of water, this depth varies with several conditions, including season, time of day, the extent of cloud cover, condition of the water, and the taxonomic composition of the flora involved. As commonly used, the compensation point refers to that intensity of light which is such that the plant's oxygen production during the day will be sufficient to balance the oxygen consumption during the whole 24-hour period.

Color bodies discharged to waterways alter the natural stream color and thereby become an aesthetic pollutant. Unnatural receiving water color detracts from the visual appeal and recreational value of the waterways.

Color when discharged to receiving waters also has detrimental effects on downstream municipal and industrial water users. Color is not treated for in conventional water treatment systems and when passed to users may result in consumer discontent and may also interfere with industrial processes which demand high quality water.

Pollutants of Specific Significance

In addition to the parameters already discussed, there are pollutants specific to various individual categories of the miscellaneous chemicals point source category. These will be covered as applicable to the discussions as is done in the following text for the explosives point source category.

Explosives Manufacturing

General parameters of significance in explosives manufacturing are BOD5, COD, TOC, TSS, lead, mercury, dissolved solids, color and nitrogen compounds including nitrates and TKN. Of special significance is the problem of trace quantities of the explosive products themselves.

Explosives such as TNT, NG, RDX, and HMX can all be considered significant, because of their potential hazard, toxicity, or inhibitory effect on microorganisms. NG has been shown to be amenable to biological treatment by some investigators while others have found little success with biological treatment.

Of particular interest to this segment are the pollutants associated whith the manufacture of TNT, the production of which far exceeds any other explosive in the military sector. These include color, sulfates, and saturation levels of TNT. The color problem is manifested in the red and pink water previously discussed in Section IV. The sulfate problem is associated with the red water condition. Saturation concentration of TNT in the effluent is an obvious problem and must be abated.

The major problem with nitrocellulose (NC) is NC fines, which generally are present in quantities large enough to cause a significant TSS problem. These fines have been shown to be successfully removed with centrifugation and a portion of the waste liquor can then be recycled to the system.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGIES

General

The entire spectrum of wastewater control and treatment technology is at the disposal of the explosives manufacturing point source category. The selection of technology options depends on the economics of that technology and the magnitude of the final effluent concentration. Control and treatment technology may be divided into two major groupings: in-plant pollution abatement and end-of-pipe treatment.

After discussing the available performance data for this segment, conclusions will be made relative to the reduction of various pollutants commensurate with the following distinct technology levels:

1. Best Practicable Control Technology Currently Available (BPCTCA)
2. Best Available Technology Economically Achievable (BATEA)
3. Best Available Demonstrated Control Technology (BADCT)

To assess the economic impact of these proposed effluent limitations and guidelines, model treatment systems have been proposed which are considered capable of attaining the recommended RWL reduction. It should be noted and understood that the particular systems were chosen for use in the economic analysis only, and are not the only systems capable of attaining the specified pollutant reductions.

There are many possible combinations of in-plant and end-of-pipe systems capable of attaining the effluent limitations guidelines and standards of performance recommended in this report. The complexity of this segment, however, dictated the use of only one treatment model for each subcategory for each effluent level.

It is the responsibility of each individual plant to make the final decision about what specific combination of pollution control measures is best suited to its situation in complying with the limitations and standards presented in this report.

Explosives Manufacturing

In-plant Pollution Abatement

A significant amount of pollution abatement can be accomplished in explosives manufacturing simply by consistent adherence to good housekeeping practices. Many of the final products such as ANFO and NCN are dry mixed, while others involve only limited water use such as water gels and slurries. Wastes generated from these products are primarily from spills, careless handling, leaks, and washdown of machinery and floors. Such wastes have the potential to be almost completely eliminated by dry cleanup, i.e., procedures involving sweeping and vacuum cleaning.

Off-site mining and construction captive blending of ammonium nitrate and fuel oil is a minor pollution problem and abatement cost would be negligible. The treatment models do not apply to this point of use activity. On-site blending of ammonium nitrate into explosive end products such as NCN and ANFO at primary explosives manufacturing plants is included in the present data base. The existing treatment model does apply. Examples of locations now included in the data base are plant no. 49 and plant no. 50.

Process changes to reduce hydraulic loadings do not have a great potential in the commercial sector of explosives manufacturing, because of the difference in the products produced. Process changes to reduce hydraulic loadings have shown promise in the military manufacturing sector such as the NC fine centrifugation system described in section VI. In the manufacture of propellants, large quantities of waters are used to transport explosive materials safely and to purify the product from one process step to another. For this task, high-quality water is not required. Hence, water reuse with perhaps slight treatment has a tremendous potential to reduce the hydraulic loading. For example, wastewater reductions for nitrocellulose production in one of the plants visited could reduce total plant discharge by 95 percent and overall propellant production wastewater discharge by 87 percent. This change is in the planning stage at that location.

The production of TNT is another area where significant reduction of hydraulic loading can be attained. As a part of the military modernization program, 100 percent reduction of current process water use is possible and will be implemented within the near future at a large army ammunitions plant.

In general, good water management, with a focus on recycling process and cooling water, can have a significant effect on hydraulic loading and would significantly reduce treatment costs. For example at one AAP in the current study, overall plant water reduction (including cooling as well as process water) reached 6 percent. This saved an estimated $900,000 per year in pumping and treatment costs. Such substantial savings show that water conservation practices can be economical as well ecologically favorable.

Separation of process and non-contact waters is not practiced universally. This is technically feasible and reduction of the hydraulic loading at a treatment plant is an essential first step in economical pollution abatement.

Studies documented in Section XV have shown explosives wastes to be treatable with present technology. However, prior to end-of-pipe treatment, certain in-plant control measures will be mandatory. Such measures will require neutralization facilities, catch tanks on finishing explosives lines, and other pretreatment facilities to ensure compatability of raw waste load with the subsequent treatment system.

Treatment and Control Technology

In developing potential treatment technology for each subcategory, sources of information were laboratory studies, pilot plants, demonstration projects, facilities under construction, and facilities in operation. First, control technology will be discussed from the viewpoint of effluent water quality. After reviewing what has been accomplished and what is feasible, control technology will be outlined for each subcategory for BPCTCA, BATEA, and BADCT.

pH

The control technology for pH is neutralization. The pH of a discharge can vary over extreme ranges; from plant visits it was observed to range from 1 to 12. An example of such ranges can be seen from the manufacture of NG, where the initial washing of NG produces an acidic wastewater and subsequent sodium carbonate washings yields an alkaline flow.

The problem of high-alkaline flows is significant in subcategory D due to the discharges from PETN, lead azide, and diazo production. The problems of acidic flows are generally associated with the manufacture of nitric and sulfuric acids as raw materials in the production of

Table VII -1

Summary of Treatment Investigations Explosives Industry

Type of Study	Reference	Treatment	Percent Reduction						
			BOD	COD	TOC	TKN	NO_3	SO_4	TSS
Pilot (3 months)	U.S. Army (PE249)	Activated Sludge (NG Waste)	86.7	78.3					
Operational	Operational	Activated Sludge (Propellant Waste)	92.8 [1]	71.5 [1]	90 [2]	Increase	96 [2]	None	88.4 [1,2]
Laboratory	Clark, Dietz Eng. Rept. HAAP	(Explosive Waste) Activated Sludge	Failed -(Filamentous Organism)						
Laboratory	Clark, Dietz Eng. Rept. HAAP	Trickling Filters	83.7	72.9					
Laboratory	Clark, Dietz Eng. Rept. HAAP	Fixed Film Denitrofication	41.4				94.9		
Laboratory	Clark, Dietz Eng. Rept. HAAP	Dual Media Filtration							75
Laboratory	Clark, Dietz Eng. Rept.	A.C.-Note Removes all explosives down to 0.0 mg/L		77.6					
Operational	Operational	(Propellant waste(Lagoon Sp. Irr.	72.0 [1]	78.9 [1]	88.7 [2]	96.6 [2]	increase	59.4 [1]	77.8 [2]
Laboratory	U.S.Army PE 249 Phase II	(NG Waste) Decompose NG & DNG by Na_2S	(Successful in Decomposing 350 mg/L NG & 130 mg/L DNG)						
	U.S. Army PE 249 Phase II	Using Lime	Successful Decomposition						
	U.S. Army PE 249 Phase II	Oxidating Agent Ozone NG DNG		20 100					
Laboratory	U.S. Army PE 249 Phase II	(Propellant Wastes) Activated Carbon	Excellent Removal of Dissolved Organics						
		Inorganic SO_4						97.5	
Pilot	U.S. Army PE 249 Phase II	NC Fines Separation & Centrifuge							99
Laboratory Demonstration	U.S. Army PE 249 Phase II	Reverse Osmosis					75	99	
Lab Unit (Pilot)	U.S.Army PE 249 Phase II	Biodenitrification		94			70-90		

Table VII -1
(Continued)

Type of Study	Reference	Treatment	Percent Reduction						
			BOD	COD	TOC	TKN	NO_3	SO_4	TSS
Pilot	Pollution Abatement Review Aug. 1973	Reverse Osmosis Treatment of Red. Water		Impractical Due To High Pressure					
Operation	Pollution Abatement Review Aug. 1973	(Pinkwater) Activated Carbon (Reduction of TNT 99.5%)		95	91.5-92.7			None	67
Operation	Pollution Abatement Review Aug. 1973	(Pinkwater) Activated Carbon	-Data not available-						
Pilot and Laboratory	Harris, 1973	Biodenitrification					70-97		
Commercial Demonstration	Pollution Abatement Review Aug. 1973	Ion Exchange					90-99		
Laboratory	Pollution Abatement Review Aug. 1973	Reverse Osmosis					90		
Laboratory.	Harris, 1973	Biodenitrification					95-99		
Pilot	Harris, 1973	Ion Exchange Countercurrent					98.8	95.4	
Laboratory	Harris, 1973	Reverse Osmosis					90	95	
Laboratory Treatability and Pilot	Harris, 1973	Calcium ppt of sulfate waste						successful	
Laboratory Tests	Harris, 1973	AC adsorption	Regeneration of carbon is feasible						
Bench Scale Pilot Plants	U.S. Navy 1972	TNT wastes							
		Activated Sludge		Not successful					
		Aerated Lagoon		Not successful					
		Trickling Filter		Not successful					
		Chemical Precipitation		Not Successful					
		Activated Carbon			98				

[1] Data
[2] Survey Data

explosives. However, as these materials are not explosives they are covered under the major inorganic industrial point source category.

There are many acceptable methods for treating either acidic or alkaline wastes, including mixing acids and alkaline wastes and using chemicals, such as lime, caustic, or sulfuric acid, to neutralize the wastewaters. Equalization is very useful in pH control. Plants that practice this operation have better control of the pH in the discharge. This is particularly important if the wastewater is to be biologically treated. Biological systems operate over a narrow pH range (usually 6 to 9) and the inclusion of equalization before biotreatment is an effective technique of operating a successful treatment system.

BOD5 and COD

Current emphasis in treatment technology for both these areas is on biological treatment. Activated sludge, lagooning, and spray irrigation are combined at one commercial plant treating propellant wastewater and this treatment technique attains excellent and consistent results. One military installation is currently completing the design of biological treatment facilities based on pilot plant test data.

Solids

High dissolved solid concentrations come from the high nitrate, sulfate, and carbonate levels, and these will be addressed separately. Suspended solids generally are low in explosives manufacturing; however, catch tanks and sumps are usually employed to catch trace explosives prior to discharge. An exception to low suspended solids in explosives manufacturing wastewaters is in the manufacture of nitrocellulose. Here, large concentrations of NC fines are present in the waste discharge from the purification process. Treatment technology focuses on sedimentation, dissolved air flotation, flocculation, granular filtration, and centrifugation. Centrifuging has produced excellent results in pilot studies at a military installation and will be implemented shortly.

Nitrates

The U.S. Army has investigated several methods for abatement of nitrates. Among these methods are biodenitrification, algae harvesting, ion exchange, reverse osmosis, distillation, and land application. After initial feasibility studies, the Army selected biodenitrification, ion exchange, and reverse osmosis as having the most potential. Current engineering emphasis is placed on biological denitrification, for which at least two plants have plans for design. Pilot plant treatability studies of biodenitrification on nitrocellulose waste have indicated 80 to 90 percent reduction of nitrates on a consistent basis. Influent nitrate values ranged from 600 to 800 mg/l and the detention time was about one day.

Additional engineering studies have been performed utilizing reverse osmosis and ion exchange. Excellent removal rates of 90 percent have been obtained at a pilot plant using reverse osmosis. Reverse osmosis can be used to treat sulfates as well. At neutral pH, removal rates of 90 to 99 percent for nitrates and sulfates, respectively, were observed during this same pilot investigation. For nitrates it appears that the economical limit of nitrates in the effluent is approximately 20 mg/l as NO3-N. Hence, reverse osmosis could be a means of nitrate recovery, while an additional step such as biodenitrification may be necessary to reduce the smaller concentration of nitrates to more acceptable levels.

Problems associated with reverse osmosis are sensitivity of membranes to acid, and concentrate disposal. Ion exchange studies have shown concentrations as high as 1,200 mg/l to be reduced 99 percent, resulting in an effluent concentration of 10 mg/l. Chemicals used for regeneration of the resin are nitric acid and ammonium hydroxide. Ammonium nitrate, a raw material in certain explosives (ANFO, NCN, etc.) can be recovered in the regeneration step.

Sulfates

Present in the water because of the use of sulfuric acid or, in the case of TNT production, the sellite wash (red water), sulfates have only recently received any attention as a pollutant. Hence, abatement studies are only in the initial assessment stages. Existing abatement involves incineration. However, incineration leads to air pollution (SO_x), and the sodium sulfate ash disposed of in landfill causes leaching problems. Several chemical processes are being considered for reusing the ash. The most promising involves a fluidized-bed reduction system which utilizes a reducing gas to liberate hydrogen sulfide from the ash. The hydrogen sulfide can then be used to manufacture sellite and, hence, complete recycling is accomplished. Additional methods under consideration for controlling high sulfate discharge are reverse osmosis, ion exchange, evaporation

TABLE VII-2 Sample Analysis of NG Process Wastewater Pollutants from Acid Separator and Nitrator Tub

Sample Analysis (Facilities in Operation at Full Capacity)

	Min.	Avg.	Max.
pH	8.4	8.6	9.2
BOD* (mg/l)	1.5	4.5	6.5
COD* (mg/l)	1,000	1,228	1,400
TOC* (mg/l)	100	230	300
Nitrates (mg/l)	7,500	13,280	20,000
Sulfates (mg/l)	534	1,416	3,550
Total Alkalinity (mg/l, $CaCO_3$)	9,000	12,700	16,400
Spec. Cond. (μmhos/cm)	8,000	13,000	19,000
Susp. Solids (mg/l)	3.0	23.0	63.3
Dissolved Solids (mg/l)	68,000	81,626	98,950
Total Solids (mg/l)	68,000	81,650	99,000
Color (units)	600	650	700
Nitroglycerin (mg/l)	800	1,300	1,800
Dinitroglycerin (mg/l)	520	850	1,180
Lead (mg/l)	0.2	1.0	2.8

*BOD - Biological Oxygen Demand

*COD - Chemical Oxygen Demand

*TOC - Total Organic Carbon

Flow from nitrator 15,200 gpd at 24 hour full capacity w/one line.

*13,000 gpd for clean-up, not included in sampling analysis

It is expected that clean-up water will not contain appreciable wastes.

TABLE VII-3 Sample Analysis of NG Process Wastewater from Emulsifier Transfer Operations'

From the N/G being removed from storehouse (emulsifier)

NG Store Houses

a. Significant Components

Nitroglycerin
Dinitroglycerin
Sodium Carbonate
Nitrates
Lead

b. Sample Analysis

	Min.	Avg.	Max.
pH	10.2	10.5	11.3
BOD (mg/l)	2.4	3.2	4.1
COD (mg/l)	460	912	1,456
TOC (mg/l)	200	477	630
Nitrates (mg/l)	270	477	665
Sulfates (mg/l)	20	130	179
Alkalinity (mg/l $CaCO_3$)	7,500	11,400	18,000
Spec. Cond. (µmhos/cm)	1,280	5,340	8,100
Susp. Solids (mg/l)	3.3	11.3	22.1
Dissolved Solids (mg/l)	2,952	13,905	30,848
Total Solids (mg/l)	2,955	13,916	30,870
Color (units)	200	477	630
Nitroglycerin (mg/l)	83	266	490
Dinitroglycerin (mg/l)	41	130	248
Lead (mg/l)	0.2	0.8	2.4

Avg. Flow = 14,800 gpd, 24 Hour @ full capacity.

TABLE VII-4 Raw Waste Load for the Continuous NG Process Excluding Wash Water for Plant 43

Continuous N/G Manufacturing (Biazzi Process)

Production	Flow	
KKg/day (1000 lb/day)	KKL/day (mgd)	L/KKg (gal/1000 lb)
24.9[1] (55.0)	.114 (.03)	4,560 (545)

	Nitrator flow .0152 mgd		Store House flow .0148 mgd			
	Conc. mg/l	lb/Day	Conc. mg/l	lb/Day	lb/Day	lb pollutant 1000 lb. prod.
BOD	4.5	.570	3.2	.395	.965	0.175
COD	1,228	156	912	113	269	4.89
TOC	230	29.2	477	58.9	88.1	1.60
Nitrates	13,280	1,680	477	58.9	1740.	31.6
Sulfates	1,416	180	130	16.0	196	3.56
Total Alk.	12,700	1,610	11,400	1,410	3,020	54.9
SS	23	2.92	11.3	1.39	4.31	0.078
DS	81,626	10,300	13,905	1,720	12,000	218
Lead	1.0	.127	.8	.0987	.226	0.0041

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(1)At full production 55,000 lb/day of N/G - 1975 level was only 15% of this.

TABLE VII-5 Comparison of NG Batch Process vs NG Continuous Process Raw Waste Loads

	Plant 43 Continous	Plant 49 Batch	Ratio Cont/Batch H	Plant 50 Batch	Ratio Cont/Batch A
BOD	0.175	163	1.07	-	-
COD	4.89	4.88	1.0	3.14	1.56
TOC	1.69	1.05	1.52	1.64	.98
Nitrate	31.6	23.0	1.37	6.12	5.16
Sulfate	3.56	46.4	.077	2.10	1.69
Total Alk.	54.9	57.8	.950	38.2	1.44
SS	.078	.002	39.0	.026	3.0
DS	218.	25.2	8.65	90.3	2.4
Lead	.0041	.0036	1.14	--	--

TABLE VII-6 Comparison of Continuous NG Process Effluent Loading to Range of Loadings for Explosives Subcategory A

	Ranges (1) lb/1000 lb	Cont. lb/1000 lb	Fall in Range?
BOD	6.35 - .085	.0175	No (Low)
COD	10.6 - .300	4.89	OK
TSS	10.7 - .054	.078	OK
TOC	4.13 - .24	1.60	OK
NO_3	9.0 - .31	31.6	No (High)
SO_4	116. - .28	3.56	OK

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(1) From Table VE-2 (Subcategory A)

(combined with reverse osmosis to reuse sulfuric acid), and calcination (precipitation with lime then heating to recover sulfuric acid and lime).

Reverse osmosis has been investigated at the pilot level, in combination with nitrate removal. High sulfate removal efficiences (99 percent or better) are reported even at acidic pH. However, membrane hydrolysis at low pH greatly decreases useful membrane life. In the absence of more resistant membranes, neutralization would likely be required for the reverse osmosis feed stream. This may result in precipitation and fouling of the membranes by solids.

The most technically feasible method of sulfate treatment appears to be calcination. However, the solubility of calcium sulfate is high and lime treatment may not be feasible for more stringent effluent requirements. The use of barium to precipitate sulfate has been suggested in the literature, but cost and the possibility of exceeding effluent barium levels appear to be major disadvantages. The economic and technical difficulties associated with treatment for pollutants such as sulfate have led to several applications for waste disposal by land irrigation in explosives manufacturing. One such plant that goes through biological activated sludge, lagooning, and spray irrigation is currently achieving 95 percent removal of sulfates.

Trace Quantities of Explosives

Unique pollutants such as NG, TNT, and RDX are hazardous and toxic.

Nitroglycerin (NG)

Treatment technology universally used for NG washwaters is catch tanks. The catch tanks make it possible to recover by sedimentation any NG that comes out of solution. However, this leaves the supernatant waters at their saturation point upon discharge. At room temperature, 20°C, the solubility of NG is recorded as 1,800 mg/l. (Table VII-1.) Therefore, during warm summer weather without further treatment, NG wastewater could pose a safety problem, especially if discharged into a cool mountain stream. If cooling water is available, the cooling of NG prior to discharge could recover additional product and decrease the waste load significantly. For a detailed comparison of process wastewater pollutants from batch and continuous NG operations refer to Tables VII-2, VII-3, VII-4, VII-5 and VII-6.

Additional technology for the treatment of wastes high in nitroglycerin is only in the experimental stage. NG wastes containing 900 to 2,100 mg/l have been shown to be amenable to activated sludge treatment. In one study, Koziorowski and Kucharski report consistent success in treatment of influent wastes containing 400 to 500 mg/l of NG at a detention time of 16 hours. NG can also be destroyed by quicklime. Lime (up to 200 mg/l) was added to the wastewater and allowed to react for three days; the result was a non-explosive sludge, but the effluent was highly alkaline. The Army has conducted experiments on the treatability of NG by biological, physical/chemical, and ozonization methods. With wastewater containing concentrations of NG and DNG (dinitroglycerin) of 1,500 mg/l and 850 mg/l, respectively, the results show that NG can be treated biologically and chemically, although with varying degrees of success. NG waste should be handled biologically together with other plant waste.

TNT

TNT has been shown to interfere with biochemical oxygen demand, and produces an inhibiting or toxic effect. Biological treatment of wastes high in TNT and DNT (red and pink water) was performed by the Navy (1972). Reduction has been successful only in the laboratory using specific cultures and nutrients. At Crane Naval Ammunition Center, treatability studies using activated sludge proved unsuccessful. Numerous other treatability studies at Crane Naval Ammunition Center included activated carbon, aerated lagoon, trickling filtration, and physical/ chemical mechanisms. Of these, activated carbon adsorption process was recommended. Spent carbon from the adsorption column cannot be regenerated at the present time and must be incinerated or landfilled. The reason is that in the regeneration step the adsorbed TNT detonates, reducing the active sites on the carbon molecules.

The Army has reached a similar conclusion regarding TNT. In tests of reverse osmosis, ozonization, and activated carbon, only the latter proved effective, reducing initial concentrations of TNT in the range of 100 mg/l down to 0.05 mg/l. The Army recommended development work in the regeneration of carbon, but it is uneconomical at present. A promising method involves dissolving the TNT in toluene then crystallizing it by a drop in temperature and filtration to separate the carbon.

If regeneration of carbon cannot be achieved, the incineration of the spent carbon is necessary. However, incineration, though inactivating TNT and its derivatives, produces a waste high in sulfates (from the sellite purification process resulting in red and pink water). This ash causes a major solid waste disposal problem. In addition, leachate from its storage can cause ground water contamination. Reclamation of this ash is being investigated by the Army. A fluid-bed reduction system is being tested presently with the focus of regenerating sellite.

RDX and HMX

The present removal of RDX and HMX from wastewaters by catch basins has only partially alleviated the problem. The Army is investigating the following treatment methods at Holston AAP: reverse osmosis, activated carbon adsorption, polymeric column adsorption, and biological treatment. Since these treatment techniques are still being studied, a definite statement as to their success cannot be drawn. However, one conclusion can be drawn: biological treatment is feasible and will break down as much as 99 percent of the explosives present.

End-of-pipe Treatment

Due to the current industrial practices of failure to use available effective treatment in all but exceptional cases in explosives manufacturing, treatment systems will be proposed for all subcategories based on the preceding discussion of laboratory studies, pilot plant investigations, demonstrated projects, facilities designed, facilities under construction, and facilities in operation.

Treatment systems were developed for the explosives industrial subcategories for the following levels of treatment technology:

1. Best Practicable Control Technology Currently Available (BPCTCA).
2. Best Available Technology Economically Achievable (BATEA).
3. Best Available Demonstrated Control Technology BADCT).

The treatment systems presented for each level of technology are not the only systems that are capable of meeting the effluent limitations prescribed. The objective of this section is not to prescribe but to suggest feasible treatment systems that will satisfy the effluent limitations and guidelines developed in this report.

BPCTCA Treatment System

Of the six plants visited during the survey, only one operated a treatment system other than neutralization and sedimentation. This is felt to be a result of many factors such as lack of technology on how to treat the explosive waste, a changing industry profile such as the advent of ammonium nitrate compounds replacing dynamite and black powder, a variable operation as a result of war or peace time product demand but primarily on the fact that there were no regulations before 1972 requiring effluent limitation. Effluent treatment cost money to implement. As a result of these and other factors, the average existing treatment systems are inadequate to meet safe effluent standards. Therefore, the levels of treatment for BPCTCA for subcategories A, B and D will be based on the performance of this existing activated sludge plant. Laboratory and pilot plant investigations summarized in Table VII-1 will be used to verify these levels of treatment. In the case of subcategory C, the level of treatment is based on technology transfer from the performance on waste waters with expected similar characteristics. Two distinctly different types of waste waters were encountered in this subcategory. From the production of NCN and ANFO, where fuel oil is utilized, the waste waters were characterized as high in oil and grease and low in suspended solids. In contrast from other load, assemble and pack operations, the waste waters contained high suspended solids but low oil and grease content. The level of treatment for BPCTCA will be based on an extended aeration packaged plant which includes screening, biological treatment, clarification with skimming and chlorination.

The results of nine months of data for this activated sludge treatment system is shown in the summary tabulation below. This treatment system was designed for a propellant waste having typical waste characteristics as indicated in Section V. The BPCTCA treatment level indicated below includes the survey data as well as historical data.

BPCTCA Treatment Level For Subcategories A, B and D

Parameter	Percent Reduction of RWL
BOD_5	93[1]
COD	72[1]
TOC	90[2]
TSS	88[2,3]

[1] Based on historical data

[2] Based on 24-hour composites from survey.

[3] Except the average of daily values for 30 consecutive days shall not exceed 50 mg/l and the maximum for any one day is 150 mg/l.

The BPCTCA treatment level for subcategory C was selected as below.

Effluent Limitations

Average of Daily Values for 30 Consecutive Days Shall Not Exceed		Maximum for Any One Day	
Parameter	mg/L	Parameter	mg/L
TSS	50[1]	TSS	150[1]
Oil and Grease	20[2]	Oil and Grease	60[2]

[1] Based on technology transfer from the fertilizer manufacturing point source category and the inorganic chemicals manufacturing point source category.

[2] Based on technology transfer from the petroleum refining point source category.

Pretreatment Requirements for BPCTCA Treatment System

Certain waste flows will have to be pretreated prior to discharging to a central treatment facility such as the one proposed for BPCTCA. The following problem wastewaters should be considered in that category:

1. Discharges high in sulfate
2. Discharges high in TNT (red water, yellow water, pink water).
3. Discharges high in NC fines
4. Heavy metals

Although discharge to municipal systems was not observed during the study suggested methods of abatement will be explored for completeness.

High sulfate concentration can disrupt a biological secondary treatment system. Therefore, the removal of high sulfate concentration by calcination may be a necessary pretreatment technique. TNT is suspected of being toxic or an inhibitor of biological processes. Wastes high in TNT may, therefore, require activated carbon adsorption prior to discharge to a biological system to remove the dissolved explosive and its isomers. High concentrations of NC suspended solids could also disrupt a biological system. Removal by the use of centrifuging has been shown to be economical.

Heavy metals concentration can be toxic to microorganisms and, subsequently, disrupt the activated sludge process. If heavy metals are a problem, some means of physical/chemical pretreatment will necessarily have to be implemented.

High concentrations of oil and grease can be disruptive to municipal systems. An upper limit of 100 mg/l is indicated for this parameter as the pretreatment standard.

BATEA Treatment System

Out of six explosives plants visited, only one had any kind of treatment that could be considered as exemplary. Hence, operational performance data from this facility was used to establish BATEA treatment levels; these levels were verified by laboratory and pilot studies.

BATEA Treatment Levels For Subcategories A, B and D

Parameter	Percent Reduction of BPCTCA Waste Effluent
BOD_5	72
COD	79
TSS	78[1]

[1] Except the average of daily values for 30 consecutive days shall not exceed 10 mg/l and the maximum for any one day is 20 mg/l.

BATEA treatment level for subcategory C.

Parameter	Percent Reduction of BPCTCA Effluent
BOD_5	72
COD	79
TSS	60[1]
Oil and Grease	80[2]

[1] Except the average of daily values for 30 consecutive days shall not exceed 20 mg/l and the maximum for any one day is 40 mg/l.

[2] Except the average of daily values for 30 consecutive days shall not exceed 10 mg/l and the maximum for any one day is 20 mg/l.

This percent reduction is based on lagooning and spray irrigation as a treatment system. However, a system specifically designed to remove dissolved and suspended explosive organics would be preferable. Therefore, for subcategories A, B and D, a system using filtration and activated carbon added to BPCTCA treatment system has been recommended for BATEA. In addition, treatment technology from the inorganic chemicals manufacturing point source category, the fertilizer manufacturing point source category and the petroleum refining point source category have been transferred to arrive at acceptable effluent limitations for TSS and O&G, respectively. In the case of subcategory C, chemical coagulation and filtration to BPCTCA treatment system has been recommended for BATEA. Laboratory and pilot plant investigations in the area of activated carbon (Table VII-1) have shown it to attain comparable percentages of removal.

BADCT Treatment Systems

Not enough information could be gathered to quantify BADCT from process changes in explosives manufacturing. Therefore, any recommendations made must be based on general experience in related industries. New explosive plants initiating production between now and 1983 should attain a level of treatment somewhere between BPCTCA and BATEA. It is recommended that for subcategories A, B and D dual-media filtration be used as an additional step after BPCTCA to comply with BADCT.

For subcategory C, a packaged dual-medai filtration system is recommended to be added to BPCTCA treatment system to comply with BADCT.

On the basis of information derived from the contractor's previous experience and EPA publications, the following percent reductions are used for dual-media filtration:

BADCT Effluent Reductions For Subcategories A, B and D

Parameter	Percent Reduction of BPCTCA Effluent
BOD_5	8.0
COD	13.0
TSS	60.0[1]

---

[1] Except the average of daily values for 30 consecutive days shall not exceed 20 mg/l and the maximum for any one day is 40 mg/l.

BADCT Effluent Reductions For Subcategory C

Parameter	Percent Reduction of BPCTCA Effluent
TSS	60[1]
Oil and Grease	80[2]

[1] Except the average of daily values for 30 consecutive days shall not exceed 20 mg/l and the maximum for any one day is 40 mg/l.

[2] Except the average of daily values for 30 consecutive days shall not exceed 10 m/gl and the maximum for any one day is 20 mg/l.

SECTION VIII

COST, ENERGY, AND NON-WATER QUALITY ASPECTS

General

In order to evaluate the economic impact of treatment on a uniform basis, end-of-pipe treatment models which will provide the desired level of treatment were proposed for each subcategory. In-plant control measures have not been evaluated because the cost, energy, and non-water quality aspects of in-plant controls are intimately related to the specific processes for which they are developed.

In the manufacture of a single product there is a wide variety of process plant sizes and unit operations. Many detailed designs might be required to develop a meaningful understanding of the economic impact of changes in process conditions, effluent limitations at the RWL's within the subcategories of explosives manufacturing, although many variations of technology and control can actually be used.

A design for an end-of-pipe treatment model has been provided, for costing purposes only. This model can be related directly to the range of influent hydraulic and organic loading within each subcategory, and the costs associated with these systems can be divided by the production rate for any given subcategory to show the economic impact of the system in terms of dollars per pound of product or per 1000 pounds of product. The actual combination of in-plant controls and end-of-pipe treatment used to attain the effluent limitations and guidelines presented in this document should be a decision made by the individual plant based generally upon economic considerations.

The major non-water quality consideration associated with in-process control measures is the means of ultimate disposal of wastes. As the volume of the process RWL is reduced, alternative disposal techniques such as incineration, pyrolysis and evaporation become more feasible. Recent regulations tend to limit the use of ocean discharge and deep-well injection because of the potential long-term detrimental effects associated with these disposal procedures. Incineration and evaporation are viable alternatives for concentrated waste streams. Considerations involving air pollution and auxiliary fuel requirements, depending on the heating value of the waste, must be evaluated individually for each situation.

Other non-water quality aspects such as noise levels will not be perceptibly affected by the proposed wastewater treatment systems. Equipment associated with in-process and end-of-pipe control systems would not add significantly to these noise levels.

Extensive annual and capital cost estimates have been prepared for the end-of-pipe treatment models to help evaluate the economic impact of the proposed effluent limitations guidelines. The capital costs were generated on a unit process basis (e.g., equalization, neutralization, etc.) and were used in the form of cost curves for all the proposed treatment systems. The particular cost curves used in the treatment models for explosives manufacturing are shown later in this section under paragraphs titled BPCTCA cost model and BATEA cost model. The following percentage figures were added on to the total unit process costs to develop the total capital cost requirements for all subcategories except subcategory C, which utilized a packaged treatment model for BPCTCA and BADCT:

Item	Percent of Unit Process Capital Cost
Electrical	14
Piping	20
Instrumentation	8
Site Work	6
Engineering Design and Construction Surveillance Fees	15
Construction Contingency	15

Land costs were computed independently and added directly to the total capital costs.

Annual costs were computed using the following cost basis:

Item	Cost Allocation
Capital Recovery plus Return	10 yrs at 10 percent
Operations and Maintenance	Includes labor and supervision, chemicals, sludge hauling and disposal, insurance and taxes (computed at 2 percent of the capital cost), and maintenance (computed at 4 percent of the capital cost).
Energy and Power	Based on $0.02/kw hr for electrical

power and 17¢/gal for grade 11 furnace oil.

The 10-year period used for capital recovery is that which is presently acceptable under current Internal Revenue Service regulations pertaining to industrial pollution control equipment.

The following is a qualitative as well as a quantitative discussion of the possible effects that variations in treatment technology or design criteria could have on the total capital costs and annual costs.

Technology or Design Criteria	Capital Cost Differential
1. Use aerated lagoons and sludge de-watering lagoons in place of the proposed treatment system.	1. The cost reduction could be 20 to 40 percent of the proposed figures.
2. Use earthen basins with a plastic liner in place of reinforced concrete construction, and floating aerators with permanent-access walkways.	2. Cost reduction could be 20 to 30 percent of the total cost.
3. Place all treatment tankage above grade to minimize excavation, especially if a pumping station is required in any case. Use all-steel tankage to minimize capital cost.	3. Cost savings would depend on the individual situation.
4. Minimize flows and maximize concentrations through extensive in-plant recovery and water conservation, so that other treatment technologies, e.g., incineration, may be economically competitive.	4. Cost differential would depend on a number of items, e.g., age of plant, accessibility to process piping, local air pollution standards, etc.

All cost data were computed in terms of August 1972 dollars, which corresponds to an Engineering News Records index (ENR) value of 1780. Current capital cost of the packaged treatment model for BPCTCA and BADCT for subcategory C have been reduced from an ENR index value of 2276 for 1975 back to a value of 1780 for 1972 in order to keep a consistent cost basis for all subcategories.

Explosives Manufacturing

This section provides quantitative cost information relative to assessing the economic impact of the proposed effluent limitations on explosives manufacturing.

In order to evaluate the economic impact on a uniform treatment basis, end-of-pipe treatment models were proposed based on design criteria that provide the desired level of treatment. A summary of the treatment models follow:

Technology Level	End-of-pipe Treatment Model
BPCTCA for subcategories A, B and D	Equalization, Neutralization, and Activated Sludge
BPCTCA for subcategory C	Extended Aeration Packaged Plant with Screening, Clarification, Skimming and Chlorination
BADCT for subcategories A, B and D	Equalization, Neutralization, Activated Sludge and Filtration
BADCT for subcategory C	Extended Aeration Packaged Plant with Screening, Clarification, Skimming and Chlorination plus Package Dual-Media Filtration
BATEA for subcategories A, B and D	Equalization, Neutralization, Activated Sludge, Filtration and Carbon Adsorption
BATEA for subcategory C	Extended Aeration Packaged Plant with Screening, Clarification, Skimming and Chlorination plus Package Dual-Media Filtration, Chemical Coagulation, and Carbon Adsorption.

The treatment technology shown above is intended to attain the effluent limitations and guidelines proposed.

Individual plants may attain effluent limitations guidelines through in-plant controls or by different end-of-pipe treatment than is shown. The decision is left up to the manufacturer to determine which is the most cost-effective.

BPCTCA Cost Models

To evaluate the economic effects of BPCTCA on explosives manufacturing, BPCTCA treatment models were developed. The treatment model is described in Table VIII-1. As shown in Figure VIII-1, there are two parallel treatment trains in the proposed system for subcategories A, B and D. This is to ensure operating flexibility and reliability. As shown in Figure VIII-1a, subcategory C has a single train treatment system, except for duplicate pumps. Treatment systems involving very low flow may not be able to use this parallel mode.

The following is a brief discussion of the treatment technology available and the rationale for the selection of the unit processes included in the described BPCTCA treatment system.

The topography of a particular plant site will dictate the type of pumping equipment required. Equalization facilities are provided for subcategories A, B and D in order to minimize short interval (e.g., hourly) fluctuations in the hydraulic loading to the treatment plant and to absorb organic sludge loads from reactor cleanouts and accidental spills and minimize the usage of neutralization chemicals. Equalization will provide continuous (seven days per week) operation of the wastewater treatment facilities even though the manufacturing facilities operate only five days a week. In the case of subcategory C, separate equalization facilities will not be required because of the small flow.

Since many of the explosives waste streams have extreme values of pH, neutralization is necessary. Alkaline neutralization is provided in the model system for subcategories A, B and D in the form of hydrated lime storage and feed facilities.

In the case of subcategories A, B and D, an activated sludge process was selected for the biological treatment portion of the system; however, for plants located in areas with available land space, aerated lagoons with clarification could provide a viable treatment alternative. For the purpose of cost estimates, activated sludge was selected. For subcategory C, an extended aeration packaged system was selected.

Table VIII-1

BPCTCA Treatment System Design Summary
Explosives Indusry

1. Subcategory A, B and D

Equalization

For plants with less than 24 hour/day and 7 day/week production, a minimum holding time of 1.5 days is provided with continuous discharge from the equalization basin over 24 hours.

For plants with less than 24 hour/day and 5 days/week production, two day equalization is provided. Discharge from the basin will be continuous over the seven days. For plants with 24 hour/day and 7 day/week batch production, one day holding capacity is provided. For continuous processes (24 hours/day, 7 days/week) no equalization is required except under special cases.

Protective liners are provided, based on the following criteria:

Influent pH	Type of Liner Required
Greater than 6	No Lining
Between 4.0 and 6.0	Epoxy Coating
Between 2.0 and 4.0	Rubber or Polypropylene
Below 2.0	Acid Brick Lining

Neutralization

The size of the two-stage neutralization basin is based on an average detention time of 10 minutes. Lime and acid handling facilities are sized according to acidity/alkalinity data collected during the survey. Bulk lime-storage facilities (20 tons) or bag storage is provided, depending on plant size. Sulfuric acid storage is either by 55-gallon drums or in carbon-steel tanks. Lime or acid addition is controlled by two pH probes, one in each basin. The lime slurry is added to the neutralization basin from a volumetric feeder. Acid is supplied by positive displacement metering pumps.

Primary Flocculation Clarifiers

Primary flocculator clarifiers with surface areas less than 1,000 square feet are rectangular units with a length-to-width ratio of 1 to 4. The side water depth varies from 6 to 8 feet and the overflow rate varies between 600 and 800 gpd/sq ft depending on plant size. Clarifiers with surface areas greater than 1,000 square feet are circular units. The side water depth varies from 7 to 13 feet and the overflow rate varies between 600 and 800 gpd/sq ft, depending on plant size. Polymer addition facilities are provided.

Table VIII -1
(continued)

Nutrient Addition

Facilities are provided for the addition of phosphoric acid to the biological system to maintain the ratio of BOD:N:P at 100:5:1.

Aeration Basin/Aerated Lagoons

The size of the aeration basins is based on historical treatability data collected during the survey. Mechanical surface aerators are provided.

The necessary design criteria for the aeration basins are:

Oxygen Utilization:	Energy	0.8 lbs O_2/lb BOD removed
Oxygen Utilization:	Endogenous	6 lbs O_2/hr/1,000 lbs MLVSS
α		0.75
β		0.90
Oxygen transfer		3.5 lbs O_2/hr/shaft HP at 20°C and zero D.O. in tap water
Motor Efficiency		85 percent
Minimum Basin D.O.		2 mg/L

Oxygen is monitored in the basins using D.O. probes.

Secondary Flocculator Clarifiers

The design basis for secondary flocculator clarifiers is the same as discussed previously for primary flocculator-clarifiers except for overflow rate. Secondary flocculator clarifiers are designed for an overflow rate of 600 gpd/sq ft. Feed facilities for anionic polymer addition are provided.

Sludge Thickener

The thickener provided was designed on the basis of a solids loading of 6 lbs/sq ft/day.

Aerobic Digester

The size of the aerobic digester was based on a hydraulic detention time of 20 days. The size of the aerator-mixers was based on an oxygen requirement of 1.6 lbs O_2/lb VSS destroyed and a mixing requirement of 165 HP/mg of digester volume.

Final Sludge Disposal

For small plants sludge is disposed of at a sanitary landfill. Sludge incineration facilities are provided for larger plants.

Table VIII - 1 (Continued)

BPCTCA Treatment

2. Subcategory C

General

Subcategory C generally includes two types of plants combined operation plants and stand alone mix plants. A combined operations plant is one located at the same site as the explosive manufacturing facilities, and the wastewater from this type of plant could be treated at the waste treatment plant for the manufacturing facilities.

For the stand alone mix plant separate waste treatment facilities will be required. This cost model is developed for that type of plant.

Extented Aeration Package Plant

The stand alone mix plant wastewaters are characterized as containing either high oil content (ANFO and NCN production) or high suspended solids content or both. The flow is small or intermittent therefore an extended aeration package plant which includes screening, biological treatment, clarification with skimming and chlorination has been selected. The sludge from the unit will be disposed at a certified landfill capable of handling such wastes.

Table VIII-2

BATEA and BADCT Treatment System Design Summary

Explosives Industry

Dual Media Filtration

Filters were sized using the criteria of 3 gpm/sq ft. Backwash rates used were 20 gpm/sq ft for 10 minute duration. In case of subcategory C chemical coagulation facility is included.

Carbon Adsorption

The unit is designed as a downflow fixed bed. Pretreatment for removal of suspended solids is provided so as to thwart clogging of the carbon column. Carbon contact time was set at 30 minutes. Hydraulic loading rates used were 4 gpm/sq ft. The spent carbon to be regenerated was calculated on a 0.5 lb of COD/lb carbon. The regeneration furnace itself was designed for 2.5 lbs/sq ft/hr.

The sludge handling scheme for subcategories A, B and D is shown in Figure VIII-1. The aerobic digester will produce a nonputrescible sludge which can be thickened and stored before being trucked to a certified landfill. For subcategory C, as the sludge quantity will be small, it will be trucked to a certified landfill.

It should be noted that the activated sludge process cost model cannot be justified for the dilute waste streams of subcategory C. However, since some load, assemble and pack operations are part of larger plant operations which include manufacturing activities in the other subcategories, activated sludge remains a viable technology for the combined wastes and the incremental cost for subcategory C becomes minimal in this case.

BATEA Cost Model

For the purpose of the economic evaluation of BATEA, it was necessary to formulate a BATEA waste treatment model (Table VIII-2). The model, composed of dual-media filters and activated carbon adsorption, is added on to the BPCTCA treatment system for subcategories A, B and D. The model for subcategory C consists of chemical coagulation and filtration added to the BPCTCA extended aeration packaged treatment system.

Dual-media filtration is intended to remove the suspended solids to avoid clogging of the activated carbon column. The down-flow fixed bed system was selected. Such regeneration of activated carbon has been a problem in TNT waste streams, however, these wastes will be part of a combined waste stream at an explosive plant and it is expected that activated carbon can be used with the combined wastes. Such development should be done by each plant to assure the most economical situations to achieve the necessary level of in-plant controls and end-of-pipe technology for pollution control. End-of-pipe technology is capable of attaining the recommended effluent limitations, guidelines and new source performance standards. To date, no studies have shown it to be a problem in composite waste streams.

BADCT Cost Model

For the purpose of the economic evaluation of BADCT, a cost model (Table VIII-2) was formulated consisting of dual-media filtration added to the BPCTCA treatment system for subcategories A, B and D. A packaged dual-media filtration

FIGURE VIII -1
COST MODEL
EXPLOSIVES INDUSTRY
BPCTCA WASTE TREATMENT MODEL
SUBCATEGORIES A, B, and D

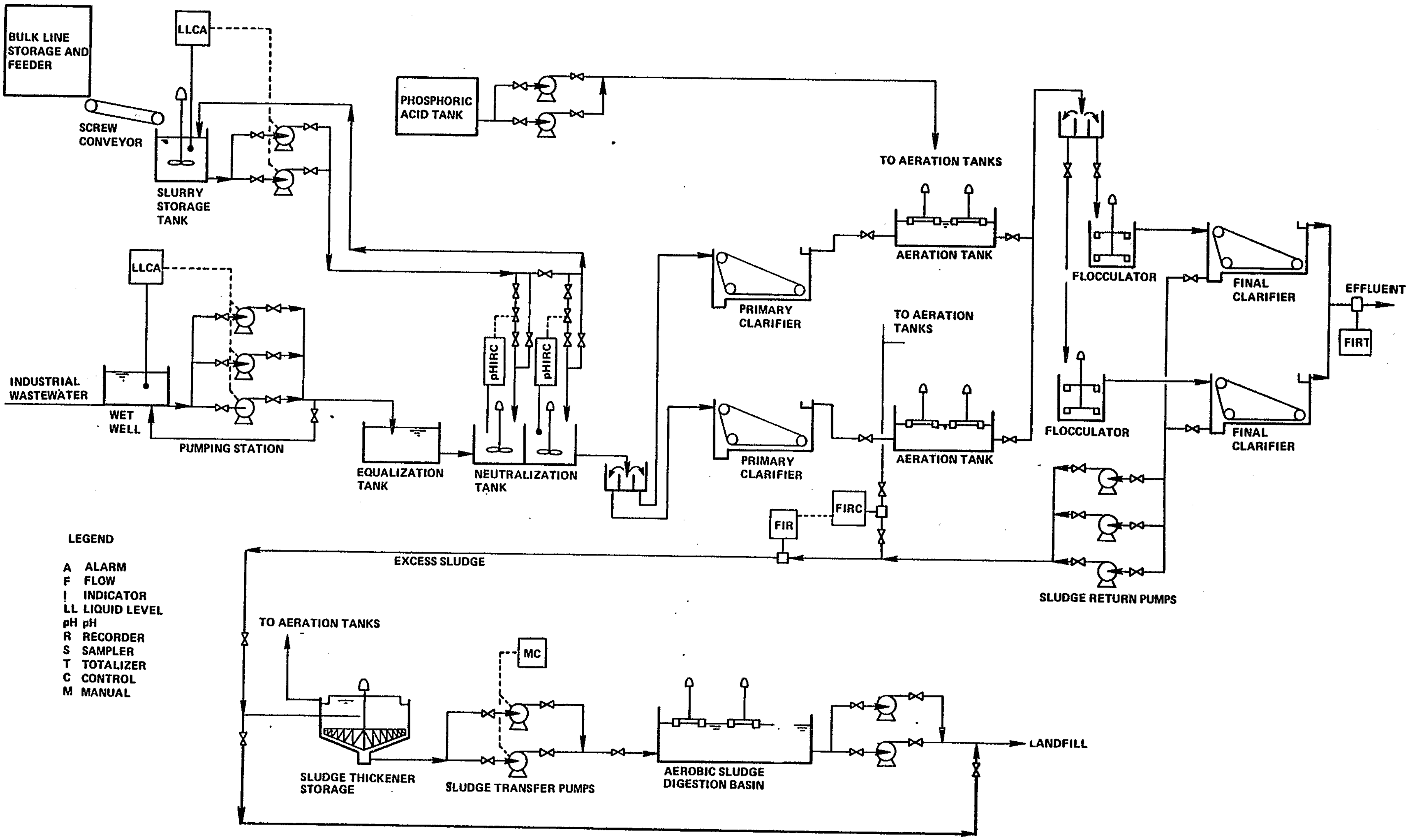


Figure VIII- 1a

BPCTCA and BADCT Cost Model for
Waste Treatment, Subcategory C

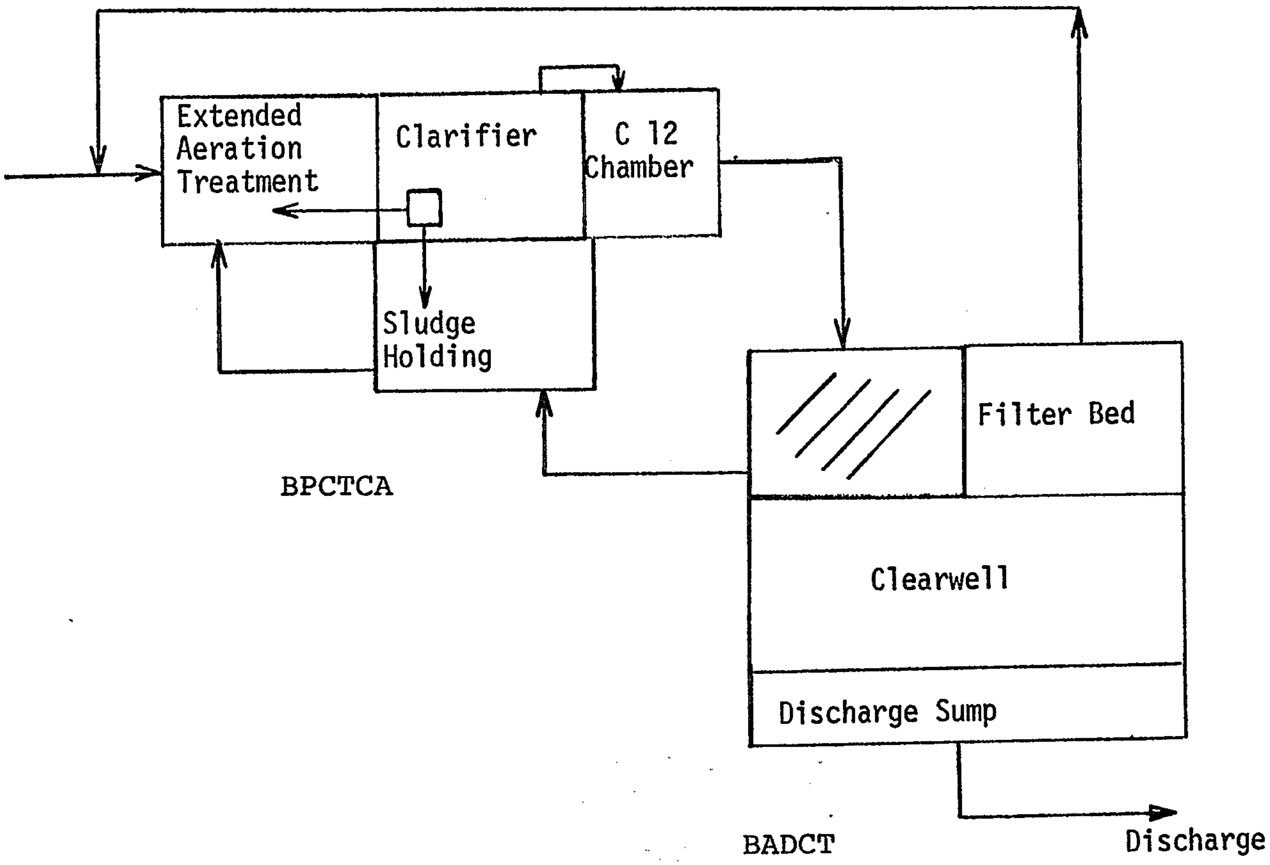
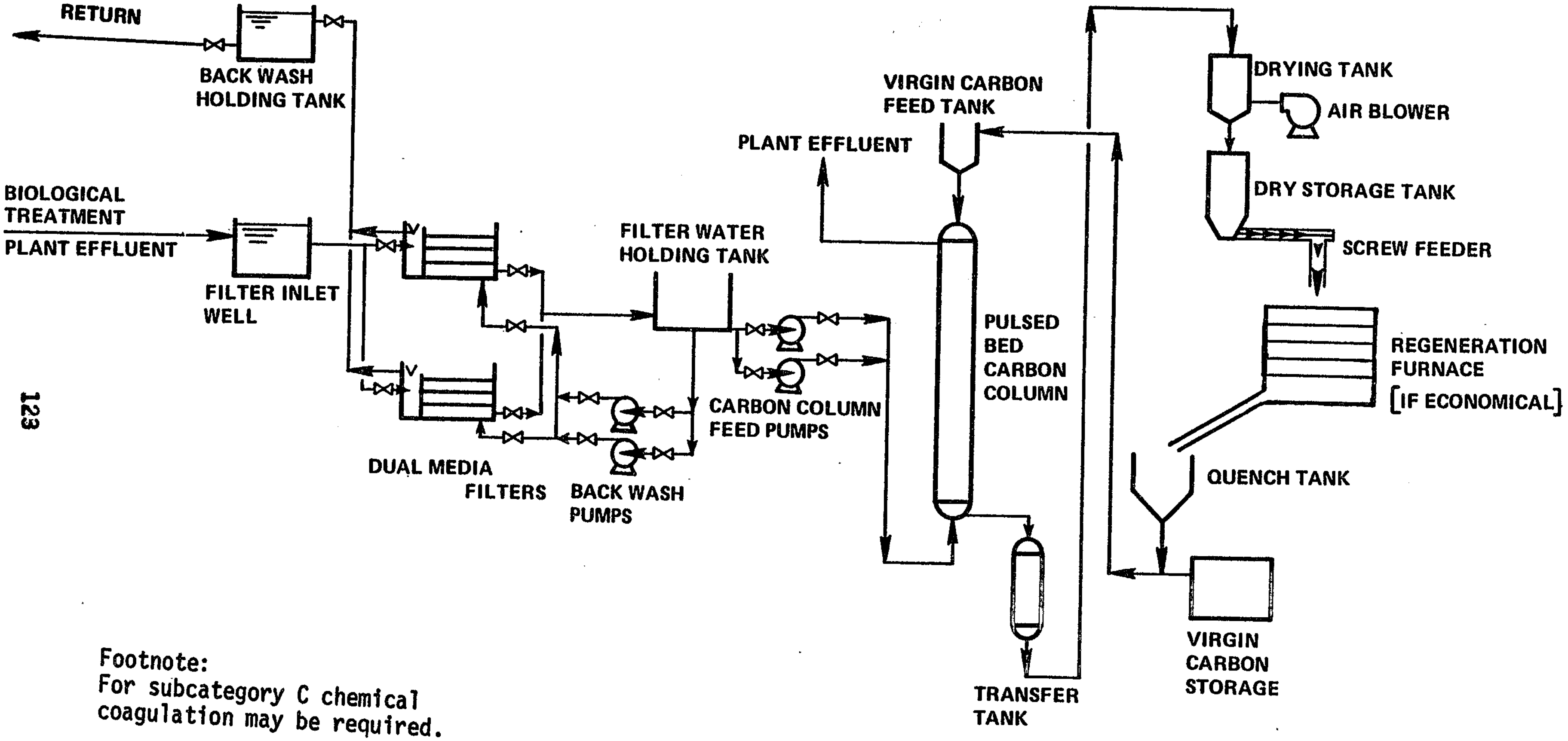


FIGURE VIII-2

EXPLOSIVES INDUSTRY
BATEA COST MODEL



Footnote:
For subcategory C chemical
coagulation may be required.

Table VIII-3

Wastewater Treatment Costs for BPCTCA, BADCT and BATEA Effluent Limitations (ENR 1780 - August, 1972 Costs)

Explosive Industry - Subcategory A

		RWL	Technology Level BPCTCA	 BADCT[2]	 BATEA[2]
Average Production	36.2 x 10^3 kg/day (79.6 x 10^3 lbs/day)				
Production Days	260				
Wastewater Flow - kL/Day	61				
(gpd)	(16,000)				
kL/1,000 kg Product		1.68			
(gal/1,000 lbs)		(201)			
BOD Effluent Limitation - kg BOD/1,000 kg product[3]		1.46	.10	.092	.028
mg/L[4]		871	61	55	17
COD Effluent Limitation - kg COD/1,000 kg product[3]		3.87	1.08	.94	.23
mg/L[4]		2310	647	560	137
Total Capital Costs			$ 192,000	$ 35,200	$108,000
Annual Costs					
Capital Recovery plus return at 10% at 10 years			$ 31,400	$ 5,800	$ 31,600
Operating + Maintenance			11,400	2,000	6,400
Energy + Power			3,000	-	-
Total Annual Cost			$ 45,800	$ 7,800	$ 38,000
Cost[1] $/1,000 kg Product			4.87	.83	4.04
($/1,000 lbs Product)			(2.21)	(.38)	(1.84)

[1] Cost based on total annual cost

[2] Incremental cost over BPCTCA cost

[3] kg/kkg product is equivalent to lbs/1,000 lbs product

[4] See Table V-3

system is added to the BPCTCA treatment system for subcategory C.

Cost

Capital and annual cost estimates were prepared for the previous end-of-pipe treatment models for all subcategories. The prepared cost estimates are presented in Tables VIII-3 through VIII-6. The costs presented in these tables are incremental costs for achieving each technology level.

For example, in Table VIII-3, the total capital cost for Subcategory A to attain BPCTCA effluent limitations is $192,000 for a plant producing an average of 79,600 pounds of explosives per day. The BPCTCA effluent limitations in Table VIII-3 were determined by using the reduction factors presented in Section VII, unless otherwise noted.

The incremental capital costs for achieving the recommended BADCT effluent limitations in Table VIII-3 would be $35,200 in addition to the capital investment made to achieve the BPCTCA effluent limitations. Similarly, the incremental capital cost for achieving the BATEA effluent limitations for subcategory A would be $108,000.

A discussion of the possible effects that variations in treatment technology or design criteria could have on capital and annual costs is presented earlier in this section.

Energy

The size ranges of the BPCTCA and BATEA treatment models preclude the application of some high-energy-using unit processes such as sludge incineration. Carbon regeneration will require significant amounts of energy; however, the overall impact on energy consumption should be minimal. Tables VIII-3 through VIII-6 also present the cost for energy and power for each treatment model for BPCTCA, BATEA and BADCT.

Non-water Quality Aspects

The major non-water quality aspects of the proposed effluent limitations and guidelines encompass ultimate sludge disposal and noise and air pollution.

The BPCTCA treatment model proposes land spreading of the digested biological sludge. If practiced correctly, this disposal method will not create health hazards or nuisance

Table VIII-4

Wastewater Treatment Costs for
BPCTCA, BADCT and BATEA Effluent Limitations
(ENR 1780 - August, 1972 Costs)

Explosive Industry - Subcategory B

		Technology Level			
		RWL	BPCTCA	BADCT[2]	BATEA[2]
Average Production	40.4 x 10^3 kg/day (89.1 x 10^3 lbs/day)				
Production Days	260				
Wastewater Flow - kL/Day	10,800				
(gpd)	(2,850,000)				
kL/1,000 kg Product		267			
(gal/1,000 lbs)		(32,000)			
BOD Effluent Limitation - kg BOD/1,000 kg product[3]		63.4	4.44	4.08	1.24
mg/L[4]		237	17	15	5
COD Effluent Limitation - kg COD/1,000 kg product[3]		118	33	29	6.9
mg/L[4]		442	124	108	26
Total Capital Costs			$5,080,000	$768,000	$2,290,000
Annual Costs					
Capital Recovery plus return at 10% at 10 years			$ 828,000	$125,000	$ 373,000
Operating + Maintenance			391,000	41,400	137,000
Energy + Power			110,000	-	-
Total Annual Cost			$ 1,329,000	$167,000	511,000
Cost[1] $/1,000 kg Product			127	15.9	48.6
($/1,000 lbs Product)			(57.5)	(7.23)	(22.1)

[1] Cost based on total annual cost

[2] Incremental cost over BPCTCA cost

[3] kg/kkg product is equivalent to lbs/1,000 lbs product

[4] See Table

Table VIII-5

Wastewater Treatment Costs for
BPCTCA, BADCT and BATEA Effluent Limitations
(ENR 1780 - August, 1972 Costs)

Explosive Industry - Subcategory C

		Technology Level		
	RWL	BPCTCA	BADCT[2]	BATEA[2]
Average Production 14.8 X 10^3 kg/day (32.6 X 10^3 lbs/day)				
Production Days 260				
Wastewater Flow - kL/Day 26 (gpd) (6,810)				
kL/1,000 kg Product	1.76			
(gal/1,000 lbs)	(211)			
BOD Effluent Limitation - kg BOD/1,000 kg product[3]	.0005	**	**	.00014
mg/L	less than 1	**	**	less than 1
COD Effluent Limitation - kg COD/1,000 kg product[3]	.08	**	**	.017
mg/L	45	**	**	10
TSS Effluent Limitation - kg TSS/1,000 kg product[3]	0.92			
mg/L	523	50 mg/L	20 mg/L	10 mg/L
Total Capital Costs		$14,300	$24,100	$117,000
Annual Costs				
Capital Recovery plus return at 10% at 10 years		$ 2,350	$ 3,910	$ 19,100
Operating + Maintenance		$ 3,360	$ 1,250	$ 14,100
Energy + Power		700	550	----
Total Annual Cost		$ 6,410	$ 5,710	$ 33,200
Cost[1] $/1,000 kg Product		1.67	1.49	8.63
($/1,000 lbs Product)		(.76)	(.67)	(3.92)

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[1] Cost based on total annual cost
[2] Incremental cost over BPCTCA cost
[3] kg/kkg product is equivalent to lbs/1,000 lbs product
**No limitation has been set

Table VIII -6

Wastewater Treatment Costs for BPCTCA, BADCT and BATEA Effluent Limitations (ENR 1780 - August, 1972 Costs)

Explosive Industry - Subcategory D

Average Production 0.01 x 10^3 kg/day
(.023 x 10^3 lbs/day)

Production Days 260

Wastewater Flow - kL/Day 9
(gpd) (2,400)

		Technology Level		
	RWL	**BPCTCA**	**BADCT[2]**	**BATEA[2]**
Wastewater Flow - kL/1,000 kg Product	873			
(gal/1,000 lbs)	(105,000)			
BOD Effluent Limitation - kg BOD/1,000 kg product[3]	1170	81.9	75.3	22.9
mg/L	1340	94	86	26
COD Effluent Limitation - kg COD/1,000 kg product	6290	1760	1530	370
mg/L	7210	2020	1760	424
Total Capital Costs		$ 395,000	$ 18,200	$135,000
Annual Costs				
Capital Recovery plus return at 10% at 10 years		$ 64,400	$ 3,000	$ 21,900
Operating + Maintenance		31,400	1,300	13,200
Energy + Power		100	-	-
Total Annual Cost		95,900	$ 4,300	$ 35,100
Cost[1] $/1,000 kg Product		36,900	1,650	13,500
($/1,000 lbs Product)		(16,800)	(751)	(6,140)

[1] Cost based on total annual cost

[2] Incremental cost over BPCTCA cost

[3] kg/kkg product is equivalent to lbs/1,000 lbs product

conditions. The possibility of trace explosives leaching into groundwater reservoirs can be minimized by carefully controlled sludge application. The following are summaries of the sludge quantities from proposed BPCTCA and BATEA treatment facilities:

Subcategory	Biological Sludge Quantity lbs/day[1]
A	17,600
B	33,000
C	30
D	480

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[1] Based on solids concentration (dry weight basis)

Noise levels will not be appreciably affected with the implementation of the proposed treatment models. Air pollution should only be a consideration if liquid incineration were selected as the waste disposal alternative.

SECTION IX

BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE (BPCTCA)

Explosives Manufacturing

The effluent limitations and guidelines for BPCTCA for explosives manufacturing point source category were developed from the information contained in Sections IV to VIII of this document. The limitations are expressed in terms of allowable pounds of pollutant per 1,000 pounds of products. The effluent limitations guidelines are based on pollutant reductions that can be achieved in this point source category at the present time.

For subcategories A, B and D, the treatment system consists of: equalization, neutralization, primary sedimentation, aeration basin, final clarification, and sludge handling facilities. For subcategory C, the treatment system consists of a packaged extended aeration plant which includes screening, biological treatment, clarification with skimming and chlorination. Subcategories C and D, however, may choose to limit their effluent by other means. Subcategory C, with a low flow of 6,800 gallons per day and moderate strength concentration, could eliminate all wastewater flow in many cases. Averaging only 2,520 gallons per day, subcategory D, with its concentrated waste, may find other pollution control approaches to be the most cost-effective solution. Subcategory C could, by employing dry clean-up and more careful operations, reduce its waste load to a level where it would be feasible to drum all wastes and ship them to a regional treatment center.

As indicated in Section VII, the following treatment levels, based on historical data, were selected for the determination of BPCTCA effluent limitations and guidelines for subcategories A, B and D:

Parameter	Average Percent Removal of RWL	Concentration Limitation
BOD_5	93	-
COD	72	-
TSS[1]	--	50 mg/l

[1] Except the average of the daily values for 30 consecutive days shall not exceed 50 mg/l and the maximum for any one day is 150 mg/l.

For subcategory C, the BPCTCA effluent limitations are selected as:

Parameter	Average[1] Percent Removal of RWL	Concentration Limitation
TSS[2]	--	50 mg/l
Oil and Grease[3]	--	100 mg/l

[1] Treatment technology from the inorganic chemicals manufacturing point source category, the fertilizer manufacturing point source category and the petroleum refining point source category have been transferred to this subcategory for these two parameters.

[2] Except the average of daily values for 30 consecutive days shall not exceed 50 mg/l and the maximum for any one day is 150 mg/l.

[3] Limitations on oil and grease are given for subcategory C only since it is expected that this pollutant will be significant only in this subcategory. In this case, the average of daily values for 30 consecutive days shall not exceed 20 mg/l and the maximum for any one day is 60 mg/l for O&G.

Note that although NO_3-N can be in certain instances a significant problem in this industry, no effluent limitation at this time has been prescribed, due to the limited data base available. An effluent limitation on NO_3-N is desirable if there is a public water supply a short distance from the industry discharge or if specific eutrophication problems may result. These conditions do not occur as a result of all explosive manufacturing discharges, and is no way of assuring that a munitions plant is significantly close it is recommended that nitrate limitations be governed by local conditions.

Application of these removal rates to the RWL produces the BPCTCA effluent limitations and guidelines shown in Table IX-1, unless otherwise noted.

It should be understood that the effluent limitations and guidelines are to be applied to individual subcategories. The information required to do this is:

1. The identity of the manufacturing process, so that it can be subcategorized.
2. The production rate, so that the specific effluent limitation can be calculated.

Table IX-1

BPCTCA Effluent Limitations Guidelines

Explosives Manufacturing

					BPCTCA (1977)			Effluent Limitations					
		Raw Waste Load (RWL)			Long-Term Average Daily Effluent			Average of Daily Values for 30 Consecutive Days Shall Not Exceed			Maximum for Any One Day		
Subcategories	Flow L/kkg Product (gal/1,000 lb)	Parameter	kg/kkg[1]	mg/L	Parameter	kg/kkg[1]	mg/L	Parameter	kg/kkg[1]	mg/L	Parameter	kg/kkg[1]	mg/L
Subcategory A Manufacture of Explosives	1,680 (201)	BOD$_5$	1.46	871	BOD$_5$	0.10	61	BOD$_5$	.24	-	BOD$_5$	0.72	-
		COD	3.87	2,310	COD	1.08	647	COD	2.59	-	COD	7.77	-
		TSS	1.16	690	TSS	-	**	TSS	.084	50	TSS	0.25	150
Subcategory B Manufacture of Propellants	267,000 (32,000)	BOD$_5$	63.4	237	BOD$_5$	4.44	17	BOD$_5$	10.7	-	BOD$_5$	32.1	-
		COD	118	442	COD	33	124	COD	79.2	-	COD	237.6	-
		TSS	64.6	242	TSS	-	**	TSS	13.3	50	TSS	40.0	150
Subcategory C Load and Pack Operations	1,760 (211)	BOD$_5$	.0005	<1	BOD$_5$	*	-	BOD$_5$	*	-	BOD$_5$	*	-
		COD	.08	45	COD	*	-	COD	*	-	COD	*	-
		TSS	.092	523	TSS	-	**	TSS	0.089	50	TSS	0.27	150
		O&G	-	-	O&G	-	**	O&G	0.035	20	O&G	0.11	60
Subcategory D Manufacture of Initiators	873,000 (105,000)	BOD$_5$	1,170	1,340	BOD$_5$	81,9	94	BOD$_5$	197	-	BOD$_5$	591	-
		COD	6.290	7,210	COD	1,760	2,020	COD	4,220	-	COD	12660	
		TSS	49.0 -	56	TSS	-	**	TSS	43.8	50	TSS	131	150

[1] kg/kkg production is equivalent to lbs/1,000 lbs product

*No limitation has been set

**Due to a limited data base in this category and the achievable level by the proposed cost model, the effluent limitations for TSS and O&G have been established by transfer of technology from the Fertilizer Chemicals and Petroleum Refining Point Source Categories, respectively.

The actual effluent limitations and guidelines would be applied directly only to a plant whose manufacturing processes fall within a single subcategory. In the case of multi-subcategory plants, the effluent limitations and guidelines to be placed upon a plant would represent a production-weighted sum of the individual effluent limitations and guidelines applied to each of its subcategory operations. This building block approach allows the guidelines to be applied to any facility regardless of its products.

It is anticipated that local conditions will control discharges of nitrates and sulfates. Because of this, nitrates and sulfates are not addressed in this discussion of BPCTCA treatment technology. Because of technology transfer from other point source categories indicated in the above footnotes and due to an insufficient data base for variability verification, a performance factor of three is used.

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BATEA)

Explosives Manufacturing

The BATEA effluent limitations and guidelines for the explosives manufacturing point source category presented below have been developed from the best available technology presently operating in the field. Historical data from other industries and situations in which filtration and carbon adsorption was applied and used to develop the guidelines. For subcategories A, B and D, the BATEA treatment focuses on filtration and carbon adsorption. For subcategory C, the BATEA treatment consists of chemical coagulation, filtration and activated carbon in addition to the BPCTCA treatment system. Published findings such as EPA and contractors studies and continuing pilot plant work in the field generally support the biodegradation of most explosives. Those explosives that are resistant to biodegradation will be removed by carbon adsorption.

BATFA Effluent Limitations Guidelines

	Parameter	Percent Removal of BPCTCA Effluent
	BOD_5	72
	COD	79
	TSS[1]	60
(Subcategory C only)	Oil and Grease[2]	80

[1] Except the effluent limitation for the average of daily values for 30 consecutive days shall not exceed 10 mg/l and the maximum for any one day is 20 mg/l.

[2] Limitations on oil and grease are given for subcategory C only since it is expected that this pollutant will be significant only in this subcategory. The average of daily values for 30 consecutive days shall not exceed 10 mg/l and the maximum for any one day is 20 mg/l.

Application of these removal rates to BPCTCA effluent waste loads is shown in Table X-1.

Table X-1

BATEA Effluent Limitations Guidelines

Explosives Manufacturing

Subcategories	Flow	BPCTCA Long-Term Average Daily Effluent			BATEA (1983) Long-Term Average Daily Effluent			Effluent Limitations: Average of Daily Values for 30 Consecutive Days Shall Not Exceed			Effluent Limitations: Maximum for Any One Day		
	L/kkg Product (gal/1,000 lbs)	Parameter	kg/kkg[1]	mg/L	Parameter	kg/kkg[1]	mg/L	Parameter	kg/kkg	mg/L	Parameter	kg/kkg	mg/L
Subcategory A Manufacture of Explosives	1,680 (201)	BOD$_5$	0.10	61	BOD$_5$	0.028	17	BOD$_5$	.067	-	BOD$_5$	0.11	-
		COD	1.08	647	COD	0.23	137	COD	.55	-	COD	.85	-
		TSS	-	**	TSS	-	**	TSS	.017	10	TSS	.034	20
Subcategory B Manufacture of Propellants	267,000 (32,000)	BOD$_5$	4.44	17	BOD$_5$	1.24	5	BOD$_5$	2.98	-	BOD$_5$	4.71	-
		COD	33	124	COD	6.90	26	COD	16.6	-	COD	26.3	-
		TSS	-	**	TSS	-	**	TSS	2.67	10	TSS	5.34	20
Subcategory C Load and Pack Operations	1,760 (211)	BOD$_5$	*	-	BOD$_5$	.00014	<1	BOD$_5$	0.00034	-	BOD$_5$	.00053	-
		COD	*	-	COD	.017	10	COD	.041	-	COD	.065	-
		TSS	-	**	TSS	-	**	TSS	.035	20	TSS	.07	40
		O&G	-	**	O&G	-	**	O&G	.018	10	O&G	.035	20
Subcategory D Manufacture of Initiators	873,000 (105,000)	BOD$_5$	81.9	94	BOD$_5$	22.9	26	BOD$_5$	55	-	BOD$_5$	87	-
		COD	1,760	2,020	COD	370	424	COD	888	-	COD	1,410	-
		TSS	-	**	TSS	-	**	TSS	8.76	10	TSS	17.5	20

[1] kg/kkg is equivalent to lb/1,000 lbs production.

*No limitation has been set

**Due to a limited data base in this category and the achievable level by the proposed cost model, the effluent limitations for TSS and O&G have been established by transfer of technology from the Fertilizer Chemicals and Petroleum Refining Point Source Categories, respectively.

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS
(BADCT)

General

The term "new source" is defined in the "Federal Water Pollution Control Act Amendments of 1972" to mean "any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance". Technology applicable to new sources shall be the Best Available Demonstrated Control Technology (BADCT), defined by a determination of what higher levels of pollution control can be attained through the use of improved production process and/or wastewater treatment techniques. Thus, in addition to considering the best in-plant and end-of-pipe control technology, BADCT technology is to be based upon an analysis of how the level of effluent may be reduced by changing the production process itself for the explosives manufacturing point source subcategories.

Explosives Manufacturing

BADCT is based upon the utilization of in-plant controls and filtration as an addition to BPCTCA end-of-pipe processes. In the case of subcategory C, a packaged dual-media filtration system will be required to be added to BPCTCA treatment. The BADCT limitations presented in Section VII were developed on the basis of the contractor's previous experience and EPA publications on the efficiency of a filter, unless otherwise noted. The wastewater load reductions are presented below. Application of these removal rates to BPCTCA effluent production loads is shown in Table XI-1.

New Source Performance Standards
For Subcategories A, B and D

Parameter	Percent Reduction of BPCTCA Effluent
BOD5	8
COD	13
TSS[1]	60

Table XI- 1

New Source Performance Standards

Explosives Manufacturing

Subcategories	Flow	BPCTCA Long-Term Average Daily Effluent			BADCT Long-Term Average Daily Effluent			New Source Performance Standards					
								Average of Daily Values for 30 Consecutive Days Shall Not Exceed			Maximum for Any One Day		
	L/kkg Product (gal/1,000 lbs)	Parameter	kg/kkg[1]	mg/L	Parameter	kg/kkg[1]	mg/L	Parameter	kg/kkg[1]	mg/L	Parameter	kg/kkg[1]	mg/L
Subcategory A Manufacture of Explosives	1,680	BOD_5	0.10	61	BOD_5	0.092	55	BOD_5	0.22	--	BOD_5	.35	--
	(201)	COD	1.08	647	COD	0.94	560	COD	2.3	--	COD	3.6	--
		TSS	--	**	TSS	--	**	TSS	.034	20	TSS	.067	40
Subcategory A Manufacture of Propellants	267,000	BOD_5	4.44	17	BOD_5	4.08	15	BOD_5	9.79	--	BOD_5	15.5	--
	32,000	COD	33	124	COD	29	108	COD	69.6	--	COD	110	--
		TSS	--	**	TSS	--	**	TSS	5.34	20	TSS	10.7	40
Subcategory C Load and Pack Operations	1,760	BOD_5	*	-	BOD_5	*	-	BOD_5	*	--	BOD_5	*	--
	(211)	COD	*	-	COD	*	-	COD	*	--	COD	*	--
		TSS	--	**	TSS	--	**	TSS	.035	20	TSS	.07	40
		O&G	--	**	O&G	--	***	O&G	.018	10	O&G	.035	20
Subcategory D Manufacture of Initiators	873,000	BOD_5	81.9	94	BOD_5	75.3	86	BOD_5	181	--	BOD_5	286	--
	105,000	COD	1,830	2,020	COD	1,530	1,760	COD	3,670	--	COD	5,810	--
		TSS	--	**	TSS	--	**	TSS	17.5	20	TSS	35	40

[1] kg/kkg is equivalent to lb/1,000 lbs production

*No limitation has been set

**Due to a limited data base in this category and the achievable level by the proposed cost model, the effluent limitations for TSS and O&G have been established by transfer of technology from the Fertilizer Chemicals and Petroleum Refining Point Source Categories, respectively.

[1] Except the average of daily values for 30 consecutive days shall not exceed 20 mg/l and the maximum for any one day is 40 mg/l.

It was anticipated that, for this level of treatment, significant reduction of hydraulic loading will be implemented by application of good water management practices.

New Source Performance Standards
For Subcategory C

Parameter	Percent Reduction of BPCTCA Effluent
TSS[1]	60
Oil and Grease[2]	80

[1] Except the average of daily values for 30 consecutive days shall not exceed 20 mg/l and the maximum for any one day is 40 mg/l.

[2] Limitations on oil and grease are given for subcategory C only since it is expected that this pollutant will be significant only in this subcategory. The average of daily values for 30 consecutive days shall not exceed 10 mg/l and the maximum for any one day is 20 mg/l.

SECTION XII

PRETREATMENT GUIDELINES

General

Pollutants from specific processes within this category may interfere with, pass through, or otherwise be incompatible with publicly owned treatment works (municipal system). The following section examines the general wastewater characteristics and the pretreatment unit operations which may be applicable to the explosives manufacturing point source category.

Explosives Manufacturing

A review of the wastewater characteristics of explosives manufacturing indicates that the process wastewaters contain high concentrations of soluble oxygen-demanding materials, varied ranges of suspended solids, nitrates, sulfates, organic nitrogen and carbon, metals, and trace quantities of explosives.

The scope of this study did not allow for a specific toxicity evaluation of explosives wastewaters. However, all but the last two parameters listed above appear to be amenable to secondary treatment.

Metals such as lead and mercury have been shown to be discharged in quantities sufficient to disrupt biological activity. In one field investigation in subcategory D, lead discharges were found in concentrations of 200 mg/l. This makes physical/chemical precipitation mandatory as a pretreatment step, where such concentrations and other inhibitory concentrations are found.

Trace quantities of explosives may present a significant problem for a municipal sewage treatment system because of their toxicity and hazardous nature. However, a pretreatment system can be designed to ensure that toxicity and safety hazards are eliminated. The system would have to ensure that a slug of explosive material from an emergency discharge could never enter the municipal system. Such a system would consist of the following unit operations: equalization, chemical precipitation of metals, and neutralization.

Since oil and grease (O&G) in high concentrations can be disruptive to municipal sewage treatment systems under certain circumstances, a pretreatment standard of 100 mg/l for O&G is set for all subcategories in the explosives point source category.

SECTION XIII

PERFORMANCE FACTORS FOR TREATMENT PLANT OPERATIONS

General

All of the factors that bring about variations in treatment plant performance can be minimized through proper dosing and operation. Variations in the performance of wastewater treatment plants are attributable to one or more of the following:

1. Variations in sampling techniques.
2. Variations in analytical methods.
3. Variations in one or more operational parameters, e.g., the organic removal rate by the biological mass, settling rate changes of biological sludge.
4. Controllable changes in the treatability characteristics of the process wastewaters even after adequate equalization.
5. Controllable fluctuations in the volume of contaminated storm runoff.
6. Prevention of contamination by segregation of storm runoff from process wastewaters.
7. Differences in the design and operation of holding systems to average out the influent before allowing it into the treatment system.
8. Disparities in spill prevention programs.
9. Inattention to the effects of cycled production scheduling and avoidable start-ups and shut-downs.
10. Negligence in the design and choice of the type of treatment system which can minimize climatic effects.
11. Lack of prudent measures to prevent the introduction of chemicals which are likely to inhibit the treatment processes.

All of these above mentioned items can be designed and/or scheduled for in a well-designed and properly operated wastewater treatment plant.

Explosives Manufacturing

Variability in historic effluent data from an exemplary biological treatment plant treating propellant wastes was statistically analyzed. The results of this analysis are shown below. Ratios of the 95 percent probability of occurrence to the 50 percent probability of occurrence were computed for this plant, with the average of the daily and monthly BOD and COD ratios as follows:

Parameter	Performance Factor for Maximum Monthly Effluent Value	Performance Factor for Maximum Daily Effluent Value
BOD5	2.4	3.8
COD	2.4	3.8

Variability in Biological Waste Treatment Systems

In the past, effluent requirements for wastewater treatment plants have been related to the achievement of a desired treatment efficiency based on long term performance. There are, however, factors that affect the performance and hence the effluent quality or treatment efficiency over the short term, such that short term performance requirements cannot be taken directly from the longer term data. Knowledge of these factors must be incorporated in the development of effluent limitations and in decisions of whether a treatment plant is in compliance with the limitations.

The effluent limitations promulgated by EPA and developed in this document include values that limit both long term and short term waste discharges. These restrictions are necessary to assure that deterioration of the nation's waters does not occur on a short term basis due to heavy intermittent discharges, even though an annual average may be attained. Because technology transfer has been used and because the data base supporting the variability is limited, a factor of three is employed to set the maximum day limitation rather than the ratio of approximately two for maximum day limitation to maximum 30 day limitation shown above.

Some of the controllable causes of variability and techniques that can be used to minimize their effect include:

A. Storm Runoff

Storm water holding or diversion facilities should be designed on the basis of rainfall history and area being drained. The collected storm runoff can be drawn off at a constant rate to the treatment system. The volume of this contaminated storm runoff should be minimized through segregation and the prevention of contamination. Storm runoff from outside the plant area, as well as uncontaminated runoff, should be diverted around the plant or contaminated area.

B. Flow Variations

Manufacturing process upsets and raw waste variations can be reduced by properly sized equalization units. Equalization is a retention of the wastes in a suitably designed and operated holding system to average out the influent before allowing it into the treatment system.

C. Spills

Spills of certain materials in the plant can cause a heavy loading on the treatment system for a short period of time. A spill may not only cause higher effluent levels as it goes through the system, but may inhibit a biological treatment system and therefore have longer term effects. Equalization helps to lessen the effects of spills. However, long term reliable control can only be attained by an aggressive spill prevention and maintenance program including training of operating personnel. Industrial associations such as the Manufacturing Chemists Association have developed guidelines for prevention, control and reporting of spills. These note how to assess the potential of spill occurrence and how to prevent spills. Each explosives manufacturing plant should be aware of the MCA report and institue a program of spill prevention using the principles described in the report. If every plant were to use such guidelines as part of plant waste management control programs, its raw waste load and effluent variations would be decreased or entirely eliminated.

D. Start-up and Shut-down

These periods should be reduced to a minimum and their effect dampened through the use of equalization facilities. At start-up, a good practice is to haul in a tank truck of sludge from an efficiently operated activated sludge wastewater treatment plant.

E. Climatic Effects

The design and choice of type of a treatment system should be based on the climate at the plant location so that this effect can be minimized. Where there are severe seasonal climatic conditions, the treatment system should be designed and sufficient operational flexibility should be available so that the system can function effectively.

F. Treatment Process Inhibition

Chemicals likely to inhibit the treatment processes should be identified and prudent measures taken to see that they do not enter the wastewater in concentrations that may result in treatment process inhibition. Such measures include the diking of a chemical use area to contain spills and contaminated wash water, using dry instead of wet clean-up of equipment, and changing to non-inhibiting chemicals.

The common indicator of the pollution characteristics of the discharge from a plant historically has been the long-term average of the effluent load. However, the long-term (yearly) average is not the only parameter on which to have an effluent limitation. Shorter term averages also are needed, both as an indication of performance and for enforcement purposes.

Wherever possible, the best approach to develop the annual and shorter term limitations is to use historical data from the industry or production line in question. If enough data is available, the shorter term limitations can be developed from a detailed analysis of the hourly, daily, weekly, or monthly data. Rarely, however, is there an adequate amount of short term data. However, using data which show the variability in the effluent load, statistical analyses can be used to compute short term limits (30 day average or daily) which should be attained, provided that the plant is designed and run in the proper way to achieve the desired long term average load. These analyses can be used to establish variability factors for effluent limitations or to check those factors that have been developed.

For the significant organic products segment of the organic chemicals manufacturing point source category, EPA has used a data base consisting of 21 organic chemicals, plastics and petrochemical plant performance data, to establish daily maximum and monthly average variability factors of 3.9 and 2.1, respectively. The performance factors for BOD5 and COD used for the explosives manufacturing point source category are 3.8 for the maximum daily and 2.4 for the maximum monthly as shown below. While these plants make different products, Agency analysis revealed that they can be grouped because the treatment plant characteristics and response to flow and constituent variables, for example, are similar.

The data base upon which EPA's variability factors are based is the most extensive available. Commenters on these and prior EPA Development Documents have suggested no other source of information on which to base BOD5 or COD variability factor calculation. While it is known that the behavior of waste characteristics such as COD is not precisely the same as BOD_5 in variations of effluent, and that use of different treatment techniques can alter expected variations, there are no data sources for COD which can be used to generate separate variability numbers. If anyone has more or better information available, the Agency will readily consider it. For these reasons, EPA has used factors of 2.4 and 3.8 for both BOD_5 and COD pollutant parameters, for regulations covering BATEA and new sources in the explosives manufacturing point source category. For existing plants, EPA has used a factor of 3 for BPCTCA even though the data indicates a ratio of approximately 2 between the maximum day limitation and the maximum 30 day limitation from the limited data in hand.

For lack of data, variability in suspended solids could not be developed by historical means. Because of the similarity of their treatment systems employed, batch type operation and related organic chemical reactions TSS variability for explosives manufacturing was assumed to be similar to the inorganic chemicals manufacturing point source category and the fertilizer manufacturing point source category.

For oil and grease, the same factor of 3 was used to develop the BPCTCA maximum day limitations for all the explosives subcategories.

These factors were applied to develop the effluent limitations and guidelines presented in Sections II, IX, X, and XI.

SECTION XIV

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SECTION XV

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SECTION XVI

GLOSSARY

Explosives Manufacturing

AAP Abgreviation for Army Ammunition Plant which usually starts with a fourth capitalized letter when referring to a particular facility. For example, the Radford plant is identified as RAAP.

Alpha TNT. This is the symmetrical isomer form, 2, 4, 6-TNT and is the desired isomer for use in explosives manufacturing end products.

Aluminum. Metal used to increase the energy of a propellant and explosive.

Bagasse. Plant residue used to bind explosives.

Ball Powder. Small arms powder made by emulsifying a mixture of propellant and solvent in a liquid in which they are not soluble. Evaporation of the emulsifying liquid and the solvent yields quite uniform round balls of powder.

Binder. In composition propellant, the solid matrix in which the granular ingredients are held.

Booster Charge. A charge that is ignited by the electric match and, in turn, initiates combustion or detonation in the propellant.

Building Block Technique. A method of allocating effluent limitations guidelines to multi-subcategory plants where the effluent limitations guidelines for that given plant would represent a production-weighted sum of effluent limitations guidelines which apply to each specific subcategory.

Carpet Rolls. Rolled powder sheets are cut into strips which subsequently are rolled into rolls in the manner of rolling up a carpet, thus the term "carpet roll." Carpet rolls of the proper size and weight are used as the charge in a solventless extrusion press.

Casting Powder. Small particles of powder used in formulating cast propellant grains; contains nitrocellulose, stabilizer, plasticizer, and usually nitroglycerin.

Cellulose. Commonly thought of as a fibrous material of vegetable origin.

Deterrent. A propellant additive that reduces the burning rate.

Detonation. The very rapid decomposition of an explosive. The reaction is propagated by a shock wave rather than by heating the area near to the flame.

DNT. Dinitrotoluene. Added as a deterrent to propellant grains; reduces burning rate.

Double Base. A propellant which is made from two explosive substances, e.g., nitroceullulose, gelatinized with nitroglycerin.

Double-Base Propellant. A propellant containing two energy-giving ingredients; nitrocellulose and nitroglycerin.

Electric Match. A bead of easily-ignited explosives formed on a thin wire used as an igniter.

Explosives. A substance (mixture) capable of rapid conversion into more stable products, with the liberation of heat and usually the formation of gases.

Extruded Propellant. Any propellant made by pressing solvent-softened or gelatinized nitrocellulose through a dye to form grains.

Grain. A single piece of formed propellant, regardless of size.

"Green". Describes a batch of cotton that was not given enough time to fully nitrate, or a cost grain not yet fully cured.

Hydroscopic. Water adsorbing.

Hypergolic. Two substances which will self-ignite on contact.

Igniters. Any device used to ignite a propellant.

Inhibitor. A coating on a propellant grain which prevents burning at that point.

Metal Modifiers. Metals used in explosvies or propellants to modify their property, e.g., aluminum increases the energy of an explosion.

MNT, DNT (Mononitrotoluene, Dinitrotoluene). Intermediate products formed during the manufacture of TNT. DNT is also used in the formulation of single-base propellants.

Modifier. A substance added to a propellant to reduce the dependence of burning rate on pressure.

NAC (Nitric Acid Concentrator). A distillation process which concentrates weak nitric acid (sixty percent) to strong nitric acid (ninety-eight percent).

Nitrocellulose. A basic ingredient used in propellant manufacturing, made by nitrating woodpulp or cotton fibers with mixed acid.

Nitroglycerin. A colorless highly explosive oil which is a nitration product of glycerin. Nitroglycerin or NG, as it is frequently called, is a principal constituent of dynamite and certain propellants (rocket grains). NG is extremely sensitive to impact and freezes at 56°F. A basic ingredient used in propellant manufacturing, made by nitrating glycerin with mixed acid.

Nitroguanidine. The third base raw material used in the manufacture of triple-base propellant. The other two are nitrocellulose and nitroglycerin.

NC Fines. Fine nitrocellulose particles as a result of the purification of nitrocellulose.

Pink Water. After loading TNT into munitions, the loading bays are washed. TNT particles in concentrations of 100-150 mg/l produce in sunlight an orange or light-rust colored effluent termed "pink water".

Plasticizer. A high boiling liquid which is used in the formulation of a propellant to help make it plastic.

Poaching. Boiling nitrocellulose (NC) in soda ash at 96°C for four hours followed by fresh water at 96°C for two hours. The NC will then settle and the water is drained off.

Primer. A small charge of easily-ignited material used to ignite the working charge of a gun or rocket.

Propellant. Any substance which can react to form more stable substances in the absence of atmospheric oxygen, giving off hot combustion gases capable of doing useful work.

Red Water. The effluent coming from the sellite wash of crude TNT. Sellite has a selective affinity for the unsymmetrical, unwanted isomers of TNT. The result is a blood red effluent high in sulfate concentration. A red waste liquid resulting from the purification of TNT, normally incinerated or sold to the paper industry.

Rolled Powder. A propellant which is formed by forcing a nitrocellulose-nitroglycerin composition between two large steel rolls to form a sheet.

SAC (Sulfuric Acid Concentrator). An evaporation process which concentrates weak sulfuric acid (sixty-eight percent) to strong sulfuric acid (ninety-two percent).

Sellite. Sodium sulfite, used in the finishing operation of TNT.

Single Base. A propellant which contains only one explosive ingredient. A propellant consisting essentially of nitrocellulose plus stabilizer and plasticizer, formed by mixing these ingredients with ether and alcohol and extruding the resultant mass through dies and cutters.

Smokeless Powder. Nitrocellulose-based propellant.

Solid Propellant. A propellant having a composition which is solid at normal temperature.

Solvent. As used in propellants either: (1) a substance added to nitrocellulose to soften it so that it can be formed; or (2) a substance that dissolves both propellant and inhibiting materials and is used to bond inhibitors to grain.

Stabilizer. A substance added to nitroceullulose propellants to prevent decomposition product from catalyzing further decomposition.

TNT. An abbreviation for trinitrotoluene, a high explosive, exploded by detonators but unaffected by ordinary friction or shock. Manufactured by reacting toluene (an organic liquid) with nitric acid in the presence of sulfuric acid.

Triple Base. A propellant that contains three explosive ingredients, e.g., NC-NG-nitroguanidine small-arms powder.

Yellow Water. The effluent coming from the first wash of crude TNT in its purification process.

General Definitions

Abatement. The measures taken to reduce or eliminate pollution.

Absorption. A process in which one material (the absorbent) takes up and retains another (the absorbate) with the formation of a homogeneous mixture having the attributes of a solution. Chemical reaction may accompany or follow absorption.

Acclimation. The ability of an organism to adapt to changes in its immediate environment.

Acid. A substance which dissolves in water with the formation of hydrogen ions.

Acid Solution. A solution with a pH of less than 7.00 in which the activity of the hydrogen ion is greater than the activity of the hydroxyl ion.

Acidity. The capacity of a wastewater for neutralizing a base. It is normally associated with the presence of carbon dioxide, mineral and organic acids and salts of strong acids or weak bases. It is reported as equivalent of $CaCO_3$ because many times it is not known just what acids are present.

Acidulate. To make acidic.

Act. The Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500.

Activated Carbon. Carbon which is treated by high-temperature heating with steam or carbon dioxide producing an internal porous particle structure.

Activated Sludge Process. A process which removes the organic matter from sewage by saturating it with air and biologically active sludge. The recycle "activated" microoganisms are able to remove both the soluble and colloidal organic material from the wastewater.

Adsorption. An advanced method of treating wastes in which a material removes organic matter not necessarily responsive to clarification or biological treatment by adherence on the surface of solid bodies.

Adsorption Isotherm. A plot used in evaluating the effectiveness of activated carbon treatment by showing the amount of impurity adsorbed versus the amount remaining. They are determined at a constant temperature by varying the amount of carbon used or the concentration of the impurity in contact with the carbon.

Advance Waste Treatment. Any treatment method or process employed following biological treatment to increase the removal of pollution load, to remove substances that may be deleterious to receiving waters or the environment or to produce a high-quality effluent suitable for reuse in any specific manner or for discharge under critical conditions. The term tertiary treatment is commonly used to denote advanced waste treatment methods.

Aeration. (1) The bringing about of intimate contact between air and a liquid by one of the following methods: spraying the liquid in the air, bubbling air through the liquid, or agitation of the liquid to promote surface absorption of air. (2) The process or state of being supplied or impregnated with air; in waste treatment, a process in which liquid from the primary clarifier is mixed with compressed air and with biologically active sludge.

Aeration Period. (1) The theoretical time, usually expressed in hours, that the mixed liquor is subjected to aeration in an aeration tank undergoing activated-sludge treatment. It is equal to the volume of the tank divided by the volumetric rate of flow of wastes and return sludge. (2) The theoretical time that liquids are subjected to aeration.

Aeration Tank. A vessel for injecting air into the water.

Aerobic. Ability to live, grow, or take place only where free oxygen is present.

Aerobic Biological Oxidation. Any waste treatment or process utilizing aerobic organisms, in the presence of air or oxygen, as agents for reducing the pollution load or oxygen demand of organic substances in waste.

Aerobic Digestion. A process in which microorganisms obtain energy by endogenous or auto-oxidation of their cellular protoplasm. The biologically degradable constituents of cellular material are slowly oxidized to carbon dioxide, water and ammonia, with the ammonia being further converted into nitrates during the process.

Algae. One-celled or many-celled plants which grow in sunlit waters and which are capable of photosynthesis. They are a food for fish and small aquatic animals and, like all plants, put oxygen in the water.

Algicide. Chemical agent used to destroy or control algae.

Alkali. A water-soluble metallic hydroxide that ionizes strongly to yield a basic solution.

Alkalinity. The presence of salts of alkali metals. The hydroxides, carbonates and bicarbonates of calcium, sodium and magnesium are common impurities that cause alkalinity. A quantitative measure of the capacity of liquids or suspensions to neutralize strong acids or to resist the establishment of acidic conditions. Alkalinity results from the presence of bicarbonates, carbonates, hydroxides, volatile acids, salts and occasionally borates and is usually expressed in terms of the concentration of calcium carbonate that would have an equivalent capacity to neutralize strong acids.

Alum. A hydrated aluminum sulfate or potassium aluminum sulfate or ammonium aluminum sulfate which is used as a settling agent. A coagulant.

Ammonia Nitrogen. A gas released by the microbiological decay of plant and animal proteins. When ammonia nitrogen is found in waters, it is indicative of incomplete treatment.

Ammonia Stripping. A modification of the aeration process for removing gases in water. Ammonium ions in wastewater exist in equilibrium with ammonia and hydrogen ions. As pH increases, the equilibrium shifts to the right, and above pH 9 ammonia may be liberated as a gas by agitating the wastewater in the presence of air. This is usually done in a packed tower with an air blower.

Ammonification. The process in which ammonium is liberated from organic compounds by microoganisms.

Anaerobic. Ability to live, grow, or take place where there is no air or free oxygen present.

Anaerobic Biological Treatment. Any treatment method or process utilizing anaerobic or facultative organisms, in the absence of air, for the purpose of reducing the organic matter in wastes or organic solids settled out from wastes.

Anaerobic Digestion. Biodegradable materials in primary and excess activated sludge are stabilized by being oxidized to carbon dioxide, methane and other inert products. The primary digester serves mainly to reduce VSS, while the secondary digester is mainly for solids-liquid separation, sludge thickening and storage.

Anion. Ion with a negative charge.

Antagonistic Effect. The simultaneous action of separate agents mutually opposing each other.

Aqueous Solution. One containing water or watery in nature.

Aquifer. A geologic formation or stratum that contains water and transmits it from one point to another in quantities sufficient to permit economic development (capable of yielding an appreciable supply of water).

Aqueous Solution. One containing water or watery in nature.

Arithmetic Mean. The arithmetic mean of a number of items is obtained by adding all the items together and dividing the total by the number of items. It is frequently called the average. It is greatly affected by extreme values.

Azeotrope. A liquid mixture that is characterized by a constant minimum or maximum boiling point which is lower or higher than that of any of the components and that distills without change in composition.

Backwashing. The process of cleaning a rapid sand or mechanical filter by reversing the flow of water.

Bacteria. Unicellular, plant-like microorganisms, lacking chlorophyll. Any water supply contaminated by sewage is certain to contain a bacterial group called "coliform".

Bateria, Coliform Group. A group of bacteria, predominantly inhabitants of the intestine of man but also found on vegetation, including all aerobic and facultative anaerobic gram-negative, non-sporeforming bacilli that ferment lactose with gas formation. This group includes five tribes of which the very great majority are Eschericheae. The Eschericheae tribe comprises three genera and ten species, of which Escherichia Coli and Aerobacter Aerogenes are dominant. The Escherichia Coli are normal inhabitants of the intestine of man and all vertbrates whereas Aerobacter Aerogenes normally are found on grain and plants, and only to a varying degree in the intestine of man and animals. Formerly referred to as B. Coli, B. Coli group, and Coli-Aerogenes Group.

Bacterial Growth. All bacteria require food for their continued life and growth and all are affected by the conditions of their environment. Like human beings, they consume food, they respire, they need moisture, they require heat, and they give off waste products. Their food requirements are very definite and have been, in general, already outlined. Without an adequate food supply of the type the specific organiequires, bacteria will not grow and multiply at their maximum rate and they will therefore, not perform their full and complete functions.

(BADCT) NSPS Effluent Limitations. Limitations for new sources which are based on the application of the Best Available Demonstrated Control Technology. See NSPS.

Base. A substance that in aqueous solution turns red litmus blue, furnishes hydroxyl ions and reacts with an acid to form a salt and water only.

Batch Process. A process which has an intermittent flow of raw materials into the process and a resultant intermittent flow of product from the process.

BAT (BATEA) Effluent Limitations. Limitations for point sources, other than publicly owned treatment works, which are based on the application of the Best Available Technology Economically Achievable. These limitations must be achieved by July 1, 1983.

Benthic. Attached to the bottom of a body of water.

Benthos. Organisms (fauna and flora) that live on the bottoms of bodies of water.

Bioassay. An assessment which is made by using living organisms as the sensors.

Biochemical Oxygen Demand (BOD). A measure of the oxygen required to oxidize the organic material in a sample of wastewater by natural biological process under standard conditions. This test is presently universally accepted as the yardstick of pollution and is utilized as a means to determine the degree of treatment in a waste treatment process. Usually given in mg/l (or ppm units), meaning milligrams of oxygen required per liter of wastewater, it can also be expressed in pounds of total oxygen required per wastewater or sludge batch. The standard BOD is five days at 20 degrees C.

Biota. The flora and fauna (plant and animal life) of a stream or other water body.

Biological Treatment System. A system that uses microorganisms to remove organic pollutant material from a wastewater.

Blowdown. Water intentionally discharged from a cooling or heating system to maintain the dissolved solids concentration of the circulating water below a specific critical level. The removal of a portion of any process flow to maintain the constituents of the flow within desired levels. Process may be intermittent or continuous. 2) The water discharged from a boiler or cooling tower to dispose of accumulated salts.

BOD5. Biochemical Oxygen Demand (BOD) is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. The BOD test has been developed on the basis of a 5-day incubation period (i.e. BOD5).

Boiler Blowdown. Wastewater resulting from purging of solid and waste materials from the boiler system. A solids build up in concentration as a result of water evaporation (steam generation) in the boiler.

BPT (BPCTCA) Effluent Limitations. Limitations for point sources, other than publicly owned treatment works, which are based on the application of the Best Practicable Control Technology Currently Available. These limitations must be achieved by July 1, 1977.

Break Point. The point at which impurities first appear in the effluent of a granular carbon adsorption bed.

Break Point Chlorination. The addition of sufficient chlorine to destroy or oxidize all substances that creates a chlorine demand with an excess amount remaining in the free residual state.

Brine. Water saturated with a salt.

Buffer. A solution containing either a weak acid and its salt or a weak base and its salt which thereby resists changes in acidity or basicity, resists changes in pH.

Carbohydrate. A compound of carbon, hydrogen and oxygen, usually having hydrogen and oxygen in the proportion of two to one.

Carbonaceous. Containing or composed of carbon.

Catalyst. A substance which changes the rate of a chemical reaction but undergoes no permanent chemical change itself.

Cation. The ion in an electrolyte which carries the positive charge and which migrates toward the cathode under the influence of a potential difference.

Caustic Soda. In its hydrated form it is called sodium hydroxide. Soda ash is sodium carbonate.

Cellulose. The fibrous constituent of trees which is the principal raw material of paper and paperboard. Commonly thought of as a fibrous material of vegetable origin.

Centrate. The liquid fraction that is separated from the solids fraction of a slurry through centrifugation.

Centrifugation. The process of separating heavier materials from lighter ones through the employment of centrifugal force.

Centrifuge. An apparatus that rotates at high speed and by centrifugal force separates substances of different densities.

Chemical Oxygen Demand (COD). A measure of oxygen-consuming capacity of organic and inorganic matter present in water or wastewater. It is expressed as the amount of oxygen consumed from a chemical oxidant in a specific test. It does not differentiate between stable and unstable organic matter and thus does not correlate with biochemical oxygen demand.

Chemical Synthesis. The processes of chemically combining two or more constituent substances into a single substance.

Chlorination. The application of chlorine to water, sewage or industrial wastes, generally for the purpose of disinfection but frequently for accomplishing other biological or chemical results.

Clarification. Process of removing turbidity and suspended solids by settling. Chemicals can be added to improve and speed up the settling process through coagulation.

Clarifier. A basin or tank in which a portion of the material suspended in a wastewater is settled.

Clays. Aluminum silicates less than 0.002mm (2.0 um) in size. Therefore, most clay types can go into colloidal suspension.

Coagulation. The clumping together of solids to make them settle out of the sewage faster. Coagulation of solids is brought about with the use of certain chemicals, such as lime, alum or polyelectrolytes.

Coagulation and Flocculation. Processes which follow sequentially.

Coagulation Chemicals. Hydrolyzable divalent and trivalent metallic ions of aluminum, magnesium, and iron salts. They include alum (aluminum sulfate), quicklime (calcium oxide), hydrated lime (calcium hydroxide), sulfuric acid, anhydrous ferric chloride. Lime and acid affect only the solution pH which in turn causes coagulant precipitation, such as that of magnesium.

Coliform. Those bacteria which are most abundant in sewage and in streams containing feces and other bodily waste discharges. See bacteria, coliform group.

Coliform Organisms. A group of bacteria recognized as indicators of fecal pollution.

Colloid. A finely divided dispersion of one material (0.01-10 micron-sized particles), called the "dispersed phase" (solid), in another material, called the "dispersion medium" (liquid).

Color Bodies. Those complex molecules which impart color to a solution.

Color Units. A solution with the color of unity contains a mg/l of metallic platinum (added as potassium chloroplatinate to distilled water). Color units are defined against a platinum-cobalt standard and are based, as are all the other water quality criteria, upon those analytical methods described in Standard Methods for the Examination of Water and Wastewater, 12 ed., Amer. Public Health Assoc., N.Y., 1967.

Combined Sewer. One which carries both sewage and storm water run-off.

Composite Sample. A combination of individual samples of wastes taken at selected intervals, generally hourly for 24 hours, to minimize the effect of the variations in individual samples. Individual samples making up the composite may be of equal volume or be roughly apportioned to the volume of flow of liquid at the time of sampling.

Composting. The biochemical stabilization of solid wastes into a humus-like substance by producing and controlling an optimum environment for the process.

Concentration. The total mass of the suspended or dissolved particles contained in a unit volume at a given temperature and pressure.

Conductivity. A reliable measurement of electrolyte concentration in a water sample. The conductivity measurement can be related to the concentration of dissolved solids and is almost directly proportional to the ionic concentration of the total electrolytes.

Contact Stabilization. Aerobic digestion.

Contact Process Wastewaters. These are process-generated wastewaters which have come in direct or indirect contact with the reactants used in the process. These include such streams as contact cooling water, filtrates, centrates, wash waters, etc.

Continuous Process. A process which has a constant flow of raw materials into the process and resultant constant flow of product from the process.

Contract Disposal. Disposal of waste products through an outside party for a fee.

Crystallization. The formation of solid particles within a homogeneous phase. Formation of crystals separates a solute from a solution and generally leaves impurities behind in the mother liquid.

Degreasing. The process of removing greases and oils from sewage, waste and sludge.

Demineralization. The total removal of all ions.

Denitrification. Bacterial mediated reduction of nitrate to nitrite. Other bacteria may act on the nitrite reducing it to ammonia and finally N2 gas. This reduction of nitrate occurs under anaerobic conditions. The nitrate replaces oxygen as an electron acceptor during the metabolism of carbon compounds under anaerobic conditions. A biological process in which gaseous nitrogen is produced from nitrite and nitrate. The heterotrophic microoganisms which participate in this process include pseudomonades, achromobacters and bacilli.

Derivative. A substance extracted from another body or substance.

Desorption. The opposite of adsorption. A phenomenon where an adsorbed molecule leaves the surface of the adsorbent.

Diluent. A diluting agent.

Dissolved Air Flotation. The term "flotation" indicates something floated on or at the surface of a liquid. Dissolved air flotation thickening is a process that adds energy in the form of air bubbles, which become attached to suspended sludge particles, increasing the buoyancy of the particles and producing more positive flotation.

Dissolved Oxygen (DO). The oxygen dissolved in sewage, water or other liquids, usually expressed either in milligrams per liter or percent of saturation. It is the test used in BOD determination.

Distillation. The separation, by vaporization, of a liquid mixture of miscible and volatile substance into individual components, or, in some cases, into a group of components. The process of raising the temperature of a liquid to the boiling point and condensing the resultant vapor to liquid form by cooling. It is used to remove substances from a liquid or to obtain a pure liquid from one which contains impurities or which is a mixture of several liquids having different boiling temperatures. Used in the treatment of fermentation products, yeast, etc., and other wastes to remove recoverable products.

DO Units. The units of measurement used are milligrams per liter (mg/1) and parts per million (ppm), where mg/1 is defined as the actual weight of oxygen per liter of water and ppm is defined as the parts actual weight of oxygen dissolved in a million parts weight of water, i.e., a pound of oxygen in a million pounds of water is 1 ppm. For practical purposes in pollution control work, these two are used interchangeably; the density of water is so close to 1 g/cm^3 that the error is negligible. Similarly, the changes in volume of oxygen with changes in temperature are insignificant. This, however, is not true if sensors are calibrated in percent saturation rather than in mg/l or ppm. In that case, both temperature and barometric pressure must be taken into consideration.

Drift. Entrained water carried from a cooling device by the exhaust air.

Dual Media. A deep-bed filtration system utilizing two separate and discrete layers of dissimilar media (e.g., anthracite and sand) placed one on top of the other to perform the filtration function.

Ecology. The science of the interrelations between living organisms and their environment.

Effluent. A liquid which leaves a unit operation or process. Sewage, water or other liquids, partially or completely treated or in their natural states, flowing out of a reservoir basin, treatment plant or any other unit operation. An influent is the incoming stream.

Elution. (1) The process of washing out, or removing with the use of a solvent. (2) In an ion exchange process it is defined as the stripping of adsorbed ions from an ion exchange resin by passing through the resin solutions containing other ions in relatively high concentrations.

Elutriation. A process of sludge conditioning whereby the sludge is washed, either with fresh water or plant effluent, to reduce the sludge alkalinity and fine particles, thus decreasing the amount of required coagulant in further treatment steps, or in sludge dewatering.

Emulsion. Emulsion is a suspension of fine droplets of one liquid in another.

Entrainment Separator. A device to remove liquid and/or solids from a gas stream. Energy source is usually derived from pressure drop to create centrifugal force.

Environment. The sum of all external influences and conditions affecting the life and the development of an organism.

Equalization Basin. A holding basin in which variations in flow and composition of a liquid are averaged. Such basins are used to provide a flow of reasonably uniform volume and composition to a treatment unit.

Esterification. This generally involves the combination of an alcohol and an organic acid to produce an ester and water The reaction is carried out in the liquid phase, with aqueous sulfuric acid as the catalyst. The use of sulfuric acid has in the past caused this type of reaction to be called sulfation.

Eutrophication. The process in which the life-sustaining quality of a body of water is lost or diminished (e.g., aging or filling in of lakes). A eutrophic condition is one in which the water is rich in nutrients but has a seasonal oxygen deficiency.

Evapotranspiration. The loss of water from the soil both by evaporation and by transpiration from the plants growing thereon.

Facultative. Having the power to live under different conditons (either with or without oxygen).

Facultative Lagoon. A combination of the aerobic and anaerobic lagoons. It is divided by loading and thermal stratifications into an aerobic surface and an anaerobic bottom, therefore the principles of both the aerobic and anaerobic processes apply.

Fauna. The animal life adapted for living in a specified environment.

Fermentation. Oxidative decomposition of complex substances through the action of enzymes or ferments produced by microorganisms.

Filter, Trickling. A filter consisting of an artificial bed of coarse material, such as broken stone, clinkers, slate, slats or brush, over which sewage is distributed and applied in drops, films for spray, from troughs, drippers, moving distributors or fixed nozzles. The sewage trickles through to the underdrains and has the opportunity to form zoogleal slimes which clarify and oxidize the sewage.

Filter, Vacuum. A filter consisting of a cylindrical drum mounted on a horizontal axis and covered with a filter cloth. The filter revolves with a partial submergence in the liquid, and a vacuum is maintained under the cloth for the larger part of each revolution to extract moisture. The cake is scraped off continuously.

Filtrate. The liquid fraction that is separated from the solids fraction of a slurry through filtration.

Filtration, Biological. The process of passing a liquid through a biological filter containing media on the surfaces of which zoogleal films develop that absorb and adsorb fine suspended, colloidal and dissolved solids and that release various biochemical end products.

Flocculants. Those water-soluble organic polyelectrolytes that are used alone or in conjunction with inorganic coagulants such as lime, alum or ferric chloride or coagulant aids to agglomerate solids suspended in aqueous systems or both, The large dense flocs resulting from this process permit more rapid and more efficient solids-liquid separations.

Flocculation. The formation of flocs. The process step following the coagulation-precipitation reactions which consists of bringing together the colloidal particles. It is the agglomeration by organic polyelectroytes of the small, slowly settling flocs formed during coagulation into large flocs which settle rapidly.

Flora. The plant life characteristic of a region.

Flotation. A method of raising suspended matter to the surface of the liquid in a tank as scum-by aeration, vacuum, evolution of gas, chemicals, electrolysis, heat or bacterial decomposition and the subsequent removal of the scum by skimming.

Fractionation (or Fractional Distillation). The separation of constituents, or group of constituents, of a liquid mixture of miscible and volatile substances by vaporization and recondensing at specific boiling point ranges.

Fungus. A vegetable cellular organism that subsists on organic material, such as bacteria.

Gland. A device utilizing a soft wear-resistant material used to minimize leakage between a rotating shaft and the stationary portion of a vessel such as a pump.

Gland Water. Water used to lubricate a gland. Sometimes called "packing water."

Grab Sample. (1) Instantaneous sampling. (2) A sample taken at a random place in space and time.

Grease. In sewage, grease includes fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oils and other nonfatty materials. The type of solvent to be used for its extraction should be stated.

Grit Chamber. A small detention chamber or an enlargement of a sewer designed to reduce the velocity of flow of the liquid and permit the separation of mineral from organic solids by differential sedimentation.

Groundwater. The body of water that is retained in the saturated zone which tends to move by hydraulic gradient to lower levels.

Hardness. A measure of the capacity of water for precipitating soap. It is reported as the hardness that would be produced if a certain amount of $CaCO_3$ were dissolved in water. More than one ion contributes to water hardness. The "Glossary of Water and Wastewater Control Engineering" defines hardness as: A characteristic of water, imparted by salts of calcium, magnesium, and ion, such as biocarbonates, carbonates, sulfates, chlorides, and nitrates, that causes curdling of soap, deposition of scale in boilers, damage in some industrial processes, and sometimes objectionable taste. Calcium and magnesium are the most significant constituents.

Heavy Metals. A general name given for the ions of metallic elements, such as copper, zinc, iron, chromium, and aluminum. They are normally removed from a wastewater by the formation of an insoluble precipitate (usually a metallic hydroxide).

Hydrocarbon. A compound containing only carbon and hydrogen.

Hydrolysis. A chemical reaction in which water reacts with another substance to form one or more new substances.

Incineration. The combustion (by burning) of organic matter in wastewater sludge.

Incubate. To maintain cultures, bacteria, or other microorganisms at the most favorable temperature for development.

Influent. Any sewage, water or other liquid, either raw or partly treated, flowing into a reservoir, basin, treatment plant, or any part thereof. The influent is the stream entering a unit operation; the effluent is the stream leaving it.

In-Plant Measures. Technology applied within the manufacturing process to reduce or eliminate pollutants in the raw waste water. Sometimes called "internal measures" or "internal controls".

Ion. An atom or group of atoms possessing an electrical charge.

Ion Exchange. A reversible interchange of ions between a liquid and a solid involving no radical change in the structure of the solid. The solid can be a natural zeolite or a synthetic resin, also called polyelectrolyte. Cation exchange resins exchange their hydrogen ions for metal cations in the liquid. Anion exchange resins exchange their hydroxyl ions for anions such as nitrates in the liquid. When the ion-retaining capacity of the resin is exhausted, it must be regenerated. Cation resins are regenerated with acids and anion resins with bases.

Kier boiling. A process of removing waxes, dirt or other foreign matter by boiling.

Lagoons. An oxidation pond that received sewage which is not settled or biologically treated.

LC 50. A lethal concentration for 50% of test animals. Numerically the same as TLm. A statistical estimate of the toxicant, such as pesticide concentration, in water necessary to kill 50% of the test organisms within a specified time under standardized conditions (usually 24,48 or 96 hr).

Leach. To dissolve out by the action of a percolating liquid, such as water, seeping through a sanitary landfill.

Lime. Limestone is an accumulation of organic remains consisting mostly of calcium carbonate. When burned, it yields lime which is a solid. The hydrated form of a chemical lime is calcium hydroxide.

Maximum Day Limitation. The effluent limitation value equal to the maximum for one day and is the value to be published by the EPA in the Federal Register.

Maximum Thirty Day Limitation. The effluent limitation value for which the average of daily values for thirty consecutive days shall not exceed and is the value to be published by the EPA in the Federal Register.

Mean. The arithmetic average of the individual sample values.

Median. In a statistical array, the value having as many cases larger in value as cases smaller in value.

Median Lethal Dose (LD50). The dose lethal to 50 percent of a group of test organisms for a specified period. The dose material may be ingested or injected.

Median Tolerance Limit (TLm). In toxicological studies, the concentration of pollutants at which 50 percent of the test animals can survive for a specified period of exposure.

Microbial. Of or pertaining to a bacterium.

Molecular Weight. The relative weight of a molecule compared to the weight of an atom of carbon taken as exactly 12.00; the sum of the atomic weights of the atoms in a molecule.

Navigable Waters. Includes all navigable waters of the United States; tributaries of navigable waters; interstate waters; intrastate lakes, rivers and streams which are utilized by interstate travellers for recreational or other purposes; intrastate lakes, rivers and streams from which fish or shellfish are taken and sold in interstate commerce; and intrastate lakes, rivers and streams which are utilized for industrial purposes by industries in interstate commerce.

Neutralization. The restoration of the hydrogen or hydroxyl ion balance in a solution so that the ionic concentration of each are equal. Conventionally, the notation "pH" (puissance d'hydrogen) is used to describe the hydrogen ion concentration or activity present in a given solution. For dilute solutions of strong acids, i.e., acids which are considered to be completely dissociate (ionized in solution), activity equals concentration.

New Source. Any facility from which there is or may be a discharge of pollutants, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance under section 306 of the Act.

Nitrate Nitrogen. The final decomposition product of the organic nitrogen compounds. Determination of this parameter indicates the degree of waste treatment.

Nitrification. Bacterial mediated oxidation of ammonia to nitrite. Nitrite can be further oxidized to nitrate. These reactions are brought about by only a few specialized bacterial species. Nitrosomonias sp. and Nitrococcus sp. oxidize ammonia to nitrite which is oxidized to nitrate by Nitrobacter sp.

Nitrifiers. Bacteria which causes the oxidation of ammonia to nitrites and nitrates.

Nitrite Nitrogen. An intermediate stage in the decomposition of organic nitrogen to the nitrate form. Tests for nitrite nitrogen can determine whether the applied treatment is sufficient.

Nitrobacteria. Those bacteria (an autotrophic genus) that oxidize nitrite nitrogen to nitrate nitrogen.

Nitrogen Cycle. Organic nitrogen in waste is oxidized by bacteria into ammonia. If oxygen is present, ammonia is bacterially oxidized first into nitrite and then into nitrate. If oxygen is not present, nitrite and nitrate are bacterially reduced to nitrogen gas. The second step is called "denitrification."

Nitrogen Fixation. Biological nitrogen fixation is carried on by a selected group of bacteria which take up atmospheric nitrogen and convert it to amine groups or for amino acid synthesis.

Nitrosomonas. Bacteria which oxidize ammonia nitrogen into nitrite nitrogen; an aerobic autotrophic life form.

Non-contact Cooling Water. Water used for cooling that does not come into direct contact with any raw material, intermediate product, waste product or finished product.

Non-contact Process Wastewaters. Wastewaters generated by a manufacturing process which have not come in direct contact with the reactants used in the process. These include such streams as non-contact cooling water, cooling tower blowdown, boiler blowdown, etc.

Nonputrescible. Incapable of organic decomposition or decay.

Normal Solution. A solution that contains 1 gm molecular weight of the dissolved substance divided by the hydrogen equivalent of the substance (that is, one gram equivalent) per liter of solution. Thus, a one normal solution of sulfuric acid (H_2SO_4, mol. wt. 98) contains (98/2) 49gms of H_2SO_4 per liter.

NPDES. National Pollution Discharge Elimination System. A federal program requiring industry to obtain permits to discharge plant effluents to the nation's water courses.

Nutrient. Any substance assimilated by an organism which promotes growth and replacement of cellular constituents.

Operations and Maintenance. Costs required to operate and maintain pollution abatement equipment including labor, material, insurance, taxes, solid waste disposal, etc.

Organic Loading. In the activated sludge process, the food to micoorganisms (F/M) ratio defined as the amount of biodegradable material available to a given amount of microorganisms per unit of time.

Osmosis. The diffusion of a solvent through a semipermeable membrane into a more concentrated solution.

Oxidation. A process in which an atom or group of atoms loses electrons; the combination of a substance with oxygen, accompanied with the release of energy. The oxidized atom usually becomes a positive ion while the oxidizing agent becomes a negative ion in (chlorination for example).

Oxidation Pond. A man-made lake or body of water in which wastes are consumed by bacteria. It receives an influent which has gone through primary treatment while a lagoon receives raw untreated sewage.

Oxidation Reduction (OR). A class of chemical reactions in which one of the reacting species gives up electrons (oxidation) while another species in the reaction accepts electrons (reduction). At one time, the term oxidation was restricted to reactions involving hydrogen. Current chemical technology has broadened the scope of these terms to include all reactions where electrons are given up and taken on by reacting species; in fact, the donating and accepting of electrons must take place simultaneously.

Oxidation Reduction Potential (ORP). A measurement that indicates the activity ratio of the oxidizing and reducing species present.

Oxygen, Available. The quantity of atmospheric oxygen dissolved in the water of a stream; the quantity of dissolved oxygen available for the oxidation of organic matter in sewage.

Oxygen, Dissolved. The oxygen (usually designated as DO) dissolved in sewage, water or another liquid and usually expressed in parts per million or percent of saturation.

Ozonation. A water or wastewater treatment process involving the use of ozone as an oxidation agent.

Ozone. That molecular oxygen with three atoms of oxygen forming each molecule. The third atom of oxygen in each molecule of ozone is loosely bound and easily released. Ozone is used sometimes for the disinfection of water but more frequently for the oxidation of taste-producing substances, such as phenol, in water and for the neutralization of odors in gases or air.

Parts Per Million (ppm). Parts by weight in sewage analysis; ppm by weight is equal to milligrams per liter divided by the specific gravity. It should be noted that in water analysis ppm is always understood to imply a weight/weight ratio, even though in practice a volume may be measured instead of a weight.

Pathogenic. Disease producing

Percolation. The movement of water beneath the ground surface both vertically and horizontally, but above the groundwater table.

Permeability. The ability of a substance (soil) to allow appreciable movement of water through it when saturated and actuated by a hydrostatic pressure.

pH. The negative logarithm of the hydrogen ion concentration or activity in a solution. The number 7 indicates neutrality, numbers less than 7 indicate increasing acidity, and numbers greater than 7 indicate increasing alkalinity.

Phenol. Class of cyclic organic derivatives with the basic chemical formula $C6H5OH$.

Phosphate. Phosphate ions exist as an ester or salt of phosphoric acid, such as calcium phosphate rock. In municipal wastewater, it is most frequently present as orthophosphate.

Phosphorus Precipitation. The addition of the multivalent metallic ions of calcium, iron and aluminum to wastewater to form insoluble precipitates with phosphorus.

Photosynthesis. The mechanism by which chlorophyll-bearing plant utilize light energy to produce carbohydrate and oxygen from carbon dioxide and water (the reverse of respiration).

Physical/Chemical Treatment System. A system that utilizes physical (i.e., sedimentation, filtration, centrifugation, activated carbon, reverse osmosis, etc.) and/or chemical means (i.e., coagulation, oxidation, precipitation, etc.) to treat wastewaters.

Point Source. Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

Pollutional Load. A measure of the strength of a wastewater in terms of its solids or oxygen-demanding characteristics or other objectionable physical and chemical characteristics or both or in terms of harm done to receiving waters. The pollutional load imposed on sewage treatment works is expressed as equivalent population.

Polyelectrolytes. Synthetic chemicals (polymers) used to speed up the removal of solids from sewage. These chemicals cause solids to coagulate or clump together more rapidly than do chemicals such as alum or lime. They can be anionic (-charge), nonionic (+ and -charge) or cationic (+charge--the most popular). They are linear or branched organic polymers. They have high molecular weights and are water-soluble. Compounds similar to the polyelectrolyte flocculants include surface-active agents and ion exchange resins. The former are low molecular weight, water soluble compounds used to disperse solids in aqueous systems. The latter are high molecular weight, water-insoluble compounds used to selectively replace certain ions already present in water with more desirable or less noxious ions.

Population Equivalent (PE). An expression of the relative strength of a waste (usually industrial) in terms of its equivalent in domestic waste, expressed as the population that would produce the equivalent domestic waste. A population equivalent of 160 million persons means the pollutional effect equivalent to raw sewage from 160 million persons; 0.17 pounds BOD (the oxygen demand of untreated wastes from one person) = 1 PE.

Potable Water. Drinking water sufficiently pure for human use.

Potash. Potassium compounds used in agriculture and industry. Potassium carbonate can be obtained from wood ashes. The mineral potash is usually a muriate. Caustic potash is its hydrated form.

Preaeration . A preparatory treatment of sewage consisting of aeration to remove gases and add oxygen or to promote the flotation of grease and aid coagulation.

Precipitation. The phenomenon which occurs when a substance held in solution passes out of that solution into solid form. The adjustment of pH can reduce solubility and cause precipitation. Alum and lime are frequently used chemicals in such operations as water softening or alkalinity reduction.

Pretreatment. Any wastewater treatment process used to partially reduce the pollution load before the wastewater is introduced into a main sewer system or delivered to a treatment plant for substantial reduction of the pollution load.

Primary Clarifier. The settling tank into which the wastewater (sewage) first enters and from which the solids are removed as raw sludge.

Primary Sludge. Sludge from primary clarifiers.

Primary Treatment. The removal of material that floats or will settle in sewage by using screens to catch the floating objects and tanks for the heavy matter to settle in. The first major treatment and sometimes the only treatment in a waste-treatment works, usually sedimentation and/or flocculation and digestion. The removal of a moderate percentage of suspended matter but little or no colloidal or dissolved matter. May effect the removal of 30 to 35 percent or more BOD.

Process Waste Water. Any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, or waste product.

Process Water. Any water (solid, liquid or vapor) which, during the manufacturing process, comes into direct contact with any raw material, intermediate product, by-product, waste product, or finished product.

Putrefaction. Biological decomposition of organic matter accompanied by the production of foul-smelling products associated with anaerobic conditions.

Pyrolysis. The high temperature decomposition of complex molecules that occurs in the presence of an inert atmosphere (no oxygen present to support combustion).

Quench. A liquid used for cooling purposes.

Raw Waste Load (RWL). The quantity (kg) of pollutant being discharged in a plant's wastewater. measured in terms of some common denominator (i.e., kkg of production or m^2 of floor area).

Receiving Waters. Rivers, lakes, oceans or other courses that receive treated or untreated wastewaters.

Recirculation. The refiltration of either all or a portion of the effluent in a high-rate trickling filter for the purpose of maintaining a uniform high rate through the filter. (2) The return of effluent to the incoming flow to reduce its strength.

Reduction. A process in which an atom (or group of atoms) gain electrons. Such a process always requires the input of energy.

Refractory Organics. Organic materials that are only partially degraded or entirely nonbiodegradable in biological waste treatment processes. Refractory organics include detergents, pesticides, color- and odor-causing agents, tannins, lignins, ethers, olefins, alcohols, amines, aldehydes, ketones, etc.

Residual Chlorine. The amount of chlorine left in the treated water that is available to oxidize contaminants if they enter the stream. It is usually in the form of hypochlorous acid of hypochlorite ion or of one of the chloramines. Hypochlorite concentration alone is called "free chlorine residual" while together with the chloramine concentration their sum is called "combined chlorine residual."

Respiration. Biological oxidation within a life form; the most likely energy source for animals (the reverse of photosynthesis).

Retention Time. Volume of the vessel divided by the flow rate through the vessel.

Reverse Osmosis. The process in which a solution is pressurized to a degree greater than the osmotic pressure of the solvent, causing it to pass through a membrane.

Salt. A compound made up of the positive ion of a base and the negative ion of an acid.

Sanitary Landfill. A sanitary landfill is a land disposal site employing an engineered method of disposing of solid wastes on land in a manner that minimizes environmental hazards by spreading the wastes in thin layers, compacting the solid wastes to the smallest practical volume, and applying cover material at the end of each operating day. There are two basic sanitary landfill methods; trench fill and area or ramp fill. The method chosen is dependent on many factors such as drainage and type of soil at the proposed landfill site.

Sanitary Sewers. In a separate system, pipes in a city that carry only domestic wastewater. The storm water runoff is handled by a separate system of pipes.

Screening. The removal of relatively coarse, floating and suspended solids by straining through racks or screens.

Secondary Treatment. The second step in most waste treatment systems in which bacteria consume the organic part of the wastes. This is accomplished by bringing the sewage and bacteria together either in trickling filters or in the activated sludge process.

Sedimentation, Final. The settling of partly settled, flocculated or oxidized sewage in a final tank. (The term settling is preferred).

Sedimentation, Plain. The sedimentation of suspended matter in a liquid unaided by chemicals or other special means and without any provision for the decomposition of the deposited solids in contact with the sewage. (The term plain settling is preferred).

Seed. To introduce microorganisms into a culture medium.

Settleable Solids. Suspended solids which will settle out of a liquid waste in a given period of time.

Settling Velocity. The terminal rate of fall of a particle through a fluid as induced by gravity or other external forces.

Sewage, Raw. Untreated sewage.

Sewage, Storm. The liquid flowing in sewers during or following a period of heavy rainfall and resulting therefrom.

Sewerage. A comprehensive term which includes facilities for collecting, pumping, treating, and disposing of sewage; the sewerage system and the sewage treatment works.

Silt. Particles with a size distribution of 0.05mm-0.002mm (2.0mm). Silt is high in quartz and feldspar.

Skimming. Removing floating solids (scum).

Sludge, Activated. Sludge floc produced in raw or settled sewage by the growth of zoogleal bacteria and other organisms in the presence of dissolved oxygen and accumulated in sufficient concentration by returning the floc previously formed.

Sludge, Age. The ratio of the weight of volatile solids in the digester to the weight of volatile solids added per day. There is a maximum sludge age beyond which no significant reduction in the concentration of volatile solids will occur.

Sludge, Digested. Sludge digested under anaerobic conditions until the volatile content has been reduced, usually by approximately 50 percent or more.

Solution. A homogeneous mixture of two or more substances of dissimilar molecular structure. In a solution, there is a dissolving medium-solvent and a dissolved substance-solute.

Solvent. A liquid which reacts with a material, bringing it into solution.

Solvent Extraction. A mixture of two components is treated by a solvent that preferentially dissolves one or more of the components in the mixture. The solvent in the extract leaving the extractor is usually recovered and reused.

Sparger. An air diffuser designed to give large bubbles, used singly or in combination with mechanical aeration devices.

Sparging. Heating a liquid by means of live steam entering through a perforated or nozzled pipe (used, for example, to coagulate blood solids in meat processing).

Standard Deviation. The square root of the variance which describes the variability within the sampling data on the basis of the deviation of individual sample values from the mean.

Standard Raw Waste Load (SRWL). The raw waste load which characterizes a specific subcategory. This is generally computed by averaging the plant raw waste loads within a subcategory.

Stillwell. A pipe, chamber, or compartment with comparatively small inlet or inlets communicating with a main body of water. Its purpose is to dampen waves or surges while permitting the water level within the well to rise and fall with the major fluctuations of the main body of water. It is used with water-measuring devices to improve accuracy of measurement.

Stoichiometric. Characterized by being a proportion of substances exactly right for a specific chemical reaction with no excess of any reactant or product.

Stripper. A device in which relatively volatile components are removed from a mixture by distillation or by passage of steam through the mixture.

Substrate. (1) Reactant portion of any biochemical reaction, material transformed into a product. (2) Any substance used as a nutrient by a microorganism. (3) The liquor in which activated sludge or other material is kept in suspension.

Sulfate. The final decomposition product of organic sulfur compounds.

Supernatant. Floating above or on the surface.

Surge tank. A tank for absorbing and dampening the wavelike motion of a volume of liquid; an in-process storage tank that acts as a flow buffer between process tanks.

Suspended Solids. The wastes that will not sink or settle in sewage. The quantity of material deposited on a filter when a liquid is drawn through a Gooch crucible.

Synergistic. An effect which is more than the sum of the individual contributors.

Synergistic Effect. The simultaneous action of separate agents which, together, have greater total effect than the sum of their individual effects.

Tertiary Treatment. A process to remove practically all solids and organic matter from wastewater. Granular activated carbon filtration is a tertiary treatment process. Phosphate removal by chemical coagulation is also regarded as a step in tertiary treatment.

Thermal Oxidation. The wet combustion of organic materials through the application of heat in the presence of oxygen.

TKN (Total Kjeldahl Nitrogen). Includes ammonia and organic nitrogen but does not include nitrite and nitrate nitrogen. The sum of free nitrogen and organic nitrogen in a sample.

TLm. The concentration that kills 50% of the test organisms within a specified time span, usually in 96 hours or less. Most of the available toxicity data are reported as the median tolerance limit (TLm). This system of reporting has been misapplied by some who have erroneously inferred that a TLm value is a safe value, whereas it is merely the level at which half of the test organisms are killed. In many cases, the differences are great between TLm concentrations and concentrations that are low enough to permit reproduction and growth. LC50 has the same numerical value as TLm.

Total Organic Carbon (TOC). A measure of the amount of carbon in a sample originating from organic matter only. The test is run by burning the sample and measuring the carbon dioxide produced.

Total Solids. The total amount of solids in a wastewater both in solution and suspension.

Total Volatile Solids (TVS). The quantity of residue lost after the ignition of total solids.

Transport Water. Water used to carry insoluble solids.

Trickling Filter. A bed of rocks or stones. The sewage is trickled over the bed so that bacteria can break down the organic wastes. The bacteria collect on the stones through repeated use of the filter.

Turbidity. A measure of the amount of solids in suspension. The units of measurement are parts per million (ppm) of suspended solids or Jackson Candle Units. The Jackson Candle Unit (JCU) is defined as the turbidity resulting from 1 ppm of fuller's earth (and inert mineral) suspended in water. The relationship between ppm and JCU depends on particle size, color, index of refraction; the correlation between the two is generally not possible. Turbidity instruments utilize a light beam projected into the sample fluid to effect a measurement. The light beam is scattered by solids in suspension, and the degree of light attenuation or the amount of scattered light can be related to turbidity. The light scattered is called the Tyndall effect and the scattered light the Tyndall light. An expression of the optical property of a sample which causes light to be scattered and absorbed rather than transmitted in straight lines through the sample.

Volatile Suspended Solids (VSS). The quantity of suspended solids lost after the ignition of total suspended solids.

Waste Treatment Plant. A series of tanks, screens, filters, pumps and other equipment by which pollutants are removed from water.

Water Quality Criteria. Those specific values of water quality associated with an identified beneficial use of the water under consideration.

Weir. A flow measuring device consisting of a barrier across an open channel, causing the liquid to flow over its crest. The height of the liquid above the crest varies with the volume of liquid flow.

Wet Air Pollution Control. The technique of air pollution abatement utilizing water as an absorptive media.

Wet Oxidation. The direct oxidation of organic matter in wastewater liquids in the presence of air under heat and pressure; generally applied to organic matter oxidation in sludge.

Zeolite. Various natural or synthesized silicates used in water softening and as absorbents.

SECTION XVII

ABBREVIATIONS AND SYMBOLS

AAP	Army Ammunition Plant
A.C.	activated carbon
ac ft	acre-foot
Ag.	silver
atm	atmosphere
ave	average
B.	boron
Ba.	barium
bbl	barrel
BOD5	biochemical oxygen demand, five day
Btu	British thermal unit
C	centigrade degrees
C.A.	carbon adsorption
cal	calorie
cc	cubic centimeter
cfm	cubic foot per minute
cfs	cubic foot per second
Cl.	chloride
cm	centimeter
CN	cyanide
COD	chemical oxygen demand
conc.	concentration
cu	cubic
db	decibels
deg	degree
DO	dissolved oxygen
E. Coli	Escherichia coliform bacteria
Eq.	equation
F	Fahrenheit degrees
Fig.	figure
F/M	BOD5 (Wastewater flow)/ MLSS (contractor volume)
fpm	foot per minute
fps	foot per second
ft	foot
g	gram
gal	gallon
gpd	gallon per day
gpm	gallon per minute
Hg	mercury
hp	horsepower
hp-hr	horsepower-hour
hr	hour
in.	inch
kg	kilogram
kw	kilowatt

kwhr	kilowatt-hour
L(l)	liter
L/kkg	liters per 1000 kilograms
lb	pound
m	meter
M	thousand
me	milliequivalent
mg	milligram
mgd	million gallons daily
min	minute
ml	milliliter
MLSS	mixed-liquor suspended solids
MLVSS	mixed-liquor volatile suspended solids
MM	million
mm	millimeter
mole	gram-molecular weight
mph	mile per hour
MPN	most probable number
mu	millimicron
NO_3	nitrate
NH_3-N	ammonium nitrogen
O_2	oxygen
PO_4	phosphate
p.	page
pH	potential hydrogen or hydrogen-ion index (negative logarithm of the hydrogen-ion concentration)
pp.	pages
ppb	parts per billion
ppm	parts per million
psf	pound per square foot
psi	pound per square inch
R.O.	reverse osmosis
rpm	revolution per minute
RWL	raw waste load
sec	second
Sec.	Section
S.I.C.	Standard Industrial Classification
SO_x	sulfates
sq	square
sq ft	square foot
SS	suspended solids
stp	standard temperature and pressure
SRWL	standard raw waste load
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TLm	median tolerance limit
TOC	total organic carbon
TOD	total oxygen demand
TSS	total suspended solids
u	micron
ug	microgram
vol	volume
wt	weight
yd	yard

SECTION XVIII

LIST OF EXPLOSIVE COMPOUNDS BY COMMON NAME

The following is the 1976 Explosives List published pursuant to 18 U.S.C. 841(d). It is comprehensive, but not all inclusive. An explosive material not appearing on the list may still be within the coverage of the law if it otherwise meets the statutory definitions in 18 U.S.C. 841. Also, the list encompasses all explosive mixtures containing any of the listed materials, according to the Bureau of Alcohol, Tobacco and Firearms, Department of the Treasury.

The explosive compounds are arranged alphabetically by their common names, followed by chemical names and synonyms in brackets.

EXPLOSIVES LIST

Acetylides of heavy metals.
Aluminum containing polymeric propellant.
Aluminum ophorite explosive.
Amatol.
Ammonal.
Ammonium nitrate explosive mixtures.
Aromatic nitro-explosive mixture.
Ammonium perchlorate having particle size less than 45 microns.
Ammonium perchlorate composite propellant.
Ammonium picrate (picrate of ammonia).
Ammonium salt lattice with isomorphously substituted inorganic salts.
ANFO (ammonium nitrate-fuel oil).

BEAF [1,2-bis (2,2-difluoro-2-nitroacetoxyethane)].
Black powder.
Blasting agents, nitro-carbo-nitrates, including slurry and water-gel explosives.
Blasting caps.
Blasting gelatin.
Blasting powder.
BTNEC [bis (trinitroethyl) carbonate].
BTNEN [bis (trinitroethyl) nitramine].
BTTN [1,3,4 butanetriol trinitrate].
Butyl tetryl.

Calcium nitrate explosive mixture.
Carboxy-terminated propellant.
Cellulose hexanitrate explosive mixture.
Chlorates and red phosphorus mixture.
Chlorates and sulphur mixture.
Copper acetylide.
Crystalline picrate with lead azide explosive mixture.
Cyanuric triazide.
Cyclonite [RDX].
Cyclotetramethylenetrinitramine.

DATB [diaminotrinitrotetramethylene tetranitramine].
DDNP [diazodinitrophenol].
DEGDN [diethyleneglycol dinitrate].
Delay powders.

Detonating cord.
Detonators.
Dimethylol dimethyl methane dinitrate composition.
Dinitroethyleneurea.
Dinitroglycerine.
Dinitrophenol.
Dinitrophenolates.
Dinitrophenyl hydrazine.
Dinitroresorcinol.
Dinitrotoluene-sodium nitrate explosive mixtures.
Dipicryl sulfone.
Dipicrylamine.
DNDP [dinitropentano nitrile].
DNPA [2,2-dinitropropyl acrylate].
Dynamite.

EDNP [ethyl 4,4-dinitropentanoate].
Erythritol tetranitrate explosives.
Esters of nitro-substituted alcohols.
EGDN [ethylene glycol dinitrate].
Ethyl-tetryl.
Explosive conitrates.
Explosive gelatins.
Explosive mixtures containing oxygen releasing inorganic salts and hydrocarbons.
Explosive mixtures containing oxygen releasing inorganic salts and nitro bodies.
Explosive mixtures containing oxygen releasing inorganic salts and water insoluble fuels.
Explosive mixtures containing oxygen releasing inorganic salts and water soluble fuels.
Explosive mixtures containing sensitized nitromethane.
Explosive nitro compounds of aromatic hydrocarbons.
Explosive organic nitrate mixtures.
Explosive liquids.
Explosive powders.

FEFO [bis(2,2-dinitro-2-fluoroethyl)].
Fulminate of mercury.
Fulminate of silver.
Fulminating gold.
Fulminating mercury.
Fulminating platinum.
Fulminating silver.

Gelatinized nitrocellulose.
gem-dinitro aliphatic explosive mixtures.
Guanyl nitrosamino guanyl tetrazene.
Guanyl nitrosamino guanylidene hydrazine.
Guncotton.

Heavy metal azides.
Hexanite.
Hexanitrodiphenylamine.
Hexanitrostilbene.
Hexogen [RDX].
Hexogene or octogene and a nitrated N-methylaniline.
Hexolites.
HMX [cyclo-1,3,5,7-tetramethylene-2,4,6,8-tetranitramine; Octogen].
Hydrazinium nitrate.
Hydrazinium nitrate/hydrazine/aluminum explosive system.
Hydrazoic acid.

Igniter cord.
Igniters.

KDNBF [potassium dinitrobenzo-furoxane].

Lead azide.
Lead mannite.
Lead mononitroresorcinate.
Lead picrate.
Lead salts, explosive.
Lead styphnate [styphnate of lead, lead trinitroresorcinate].
Liquid nitrated polyol and trimethylolethane.
Liquid oxygen explosives.

Magnesium ophorite explosives.
Mannitol hexanitrate.
MDNP [methyl 4,4-dinitropentanoate].
Mercuric fulminate.
Mercury oxalate.

Mercury tartrate.
Mononitrotoluene-nitroglycerin mixture.
Monopropellants.

Nitrate sensitized with gelled nitroparaffin.
Nitrated carbohydrate explosive.
Nitrated glucoside explosive.
Nitrated polyhydric alcohol explosives.
Nitrates of soda explosive mixtures.
Nitric acid and a nitro aromatic compound explosive.
Nitric acid and carboxylic fuel explosive.
Nitric acid explosive mixtures.
Nitro aromatic explosive mixtures.
Nitro compounds of furane explosive mixtures.
Nitrocellulose explosive.
Nitroderivative of urea explosive mixture.
Nitrogelatin explosive.
Nitrogen trichloride.
Nitrogen tri-iodide.
Nitroglycerine [NG, RNG, nitro, glyceryl trinitrate, trinitroglycerine].
Nitroglycide.
Nitroglycol.
Nitroguanidine explosives.
Nitronium perchlorate propellant mixtures.
Nitrostarch.
Nitro-substituted carboxylic acids.
Nitrourea.

Octogen [HMX].
Octol [75 percent HMX, 25 percent TNT].
Organic amine nitrates.
Organic nitramines.
Organic peroxides.

Pellet powder.
Penthrinite composition.
Pentolite.
Perchlorate explosive mixtures.
Peroxide based explosive mixtures.
PETN [nitropentaerythrite, pentaerythrite tetranitrate, pentaerythritol tetranitrate].
Picramic acid and its salts.
Picramide.

Picrate of potassium explosive mixtures.
Picratol.
Picric acid.
Picryl chloride.
Picryl fluoride.
Polynitro aliphatic compounds.
Polyolpolynitrate-nitrocellulose explosive gels.
Potassium chlorate and lead sulfocyanate explosive.
Potassium nitroaminotetrazole.

RDX [cyclonite, hexogen, T4, cyclo-1,3,5,-trimethylene-2,4,6-trinitramine; hexahydro-1,3,5-trinitro-5-triazine].

Safety fuse.
Salts of organic amino sulfonic acid explosive mixture.
Silver acetylide.
Silver azide.
Silver fulminate.
Silver oxalate explosive mixtures.
Silver styphnate.
Silver tartrate explosive mixtures.
Silver tetrazene.
Slurried explosive mixtures of water, inorganic oxidizing salt, gelling agent, fuel and sensitizer.
Smokeless powder.
Sodatol.
Sodium amatol.
Sodium dinitro-ortho-cresolate.
Sodium nitrate-potassium nitrate explosive mixture.
Sodium picramate.
Squibs.
Styphnic acid.

Tacot [tetranitro-2,3,5,6-dibenzo-1,3a,4,6a-tetrazapentalene].
TEGDN [triethylene glycol dinitrate].
Tetrazene [tetracene, tetrazine, 1(5-tetrazolyl)-4-guanyl tetrazene hydrate].
Tetranitrocarbazole.
Tetranitromethane explosive mixtures.
Tetryl [2,4,6 tetranitro-N-methylaniline].
Tetrytol.
Thickened inorganic oxidizer salt slurried

explosive mixture.
TMETN [trimethylolethane trinitrate].
TNEF [trinitroethyl formal].
TNEOC [trinitroethylorthocarbonate].
TNEOF [trinitroethyl orthoformate].
TNT [trinitrotoluene, trotyl, trilite, triton].
Torpex.
Tridite.
Trimethylol ethyl methane trinitrate composition.
Trimethylolthane trinitrate-nitrocellulose.
Trimonite.
Trinitroanisole.
Trinitrobenzene.
Trinitrobenzoic acid.
Trinitrocresol.
Trinitro-meta-cresol.
Trinitronaphthalene.
Trinitrophenetol.
Trinitrophloroglucinol.
Trinitroresorcinol.
Tritonal.

Urea nitrate.

Water bearing explosives having salts of oxidizing acids and nitrogen bases, sulfates, or sulfamates.

Xanthamonas hydrophilic colloid explosive mixture.

TABLE XIX

METRIC TABLE

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS)		by	TO OBTAIN (METRIC UNITS)	
ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre-feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram-calories
British Thermal Unit/Pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	°F	0.555 (°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	killowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
ton (short)	ton	0.907	kkg	metric ton (1000 kilograms)
yard	yd	0.9144	m	meter

*Actual conversion, not a multiplier

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