Department of the Army
Program Manager for
Assembled Chemical Weapons Assessment
Aberdeen Proving Ground, MD

WHEAT
Water Hydrolysis of Explosives and Agent Technology

Final Submittal
ACWA EDS WHEAT
Design Basis

PREPARED UNDER
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ABSTRACT

This document serves as the Design Basis (DB) for the Parsons-Honeywell's Water Hydrolysis of Explosives and Agent Technologies (WHEAT) process for the demilitarization of mustard (chemical agents HD and HT) projectiles and mortars. WHEAT is a full-scale total solution process developed as an alternative to the CSDP baseline incineration process.

This document is divided into eight sections:

- Section 1 is an introduction to the Engineering Design Study (EDS)
- Section 2 describes the overall process and design parameters, including munitions stockpile definition, capacity and throughput analysis, raw material requirements and effluents listing.
- Section 3 describes the overall process design criteria.
- Section 4 defines the process description of all the core systems.
- Section 5 includes the process flow diagrams and heat and material balance cases.
- Section 6 describes the environmental design basis.
- Section 7 identifies the process control criteria and strategy.
- Section 8 describes the materials selection of the core equipment.
- Section 9 describes the overall facility description.
- Section 10 identifies the design criteria of the WHEAT facility. Civil, architectural, structural, mechanical, electrical, and fire protection design basis are described.
- Section 11 specifies the design requirement for the non-baseline building and facility.
- Section 12 introduces the Safety Design Requirement Manual (SDRM) in Appendix E.
- Section 13 refers to the Fire Protection Design Analysis report in Appendix F.
- Section 14 lists all the technical documents that are provided to support this EDS.

ACWA EDS WHEAT Basis of Design

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

The Undersecretary of Defense for Acquisition and Technology has appointed the Program Manager for Assembled Chemical Weapon Assessment (ACWA) with the mission to demonstrate viable alternative technologies to “baseline” incineration for the disposal of assembled chemical weapons. Parsons proposed solution is an alternative technology to incineration using water hydrolysis-steam reformation and biotreatment for the disposal of explosives and agent. This alternative technology was successfully demonstrated and validated for mustard agent and explosives during testing that was completed in April 1999. The test results were documented in the draft of “Demonstration Test Final Report” Contract DAAM01-98-D-0005, Delivery Order 0003, July 1, 1999.

This document defines the technical design of the Water Hydrolysis of Energetic and Agent Technologies (WHEAT) process, and is part of the submittal for the Assembled Chemical Weapons Assessment Engineering Design Study (ACWA EDS) phase of project development.

WHEAT is a full-scale total solution process developed as an alternative to the Chemical Stockpile Disposal Program (CSDP) baseline incineration process for the destruction of stockpiled chemical warfare munitions. The process was developed for the Department of Defense (DoD) ACWA program in response to Public Law 104-208 to determine if mature technology alternatives exist to replace the baseline incineration process.

The WHEAT process is one of two technologies that were successfully developed and verification tested as part of Phase-1 of the ACWA program.

WHEAT, the alternative chemical weapons demilitarization technology, described in this document, has been developed by the Parsons-Honeywell team for Program Manager, Assembled Chemical Weapons Assessment (PMACWA), and is geared for the destruction of chemical weapons containing mustard only (chemical agents HD and HT). A variation of WHEAT not described in this document is capable of destroying nerve gas/agents and demilitarize other types of munitions.

The WHEAT process consists of the hydrolysis of mustard, and the destruction of the resulting hydrolysate in Immobilized Cell Bioreactors (ICB™); the effluent from the ICB™ will be further processed to remove dissolved and suspended solids and to recover/recycle water. The munition shells and other metallic components of the munitions will be thermally heat treated to 5X conditions (exposure to 1000°F for a minimum of 15 minutes). The facility will be a total solution site, meaning there will be no discharges in the form of liquid, solid or gas of agent contaminated hazardous waste.

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1.2 ENGINEERING DESIGN – STUDY OBJECTIVES

The overall objective of the engineering development study is to generate all required design/ operating data to develop a full-scale pilot facility (FSPF) process design and a more detailed, accurate full-scale cost and schedule for the WHEAT for processing mustard agent projectiles (4.2-inch mortars, 155-mm projectiles, and 105-mm projectiles).

WHEAT represents a complete destruction system for chemical warfare munitions that contain mustard agents. The study will also provide design/operating data for the toxicity, quantity, and composition of byproduct wastes generated from these processes. The overall EDS objectives are listed below:

(1) Provide design/operating data for the proposed technologies that represent a total solution for assembled chemical weapons.

(2) Provide critical design and operating data for the proposed technologies.

(3) Provide more design data for the critical process steps [e.g., biodegradation of hydrolysates derived from agent and energetic materials and decon of munitions in the metal parts treater (MPT) to the 5X criterion] and their ability to be integrated into an overall operating system.

(4) Provide operating data for the type, quantity, and chemical/physical characteristics process emissions (gas, liquid, and solid) to assist in future permitting efforts.

(5) Provide design/operating data to support subsequent environmental, health, and safety activities/documentation.

(6) Provide design/operating data for the process safety hazards analysis and preliminary hazards list for the total integrated solution.

(7) Provide data for a life cycle estimate of an FSPF.

1.3 PROCESS DESIGN OVERVIEW AND BLOCK FLOW DIAGRAM

The current ACWA EDS WHEAT full-scale process design incorporates some of the results from the testing[1] of selected process areas. The objective of these tests was to generate design and operating data required to technically define and estimate the cost of a facility to destroy 4.2-inch mortars, 155-mm projectiles and 105-mm projectiles. The objectives also included the generation of emissions data to assist future permitting efforts, and data to be able to perform a safety hazard analysis of the integrated demilitarization facility.

Tests conducted during the summer and fall of 2000 included the following WHEAT systems:

- Continuous steam treater (CST) system for the 5X heat treatment of non-process wastes consisting of shredded wood simulating ground projectile pallets, shredded plastic Demilitarization Protective Ensemble (DPE) suits, and charcoal simulating the spent activated carbon from HVAC carbon filters. The test is partially completed (Jan. 2001) and is expected to enter a second phase of testing starting in March 2001.

- Biodegradation of the hydrolysates derived from the agent and energetic materials; including the generation of solid residue from the biodegradation effluent.

- Agent HD challenge of catalytic oxidation (CATOX®) to ascertain system capability for prolonged operation. CATOX® systems are used in the process to treat the offgases resulting from agent destruction operations as well as from other process areas to be detailed later.

Lessons learned from these tests, along with failure conditions and factors identifying full-scale process design unresolved issues will be included in the reporting of the test results. The test reports will be published during March 2001.

In addition to the above, testing will be performed on a system to access and wash chemical agent out of projectile and mortar casings.[2] This testing is scheduled for the first quarter of 2001. The results of this last test will be used to validate assumptions made in the process design of the respective agent access and washout area as presented in this document.

The WHEAT EDS mustard processing full-scale design uses the process steps outlined below to handle and destroy agent HD munitions and to treat the resultant nonagent stream (hydrolysate) and decontaminate all metal parts and non-process wastes (dunnage):

(1) Reconfiguration. Propellant and igniter are removed from all the 4.2-inch mortars and the nonconfigured 105-mm projectiles.

(2) Projectile disassembly. Bursters, nose cones/fuzes/miscellaneous parts are removed. Burster energetics are washed out and sent to energetics neutralization. Fuzes and booster cups are thermally deactivated in the energetics rotary deactivator (ERD). Apart from the deburstered shell casings, all other metal parts are sent to 5X treatment in a batch metal parts treater (B-MPT).

(3) Projectile demilitarization. Mustard is accessed and removed from the deburstered shell casings. Agent is accessed in a two-step process (draining and washout) and sent to storage. The empty shell casings are sent to 5X heat treatment in a continuous rotary metal parts treater (R-MPT).

(4) Toxic liquid storage. Drained agent and washed-out agent concentrate are stored in a baseline-type toxic storage area and fed on demand to the agent neutralization reactors (hydrolysers).

(5) Agent neutralization or hydrolysis with water. The product agent hydrolysate is sent to biotreatment, while gaseous effluent is sent to the MPT offgas treatment (CATOX®) system.

(6) Energetics neutralization with strong caustic (50% sodium hydroxide solution). The product energetics hydrolysate is sent to biotreatment, while gaseous effluent is sent to the MPT quench scrubber and consequently to the MPT offgas treatment (CATOX®) system.

(7) Biotreatment. The incoming hydrolysate streams are further diluted with water, mixed with inorganic nutrients and fed to ICB™ units containing aerobic bacteria that destroy the organic constituents of the feed stream. The spent air vented from the

ICB™ units is treated through a CATOX® system to control odor. The biotreatment liquid effluent is clarified and evaporated to recover the water content and to reclaim the inorganic solid residue, which is the end product of the agent destruction process.

(8) Metal parts treatment. Empty mortar and projectile shells are decontaminated via 5X heat treatment (15 minutes minimum at 1000°F) in the induction-heated R-MPT in the presence of superheated steam; burster tubes/wells, fuzes/nose cones, lifting lugs, booster cups, and miscellaneous parts are placed in containers and 5X heat treated in a batch processing mode in the induction heated B-MPT in the presence of superheated steam. Offgases are quench scrubbed and fed through a CATOX® system.

(9) Continuous steam treatment. Non-process wastes consisting of shredded wood pallets, shredded DPE suits and spent carbon are 5X heat treated in an induction heated CST in the presence of superheated steam. Offgases are quench scrubbed and fed through a CATOX® system.

(10) Brine reduction (removal of inorganic salts through evaporation). The recovered water is fully recycled and reused throughout the process system as a feed to the agent and energetics hydrolysis reactors, to the bioreactors, and also at other various process water users.

(11) Offgas treatment system. There are three offgas treatment systems: MPT, CST, and bioreaction. Process vent gases are mixed with air; the mixture then is heated to reaction temperature (850-900ºF) and passed through a catalytic oxidation (CATOX®) reactor where potential pollutants are destroyed. The CATOX® discharge stream is cooled; and in the case of the MPT and CST offgas treatment systems, vented through the building HVAC carbon filters to the atmosphere. In the case of the bioreaction offgas treatment system, the gaseous effluent is vented to the atmosphere.

The process systems described above are shown on the ACWA WHEAT HD processing block flow diagram, Figure 1-1. The process steps shown apply to all three of the munitions campaigns.

This document contains information for which a patent application has been made.

1.4 PROCESS COMPARISON TO BASELINE

The WHEAT process, as proposed, completely eliminates the need to use incineration to destroy agent and energetic materials. The differences between the baseline process and the WHEAT process can be summarized by the following figures (Figures 1-2, 1-3, and 1-4).

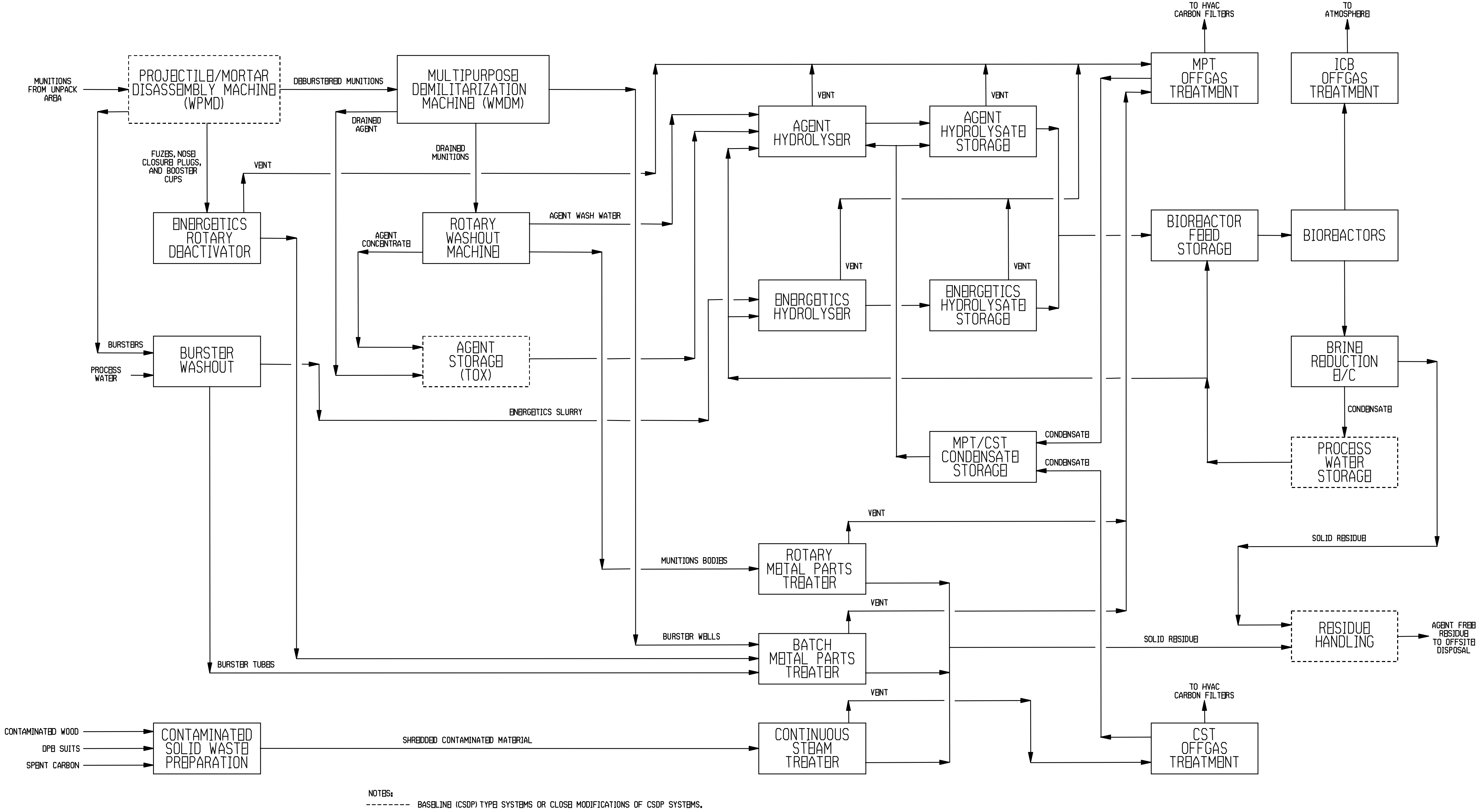

Figure 1-1—ACWA WHEAT - HD Processing Block Flow Diagram

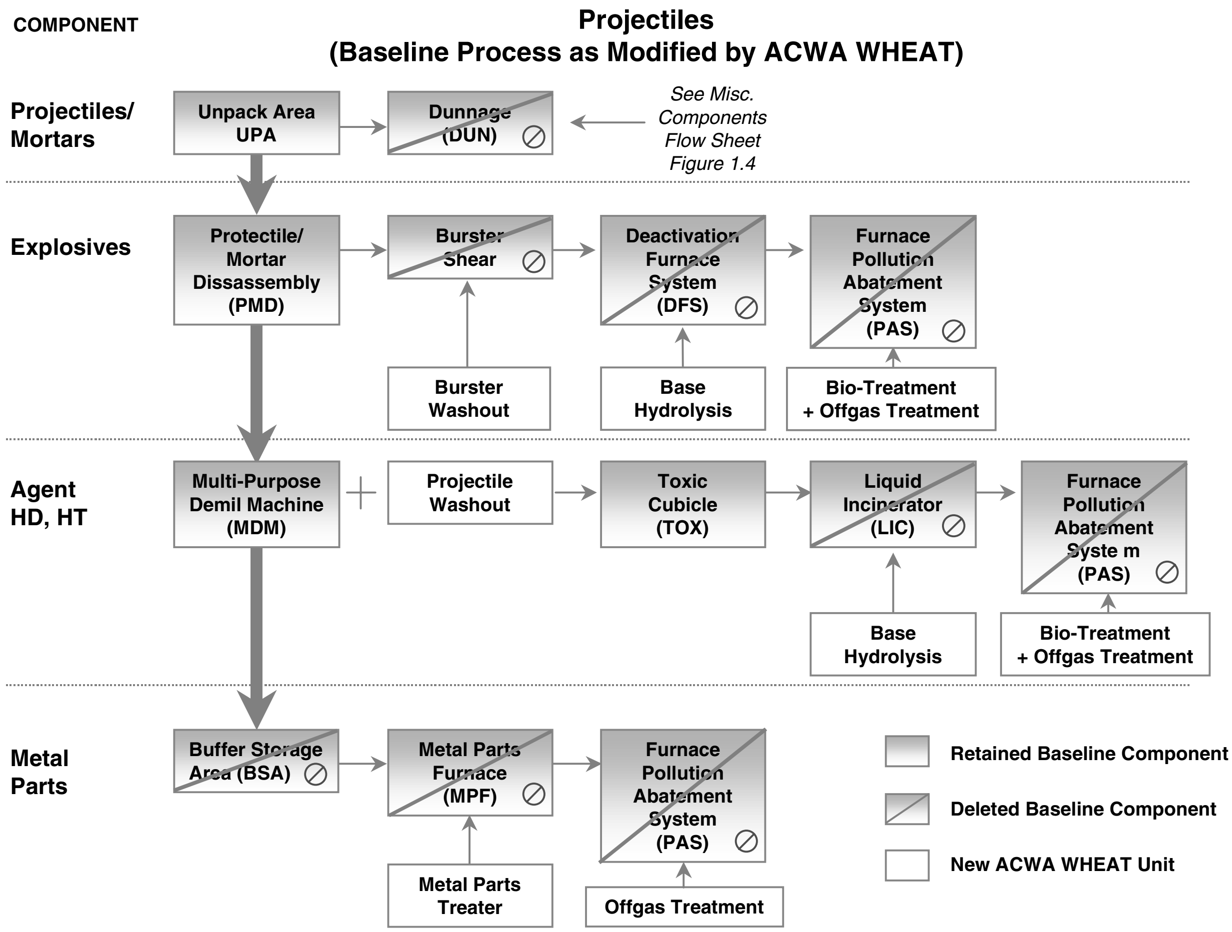

Figure 1-2—Process Comparison - Projectiles

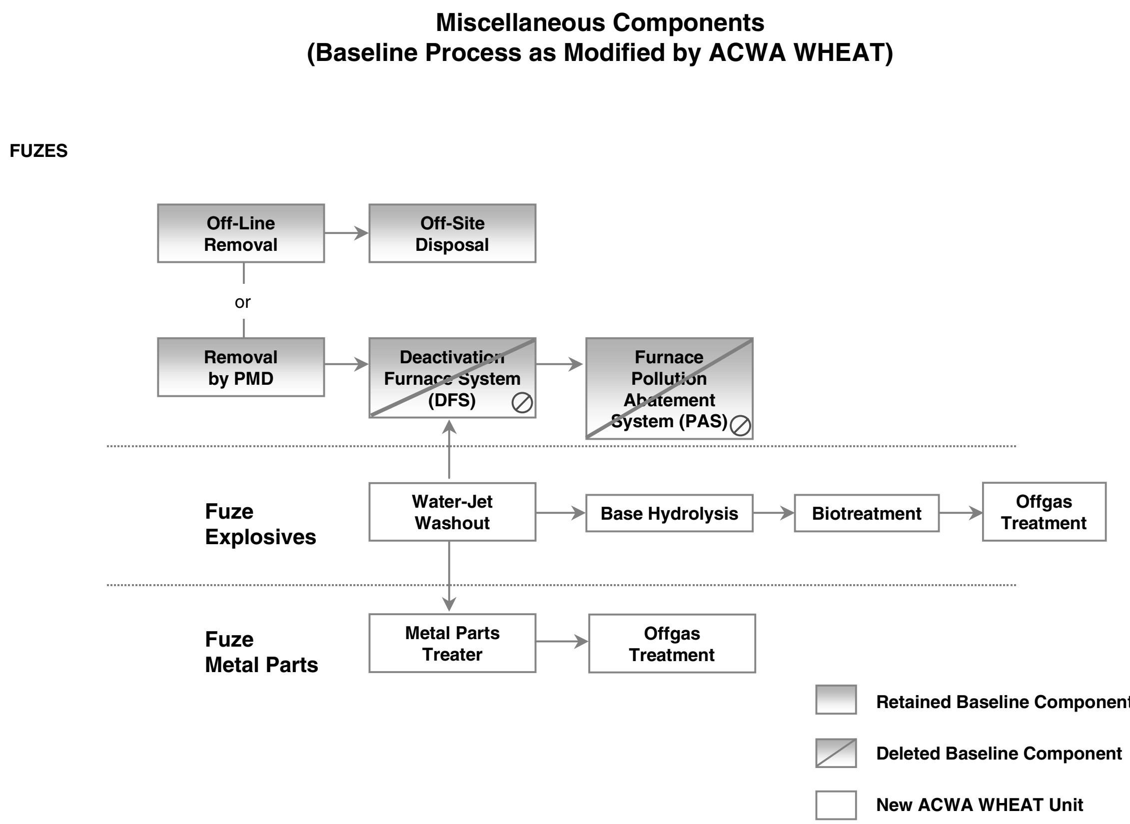

Figure 1-3—Process Comparison – Miscellaneous Components (Fuzes)

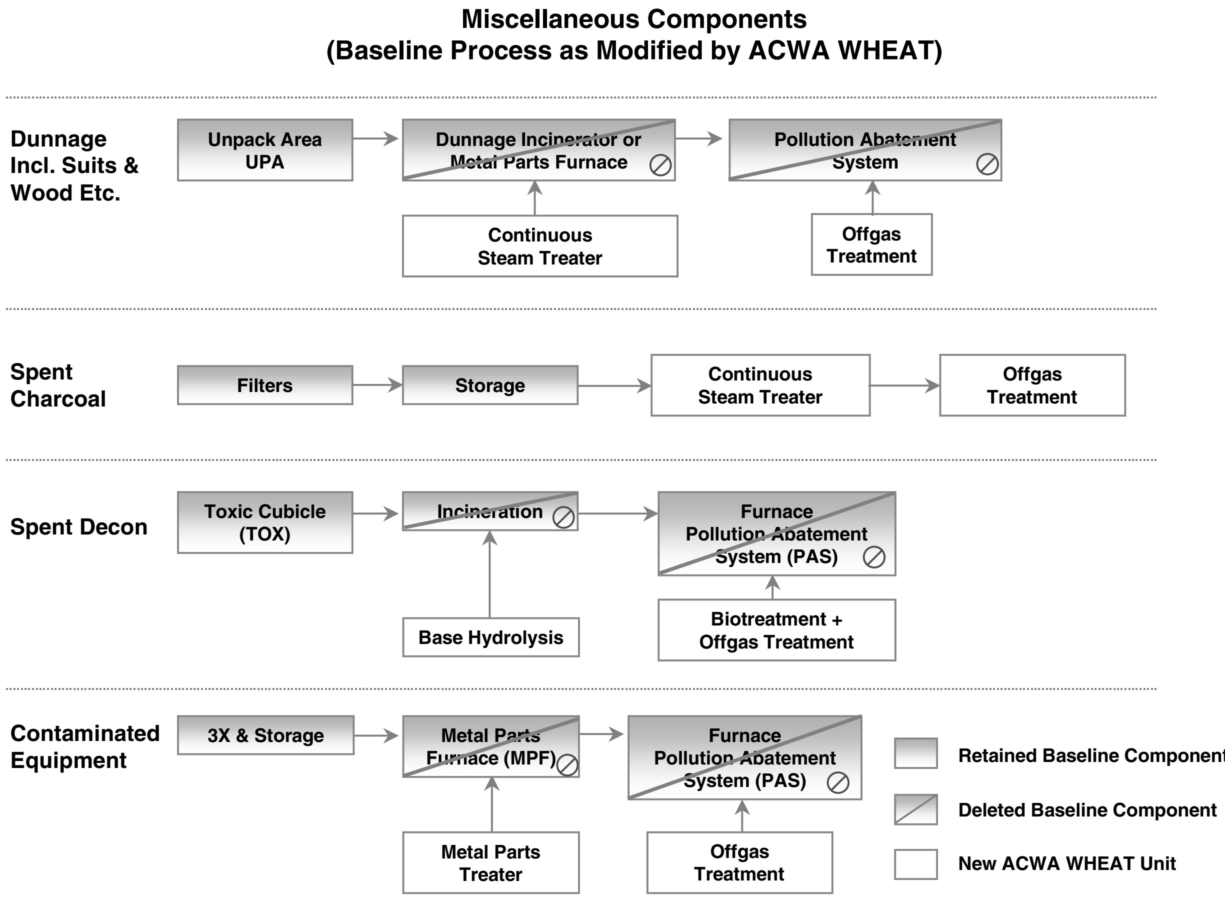

Figure 1-4—Process Comparison – Miscellaneous Components

1.5 SOURCES

[1] Parsons Infrastructure & Technology Group Inc., "ACWA Engineering Design Study Test Plan," Level 3, Revision 0, June 14, 2000.

[2] "Description of Proposed Test to Wash-out HD Projectiles and Dispose of Associated Liquid and Solid Wastes at the CAMDS Test Facility," Parsons Infrastructure & Technology Group Inc., ACWA Project Team, October 5, 2000.

SECTION 2

PROCESS DESIGN PARAMETERS

This section discusses the overall process design parameters that define the ACWA WHEAT mustard munitions processing demilitarization facility. It includes a subsection on the plant capacity to process the munitions, a throughput analysis of the reverse assembly process and the buffering capabilities between the connected process systems. It also includes subsections on new materials and utilities requirements, and a process effluents listing and summary.

2.1 STOCKPILE DEFINITIONS

The ACWA EDS WHEAT HD munitions processing facility feedstock contains only one type of agent, mustard of the HD or HT type, in projectiles or mortars.[1] The agent is the feedstock to the agent hydrolyser, which is the beginning of the chemical processing systems; whereas the munitions metal parts/bodies must be decontaminated and rendered agent free, following the extraction of agent, in order to be able to release the emptied munitions/components outside of the chemical demilitarization facility.

Table 2-1 shows the type and number of HD munition in the stockpile used for the design of the ACWA EDS munitions processing facility.

Table 2-1—Stored Mustard Munitions Data – Agent[1]

Munition	Type	Caliber	Quantity	Total Weight lb/munition	Agent	Agent wt. lb/munition
M60	Projectile	105 mm	383,418	38.8	HD	3
M104/M110	Projectile	155 mm	299,554	94.6	HD	11.7
M2/2A1	Mortar	4.2 in.	76,722	25	HD	6
M2	Mortar	4.2 in.	20,384	25	HT	6

Table 2-2 shows the munitions configuration status for the typical mustard stockpile.[2] Note that the 105-mm M60 projectiles are partially reconfigured, whereas the 155-mm M110 and M104 projectiles are totally reconfigured, and none of the 4.2-inch mortars are reconfigured.

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Table 2-2—Stored Munitions Configuration Status[2]

Total Number and Configuration for 105MM, HD, M60 (442) (C442)			
Boxed			28,375
	Boxes	14,188 ea	
M57	Fuzes	28,375 ea	
M5	Bursters	28,375 ea	
M14B1	Cartridge case	28,375 ea	
M28B2	Primer	28,375 ea	
M67	Propellant	78,031 lbs	
Reconfigured 105mm, HD, M60: 24 Rounds per/Pallet			
Rounds			355,043
	Pallets	14,794 ea	
M5	Bursters	355,043 ea	
Total Number and configuration for 155mm, HD, M110 and M104: *8 rounds per/Pallet			
Rounds			299,554
	Pallets	37,445 ea	
M6	Bursters	299,554 ea	
Total Number and Configuration for 4.2" mortar, HT & HD M2 & M2A1			
Rounds			97,106
	Boxes	48,553 ea	
M8	Fuzes W/M14 Bursters	97,106 ea	
M2	Ignition cartridge	97,106 ea	
M6	Propellant	60,011 lbs. (M8 Sheet)	

2.2 CAPACITY AND THROUGHPUT ANALYSIS

In the discussion that follows, munitions are 105-mm M60 HD projectiles; 155-mm M104 and M110 HD projectiles; 4.2-inch M2/M2A1 HD mortars and 4.2-inch M2 HT mortars. Each one of the three munitions types to be processed has a unique weight and structure, as well as unique agent and energetic component contents. The principle common factor is that all contain mustard (agent HD or HT). Due to the preponderance of the munitions containing HD mustard is referred to as HD and the behavior of the HT type agent is assumed to be similar to HD.

In chemical demilitarization facility (CDF) operations, plant capacity is the amount of chemical agent destroyed per day, which also corresponds to the quantity of munitions disassembled.

The ACWA WHEAT process design for the CDF is a synergistic network of continuous processing and batch processing systems, with buffering storage capabilities in between the systems. However, the provision of buffering is not a general rule. There are instances of continuous feeding of material to downstream receiving systems with no provision of buffering due to safety reasons (e.g., storage of energetic slurries); or due to cost effectiveness (e.g., munitions line from reverse assembly to agent access). Therefore, overall plant capacity is affected by the inter-relationship between the different systems/components that make up the total facility. System availabilities play a significant role in achieving the throughput that is desired. Plant capacity is defined in conjunction with a throughput analysis of the CDF system.

The plant throughput analysis identifies the number of on-stream or operating days required to destroy the designated stockpile, or the campaign duration.

To calculate a campaign duration that takes into account the failure of various systems or subsystems, a number of operating (or failure) scenarios were identified and for each scenario a steady state munitions throughput was calculated. Steady state is defined here as the condition where buffers can be maintained indefinitely (or for prolonged periods of operation), such that operations can be maintained at a given munitions throughput rate indefinitely or until a failure alters the scenario.

A string of such scenarios given a probability as a percentage of the duration of the overall specific munitions campaign, makes it possible to calculate an overall CDF agent campaign duration.

Campaign duration as discussed here does not include the time required for munitions campaign systemization, changeover, or closeout. Those schedule increments are administratively determined and are not process dependent.

The throughput analysis is based on the assumption that the ACWA WHEAT CDF will operate 24 hours per day, seven days per week.

The throughput analysis is not a rigorous RAM analysis, and is not the result of a statistical failure analysis. System failure probabilities utilized are based on general experience from systems having similar complexity and not from the probability analysis of the failure of individual components within subsystems.

During later, maturer, phases of this project it is recommended that a complete RAM analysis be performed.

2.2.1 CAPACITY

Referring to the scenario case studies shown in Tables 2-10 and 2-11, plant capacities for each munition campaign can be reported as the result of the munitions throughputs calculated.

Three overarching throughput scenarios have been considered: design peak, optimum steady-state, and campaign average.

2.2.1.1 Design Peak Munitions Processing Rates

The design peak throughput for munitions processing does not translate to the maximum plant capacity because of the impending shutdown of the munitions processing train (the WPMDs, WMDMs, projectile washout and R-MPT). Because, the agent processing train, inherently being more reliable than the munitions processing train, has not been designed to process the volume of agent accessed on a sustained basis.

These peaks apply to the mechanical performance that the munitions processing train machinery is designed for each munitions campaign: 60 projectiles/hour for 155-mm M110; 120 projectiles/hour for 105-mm M60; and 120 mortars/hour for 4.2-inch M2/M2A1.

2.2.1.2 Optimum Steady-State Munitions Processing Rates

The optimum munitions throughput calculated for the scenario titled "Steady-State All Systems Go" is the highest for all the scenarios calculated. These are the maximum capacities that the CDF can attain at a sustainable rate. The optimum munitions throughput rates and corresponding maximum agent destruction capacities are shown in Table 2-3 for the hydrolyser working capacity at ABCDF-scale-1.00 case (refer to Table 2-10).

Table 2-3—Munitions Throughput for "Steady-State All System Go" Scenario

Munitions Campaign	Munitions/hour	HD destroyed, lbs/day
155-mm M110	36.6	10,277
105-mm M60	120.0	8,640
4.2-inch M2/M2A1	70.3	10,123

The optional larger hydrolyser working capacity ABCDF-scale-1.33 case (refer to Table 2-11), optimum munitions throughput rates and corresponding maximum agent destruction capacities are shown below in Table 2-4.

Table 2-4—Optional Munitions Throughput for "Steady-State All System Go" Scenario

Munitions Campaign	Munitions/hour	HD destroyed, lbs/day
155-mm M110	39.8	11,176
105-mm M60	120	8,640
4.2-inch M2/M2A1	76.7	11,045

2.2.1.3 Campaign Average Munitions Processing Rates

The campaign average munitions throughput calculated for the duration is based on the string of system availability scenarios that make up a campaign including a scenario for unplanned downtime (refer to the discussion below in subsection 2.2.2 on the subject of throughput scenario strings). Table 2-5 shows the campaign munition throughput rates. The resulting rates are the campaign average munition throughput rates and corresponding campaign average agent destruction capacities that the CDF can attain. These are for the hydrolyser working capacity at ABCDF-scale-1.00 case (refer to Table 2-10).

Table 2-5—Campaign Munition Throughput Rates

Munitions Campaign	Munitions/hour	HD destroyed, lbs/day
155-mm M110	23.1	6,478
105-mm M60	67.5	4,863
4.2-inch M2/M2A1	44.8	6,455

The optional larger hydrolyser working capacity ABCDF-scale-1.33 case (refer to Table 2-11) for campaign average munitions throughput rates and corresponding campaign average agent destruction capacities are shown below in Table 2-6.

Table 2-6—Optional Campaign Average Throughput Rates

Munitions Campaign	Munitions/hour	HD destroyed, lbs/day
155-mm M110	24.8	6,962
105-mm M60	68.7	6,945
4.2-inch M2/M2A1	48.3	6,955

2.2.2 THROUGHPUT ANALYSIS

This throughput analysis is limited to the relationship between the munitions processing or reverse assembly train, and the agent processing train of the ACWA WHEAT process. Each one of these two main processing trains or systems consists of subsystems that feed to downstream subsystems.

The approach taken in this throughput analysis is to identify the integrated system limitations, and to adjust munitions processing rates such that buffers separating subsystems operate at steady state conditions, i.e. the storage tank levels holding steady. Then, as explained above, a string of scenarios is devised that best represent the overall operational experience of a complete campaign and hence campaign duration (as operating days) is calculated.

2.2.2.1 Munitions Processing Train

Inputs to the munitions processing train are the munitions from the unpack area (UPA), and the outputs are 5X heat treated munitions exiting the R-MPT, and the agent extracted from the WMDM which is the feed to the agent processing train. There are actually two munition processing trains starting at the UPA which converge at the R-MPT. Individual system components are:

- 2 WPMD machines, one per munitions processing train.
- 2 WMDM where drained agent is accessed and sent to storage (TOX), one per munitions processing train. Drained agent is assumed to be 60% of the total agent accessed (i.e. 60% of the total agent in the munitions less the un-accessed heel that remains in the shell and is destroyed in the R-MPT).
- 2 projectile washout machines where agent concentrate is accessed and sent to storage (TOX), one per munitions processing train. Agent concentrate is assumed to be 40 % of the total agent accessed.
- One R-MPT, common to both munitions processing trains. Agent heel or sludge at 2% of the total agent present in the incoming munitions is destroyed in the R-MPT.

There is no buffering or storage provided within the munitions processing trains apart from the munitions hold-up provided by the individual system components including the conveying equipment. This minor buffering capability is not considered in the throughput analysis since it will be filled, or depleted, within minutes of a processing train becoming operational.

The two munitions processing trains have combined peak hourly munitions processing rates of 60, 120, 120 for the reverse assembly of 155-mm M110 projectiles, 105-mm M60 projectiles and 4.2-inch mortars respectively. Except for the R-MPT all the other individual subsystems have half the peak operating rate of the train as a whole; for example the peak 155-mm projectile processing rate for an individual WPMD is 30 projectiles per hour.

As a point of reference, it is instructive to compare the peak hourly munitions processing rates given above for the ACWA WHEAT design with the baseline CSDP design for two parallel trains, see Table 2-7 below:[3]

Table 2-7—Peak Processing Rate Comparison

Munitions type	155-mm M110	105-mm M60	4.2-inch M2/2A1
Baseline PMD	276.0	288	274.0
WHEAT WPMD	60.0	120	120.0
Baseline MDM[a]	189.6	225	203.4
WHEAT WMDM[b]	60.0	120	120.0

Notes:

[a]Baseline MDM munitions processing rate shown is for three MDMs.

[b]WHEAT WMDM munitions processing rate is for two WMDMs.

The lower munitions processing rates of the WPMD points to the conservatism in ACWA WHEAT design, especially when upon considering that the WPMD is a clone of the baseline PMD.

The same conservatism in design is illustrated when comparing the munitions processing peak hourly rates for WMDM and MDM. Furthermore, the burster well pull and tilt-and-drain actions of the WMDM, are much simpler than the burster well pull, probe insertion and drain (by vacuum), burster well crimping and re-insertion actions of the baseline MDM.

2.2.2.2 Agent Processing Train

The agent processing train is a combination of storage tanks that provide buffering capacity, and reaction areas consisting of the batch processing agent neutralization reactors (hydrolysers), and continuously processing immobilized cell bioreactors (ICB™) that accept the agent hydrolysate mixed with other feeds and convert the organic components to inorganic salts. The input to the train is agent, drained and/or concentrate, and the output is ICB™ effluent. Individual components of the agent processing train are:

- One 500-gallon drained agent (100% HD) storage tank in the TOX.
- One 500-gallon agent concentrate (90% HD) storage tank in the TOX.

- Six agent hydrolyser systems. Each hydrolyser system consists of a jacketed reaction vessel, agitator, recirculation pump, heat exchanger and inline mixer. The reaction system proposed by ACWA WHEAT is modeled after the system originally adopted by the ABCDF project[4] and uses the same scale reactors having 1,525 gallon operating capacity each, and a reactor HD loading of 4% which is close to the 3.8% HD loading used for the ABCDF ADP. The agent hydrolysers also process spent decon.

- One agent hydrolysate tank having 42,000 gallon capacity (and a utilization factor of 90%). Besides agent hydrolysate this tank also receives purge streams (MPT and CST condensate) from the MPT and CST quench tower recirculation brine systems.

- Sixteen ICB™ units, arranged in clusters or modules of four. Each ICB™ unit has a 40,000-gallon operating capacity and a 5-day residence time. Each module has its own ancillary equipment such as ICB™ feed tank and pump, air blower, offgas treatment (CATOX®) system, and ICB™ effluent tank and pump. Due to this arrangement, the ICB™ failure scenarios considered later will be for one module of 4 ICB™ units at a time, i.e. for instance due to a failure of the common air blower.

2.2.2.3 Systems Not Included in the Throughput Analysis

Other important processing trains, which are part of ACWA WHEAT, are not included in this throughput analysis because of their minimal impact on the throughput or availability of the two main processing trains. These systems are:

- Energetics neutralization reactor systems (ENR). The ENR is expected to be more reliable than the upstream WPMD system feeding it; and also because the ENR system has more than 50% spare reaction capacity available when processing burster energetics, when the WPMDs are operational at peak operating rates. For safety reasons, there is no buffer provided between the WPMD and ENR, hence the energetics feed to the ENR ceases when the WPMD stops operating. The energetics hydrolysate product from the ENR feeds the bioreaction systems; due to the relatively larger volume of the receiving bioreaction system, the latter is always available to receive energetics hydrolysate.

- Continuous steam treatment (CST) of nonprocess wastes because operation of the CST is decoupled from munitions processing and agent processing. The feeds (wood, DPE and spent HVAC carbon) are independent of munitions processing, though the small (less than one gpm) CST condensate purge stream from CST quench scrubbing is included in the make-up of the bioreaction feed streams.

Brine reduction and recovered water systems are excluded because they are expected to have similar reliabilities as the upstream agent neutralization and bioreaction systems; and are not expected to bottleneck the throughput of the munitions processing and agent processing systems.

2.2.2.4 The Throughput Model

The throughput model is an Excel spreadsheet (see Figure 2-1) that calculates for each subsystem of the munitions processing train the agent access rate in pounds per day. The calculation lists all three munition campaigns.

For the agent processing train the throughput model calculates:

- Time (in hours) required to fill and to empty the buffers of the drained agent and agent concentrate storage tanks, taking into account independent input and output flow rates from the tanks.

- The number of hydrolyser batches required per day, and the number of hydrolyser batches processed per day.

- Time (in hours) required to fill and to empty the buffers of the hydrolysate storage tank, taking into account independent input and output flow rates from the tank.

- The number of ICB units required for the individual scenario versus the number of ICB units used.

For each munitions campaign the number of operating days required for each scenario is also calculated. The number of operations period is dependent on the number of stockpiled munitions for the HD processing CDF as defined in Table 2-1 (refer to Section 2.1 above – stockpile definition). The throughput analysis calculation for the 155-mm M110 projectiles takes credit for the 90-day pilot test, thus reducing the M110 stockpile for the operations campaign from 299,554 munitions to 233,637 munitions.

2.2.2.5 Individual Scenario Input Variables and Criteria

Table 2-8 specifies the input variables used to calculate the CDF throughput. Different operating scenarios use the same set of nonvariable input criteria as set forth in Table 2-8, plus a set of variable criteria. The variable criteria are shown highlighted in Table 2-8 and are also listed below:

- **Munitions Feed Rate:** is adjusted to obtain steady-state conditions at the buffers/storage tanks for the scenario in effect.

- **WPMD Operating Limit:** this variable is kept at "1.00" when the throughput model is used for defining steady state cases, meaning that the WPMD is being continuously operated (i.e., at 100% availability) at the stated munitions feed rate. The WPMD operating limit is useful when nonsteady state scenarios are tested, with the WPMD operating at peak operating rates and filled-up buffers forcing operating time limits on the upstream equipment. Note that the WPMD operating limit also applies equally to the WMDM and other subsystems of a munitions processing train.

Munitions from UPA

2 WPMD (1 per reverse assembly line)			
projo type	155-mm	105-mm	4.2-inch
WPMD on-stream factor	1	1	1
projo/hr	36.6	120	70.3
agent lb/day	10277	8640	10123
operating limit	1.00	1.00	1.00

2 WMDM (1 per reverse assembly line)			
projo type	155-mm	105-mm	4.2-inch
WMDM on-stream factor	1	1	1
projo/hr	36.6	120	70.3
agent lb/day	6043	5080	5952
operating limit	1.00	1.00	1.00

Agent (100% HD) Storage one 500 gal.		
projo type	hours buffer to fill	hours buffer to empty
155-mm	NO LIMIT	21.4
105-mm	NO LIMIT	24.5
4.2-inch	NO LIMIT	21.4

2 Projectile (Rotary) Washout Machines (I per rev. ass. Line)			
projo type	155-mm	105-mm	4.2-inch
WHEAT peak	60 projo/hr	120 projo/hr	120 projo/hr
projo/hr	36.6	120	70.3
agent lb/day	4029	3387	3968
operating limit	1.00	1.00	1.00

Agent Concentrate (90% HD) Storage one 500 gal.		
projo type	hours buffer to fill	hours buffer to empty
155-mm	NO LIMIT	28.9
105-mm	NO LIMIT	33.1
4.2-inch	NO LIMIT	28.9

R-MPT (one for the 2 reverse assembly lines)			
projo type	155-mm	105-mm	4.2-inch
WHEAT peak	60 projo/hr	120 projo/hr	120 projo/hr
projo/hr	36.6	120	70.3
agent lb/day	206	173	202
operating limit	1.00	1.00	1.00

5X Projo Shells

Agent Neutralization 6 Agent Hydrolysers			
projo type	batches required/day	batches processed/day	HD batch/total batch
155-mm	24.0	24.0	0.9722
105-mm	21.0	21.0	0.967
4.2-inch	24.0	24.0	0.9718

Max number batches available/day = 24
Batch cycle hours = 6.00
Reaction volume = ABCDF scale 1.00
HD concentration = 0.034
Agent hydrolysers on-stream factor = 1
Spent decon included

Hydrolysate Tank one 42,000 gal.			
projo type	hours buffer to fill	hours buffer to empty	tank mix / hydrolysate
155-mm	684	20	1.31
105-mm	(4,212)	22	1.35
4.2-inch	761	20	1.31

MPT/CST cond. Included
ICB Feed Tanks not Included in buffer
Hours buffer to empty based on no infeed at the time

Bioreaction 40,000 gal / ICB		
projo type	No. of ICB req'd	ICB utilized
155-mm	14.65	15
105-mm	12.77	13
4.2-inch	14.62	15

Max. number ICB available = 16
ICB on-stream factor = 1.00
No. of ICB req'd based on hydrolyser batches processed

Operations days required for scenario			
Campaign	155-mm	105-mm	4.2-inch
Days	266	133	58

Does not include 5 ICB days
Basis: 3 x 8-hr shifts x 7 days/week

Figure 2-1—ACWA WHEAT System Throughput and BUFFER Capabilities
(Operating scenario is for steady state operation)

Table 2-8—ACWA WHEAT Throughput Analysis
Input Criteria and Assumptions for Individual Scenarios
(highlighted cells define "Steady State All Systems Go" scenario)

Munitions Data			
Munitions Type	155-mm	105-mm	4.2-inch
Stockpiled quantity of munitions	233637	383418	97106
Burster energetics wt: lb/munition	0.41	0.26	0.14
Agent content: lb/munition	11.7	3	6
Empty shell weight: lb/munition	78.06	26.57	15.331
Fuzes & misc. parts: lb/munition	4.26	3.2	2.026
Munitions feed rate:	36.6	120	70.3
WPMD operating limit:	1.00	1.00	1.00
Total number of WPMDs:		2	
Number of WPMDs in operation:		2	
Total number of WMDMs:		2	
Number of WMDMs in operation:		2	
Munition residual agent heel:		0.02	
Drained agent fraction:		0.6	
R-MPT trains working in parallel:		1	
Drained agent tank capacity: gallons		500	
Agent (HD) density: lb/ft^3.		79.5	
Agent conc. tank capacity: gallons		500	
Fraction HD in agent concentrate:		0.9	
Agent concentrate density: lb/ft^3.		77.8	
Assume CST condensate at max. rate: gpm		0.67	
Assume MPT condensate: gal / lb HD heel		50	
Number of MPT/CST batch tanks:		2	
MPT/CST batch tank capacity: gal. each		6800	
Spent decon: lb / munition		5	
Spent decon density: lb/gal:		8.2	
Number of spent decon batch tanks:		3	
MPT/CST batch tank capacity: gal. each		2300	

Table 2-8—ACWA WHEAT Throughput Analysis
Input Criteria and Assumptions for Individual Scenarios
(highlighted cells define "Steady State All Systems Go" scenario) (Contd)

Munitions Data			
Munitions Type	155-mm	105-mm	4.2-inch
Total number of agent Hydrolysers		6	
Number of Hydrolysers in operation		6	
Agent hydrolyser batch cycle time: hours		6	
ABCDF reactor working capacity: gallons		1525	
WHEAT reactor as ABCDF scale factor		1.00	
HD loading in reaction mix. as hydrolysate		0.034	
Agent hydrolysate density at 194 °F: lb/gal		8.22	
Agent hydrolysate tank volume: gallons		42000	
Agent hydrolysate tank utilization		0.90	
Total number of ICB units		16	
Number of ICB units in operation		16	
ICB unit volume: gallons		40000	
ICB residence time: days		5	
ICB feed recipe: lbs total feed / lb HD		97.279	
ICB feed density: lb/cu.ft.		61.7	

NOTES & ASSUMPTIONS	
1	CST operation is decoupled from munitions processing. The feeds: wood, DPE and carbon processing rates are independent of munitions processing.
2	MPT and CST condensates (purge streams from the respective tower recirculation brine loops) are agent free and do not need to be hydrolyzed.
3	MPT condensate: H&M balance stream No. 0752; assumes used 50% excess steam over stoichiometric requirement.
4	CST condensate: PFD stream No. 7554; assumes 50% excess steam over stoich. requirement; DPE is design case.
5	Pilot test credit of 90 days of munition destruction taken out of a total of 409 days (per data used in life cycle costs) reduces 155-mm projectile stockpile inventory for normal campaign from 299,554 munitions to 233,637 munitions.
6	No propellants in reaction mix; no co-processing.
7	Downtime between campaigns is not included in throughput analysis.

- **Number of WPMDs in Operation:** normally is "2," but different failure scenarios can result in "1" or "0" WPMDs being in operation.
- **Number of WMDMs in Operation:** normally "2," but different failure scenarios can result in "1" or "0" WMDMs being in operation.

- **Number of Hydrolysers in Operation:** can be "6" or any number less than "6." The throughput analysis scenarios use "5" and "4" as alternates corresponding to 1 or 2 hydrolysers being out of commission at a time.

- **Agent Hydrolyser Batch Cycle Time:** is maintained at 6-hours, even though the proposed ideal batch cycle time is 4 hours. This allows a degree of conservatism (50%) in calculating the number of batches a single hydrolyser can process within an operating day.

- **WHEAT Hydrolyser Scale in Reference to the ABCDF Hydrolyser:** WHEAT agent neutralization reaction operating volume scaled to the ABCDF neutralization reactor operating volume. Two reactor scale factors were tested: scale 1.00 corresponding to 1,525 gallon working capacity; and scale 1.33 corresponding to a 2030 gallon working capacity.

- **HD Loading Weight Fraction in the Reaction Mixture as Hydrolysate:** only 0.034 equivalent HD in the hydrolysate has been utilized. This corresponds to a 4 % HD loading in the reaction mixture (prior to neutralization with caustic). HD loading at the reactor provides an easy means to increase agent hydrolysis capacity.

- **Number of ICB Units in Operation:** are usually "16" corresponding to the more probable 100 % availability; or "12", corresponding to the alternate probability, that the failure of ancillary equipment common to a whole module (of 4 ICB units) will result in the temporary unavailability of all 4 ICB units.

For a more complete look at the individual scenario input variables and underlying assumptions, refer to Table 2-8.

2.2.2.6 Individual Scenario Calculated results

For each individual scenario evaluated per the input variables specified in the preceding section, an optimum steady-state condition is calculated for the output variables as shown in Table 2-9.

Note the "No Limit" result printed in the cells for agent storage hours available for the buffer to fill. This means that input to the storage tank equals output.

Also note the hydrolysate storage tank hours taken to fill the buffer; it will take 684 hours and 761 hours to fill the agent hydrolysate buffer for the 155-mm projectiles and 4.2-inch mortar campaigns respectively for the scenario in question. The length of these buffer fill periods are also an indication that input to the storage tank equals output.

The calculated results for buffers to empty can be interpreted as the time available to do repairs on upstream systems that may have failed, causing the buffers to empty. The emptying rate is calculated for the prevailing scenario for the downstream system. For example, upon the failure of a WPMD, when the system is operating on a limited number of hydrolysers being available, the agent buffer emptying rate is the time available to bring the WPMD back on stream and still maintain the operating throughput.

Note that the last item in Table 2-9, the "operations days required for scenario" refers to the individual scenario in question and not the duration of the overall campaign. The latter are calculated in conjunction with a string of scenarios and assigned duration probabilities (as shown in Tables 2-10 and 2-11 and explained in the next subsection).

The throughput (and buffer capabilities) model also calculates other results which are not listed in Table 2-9 as they are not essential to calculate overall campaign duration. Refer to Figure 2-1 for these other calculation results.

Table 2-9—Calculation Results Summary for "Steady State All Systems Go" Scenario

Munitions Type	155-mm	105-mm	4.2-inch
Agent destruction: lb/day	10277	8640	10123
Drained agent storage: hours buffer to fill	No limit	No limit	No limit
Drained agent storage: hours buffer to empty	21.4	24.5	21.4
Agent concentrate storage: hours buffer to fill	No limit	No limit	No limit
Agent concentrate storage: hours buffer to empty	28.9	33.1	28.9
Agent hydrolyser batches processed / day	24.0	21.0	24.0
Hydrolysate storage: hours buffer to fill	684	-4212	761
Hydrolysate storage: hours buffer to empty	19.5	21.7	19.5
Number of ICB units used	14.6	12.8	14.6
Operations days required for scenario	266	133	58

2.2.2.7 String of Throughput Scenarios

Microsoft Excel scenario manager was used to compile the calculated results of throughput analyses for a string of scenarios that would make up an agent campaign. Probabilities were assigned as "Duration as % of Campaign Total" for each scenario in the string. Refer to Tables 2-10 and 2-11, for an example of how this works. These are the input variables for two cases; with all other input variables being equal for the same string of scenarios, the sensitivity of the calculated campaign duration system to hydrolyser operating capacity (for ABCDF scales 1.00 and 1.33) was tested. The results indicate that the overall campaign can be reduced by 40 days, for the given operating string of scenarios and their duration probabilities.

The string of scenarios is as follows:

- **Optimum Steady State All Systems Go:** This is the base operating scenario, and as the name implies, all systems are 100% available. The steady-state conditions require optimum total munitions throughput to be 36.6, 120, 70.3 munitions per hour for the 155-mm projectiles, 105-mm projectiles, and 4.2-inch mortars, respectively. A 35% duration probability has been assigned to this scenario based on the subjective operating experience of Parsons' staff. Note that except for the 105-mm campaign, the other campaigns are constrained by the agent processing train, specifically the hydrolysers for the scale-1.00 hydrolyser case, and the number of available ICB units for the scale-1.33 hydrolyser case. The constraint on the 105-mm campaign is the processing rate of the WPMD/WMDM equipment.

- **1WPMD-down:** This scenario includes the downgrading of one of the two munitions processing trains. Note that the throughput of the single remaining WPMD and the rest of its munitions processing train can be pushed to the design peak operating rate of the machine(s), because the agent processing train is no longer the bottleneck. All the available hydrolyser and ICB™ unit capacities are not being utilized. A probability of 20% is assigned to this single failure scenario.

- **1Hydro-down:** Note that for the scale-1.33 case the loss of one hydrolyser has no impact on munitions throughput. A probability of 3% is assigned to this single failure scenario.

- **2Hydro-down:** The loss of 2 hydrolysers, one hydrolyser module or room (possibly due to factors external to the hydrolyser systems themselves – e.g. HVAC failure) has a stronger impact on the munitions throughput for this case than the previous one. A probability of 3% is also assigned to this single failure scenario.

- **4ICB-down:** This case dealing with the failure of a blower or CATOX® system, shutting down a whole ICB module. The assigned failure probability is 3%.

- **1WPMD-1Hydro-down:** A combined failure of a munitions processing line and one hydrolyser**.** A probability of 3% is assigned to this single failure scenario.

- **1WPMD-4ICB-down:** A probability of 1% is assigned to this single failure scenario.

- **1Hydro-4ICB-down:** 0.5% probability assigned.

- **2Hydro-1WPMD:** 1% probability assigned.

- **2Hydro-4ICB-down:** 0.5% probability assigned, and out of the operating scenarios this one has by far the most severe impact on munitions throughput.

- **Unplanned Down Time:** There is no munitions processing being done in this scenario. The implication is for the R-MPT being down, or possibly the munitions deformation machine, or both WPMDs, or both WMDMs. This failure scenario is assigned a high probability of 30% of the overall campaign duration again based on Parsons' staff experience. This also includes administrative downtime not accounted for as a scheduled activity. Examples may be emergency drills, spot training, laboratory QA/QC problems, control system malfunctions, and downtime not attributable to a specific system.

Due to the history of low reliability of the munitions processing or reverse assembly systems, the combined duration of all the failure scenarios involving the munitions processing systems exceeds 50% (including unplanned down-time), mainly due to the difficulty of on-line access for repairs. In contrast the proposed duration of failure scenarios for the agent hydrolysis and bioreaction systems are 11% and 5% respectively, as these are chemical processing systems not unlike identical industrial operations, and both systems have ease of access for repairs, as well as installed spares for critical ancillary subsystems.

2.2.2.8 Overall Availability

Overall availabilities for the CDF with the munitions processing and agent processing trains combined is calculated and shown in Tables 2-10 and 2-11, taking into account the string of operating scenarios. They range from 37% to 57% depending on the munition campaign and hydrolyser scale case studied.

Overall availability is calculated by first calculating the campaign duration total for the string of scenarios, from which a campaign average munitions processing rate (or feed to the WPMD/WMDM) is determined based on the munition stockpile quantity. Overall availability is calculated as the ratio of the calculated campaign average feed rate to the design peak feed rate of the WPMD/WMDM munition processing train.

The throughput analysis calculated results are heavily dependent on the scenario duration probabilities assigned. The latter values used in this analysis are the result of consensus among the planners of munition campaigns.

Table 2-10—ACWA WHEAT Throughput Scenarios
(Agent Hydrolysers Sized for ABCDF Scale 1.00:1525 Gallon
Working Capacity)

Scenario Summary	Steady State All Systems Go	1WPMD-down	1Hydro-down	2Hydro-down	4ICB-down	1WPMD-1Hydro-down	1WPMD-4ICB-down	1Hydro-4ICB-down	2Hydro-1WPMD-down	2Hydro-4ICB-down	Unplanned Down-time	Campaign Duration Totals for all Scenarios
Changing Cells:												
Optimum Feed Rate for WPMDs 155-mm projectiles / hr	36.6	30	30.53	24.45	29.9	30	29.75	29.9	24.45	24.5	-	**23.1**
Optimum Feed Rate for WPMDs 105-mm projectiles / hr	120	60	114.2	91.5	111.9	60	60	111.8	60	91.4	-	**67.5**
Optimum Feed Rate for WPMDs 4.2-inch mortars / hr	70.3	60	58.73	47	57.5	58.6	57.5	57.5	47	47	-	**44.8**
WPMD operating limit 155-mm projo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-
WPMD operating limit 105-mm projo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-
WPMD operating limit 4.2-inch mortars	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-
No. of WMDMs in operation	2	1	2	2	2	1	1	2	1	2	-	-
No. of WPMDs in operation	2	1	2	2	2	1	1	2	1	2	-	-
No. of Hydrolysers available	6	6	5	4	6	5	6	5	4	4	-	-
Hydrolyser Cycle: Hrs	6	6	6	6	6	6	6	6	6	6	-	-
Hydrolyser Scale (re: ABCDF as 1.00)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-
HD equivalent wt. fraction in hydrolysate	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	-	-
No. of ICBs available	16	16	16	16	12	16	12	12	16	12	-	-
Result Cells:												
Lbs HD processed/day (155-mm)	10277	8424	8573	6866	8396	8424	8354	8396	6866	6880	0	**6478**
Lbs HD processed/day (105-mm)	8640	4320	8222	6588	8057	4320	4320	8050	4320	6581	0	**4863**
Lbs HD processed/day (4.2-inch)	10123	8640	8457	6768	8280	8438	8273	8280	6768	6768	0	**6455**
Drained HD buffer to fill Hrs (155-mm)	NO LIMIT	NO LIMIT	902	1088	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	1088	1018	-	-
Drained HD buffer to fill Hrs (105-mm)	NO LIMIT	NO LIMIT	908	1080	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	1118	-	-
Drained HD buffer to fill Hrs (4.2-inch)	NO LIMIT	NO LIMIT	896	1107	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	1107	1107	-	-
Drained HD buffer to empty Hrs (155-mm)	21.4	26.1	25.7	32.1	26.2	26.1	26.3	26.2	32.1	32.1	-	-
Drained HD buffer to empty Hrs (105-mm)	24.5	50.2	25.7	32.1	26.2	50.1	50.1	26.2	49.6	32.1	-	-
Drained HD buffer to empty Hrs (4.2-inch)	21.4	25.1	25.7	32.1	26.2	25.7	26.2	26.2	32.1	32.1	-	-
HD concentrate buffer to fill Hrs (155-mm)	NO LIMIT	NO LIMIT	1192	1437	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	1437	1345	-	-
HD concentrate buffer to fill Hrs (105-mm)	NO LIMIT	NO LIMIT	1200	1426	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	1478	-	-
HD concentrate buffer to fill Hrs (4.2-inch)	NO LIMIT	NO LIMIT	1184	1462	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	1462	1462		-
HD concentrate buffer to empty Hrs (155-mm)	28.9	35.3	34.6	43.3	35.3	35.2	35.5	35.3	43.3	43.3	-	-
HD concentrate buffer to empty Hrs (105-mm)	33.1	67.8	34.7	43.3	35.4	67.7	67.6	35.4	67.0	43.3	-	-
HD concentrate buffer to empty Hrs (4.2-inch)	28.9	33.9	34.6	43.3	35.4	34.7	35.4	35.4	43.3	43.3	-	-
Number of Hydrolyser Batches used (155-mm)	24.0	19.7	20.0	16.0	19.6	19.7	19.5	19.6	16.0	16.0	-	-
Number of Hydrolyser Batches used (105-mm)	21.0	10.5	20.0	16.0	19.6	10.5	10.5	19.6	10.5	16.0	-	-
Number of Hydrolyser Batches used (4.2-inch)	24.0	20.4	20.0	16.0	19.6	20.0	19.6	19.6	16.0	16.0	-	-
Hydrolysate Buffer to fill Hrs (155-mm)	684	658	815	1013	832	673	686	832	835	1015	-	-
Hydrolysate Buffer to fill Hrs (105-mm)	-4212	-143	1122	1386	1140	-142	-144	1150	-241	1430	-	-
Hydrolysate Buffer to fill Hrs (4.2-inch)	761	501	896	1120	917	654	771	917	1001	1139	-	-
Hydrolysate Buffer to empty Hrs (155-mm)	19.5	19.5	23.3	29.0	23.8	19.5	19.7	23.8	23.9	28.9	-	-
Hydrolysate Buffer to empty Hrs (105-mm)	21.7	28.4	23.3	29.0	23.8	28.3	28.4	23.8	30.9	29.0	-	-
Hydrolysate Buffer to empty Hrs (4.2-inch)	19.5	19.1	23.3	29.0	23.8	19.3	19.6	23.8	23.9	29.0	-	-
Number of ICBs used (155-mm)	14.6	12.0	12.2	9.8	12.0	12.0	11.9	12.0	9.8	9.8	-	-
Number of ICBs used (105-mm)	12.8	6.2	12.2	9.8	12.0	6.2	6.3	11.9	6.3	9.8	-	-
Number of ICBs used (4.2-inch)	14.6	12.5	12.2	9.8	12.0	12.2	12.0	12.0	9.8	9.8	-	-
Operating Days (155-mm)	266	324	319	398	326	324	327	326	398	397	0	-
Operating Days (105-mm)	133	266	140	175	143	266	266	143	266	175	0	-
Operating Days (4.2-inch)	58	67	69	86	70	69	70	70	86	86	0	-
Duration of Scenario 100 % basis: days	457	658	528	659	539	660	664	539	751	658		
Duration as % of Campaign Total	**35.00%**	**20.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**1.00%**	**0.50%**	**1.00%**	**0.50%**	**30.00%**	**100.00%**
CAMPAIGN Duration 155-mm : days	84	13	13	13	13	13	4	2	4	2	127	**422**
CAMPAIGN Duration 105-mm : days	47	7	7	7	7	7	2	1	2	1	71	**237**
CAMPAIGN Duration 4.2-inch : days	18	3	3	3	3	3	1	0	1	0	27	**90**
				WPMD FAILURES AS DURATION OF TOTAL CAMPAIGN :				**25.00%**	**OVERALL AVAILABILITY 155-mm Projo Campaign**			**0.38**
TOTAL CHEMICAL DEMIL. CAMPAIGN DURATION : DAYS			**749**	**HYDROLYSER FAILURES AS DURATION OF TOTAL CAMPAIGN :**				**11.00%**	**OVERALL AVAILABILITY 105-mm Projo campaign**			**0.56**
TOTAL CHEMICAL DEMIL. CAMPAIGN DURATION : WEEKS			**107**	**ICB FAILURES AS DURATION OF TOTAL CAMPAIGN :**				**5.00%**	**OVERALL AVAILABILITY 4.2-inch Mortar Campaign**			**0.37**

Table 2-11—ACWA WHEAT Throughput Scenarios Agent hydrolysers sized for ABCDF scale 1.33 : 2030 gallon working capacity)

Scenario Summary	Steady State All Systems Go	1WPMD-down	1Hydro-down	2Hydro-down	4ICB-down	1WPMD-1Hydro-down	1WPMD-4ICB-down	1Hydro-4ICB-down	2Hydro-1WPMD-down	2Hydro-4ICB-down	Unplanned Down-time	Campaign Duration Totals for all Scenarios
Changing Cells:												
Optimum Feed Rate for WPMDs 155-mm projectiles / hr	39.8	30	39.8	32.5	29.9	30	29.9	29.9	30	29.9	-	**24.8**
Optimum Feed Rate for WPMDs 105-mm projectiles / hr	120	60	120	120	111.9	60	60	111.9	60	111.9	-	**68.7**
Optimum Feed Rate for WPMDs 4.2-inch mortars / hr	76.7	60	76.7	62.5	57.5	60	57.5	57.5	60	57.5	-	**48.3**
WPMD operating limit 155-mm projo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-
WPMD operating limit 105-mm projo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-
WPMD operating limit 4.2-inch mortars	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-
No. of WMDMs in operation	2	1	2	2	2	1	1	2	1	2	-	-
No. of WPMDs in operation	2	1	2	2	2	1	1	2	1	2	-	-
No. of Hydrolysers available	6	6	5	4	6	5	6	5	4	4	-	-
Hydrolyser Cycle : Hrs	6	6	6	6	6	6	6	6	6	6	-	-
Hydrolyser Scale (re: ABCDF as 1.00)	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	-	-
HD equivalent wt. fraction in hydrolysate	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	-	-
No. of ICBs available	16	16	16	16	12	16	12	12	16	12	-	-
Result Cells:												
Lbs HD processed/day (155-mm)	11176	8424	11176	9126	8396	8424	8396	8396	8424	8396	0	**6962**
Lbs HD processed/day (105-mm)	8640	4320	8640	8640	8057	4320	4320	8057	4320	8057	0	**6945**
Lbs HD processed/day (4.2-inch)	11045	8640	11045	9000	8280	8640	8273	8280	8640	8280	0	**6955**
Drained HD buffer to fill Hrs (155-mm)	NO LIMIT	NO LIMIT	NO LIMIT	834	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	-	-
Drained HD buffer to fill Hrs (105-mm)	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	-	-
Drained HD buffer to fill Hrs (4.2-inch)	NO LIMIT	NO LIMIT	NO LIMIT	837	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	-	-
Drained HD buffer to empty Hrs (155-mm)	19.7	26.1	19.7	24.1	26.2	26.1	26.2	26.2	26.1	26.2	-	-
Drained HD buffer to empty Hrs (105-mm)	24.6	50.2	24.6	24.4	26.2	50.2	50.1	26.2	50.2	26.2	-	-
Drained HD buffer to empty Hrs (4.2-inch)	19.6	25.1	19.6	24.1	26.2	25.1	26.2	26.2	25.1	26.2	-	-
HD concentrate buffer to fill Hrs (155-mm)	NO LIMIT	NO LIMIT	NO LIMIT	1101	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	-	-
HD concentrate buffer to fill Hrs (105-mm)	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	-	-
HD concentrate buffer to fill Hrs (4.2-inch)	NO LIMIT	NO LIMIT	NO LIMIT	1105	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT	NO LIMIT		-
HD concentrate buffer to empty Hrs (155-mm)	26.6	35.3	26.6	32.5	35.3	35.3	35.3	35.3	35.3	35.3	-	-
HD concentrate buffer to empty Hrs (105-mm)	33.2	67.8	33.2	33.0	35.4	67.8	67.6	35.4	67.8	35.4	-	-
HD concentrate buffer to empty Hrs (4.2-inch)	26.5	33.9	26.5	32.6	35.4	33.9	35.4	35.4	33.9	35.4	-	-
Number of Hydrolyser Batches used (155-mm)	19.6	14.8	19.6	16.0	14.7	14.8	14.7	14.7	14.8	14.7	-	-
Number of Hydrolyser Batches used (105-mm)	15.8	7.9	15.8	15.8	14.7	7.9	7.9	14.7	7.9	14.7	-	-
Number of Hydrolyser Batches used (4.2-inch)	19.6	15.4	19.6	16.0	14.7	15.4	14.7	14.7	15.4	14.7	-	-
Hydrolysate Buffer to fill Hrs (155-mm)	628	658	628	767	832	658	686	832	658	832	-	-
Hydrolysate Buffer to fill Hrs (105-mm)	-948	-143	-948	1211	1140	-143	-142	1140	-143	1140	-	-
Hydrolysate Buffer to fill Hrs (4.2-inch)	680	501	680	846	917	501	829	917	501	917	-	-
Hydrolysate Buffer to empty Hrs (155-mm)	18.0	19.5	18.0	21.9	23.8	19.5	19.6	23.8	19.5	23.8	-	-
Hydrolysate Buffer to empty Hrs (105-mm)	21.3	28.4	21.3	22.2	23.8	28.4	28.3	23.8	28.4	23.8	-	-
Hydrolysate Buffer to empty Hrs (4.2-inch)	18.0	19.1	18.0	21.9	23.8	19.1	19.6	23.8	19.1	23.8	-	-
Number of ICBs used (155-mm)	15.9	12.0	15.9	13.0	12.0	12.0	12.0	12.0	12.0	12.0	-	-
Number of ICBs used (105-mm)	12.7	6.2	12.7	12.8	12.0	6.2	6.3	12.0	6.2	12.0	-	-
Number of ICBs used (4.2-inch)	16.0	12.5	16.0	13.0	12.0	12.5	12.0	12.0	12.5	12.0	-	-
Operating Days (155-mm)	245	324	245	300	326	324	326	326	324	326	0	-
Operating Days (105-mm)	133	266	133	133	143	266	266	143	266	143	0	-
Operating Days (4.2-inch)	53	67	53	65	70	67	70	70	67	70	0	-
Duration of Scenario 100 % basis : days	430	658	430	497	539	658	662	539	658	539		
Duration as % of Campaign Total	**20.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**1.00%**	**0.50%**	**1.00%**	**0.50%**	**30.00%**		**100.00%**
CAMPAIGN Duration 155-mm : days	79	12	12	12	12	4	2	4	2	118		**393**
CAMPAIGN Duration 105-mm : days	47	7	7	7	7	2	1	2	1	70		**233**
CAMPAIGN Duration 4.2-inch : days	17	3	3	3	3	1	0	1	0	25		**84**

		WPMD FAILURES AS DURATION OF TOTAL CAMPAIGN :	**25.00%**	**OVERALL AVAILABILITY 155-mm Projo Campaign**	**0.41**
TOTAL CHEMICAL DEMIL. CAMPAIGN DURATION : DAYS	**709**	**HYDROLYSER FAILURES AS DURATION OF TOTAL CAMPAIGN :**	**11.00%**	**OVERALL AVAILABILITY 105-mm Projo campaign**	**0.57**
TOTAL CHEMICAL DEMIL. CAMPAIGN DURATION : WEEKS	101	**ICB FAILURES AS DURATION OF TOTAL CAMPAIGN :**	**5.00%**	**OVERALL AVAILABILITY 4.2-inch Mortar Campaign**	**0.40**

2.2.2.9 Campaign Duration

Campaign duration data, shown in Table 2-12, is explicitly for the duration of the agent destruction campaigns reported as operations days for the string of scenarios that make up a campaign.

Table 2-12—Campaign Duration

Hydrolysis reactor capacity	Scale-1.00	Scale-1.33
Munitions Campaign	Op. days	Op. days
155-mm M110	422	393
105-mm M60	237	233
4.2-inch M2/M2A1	90	84
Campaign total duration	**749**	**710**

Campaign duration as calculated by the throughput analysis model is based on the assumption that the string of scenarios will be repeatable for all three munitions campaigns.

2.3 PROPELLANT CAMPAIGN

Propellant Disposal Campaign

The ACWA WHEAT energetics neutralization system will be used to destroy propellants obtained from the non-reconfigured munitions during the propellant disposal campaign following the agent destruction campaigns. Refer to Section 2.1, Table 2-2, stored munitions configuration status.

According to Table 2-2, munitions needing reconfiguration consist of 28,375 rounds of 105-mm M60 projectiles and 97,106 rounds of 4.2-inch mortars.

The calculated propellant campaign duration is 35 days for the 105-mm projectiles, and 45 days for the 4.2-inch mortars. The total duration is 80 days based on the assumption that there will be no down time necessary in between propellant campaigns.

The operation of the energetics neutralization system during the propellant campaign is based on the 80% availability of 3 energetics neutralization reactors, each reactor having a 200-gallon operating volume, and an 8-hour batch cycle.

The separate propellant campaign can be eliminated provided co-processing of propellants and munition burster energetics can be proven and conducted as part of the normal agent destruction campaigns. The 200-gallon reactor system is capable of co-processing of "mixed" campaigns under the condition they are processed at a rate no more than one propellant per every three burster tubes (energetics). This approach is currently only hypothetical until proven feasible by conducting biotreatment tests of the combined propellant-burster energetics, and for the time being can only be recommended for further study in the future.

Other options in the bid to eliminate the separate propellant disposal campaigns are:

- To install more reactors or larger reactors and simultaneously process propellants and burster energetics in separate batches.

- To supply the CDF with munitions that are already reconfigured.

2.4 NONPROCESS WASTE DISPOSAL CAMPAIGN

Nonprocess wastes or dunnage generated by the CDF, consisting of wood, DPE and spent HVAC carbon, will be heat treated in the continuous steam treater (CST) system. The operation of the CST is decoupled from munitions processing and agent processing operations except for a CST condensate purge stream of less than 1-gpm from CST quench scrubbing that is mixed in with the rest of the feed streams to the bioreaction system.

2.4.1 DPE DISPOSAL CAMPAIGN

The DPE disposal campaign is based on the generation of 12 suits per day, each suit weighing 9.0 lb. The contaminated DPE suit generation rate is estimated on 2 DPE entries per shift, and is based on the experience of Parsons' staff. This figure is close to the approximately 15 DPE suits generated daily at TOCDF for 1999.[6]

The total disposal load is 80,892 pounds assuming the campaign total duration is 749 days (refer to "Campaign Duration" for hydrolysis reactor scale-1.00 cases in Section 2.2 above).

2.4.2 WOOD DUNNAGE

The generation of wood dunnage is based on 2.8 pounds per munition.[7]

The campaign total quantities of wood dunnage generated are 233,637 pounds for the 155-mm projectiles*, 383,418 pounds for the 105-mm projectiles and 97,106 pounds for the 4.2-inch mortars; giving a total of 714,161 pounds for all three munition campaigns.

*Note that the stockpile of 155-mm projectiles has been reduced from 299,554 rounds to 233,637 rounds to credit munitions destroyed during pilot testing.

2.4.3 SPENT CARBON

Spent carbon from the HVAC carbon filtration systems will be processed.

2.4.4 CST DUNNAGE PROCESSING RATES

The CST will be processing feeds at the following rates:

- DPE: 15 lb/hr

- Wood: 100 lb/hr

- Spent carbon: 300 lb/hr

- Mixed DPE & wood: 15 & 85 lb/hr

It is assumed the CST will be 80 % available during the nonprocess waste disposal campaigns.

2.4.5 NONPROCESS WASTE CAMPAIGN DURATION

Two processing options exist.

Option 1: Sequential Processing of Dunnage

Option 1 assures that the wood and DPE are process sequentially. Table 2-13 shows the Option 1 processing time.

Table 2-13—Option 1: Processing Time

Processing Time	hrs	days
DPE	6,741	281
Wood	24,996	1,041
Carbon	579	24
Total Processing time	**32,316**	**1,346**

Table 2-14 shows the amount of wood that can be processed during the agent campaign and after the agent campaign. In this option, 597 days are secured to process the excess wood and carbon after the completion of the agent processing campaign.

Table 2-14—Option 1: Campaign Duration

Item	During Agent Processing Campaign	After Agent Processing Campaign
DPE, lbs	80,892	-
Wood, lbs	898,800	1,100,851
Carbon, lbs	-	139,000
Duration, days	749	597

Option 2: Combined Processing of Wood and DPE Dunnage

Option 2 assures that the wood and DPE will be process concurrently. Table 2-15 shows Option 2 processing time.

Table 2-15—Option 2: Processing Time

Processing Time	hrs	days	Quantity of Wood Processed, lbs	
DPE + Wood	6,741	281	With DPE @ 85 lb/hr	458,388
Wood	19,266	803	Alone @ 100 lb/hr	1,541,263
Carbon	579	24		
Total Processing Time	**26,586**	**1,108**		

Table 2-16 shows that the amount of dunnage that can be processed during and after the agent campaign. In the option, 359 days are required to process the excess wood. This can be further reduced to 335 days if the spent carbon from the HVAC filters and the wood are processed together.

Table 2-16—Option 2 Campaign Duration

Material	During Agent Processing Campaign	After Agent Processing Campaign
DPE, lbs	80,892	-
Wood, lbs	1,357,188	642,463
Carbon, lbs	-	139,000
Duration, days	749	359
Duration if Carbon is processed with Wood, days		335

2.5 RAW MATERIALS AND UTILITIES

The ACWA WHEAT mustard munitions processing chemical weapons destruction facility will consume raw materials and utilities as listed below.

2.5.1 RAW MATERIALS

Raw materials required to operate the plant are listed in Table 2-17.

Table 2-17—Maximum Amount of Raw Materials Needed for ACWA – WHEAT

M110/104 (155 mm) Projectiles	Sodium Hydroxide (50% wt.)	Sodium Hypochlorite (12% wt.)	Inorganic Nutrients (25% wt.)	Sulfuric Acid (98% wt.)
Agent Neutralization	11.66	2.32		
Energetics Neutralization	0.41			
Bioreaction System	11.56		2.62	
Rotary MPT	0.70			
Brine Reduction Package	0.41			0.70
Total (lb/munition)	25	2.3	2.6	0.70

M2/2A1 (4.2-inch) Mortars	Sodium Hydroxide (50% wt.)	Sodium Hypochlorite (12% wt.)	Inorganic Nutrients (25% wt.)	Sulfuric Acid (98% wt.)
Agent Neutralization	5.97	2.31		
Energetics Neutralization	0.14			
Bioreaction System	5.92		1.34	
Rotary MPT	0.35			
Brine Reduction Package	0.21			0.34
Total (lb/munition)	13	2.3	1.3	0.34

M60 (105 mm) Projectiles	Sodium Hydroxide (50% wt.)	Sodium Hypochlorite (12% wt.)	Inorganic Nutrients (25% wt.)	Sulfuric Acid (98% wt.)
Agent Neutralization	2.96	2.29		
Energetics Neutralization	0.25			
Bioreaction System	2.93		0.66	
Rotary MPT	0.18			
Brine Reduction Package	0.07			0.19
Total (lb/munition)	6.4	2.3	0.66	0.19

CST Dunnage (lb/lb dunnage)	Sodium Hydroxide (50% wt.)	CST Aggregate/ Carrier Material
DPE	1.1008	Note 5
Wood	0.0022	Note 5
Wood/DPE	0.1692	Note 5

Notes:

1. Above numbers are in pounds per munition, except for the CST, which are in pounds per pound of dunnage processed through the CST.
2. Sodium Hydroxide is provided at a 50% wt. concentration. It is partially diluted to 18% for specific units.
3. Inorganic Nutrients provided at 27.5% weight solution, consist of the following:
   - 27% K_2HPO_4
   - 44% $(NH_4)_2HPO_4$
   - 29% NH_3
4. Flocculant material for the clarifier to be alum while a polyamine sludge preconditioning and dewatering chemical is to be used for the thickeners and filters. During normal operations, the clarifiers and thickeners will not be used.
5. CST aggregate/carrier material consumption will be determined upon conclusion of the ACWA EDS CST testing. The mass balance is based on the assumption of a 10% attrition rate of the aggregate/carrier material.
6. Sodium hypochlorite is provided at a 12% wt. concentration, which is then diluted to 5.5% wt. for decontamination use. The amount of sodium hypochlorite is based on the consumption of 5 lb of 5.5% NaOCl solution per munition round.
7. Ferric chloride (for the agent reactors) and anti-foam (for the energetics reactors, CST quench tower, and brine reduction package) consumption requirements will be determined later during the detailed design phase of the project.

2.5.2 UTILITIES

Utilities imported across the facility battery limits are listed in Table 2-18 below. Electrical loads and power consumption of the facility are listed in Table 2-19. Utilities generated within the plant facility and a detailed utility users list are provided in the Process Systems - Design Data and Assumptions of Section 2.

Table 2-18—Utilities Imported Across Battery Limits

Commodity	Usage Rate	B/L Conditions
Natural gas	530,000 scfd	35 psig; amb. temp.
Plant water	53,000 gpd	50 psig; amb. temp.
Liquid nitrogen	5,664 lb/day	225 psig; -250^{o}F

Table 2-19—Electrical Load and Power Consumption

Summary of all Electrical Loads		Full-Capacity Load (kW)			Energy Consumption (kWh x 1,000)								
					Daily Basis (Note 1)			Campaign Duration (Notes 2 & 3)			Annual Basis (Note 4)		
System	System Description	155	105	4.2	155	105	4.2	155	105	4.2	155	105	4.2
System "10" :	Projectile Disassembly / Burster Washout	127	185	123	3.04	4.44	2.95	898	737	186	1111	1619	1076
System "20" :	Munition Demilitarization - Agent Processing	96	140	93	2.30	3.36	2.23	680	558	141	841	1227	815
System "30" :	Agent Collection / Toxic Storage / Spent Decon	8	7	8	0.20	0.18	0.20	59	29	13	73	64	73
System "40" :	Neutralization – Agent	356	312	356	8.55	7.48	8.55	2522	1242	539	3120	2730	3120
System "50" :	Neutralization – Energetics	5	8	5	0.13	0.19	0.12	38	31	8	47	69	46
System "60" :	Bioreactors	1125	844	1125	27.00	20.25	27.00	7964	3361	1701	9854	7390	9854
System "70" :	Rotary Metal Parts Treatment	215	314	209	5.17	7.54	5.01	1525	1251	315	1887	2752	1827
System "75" :	Continuous Steam Treater	281	281	281	6.74	6.74	6.74	1988	1119	425	2460	2460	2460
System "76" :	Batch Metal Parts Treatment	212	309	205	5.08	7.40	4.92	1498	1229	310	1854	2703	1795
System "80" :	Offgas Treatment – MPT	211	307	204	5.06	7.38	4.90	1493	1225	309	1847	2693	1788
System "85" :	Offgas Treatment – CST	365	365	365	8.77	8.77	8.77	2587	1456	552	3201	3201	3201
System "87" :	Offgas Treatment – Bioreactor	2592	1944	2592	62.22	46.66	62.22	18355	7746	3920	22710	17032	22710
System "90" :	Water Recovery /Dewatering	12	9	12	0.29	0.22	0.29	85	36	18	105	79	105
System "100" :	Brine Reduction Package	668	501	668	16.04	12.03	16.04	4731	1996	1010	5853	4390	5853
System "110" :	Bulk Chemical Storage	12	12	12	0.29	0.29	0.29	85	48	18	105	105	105
System "120" :	Contaminated Waste Preparation	7	7	7	0.17	0.17	0.17	51	28	11	62	62	62
System "130" :	Residue Handling	6	9	6	0.15	0.22	0.14	44	36	9	55	80	53
System "140" :	Water Balance	1	1	1	0.01	0.01	0.01	4	2	1	5	5	5
System "170" :	Sec Heat Transfer Fluid Circ System – Agent		57	65	1.56	1.37	1.56	460	227	98	570	499	570
System "180" :	Sec Heat Transfer Fluid Circ System – Energetics		3	2	0.06	0.08	0.05	16	13	3	20	29	20
System "200" :	Utilities	1400	1400	1400	33.61	33.61	33.61	9914	5579	2117	12267	12267	12267
BTA-Process :	Miscellaneous Process Load in BTA	84	84	84	2.00	2.00	2.00	591	333	126	732	732	732
MDB-Process :	Miscellaneous Process Load in MDB	519	519	519	12.45	12.45	12.45	3674	2067	785	4546	4546	4546
PAB-Process :	Miscellaneous Process Load in PAB	61	61	61	1.47	1.47	1.47	434	244	93	537	537	537
Site-Process :	Miscellaneous Process Load at Site	58	58	58	1.40	1.40	1.40	414	233	88	512	512	512
UB-Process :	Miscellaneous process load in ub	69	69	69	1.65	1.65	1.65	485	273	104	600	600	600
Total Process Load:		8,559	7,806	8,531	205	187	205	60,595	31,100	12,899	74,974	68,382	74,732
BTA-Facility :	Miscellaneous Facility Load in BTA	72	72	72	1.74	1.74	1.74	733	412	156	634	634	634
MDB-Facility :	Miscellaneous Facility Load in MDB	2142	2142	2142	51.42	51.42	51.42	21699	12186	4628	18768	18768	18768
PAB-Facility :	Miscellaneous Facility Load in PAB	110	110	110	2.63	2.63	2.63	1111	624	237	961	961	961
Site-Facility :	Miscellaneous Facility Load at Site	13	13	13	0.31	0.31	0.31	130	73	28	112	112	112
Ub-Facility :	Miscellaneous Facility Load in UB	192	192	192	4.61	4.61	4.61	1947	1093	415	1684	1684	1684
Total Facility Load:		2,530	2,530	2,530	61	61	61	25,619	14,388	5,464	22,158	22,158	22,158
Total Process and Facility Load:		11,088	10,336	11,061	266.12	248.06	265.45	86,214	45,488	18,363	97,132	90,541	96,890

NOTES:
1. Energy Consumption on Daily Basis = {[(Full-Capacity Load) x (24 Hours)] / 1000} kilowatt-hours x 1000.
2. Energy Consumption for Campaign Duration = {[(Full-Capacity Process Load) x (24 Hours) x ("On-Line" Campaign Duration Days)] / 1000]} kilowatt-hours x 1000.
3. Energy Consumption for Campaign Duration = {[(Full-Capacity Facility Load) x (24 Hours) x (Campaign Duration Days)] / 1000} kilowatt-hours x 1000.
4. Energy Consumption on Annual Basis = {[(Full-Capacity Load) x (24 Hours) x (365 Days)] / 1000} kilowatt-hours x 1000.

2.6 PROCESS EFFLUENTS SUMMARY

The process produces, by design, only solid effluents and treated air. The types and constituents as well as their ultimate treatment and disposal are described in this section. The stream compositions discussed in the next section are based on inputs from the heat and material balance for the final effluents exiting the system. Table 2-20 details the summary of the process effluents for the ACWA WHEAT program, for processing HD/explosive-filled munitions.

2.6.1 LIQUID EFFLUENT

The system is a zero liquid discharge system designed to recycle all liquid streams in order to conserve water and to avoid the need for a discharge permit and public concern. All water introduced into the facility, whether as process water, spent decon, or equipment washdown, is treated and reused either in the hydrolysers or at other locations within the plant. However, there are discharge scenarios connected to climatic conditions outside the normal operating atmospheric design conditions for the site, for details refer to the subsection dealing with the water balance in the Process Design Criteria section of this document.

Lab chemical waste, in keeping with CSDP practice, will be trucked offsite for disposal.

2.6.2 GASEOUS EFFLUENTS

Process gas effluents generated by the WHEAT process with their stream numbers are as follows:

(1) MPT CATOX® Offgas, represented by Stream No. 0852 on PFD AAC-01-F-080. The sources of this offgas are the agent hydrolysers, hydrolysate tank and MPT quench tower. The treated gas is routed to HVAC (carbon filters).

(2) CST CATOX® Offgas, represented by Stream No. 8552 on PFD AAC-50-F-085. The source of this offgas is the CST quench tower. The treated gas is routed to HVAC (carbon filters).

(3) ICB™ CATOX® Offgas, represented by Stream No. 8751 on PFD AAC-40-F-087. The sources of this offgas are the ICB™ units and it is vented to atmosphere after treatment.

Table 2-20—Summary of Process Effluents for ACWA WHEAT Program

	SOLID												GAS						
STREAM	Brine Reduction Residue			Rotary MPT 5X Treated Munitions			CST Light Particulate Material			Batch MPT 5X Treated Miscellaneous Parts			MPT Offgas			CST Offgas			ICB Offgas
STREAM NO.	1053			0753			1251			7652			0852			8552			8751
CASE	155 mm	4.2"	105 mm	155 mm	4.2"	105 mm	DPE	Wood	Wood/DPE	155 mm	4.2"	105 mm	155 mm	4.2"	105 mm	DPE	Wood	Wood/DPE	
SOURCE	Solids Dewatering Unit			Rotary MPT			CST			Batch MPT			MPT CATOX			CST CATOX			ICB™ CATOX
DESTINATION	Residue Handling Area			Residue Handling Area			Residue Handling Area			Residue Handling Area			To HVAC (Carbon Filters)			To HVAC (Carbon Filters)			Vent to ATM
COMPONENTS													(Note 2)			(Note 2)			
K_2HPO_4	3.35	3.41	2.64																
$(NH_4)_2HPO_4$	5.68	5.68	4.41																
$NaNO_3$	25.27	17.38	48.92																
Water	336.99	339.36	281.23										108.56	130.87	116.28	35.66	116.21	119.66	1583.24
SO_2													0.001	0.002	0.001				
NaCl	344.17	349.78	273.21																
Na_2SO_4	382.85	392.43	301.21																
Biomass	18.93	19.25	14.94																
N_2													4130.20	4459.37	4459.34	3499.63	3499.48	3499.48	22105.04
O_2													1031.77	1030.97	1043.66	1040.09	965.84	963.10	5768.99
CO_2													23.77	33.01	19.44	20.63	127.25	126.30	125.27
$NaHCO_3$	6.05	3.91	10.88																
Aggregate/Carrier Material							28.5	20	20										
Ash							2.25	15.00	15.00										
NO_2														0.31	0.53				
N_2O													1.19	0.81	1.52				
Solid				4684	1840	3188				256	243	384							
Trace Components	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)
Total (lb/hr)	1123.29	1131.20	937.43	4684	1840	3188	30.75	35.00	35.00	256	243	384	5295.50	5655.35	5640.77	4596.02	4708.77	4708.53	29582.54
Total (lbmole/hr)	27.72	27.89	23.16	-	-	-	-	-	-	-	-	-	186.29	199.46	198.76	159.89	164.46	164.54	1060.17
Avg. mw	40.53	40.55	40.49	-	-	-	-	-	-	-	-	-	28.43	28.35	28.38	28.74	28.63	28.62	27.90

Notes:

1. For trace components/ elements of the effluent streams, refer to ACWA EDS test reports.
2. Total HVAC system flowrate is 156,560 ACFM (for the MDB). The process vent/ offgas streams specified above will be discharged into the larger HVAC system airflow and sent to the HVAC carbon filters.

All ventilation and process offgas streams are passed through treatment devices to eliminate compounds of concern. Ventilation air is processed the Baseline Technology's carbon filter system. Process offgas streams are treated by catalytic oxidation prior to release to the atmosphere.

2.6.3 PROCESS DISCHARGES INTO VENTILATION SYSTEM

The main process discharges into the ventilation system are the discharges from the CATOX® treaters on the MPT offgas treatment system and the CST offgas treatment system. Refer to subsection 2.4.2 and Table 2-10 for details.

Other process discharges come from process tank vents, the MPT/CST condensate holding tanks, from the vent (carbon) filter inside the toxic room from the agent holding tank and the agent concentrate holding tank (the agent surgent tank is not in use during normal operation). The impact on the MDB building ventilation system from these tank vents is minimal due to the small liquid flow rates involved: typically 0.2-0.7 gpm for agent streams (ca 0.1 cfm), and typically 5.7 to 9 gpm for the combined MPT and CST streams (ca 0.8-1.2 cfm).

Transient discharges exist but are not enumerated; these are the discharge air from air driven pumps (the majority are sump pumps).

2.6.4 SOLIDS

Process solid effluents generated by the WHEAT process with their stream numbers are as follows:

(1) Evaporator/crystallizer filter cake, with a moisture content of about 30%. It is represented by Stream No. 1053 on PFD AAC-44-F-100/Sheet 2.

(2) Rotary MPT 5X treated munition bodies, for M60 and M110 projectiles, and for 4.2-inch mortars. It is represented by Stream No. 0753 on PFD AAC-01-F-070.

(3) CST light particulate residue, which is basically ash. It is a component of Stream No. 1251 on PFD AAC-50-F-120.

(4) Batch MPT 5X treated miscellaneous munition parts, such as burster wells and tubes, fuzes, booster cups and nose closure plugs. It is represented by Stream No. 7652 on PFD AAC-50-F-076.

The process produces biosolids (sludge), dried mineral salts, spent filter carbon, 5X metal parts and the residues from treatment of various non-process wastes as described below.

2.6.5 BIOSOLIDS

Biosolids are the solid effluent from the bioreactor (ICB™) system. They consist of microbial biomass and adsorbed metals, grit and dirt. ACWA EDS testing has shown that the quantity of suspended solids in the ICB effluent stream is not sufficient to justify removal by the clarification/dewatering equipment system. Instead, the effluent will be routed directly to the brine reduction system, and any suspended solids will be removed along with evaporator/crystallizer solids removed by the filtration unit. However, the clarifiers will be retained to handle upset conditions as well as shutdowns at the ICB, when the sludge generated in the ICB™ system will be removed in the sludge treatment systems downstream of the ICB™. The sludge will be separated from the water by means of a clarifier and will be dewatered and compacted in a filter press. Drummed filter cake will be sent for ultimate disposal in a secure landfill in the same manner as the dried salts described in the next section.

2.6.6 SALTS

The salts are the result of agent and energetic material hydrolysis, chemical decontamination from facility washdown and the biotreatment process. These salts will contain metals (e.g., lead) derived from munition components. In the Baseline process these salts are considered listed wastes and are processed through the residue handling area (RHA) for onsite storage and ultimate disposal in a permitted landfill. The proposed process does not deviate from this accepted method of disposal, since the salts produced are essentially identical to those produced in the Baseline technology.

2.6.7 METAL PARTS

Metal parts come from the MPT in a 5X condition and are subsequently deformed to meet the requirements of chemical weapon conversion. Historically, this material has been sold to commercial firms for steel recycle. However, the materials from JACADS and Tooele are being held as a listed waste due to commercial reluctance to accept it because of its association with chemical warfare agent.

2.6.8 OTHER PLANT WASTES

These wastes are not direct products of the hydrolysis/biotreatment process. They are generated through operational activities or maintenance activities yet they represent a category of material that must meet ultimate disposal criteria. Each of the following waste types consists of material that is either contaminated with agent or is noncontaminated. The latter waste is not processed other than packaging for disposal per government direction. The contaminated portion requires processing through the ACWA system to render it suitable for disposal. It is essential that contaminated waste be strictly separated from noncontaminated.

2.6.9 DUNNAGE

The Baseline process currently retains the dunnage (non-contaminated wood, fiberboard, steel bands, glass, plastic, paper, etc. for disposal by a non-incineration means as yet unspecified due to the apparent failure of the dunnage incinerator to perform adequately. The ACWA process intends to follow the lead of the Baseline process with regard to any non-incineration disposal method. However, contaminated dunnage will be held for the plant closure effort and processed in the CST. The batch MPT will also be available and is capable of processing wastes as needed during the plant closure campaign.

The CST system is designed to process 100 lb/hr of shredded wood in mixture with 200 lb/hr of aggregate feed.

2.6.10 USED PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT (PPC&E)

This waste stream consists of DPE ensembles, Tyvek coveralls, gloves, boots, masks, canisters, filters, hoses, etc. The disposal method for this type of waste depends on whether it is considered 3X contaminated or has never been in contact with agent. Current Baseline process disposal consists of retention for placement in a landfill as a listed waste. The ACWA Plant would follow Baseline criteria for disposal of this material as a minimum. However, an alternative method is to process the DPE suits and other PPC&E through the CST after size reduction to improve homogeneity and handling.

The CST system is designed to process 15 lb/hr of shredded DPE material in mixture with 285 lb/hr of aggregate feed or as a mixed feed-with 85 lb/hr of wood and 200 lb/hr of aggregate.

2.6.11 WASTE OILS AND SPENT HYDRAULIC FLUIDS

Non-agent contaminated waste oil will be removed to an outside oil recycling vendor. Glycol-based hydraulic fluid will be treated through the CST. All hydraulic fluids will be glycol based. There are no agent contaminated petroleum-based wasted oils expected from the WHEAT process.

2.6.12 MISCELLANEOUS METAL PARTS

Contaminated broken or replaced parts, instruments, piping valves, pumps, etc. are capable of being decontaminated to 5X condition or otherwise rendered harmless in the Batch MPT and subsequently disposed of as scrap.

2.6.13 SPENT CARBON FILTER

Spent filter carbon results from the changeout of the filter medium in the ventilation system's carbon filter units. This material has adsorbed chemical agent as a contaminant, as well as other volatile organic compounds. Baseline Technology currently places this material into storage pending government decision regarding treatment and disposal methods. The ACWA process would follow this resolution as a minimum; however, as part of the plant closure activities the spent carbon is to be processed through the CST. This process is similar to commercial carbon regeneration processes and may result in a reusable product rather than a waste.

The CST system is designed to process 300 lb/hr of spent carbon.

2.7 SOURCES

[1]U.S. Army CBDCOM, ACWA RFP (Solicitation Number DAAM01-97-R-0031) 7/28/97, Table 2, page c-2.

[2]E-Mail from Scott Susman to Karl Burchett, 4/5/2000, Subject "Propellant Information."

[3]CSDP, "PUCDF - Process Design Basis", 90 % Final Design Submittal, Task D-5B, September 1995, Section 2, Table 2-3.

[4]Stone and Webster Inc., "Process Description", Acquisition Development Package (ADP) for Aberdeen Chemical Agent Disposal Facility (Contract No. DAAM01-96-D-0010), Edgewood, Maryland, April 1997.

[5]Currently 8.6 % HD loading is being tested at ABCDF. Refer to E-mail from Janet Scanlon, ADL to Scott Susman, "Questions from design review", 12/08/2000.

[6]U.S. Environmental Protection Agency, Form GM - Waste Generation and Management, "1999 Hazardous Waste Report" for Deseret Chemical Depot (EPA ID No. UT5210090002).

[7]U.S. Army CBDCOM, ACWA RFP (Solicitation Number DAAM01-97-R-0031), 7/28/97, Section J.7.

SECTION 3

PROCESS DESIGN CRITERIA

This section provides a description of the process design criteria that were used to prepare the process heat and material (H&M) balances and that will govern the engineering design of the water hydrolysis of explosives and agent technologies (WHEAT) process for the demilitarization of mustard projectiles and mortars. It also summarizes the key data and assumptions for each major category of process calculation data (i.e., agent, residual agent in the munitions, energetics, thermal reactions and chemical reactions).

3.1 PROPERTIES OF MATERIALS USED IN MUNITIONS DEMILITARIZATION

This subsection summarizes the chemical and physical properties of compounds and materials used in the process calculations. The information is grouped into the following categories:

(1) Munitions
(2) Agent
(3) Residual agent (or sludge heel) in HD projectiles
(4) Munition energetics
(5) Other materials
(6) Metal (munition shells and components)

The properties for each category are discussed separately in the following subsections.

3.1.1 MUNITIONS

Refer to Section 2.1 for definition of the stockpile munitions, the feedstock to the chemical demilitarization facility.

3.1.2 AGENT

The agent contained in the projectiles and mortars, besides the energetic components, is the basic reactant used in the process calculations. The physical and chemical properties of the different forms of mustard are contained in Appendix B.2.1, Table B.2.1-1. The compositions of agents HD and HT stored in steel munitions (data provided in Section J-2 of the request for proposal for ACWA) are contained in Appendix B.2.1, Tables B.2.1-2 and B.2.1-3, respectively.

The process design and material balance is based on the composition being 100 % HD and not the compositions given in Tables B.2.1-1 and B.2.1-2.

Mustard viscosity versus temperature curve is shown in Appendix B.2.1, Table B.2.1-4.

Return

3.1.3 RESIDUAL AGENT (OR SLUDGE HEEL) IN HD PROJECTILES

Experience with mustard-filled munitions at JACADS has shown draining to be a problematic operation due to the presence of an unpredictable quantity of degradation products in the form of mustard sludge/solids which were found to be adhering to the walls of the projectile. The solid residue was analyzed and found to be iron chloride and iron oxide; this residue or sludge was found to be soluble in water at room temperature.[1,2]

The aforesaid condition of the agent has disqualified the use of a baseline (CSDP) type munitions demilitarization machine (MDM), which used an agent draining station and relies on a suction probe to extract agent from the munition shell. The system used by ACWA WHEAT will be a tilt-and-drain station to remove liquid agent. The solid heel or sludge that remains inside the munition casing will be washed out with water. The resulting agent slurry will be allowed to separate into a heavy phase consisting mostly of agent, and a lighter phase being wash water contaminated with agent and hydrolysis products.

The ratio of nondrainable to drainable agent was quantified during Operational Verification Testing of HD projectiles done at JACADS (OVT IV) between October 1992 and March 1993. Results extracted from OVT IV, on (281 and 613) 155-mm M110 projectiles, indicate that about 60% of the agent is drainable.[3] These results refer to the use of a baseline-type MDM. The same 60% drained HD, used as the basis for extracting drainable HD from the WHEAT-type MDM (WMDM), incorporating a tilt-and-drain mechanism, is expected to yield a conservative estimate of the amount of agent drained from the M110 projectiles. The liquid heel resulting from the baseline drain probe probably will be extracted during the WMDM tilt-and-drain operation and not stay in the munition.

The amount of agent drained from the other types of munitions (4.2-inch mortars and 105-mm M60 projectiles) will differ from the 60% given above. Agent tilt-and-drain and wash-out testing will be performed on 4.2-inch mortars as part of the ACWA EDS WHEAT test program during the spring of 2001, in order to obtain design data for the agent access system.[4]

3.1.4 MUNITION ENERGETICS

The energetics (bursters, propellants, supplemental charges, etc.), which are an integral part of mortars and projectiles, are elements in sizing the energetics rotary deactivator, the burster washout machine, the energetics neutralizers and their support systems, and downstream processing systems including the bioreactors.

Table 3-1 identifies the explosive components contained in each munition and the weights of each component.[5]

Appendix B.2.2, Table B.2.2-1, lists the physical/chemical properties (molecular weight, high heating value, and chemical formula) for each explosive component. Table B.2.2-1 also has these explosive components grouped into the explosive "mixtures" that are actually contained within each munition. For example, the tetrytol explosive "mixture" consists of 70 wt% tetryl and 30 wt% TNT. It should be noted that the weight percentages of each explosive compound appear in a separate column in Table B.2.2-1.

Table 3-1—Mustard Munitions Data - Energetics

Munitions Data		Burster Energetics			Propellants		
Munition	Quantity	Type	Weight (lb)	Inventory Weight (lb)	Type	Weight (lb)	Inventory Weight (lb)
155-mm M110 HD	299,554	Tetrytol	0.41	122,817			-
4.2-inch M2/2A1 HD	76,722	Tetryl	0.14	10,741	M8	0.62	47,568
105-mm M60 HD	383,418	Tetrytol	0.26	99,689	M67	0.20	76,684
4.2-inch M2/2A1 HT	20,384	Tetryl	0.14	2,854	M8	0.62	12,638

The chemical formula for each explosive component also appears in Table B.2.2-1, as well as the average chemical formula for the mixture. The chemical formula for the mixture includes several fractions for the various elements shown in the chemical formula. These fractional representations do not imply actual chemical composition because fractional elemental composition is not possible. This fractional representation of elements in an explosive mixture is shown only for convenience in the calculations, illustrating the average elemental composition of the mixture. The molecular weights and heating values of the explosive mixtures are also shown and have been determined by averaging the respective contribution (by weight percent) of the individual components of each mixture.

Appendix B.2.2, Table B.2.2-2, provides the munitions energetics type, composition, weight, and the ignition temperatures for the energetics. The latter data is important for designing the energetics rotary deactivator, as well as other design applications.

3.1.5 OTHER MATERIALS

3.1.5.1 Process Fluids

Recycled evaporator condensate from brine reduction will normally be recycled and re-used as process water for hydrolysis, for preparing the bioreactor feed mixture, for 18 wt% sodium hydroxide (NaOH) production, for decon solution (5.5 wt% NaOCl) production, and for other process water users. Plant water will be demineralized and used as an alternative and for makeup.

Fifty wt% NaOH solution will be used in the energetics neutralization reactors. This NaOH solution will also be used for dilution with process water to produce an 18 wt% solution. The 18 wt% solution will be used for pH adjustment, and for equipment decontamination.

Twelve wt% NaOCL solution will be stored and diluted with process water to produce a 5.5 wt% NaOCl solution that will be used for personnel decontamination.

Agent hydrolysis takes place mainly in the agent hydrolyser and the liquid resulting from agent hydrolysis in the agent hydrolyser is termed “agent hydrolysate.” Energetics neutralization takes place in the energetics neutralization reactor and the resulting liquid is termed “energetics hydrolysate.”

Purge brine streams from the MPT and CST offgas treatment quench tower recirculation brine systems are termed "MPT condensate" and "CST condensate," respectively. These two condensate streams are collected and tested for agent; if free of agent the mixed stream is added to and becomes part of the agent hydrolysate. If agent is detected in the MPT/CST condensate stream it is sent to the agent hydrolysers to destroy any residual agent.

The agent and energetics hydrolysates, combined with process water and a prescribed inorganic nutrients feed stream become the feed to the bioreactors.

3.1.5.2 Limestone

Pebble limestone (size distribution 99%: + ¼-inch, -3/8-inch) was used as aggregate material along with the shredded wood and shredded DPE (PVC) feedstock to the EDS test CST.

Limestone initially was the chosen ACWA EDS CST test material. The ACWA EDS full-scale design also indicated limestone as the aggregate feed material into the CST. However, this choice was tentative pending the conclusion and the results of the CST test. Preliminary results indicated that limestone caused plugging of vapor lines and also calcined limestone powder resulted in induction heated surface failure. Consequently limestone was discontinued.

3.1.5.3 Alumina

Crushed tabular alumina, double screened (size distribution 99%: + ¼-inch, -3/8-inch) is a preferred alternate aggregate feed material for the CST.

The composition of alumina is 99.7% Al_2O_3 on a dry basis.

3.1.5.4 Carbon with Sodium Hydroxide

The mixture of carbon treated with caustic has been substituted for limestone as the aggregate material in the testing of wood/DPE feeds.

3.1.6 METAL (MUNITION SHELLS AND COMPONENTS)

For metal (munition shells and components) refer to Appendix B.2.3, Munition Metal Parts.

3.2 CHEMICAL REACTIONS

Chemical reactions taking place are described below.

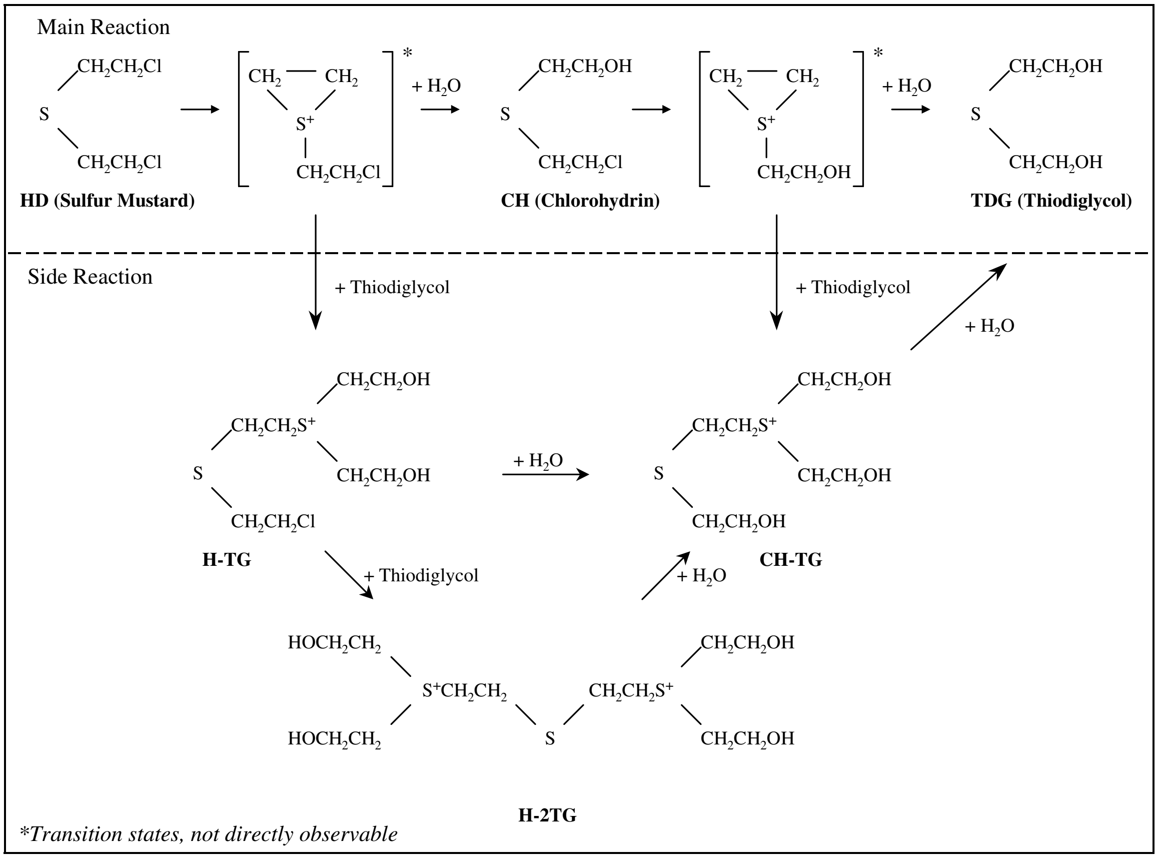
3.2.1 HD HYDROLYSIS

Throughout the testing of base hydrolysis for the mustard agents, HD has been used as an analog for H and HT due to the similarity of the hydrolysis chemistry with the coconstituents of H and the vesicant agent T.

The initial step in the demilitarization of HD is the destruction of HD by neutral hydrolysis, the reaction with water at approximately 90°C (194°F), to form thiodiglycol (bis(2-hydoxyethyl) sulfide) and hydrochloric acid:

$$S(CH_2CH_2Cl)_2 + 2H_2O \rightarrow S(CH_2CH_2OH)_2 + 2HCl$$

A mechanism has been postulated for the hydrolysis step.[6]



The dilute solution goes from neutral to acidic during the course of the reaction. The hydrolysis step is in principle reversible, but reformation of HD is prevented by the addition of caustic after the reaction has reached equilibrium to neutralize the hydrochloric acid formed in the hydrolysis and drive the reaction to completion.

Intermediates and products from the hydrolysis operation are listed below; however, the hydrolysate is passed to the bioreactor where most is destroyed (see below).

3.2.1.1 HD Hydrolysis Intermediates

Intermediates for HD hydrolysis are indicated above, and include CH (chlorohydrin), H-TG, CH-TG, and H-2TG. The final products from the hydrolysis are thiodiglycol and HCl; the HCl is subsequently neutralized with NaOH to give NaCl and H_2O. This product is then passed on to the ICB™ unit.

3.2.1.2 Generation of Compounds of Concern to the Chemical Weapons Convention Treaty (CWCT)

The organosulfur compound generated from HD hydrolysis is completely destroyed by subsequent biodegradation to sulfate, carbon dioxide and water, which are innocuous compounds that cannot be reconverted to chemical warfare agents.

3.2.1.3 Evidence of Irreversibility of Intermediates and Final Products

Biological treatment of agent hydrolysate results in the mineralization of organics to carbon dioxide and water. Organosulfates are mineralized to inorganic sulfate (with the organic fraction being mineralized to carbon dioxide and water) and most of the inorganic sulfate is incorporated into biomass. Therefore, biological destruction eliminates the possibility of reformation of agent from organosulfates.

3.2.1.4 Biodegradation of HD Hydrolysate

Microbes utilize the organics present in the HD hydrolysate as sources of food and energy. They metabolize most of the substrate to carbon dioxide and water to generate metabolic energy, and a smaller quantity of carbon is anabolically metabolized to make organic molecules for growth and produce biomass (living matter).

Microbes utilize thiodiglycol as a substrate using metabolic pathways common to the biodegradation of organic acids, alcohols and fats. In doing so, they mineralize the sulfur present in the thiodiglycol to sulfuric acid.

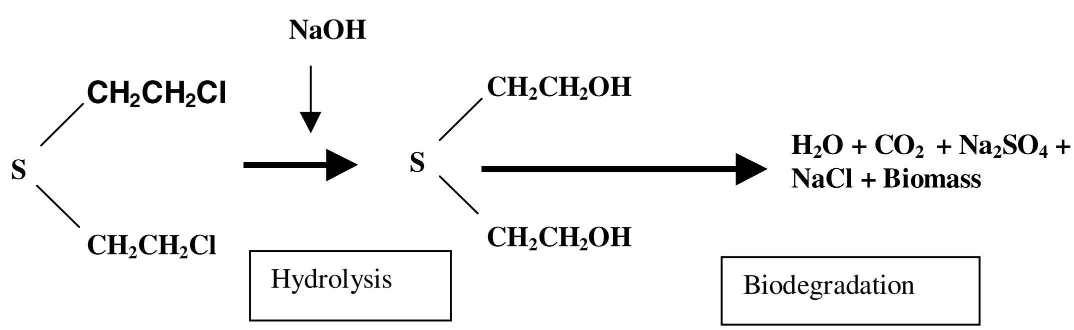
$$HO\text{-}(CH_2)_2\text{-}S\text{-}(CH_2)_2\text{-}OH + 7O_2 \rightarrow 4CO_2 + H_2SO_4 + 4H_2O + \text{BIOMASS}$$

This results in the production of acidity which must be counterbalanced by the addition of a base such as sodium hydroxide or sodium bicarbonate.

$$H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O$$

For this reason the bioreactor must have a pH control loop to keep the pH in the neutral range (pH 6.5 - pH 7.5) that the microbes prefer. 1,4-Thioxane, 1,4-Dithiane and other organic impurities present in HD hydrolysate are also biodegraded in the bioreactor to carbon dioxide, water, sulfuric acid and biomass. Biomass consists of the biological material that compose bacteria and other living organisms, i.e., proteins, lipids, polysaccharides and nucleic acids.

The overall breakdown of mustard by hydrolysis and biodegradation can be represented as follows:



3.2.2 ENERGETICS (TNT, TETRYL, PRIMARIES) HYDROLYSIS

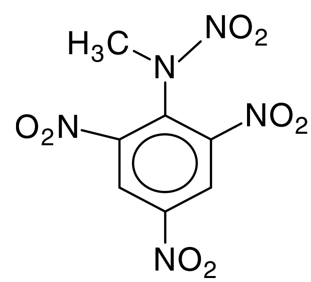
The destruction mechanism for each material is described below.

3.2.2.1 TNT

TNT is rapidly hydrolyzed by hot aqueous NaOH (3 moles NaOH/mole TNT, 90°C) to form the 2,4,6-trinitrobenzyl anion which subsequently decomposes via a complex chemistry to form formaldehyde, formic acid, nitrous oxide, ammonia and nitrogen gas. TNT can also react with hot base to form phenolic intermediates, which subsequently polymerize into non-energetic organic compounds. The resulting organic compounds are mineralized in the bioreactor.[7] The formaldehyde is unstable in base and undergoes Cannizzaro reaction to form formate. It is important to note that alkaline hydrolysis of TNT requires aqueous base at 90°C and not metal alcoholates which do not promote hydrolytic reactions due to their anhydrous nature.[8]

3.2.2.2 Tetryl

Preliminary hydrolysis data for tetryl have been obtained at Los Alamos National Laboratory (LANL). These data show that tetryl decomposes by base hydrolysis at a rate comparable to the rate for TNT. The expected products are acetate, formate, ammonia, nitrous oxides and nitrogen.[9]



Tetryl

3.2.2.3 Lead Azide

Lead azide is partially soluble in hot water. In the presence of hot aqueous base (1.5 M NaOH, 90°C) lead azide will be converted to sodium salts and nitrogen gas. Lead will precipitate from solution as a hydroxide. Any sodium azide left unconverted in the hydrolysis reactor will thermally decompose in the evaporator step of the water recovery system to form sodium salts and nitrogen gas.[10]

3.2.2.4 Propellants

The destruction of propellants is accomplished by base hydrolysis, which degrades the propellant components into small molecular weight organic acids, alcohols, ketones, sugars and inorganic nitrogen compounds such as ammonia, nitrite and nitrate.[11]

3.2.2.5 Identification of Intermediates

The intermediate compounds formed from the base hydrolysis of explosives are small molecular weight organic compounds such as acetic acid, formic acid, formaldehyde, methanol, ethanol, or inorganic nitrogen species such as ammonia, nitrite and nitrate. In addition, some organic condensation products will be formed. These compounds are all good substrates, nutrients or in some cases like nitrite and nitrate, electron acceptors to support microbial growth. The other intermediate compounds of concern are lead salts and hydroxides formed from lead stearate and lead azide. The lead salts will end up in the biosolids and the salt cake generated from the water recovery process. If the solid waste generated from this process fails the TCLP analysis for lead it may be a characteristic hazardous waste.

The intermediate products from the base hydrolysis of propellants are also small molecular weight organic compounds like acetate or formate or are inorganic nitrogen compounds such as nitrite or nitrate. In addition, some organic condensation products will be formed. These compounds are all good substrates, nutrients or in some cases like nitrite and nitrate, electron acceptors to support microbial growth.[11]

3.2.2.6 Generation of Compounds of Concern to the Chemical Weapons Convention Treaty (CWCT)

None of the intermediate compounds are of concern to the CWCT as none can be reverse assembled into energetic compounds. Subsequent biodegradation will completely mineralize these compounds to carbon dioxide, water, nitrogen gas, salts and biological biomass.

3.2.2.7 Evidence of Irreversibility of Intermediates and Final Products

Since all of the intermediate products of base hydrolysis of energetics are small molecular weight organic and inorganic compounds, they are not reversible to make energetic compounds. Furthermore, these compounds are completely mineralized by subsequent biodegradation to carbon dioxide, water, salt, nitrogen gas and biological solids.

3.2.2.8 Biodegradation of Energetics and Propellant Hydrolysates

Hydrolysis in hot water or hot aqueous base is the primary destruction mechanism for the agents and for the energetic materials. The hydrolysis reactions provide exceptionally high conversion values for all of these materials. This results in essential detoxification of the chemical agents and converts the energetic materials into nonenergetic materials. Although the acute hazards associated with energetic materials and chemical warfare agents have been removed at this point, the resulting mixture is a waste material. The function of the bioreactor is to mineralize this waste.

Biodegradation of base hydrolysates of both chemical agents and energetics have been tested separately by a number of different government and private research organizations in the U.S. and abroad. All these hydrolysate solutions contain some components that are required for microbial growth, but also lack some essential nutrients or substrates. HD hydrolysate is rich in organics, but lacks nitrogen and phosphate, and hydrolysates of energetics like HMX, TNT, and nitrocellulose containing propellants that are very rich in organics, which can support growth but lack phosphorous and sulfur. The combination of agent and energetic hydrolysate provides a rich mixture of organic compounds, phosphorous sources, nitrogen sources, and sulfur sources, but still lacks phosphorus, which has to be made up as a nutrient solution. This combination of both agent and energetic hydrolysate, and a phosphorus-rich nutrient solution will produce an excellent microbial growth mixture.

3.2.3 ESTIMATED DESTRUCTION EFFICIENCIES

3.2.3.1 Agent

The destruction of chemical agent HD is based upon the existing neutralization technology accepted by the Program Manager for Assembled Chemical Weapon Assessment. The destruction efficiency of base neutralization and biotreatment is >99.9999%.

3.2.3.2 Energetics

R. Flesner and J. Sanchez of LANL provided the destruction efficiencies for base hydrolysis of Comp-B and TNT.

Energetic	Destruction Efficiency Based Upon Base Neutralization and Biotreatment
TNT	>99.99%
Nitrocellulose	>99.99%
Nitroglycerin	>99.99%

3.2.4 THERMAL REACTIONS

3.2.4.1 MPT and MPT Reheater

Steam is the carrier of vapors through the MPT system.

Two types of decomposition reactions are expected to occur in the MPT system: hydrolysis and steam reforming. The hydrolysis reaction forms thiodiglycol and hydrochloric acid while the steam reforming reaction forms carbon dioxide, hydrogen chloride and sulfur dioxide according to the following reactions.

(1) Hydrolysis:

$$C_4H_8Cl_2S + 2H_2O \rightarrow C_4H_{10}O_2S + 2HCl$$

(2) Steam Reforming:

Subreaction 1:

$$C_4H_8Cl_2S + 10H_2O \rightarrow 4CO_2 + 2HCl + 13H_2 + SO_2$$

Subreaction 2:

$$C_4H_8Cl_2S + 6H_2O \rightarrow 4CO + 2HCl + 9H_2 + SO_2$$

The heat and material balance is based on the criteria of hydrolyzing one third of the MPT feed whereas the balance is oxidized. This is achieved by maintaining high temperatures with large enough amounts of steam inside the MPT, which in return will result in an overall HD destruction and removal efficiency of 99.9999%.

3.2.4.2 CST and CST Reheater

The continuous steam treater (CST) system is designed to achieve 5X conditions for the plant dunnage (i.e., carbon, shredded wood and shredded plastic) by heating the materials to a minimum 1,000^{o}F and holding at that temperature for at least 15 minutes. Steam is the carrier of vapors through the CST system.

The following summary describes the different decomposition reactions expected to occur in the CST system.

(1) Carbon Feed Case:

Reaction 1:

$$C + 2H_2O \rightarrow CO_2 + 2H_2$$

Reaction 2:

$$C + H_2O \rightarrow CO + H_2$$

(2) Wood Feed Case:

Reaction 1:

$$CH_2O + H2O \rightarrow CO2 + 2H2$$

Reaction 2:

$$CH_2O \rightarrow CO + H_2$$

(3) DPE Feed Case:

Reaction 1:

$$C_2H_3Cl + 4H_2O \rightarrow 2CO_2 + HCl + 5H_2$$

Reaction 2:

$$C_2H_3Cl + 2H_2O \rightarrow 2CO + HCl + 3H_2$$

The ACWA EDS WHEAT heat and material balance is based on 1% conversion (or gasification) of the carbon fed to the CST, and 85% conversion for wood and DPE. In all three cases, it is assumed that two thirds of the gasified product will form carbon dioxide and hydrogen chloride while the balance will be products of incomplete oxidation (i.e., carbon monoxide). These criteria will be verified upon completion of the CST testing.

3.2.4.3 Catalytic Oxidation System (CATOX®)

The catalytic oxidation (CATOX®) system consists of a catalyst bed to oxidize agent HD, schedule 2 compounds, and other organic compounds. Products from the CATOX® system are typically H_2O and CO_2 when feed stream contains pure hydrocarbons.

The primary decomposition reaction for catalytic oxidation of HD is to form water vapor, carbon dioxide, sulfur dioxide and hydrochloric acid according to the following reaction.

$$C_4H_8Cl_2S + 6.5O_2 \rightarrow 4CO_2 + 3H_2O + SO_2 + 2HCl$$

Secondary decomposition reactions may occur, mainly for schedule 2 compounds such as thiodiglycol, 1,4-dithiane and 1,4-thioxane, which will form products as the primary reactions, according to the following equations.

$$C_2H_4S_2 + 5O_2 \rightarrow 2CO_2 + 2H_2O + 2SO_2$$

$$C_2H_4OS + 3.5O_2 \rightarrow 2CO_2 + 2H_2O + SO_2$$

$$C_5H_{10}Cl_2S + 8O_2 \rightarrow 5CO_2 + 4H_2O + SO_2 + 2HCl$$

3.3 PROCESS SYSTEM – DESIGN CRITERIA, DATA, AND ASSUMPTIONS

3.3.1 GENERAL

The following design assumptions are applicable to more than one process system:

(1) One type of munition campaign at a time.

(2) The munitions handling system design is based on a design peak feed rate of 120 4.2-inch mortars per hour, or 120 105-mm projectiles per hour, or 60 155-mm munitions per hour.

(3) Atmospheric pressure is 12.41 psia.

(4) All M&E balances are based on all reactions going to completion.

(5) The neutralization process is a batch operation.

(6) The material balance is based on the reaction of HD. Agent impurities are not quantified.

3.3.2 MUNITIONS RECONFIGURATION

ACWA EDS WHEAT Mustard Munitions Processing plant design is based on non-reconfigured munitions, consisting of 105-mm M60 projectiles and 4.2-inch M2/2A1 mortars, being part of the munitions feed to the facility. These munitions will require the dismantling of propellants and primers, which then will be stored in an empty munitions storage igloo at the depot pending destruction during the post-agent destruction campaign.

The propellant destruction process is based upon shredding under water in the energetics shredders located inside the two explosive containment rooms (ECRs), and feeding the resultant slurry to the energetics neutralization reactors. The energetics content of the aqueous slurry is not to exceed 20% by weight.

An inventory of such a stockpile of munitions requiring reconfiguration is detailed above in subsection 2.1, Properties of Materials Used in Demilitarization.

Munition		Energetics (lb/round)	Propellants (lb/round)	Munitions with Energetics Only (rounds)	Munitions with Propellants & Energetics (rounds)
M110	155-mm	0.41	0.00	299,554	0
M2/2A1	4.2-inch	0.14	0.62	0	97,106
M60	105-mm	0.26	2.75	355,043	28,375

3.3.3 PROJECTILE/MORTAR DISASSEMBLY AND BURSTER WASHOUT

WHEAT projectile/mortar disassembly (WPMD) machine maximum design operating rates are given in paragraph 3.3.1, and are the same as for the overall munition handling system.

Table 3-2 shows the design feed rates to energetics rotary deactivator.

3.3.4 MUNITIONS DEMILITARIZATION AND AGENT WASHOUT

WHEAT munitions demilitarization machine (WMDM) maximum design operating rates are given in paragraph 3.3.1, and are the same as for the overall munition handling system. There is no buffer storage provided in between the WPMD and the WMDM.

The rinse operation requires 5-gpm process water, and the water jet wash operation requires 20 gpm of recirculated wash water in three wash stations. These operations occur simultaneously. The actual design and number of wash stations is dependant upon the completion and results of projectile washout testing.

Table 3-2—Design Feed Rate to Energetics Rotary Deactivator

Munition Type	Item	lb/Munition	lb/hr
155-mm	Fuze Well Cup	0.060	3.60
	Lifting Plug	1.750	105.00
Total		**1.810**	**108.6**
4.2-inch	Fuze	0.782	93.84
	Detonator	0.001	0.11
Total		**0.783**	**94.0**
105-mm	Fuze Well Cup	0.060	7.20
	Fuze	1.405	168.56
	Detonator	0.001	0.06
Total		**1.465**	**175.8**

The total daily amount of agent treated includes the amount drained to the agent holding tank (5,234 lb for processing the maximum design case which is 4.2-inch mortars) and sent to the drained agent reactors. The amount left in the projectiles is recovered as a 90-wt% agent concentrate solution and transferred to the agent concentrate holding tank (consisting of 3,489 lb of agent for processing 4.2-inch mortars).

The drained agent is transferred to the agent holding tank at a nominal rate of 0.7 gpm. The agent concentrate is transferred to the agent concentrate holding tank at a nominal rate of 0.5 gpm. Both rates refer to the maximum design case (4.2-inch mortars).

The agent concentration in the agent concentrate is specified at a minimum of 90 wt% HD. This concentration is set as a minimum performance specification and will be amended upon completion of projectile washout testing.

3.3.5 TOXIC CUBICLE AND MPT/CST CONDENSATE STORAGE

3.3.5.1 Agent Storage

The agent holding tank is the same size as those used at the baseline CSDP sites, 500 gallons of agent equivalent to 5,314 lb of HD.

The agent surge tank is designed for emergency use only. It can hold the contents of the agent holding tank and agent concentrate tank and has excess capacity.

The agent concentrate tank is sized to contain 500 gallons of agent concentrate (a nominal 90 wt% HD solution in water) and the agent holding capacity is equivalent to 4680 lb of HD. This figure is a design performance specification figure which will be verified pending projectile washout testing.

3.3.5.2 MPT/CST Condensate Storage

There are two MPT/CST condensate holding tanks operating in batch mode. Each tank has a 6,800-gallon operating capacity.

The MPT and CST condensate streams are the purge brine streams from the MPT and CST quench tower recirculating brine systems. These streams are expected to be agent free. The MPT/CST condensate will be analyzed for agent presence. If there is no agent detected, the combined condensate will be discharged to the agent hydrolysate tank for transfer to the bioreaction as part of the feed mixture.

The storage capacity represents approximately 12 hours of buffer storage capability of the feed streams under maximum operating conditions (provided the MPT and CST steam rates are kept within the process design parameter of 50% excess steam utilization over stoichiometric requirement).

3.3.6 AGENT HYDROLYSIS

Each agent hydrolyser is designed to process 491 lb of HD per batch.

The percentage of agent in the projectile that is recovered during the draining and subsequent wash operation is set at approximately 98%, based on a performance specification set for the WMDM and the projectile rotary washout system. The 2% heel remaining in the munition will be recovered during the downstream rotary-MPT and batch-MPT operations. This heel includes the agent wetting the outside surfaces of the burster well, as well as the munitions.

The performance specification of 98% agent removal will be used during the WMDM testing to define how long the munition wash process will take to achieve the level of agent removal. This will determine, for the final design, the number of agent wash nozzles that will be required to achieve this performance in the allotted time.

Upon completion of HD hydrolysis, the amount of 18% NaOH required for the HCl neutralization step, is 0.503 lb NaOH (100 wt% basis) per lb of agent fed to the hydrolyser.

The hydrolyser is charged with 18 wt% NaOH in 15 minutes.

The hydrolysers are kept under a nitrogen blanket at less than or equal to 18 psig. When the hydrolysers are empty they are maintained at a pressure of 3 psig; as the hydrolysers are charged with the reactants the pressure is allowed to increase to 18 psig before the vapor space is vented. The nitrogen blanketing is used to limit the volume of the hydrolyser vent gas discharged to the offgas treatment system.

The agent is fed to the reactor circulation loop in 30 minutes with the hydrolyser temperature maintained at 194°F. The agent loading in the drained agent reactor after the agent is added is 4 wt%. Note that this percentage is based on the total reactants in the drained agent reactor before reaction.

The agent reactor circulation loop nominal flow rate is approximately 150 gpm.

The average heat of reaction is 208 British thermal units (Btu) of energy released per lb of HD agent reacted. The heat of reaction for caustic addition is 599 Btu per lb of NaOH.

The hydrolyser contents are agitated, recirculated, and maintained at 194°F for 90 minutes.

The reactor contents are then sampled.

The hydrolyser receives the agent wash water generated in the projectile washing operation.

After the reaction is completed, the reactor contents are sampled and, if there is confirmation that the agent HD concentration is less than 330 ppb by weight, the pH of the reactor contents is adjusted to approximately but less than 12 by adding 18% NaOH.

The hydrolyser contents at the end of pH adjustment are fed to the agent hydrolysate tank in 15 minutes.

The hydrolyser agitators are designed with two impellers: the upper impeller is of the propeller type and the lower impeller is of the turbine type. The agitator is assumed to operate at 95 rpm.

3.3.7 ENERGETICS NEUTRALIZATION

The energetics neutralization system design basis is the 200-gallon reactor system at the Pantex Plant, Amarillo, Texas. In support of the ACWA program the Pantex Plant conducted caustic hydrolysis reactions using sodium hydroxide solution and Composition B and tetrytol explosives. The objectives of these tests was to provide energetics hydrolysate feeds for testing of ACWA technology provider downstream treatment systems.[12,13,14] The ACWA EDS WHEAT energetics neutralization reactor system major design deviates from the Pantex design as follows:

(1) Energetics feed is a liquid slurry versus solids at Pantex.

(2) Reactor material of construction is 304 stainless steel versus glass lined steel at Pantex.

(3) Energetics hydrolysate is neutralized (with acid) and then filtered at Pantex versus no neutralization or filtration in the ACWA EDS WHEAT design because the energetics feed is a slurry (has been already shredded) and because during bioreaction caustic is added to neutralize acid formation within the ICB™ system.

The energetics neutralization reactor during agent campaigns receives and treats the burster energetics consisting of tetryl or tetrytol, depending on the munitions being processed (see section 3.1.4, Munition Energetics). Propellants removed from nonreconfigured munitions will be treated prior to the demilitarization facility closeout campaign, at the end of the chemical demilitarization campaign.

Each energetics neutralization reactor has a 200 gallon operating capacity, and is designed to process a 20 wt% energetics slurry feed as a final 12 wt% energetics content in the reactor when the rest of the reaction feed components are added.

There are three energetics reactors: two operating and one as a standby spare.

Energetics reaction batch cycle is 8 hours total.

During the operation of a batch reaction cycle, the alternate/standby reactor is to be filled with energetics. For safety reasons, to minimize the storage of energetics within the MDB, there is no buffer storage provided for the energetics slurry

The energetics neutralization reagent is 50 wt% sodium hydroxide.

Caustic to TNT or tetryl reaction molar ratio is 4.5:1.[12]

The energetics neutralization reactors are kept under a nitrogen blanket at less than or equal to 18 psig. When the reactors are empty they are maintained at a pressure of 3 psig; as the reactors are charged with the reactants the pressure is allowed to increase to 18 psig before the vapor space is vented. The nitrogen blanketing is used to limit the volume of the neutralization reactor vent gas discharged to the offgas treatment system.

The energetics neutralization reactor temperature is maintained at 194°F.

The reactor has an external recirculation loop in order to prevent solids from settling to the bottom of the reactor.

Specific gravity of energetics/propellant slurry is 1.2.

Energetics neutralization reaction system availability is assumed to be 90%.

Based on 100% hydrolyser availability, 9 batches would be available for energetics and/or propellants processing per day.

80 days are required to process all the propellants following the agent destruction campaigns.

3.3.8 HYDROLYSATE STORAGE

There are two types of hydrolysate, agent hydrolysate and energetics hydrolysate, stored separately and subsequently sent as feed to bioreaction.

3.3.8.1 Agent Hydrolysate Storage

(1) There is one agent hydrolysate tank and it receives feed from the six agent hydrolysers and from the MPT/CST condensate holding tanks.

(2) The agent hydrolysate tank is sized to hold 24 hours of agent hydrolysate production at the peak operating rate corresponding to all 16 of the ICB™ units operating at 100% availability basis. This corresponds to 22 agent hydrolysate batches produced per day during a 4.2-inch mortar campaign (maximum agent hydrolysate production design case).

(3) Agent hydrolysate temperature is assumed to be 194°F; MPT/CST condensate temperature is assumed to be 77°F.

(4) The agent hydrolysate pump design flow rate is 50 gpm.

(5) The stored agent hydrolysate density is 61.5 lb/ft^3.

3.3.8.2 Energetics Hydrolysate Storage

(1) There is one energetics hydrolysate tank and it receives feed from the three energetics neutralization reactors.

(2) The energetics hydrolysate tank is sized to hold energetics hydrolysate production based on 40 hours of WPMD or burster washout operation during the processing of tetrytol from 105-mm M60 projectile burster energetics (the energetics design case). This corresponds to the production of 3.6 energetics neutralization batches produced per day.

(3) During the facility closeout propellant campaign, the energetics hydrolysate tank will be capable to hold approximately the production of six propellant-energetics neutralization batches.

(4) Energetics hydrolysate temperature is assumed to be 194°F.

(5) The energetics hydrolysate pump design flow rate is 5 gpm. The stored energetics hydrolysate density is assumed to be 64.6 lb/ft^3.

3.3.9 BIOREACTION

The bioreactor system consists of 16 immobilized cell bioreactors (ICB™), arranged in 4 modules, each module comprising 4 ICB™. Each ICB™ has a 40,000-gallon liquid capacity and a residence time of 5 days. Each ICB™ is fed 1,600 scfm of aeration air from a 6,400-scfm air blower common to the 4 ICB™ in a module. The air distribution header is designed for 8,000 scfm. The bioreaction system has been tested and designed to process agent and energetics hydrolysate.

Thiodiglycol (TDG) removal will be >99%. Caustic requirement for pH control is 0.65 lb NaOH per lb TDG in the feed to the bioreactor; a 6-8 pH range is to be maintained.

ICB™ feed allowable temperature range is 75° to 115°F. ICB™ feed loading is 98.8 ponds per pound of agent (HD) processed through the system. ICB™ liquid density is 63.1 lb/ft^3 at 77°F.

The ICB system is designed upon the input and output data shown in Table 3-3. This design is based upon data that has been obtained during the EDS pilot study.

Table 3-3—Bioreactor Design Data and Assumptions

Parameter	Bioreactor Input	Bioreactor Output
Chemical oxygen demand (mg/L)	15,500	1,500
Total organic carbon (mg/L)	3,500	350
Thiodiglycol (mg/L)	7,100	<1
Ammonia-N (mg/L)	135	<10
o-Phosphate (mg/L)	55	<10
Total suspended solids (mg/L)	<50	650
Oils & grease (mg/L)	<20	<1
pH (S.U.)	7.5 – 10.0	6.5 – 7.5
Temperature (^{o}F)	75 – 115	75 - 115
Aeration rate (SCFM)	1,600	1,600
Daily feed volume (gallons)	8,000	6,880
Bioreactor volume = 40,000 gallons. Biomass within ICB ≥10,000 mg/L dry wt solids. The COD loading to the bioreactor is 3.1 kg COD/m^3 bioreactor volume/day. The biomass yield in the bioreactor will be 0.2 kg dry wt. biomass/kg TOC consumed. pH within the bioreactor will be monitored and controlled with addition of 10% NaOH.		

3.3.10 DEWATERING

Note that during normal operations of the bioreactors dewatering systems will not be in use. The bioreactor effluent stream shall by-pass it and go directly to brine reduction.

Bioreactor effluent dewatering consists of a clarifier to separate solids, a thickener to concentrate the sludge and separate it, and a solid separation system to separate sludge and recover water.

Hydraulic loading for the system is designed for 100-gpm bioreactor effluent. It is based on daily production of bioreactor effluent plus 25% contingency to cope with any variation in the feed rate due to fluctuations in the bioreactor dilution ratio and/or any other unforeseen variation upstream of the unit.

Solid loading rate is based on the original proving test results of 450 mg/liter or 540 lb per day suspended solid in the reactor effluent. The clarifier surface area required to separate the solids is calculated to be 450 ft^2, based on 320 gallons per day (gpd) per square feet. To provide turndown capability and to reduce effect of downtime due to maintenance and repair, two clarifier units with 225 ft^2 area each will be installed. Sludge with 1% suspended solids is collected in the clarifier and is transferred to the thickener at a rate of 25 gpm.

The thickener is designed with an intermittent hydraulic loading rate of 25 gpm. Basis of the design for the solid separation area is 8 lb of solids per square foot per day (ft^2/d). On this basis a thickener surface area of 81 square feet is required. It has been assumed that 90% of the solids will be captured in the thickener. The remaining 10% will be returned to the system together with the recovered water. The solids separated in the thickener will be fed intermittently into a solid separation unit. JWI filter press is used for solid separation unit. Assuming two cycles five days a week operation for the filter press, based on the amount of solids available, a solid separation unit with a capacity of 24 ft^3 is required. Again to provide turndown capability and to reduce effect of downtime due to maintenance and repair two JWI filter press with a capacity of 12 ft^3 is selected for this purpose.

Flocculent (alum) and polymer injection facilities are also part of the dewatering section. A flocculent dosage rate of 20 mg/liter for the clarifier and a polymer injection dosage rate of 10 lb dry polymer per ton of dry solids are used for designing the chemical injection facilities.

It should be noted that the latest testing in Edgewood shows a very small amount of suspended solids coming out of the bioreactor. This means that clarification may not be required. A series of tests are underway at this stage in Edgewood to verify this assumption. If results of the test confirms this assumption then bioreactor effluent will be fed directly to the brine concentrator and the clarifier and dewatering facilities will be removed from the process train.

3.3.11 BRINE REDUCTION

Hydrolysate from HD and energetics neutralization processes is treated in the bioreactor under the ACWA WHEAT program. The bioreactor effluent after clarification is desalinated and recycled back to the unit for process re-use. A single train of brine concentrator and evaporator/crystallizer has been selected for this treatment. The installed capacity of this unit including a 25% contingency factor is determined to be 100 gpm.

The quantity and analysis of bioreactor effluent available from 8 different cases are shown in the M&E balances provided with this design package. The 8 cases represent the options considered for ACWA EDS WHEAT Mustard Processing of Pueblo Chemical Arsenals. The ICB effluent rates for these cases vary from 19,786 lb per hour in the case of processing 105-mm projectiles up to 338,860 lb per hour in the case of processing 4.2-inch HD mortars. The case with maximum effluent, 4.2-inch HD Mortar case, is selected as the basis for the design of brine reduction system. A 30% turndown ratio capability will be provided in the design of the unit in order to accommodate the lower rates as applicable for the other cases. Consequently the brine reduction system feed rate will be in the order of 77 gpm. The E/C units require biweekly boilouts that last for a period of 16 hours. Allowing for this factor, the unit design capacity needs to be about 80 gpm. A single train brine concentrator and evaporator/crystallizer unit is selected.

It should be noted that at this stage of the design there are many factors that may affect throughput of the upstream units specifically the bioreactor feed rate and its dilution ratio. In order to allow for such uncertainties, an additional 25% contingency factor was added to the rate calculated and the design of the unit is based on 100 gpm. This contingency rate can be adjusted at later stages of the design based on a more defined feed rate.

Feed analyses used for the design of BRS system are given in Table 3-4 below.

Table 3-4—Design of BRS System

Component	155 mm Projectiles	105 mm Projectiles	4.2-inch Mortars	Units
Total Organic Content (TOC)	---	---	195	mg/l
Dissolved Organic Content, filtered through 0.45 micron membrane	---	---	182	mg/l
Total Suspended Solids	---	---	14	mg/l
Total Solids	20046	21018	19783	mg/l
K_2HPO_4	3.35	1.72	3.41	lbs/hr
$(NH_4)2HPO_4$	5.58	2.68	5.68	lbs/hr
$NaNO_3$	25.07	31.80	16.98	lbs/hr
NaCl	340.57	180.46	346.18	lbs/hr
Na_2SO_4	379.25	194.49	385.73	lbs/hr
Biomass	18.92	9.70	19.25	lbs/hr
$NaHCO_3$	5.68	7.14	3.91	lbs/hr
Water	37,459.55	19,369.62	38,104.46	lbs/hr
Specific Conductance Micro mho	----	-----	17,450	

The solids separation unit considered for this design is an automatic pressure filter. These types of units are more economical and do not require additional media such as air or steam for separation of the solids, creating disposal problem. However, relatively high concentration of dissolved organics in the feed may pose difficulty in finding the right type of filtering media. A laboratory bench scale testing revealed that, acidity of the slurry should be lowered in order to promote filtration. The rate of acid injection has not been optimized yet. The laboratory runs were made at 6-ml concentrated sulfuric acid injection per liter of slurry. An acid injection system has been provided in the design of this plant to reduce pH of the slurry for better filtration. Analysis of the solid cake from the laboratory testing is given in Table 3-5 below.

Organics present in the ICB effluent are high-boiling-point components that are expected to end up in the solid cake produced in the unit. However, for safety considerations, the combined vent stream from this unit is directed to the suction of the ICB CATOX® unit. So that any trace of noncondensable organic compounds present in this stream would be destroyed prior to releasing the vent to the atmosphere.

Table 3-5—Characteristics of Filtered Cake and Filtrate

Cake Property	Firm
Total Solids (% by weight)	83
Specific Gravity	1.94
Wet Cake Density (lb./cu. Ft)	121
Filtrate Quality	No solids – brown tint

Recovered water from this unit is expected to contain less than 250 ppm wt. solid.

Two solids separation units at 50% capacity each are considered for this design.

3.3.12 ROTARY METAL PARTS TREATMENT OF MUNITIONS

Rotary-MPT design is based on a design peak feed rate of 120 4.2-inch M2/2A1 mortars per hour, or 120 105-mm M60 projectiles per hour, or 60 155-mm M104/M110 projectiles per hour (Table 3-6).

Steam is fed at 50% surplus rate of the stoichiometric amount required to neutralize the 2% HD heel.

Table 3-6—Design Feed Rate of Solids Mass to Rotary-MPT

Munition Type	Item	lb/Empty Munition	Total[a] lb/hr
155-mm proj.	Empty Shell	78.060	4683.6
4.2-inch mortar	Empty Shell	15.331	1839.7
105-mm proj.	Empty Shell	26.570	3188.4
[a]Total lb/hr of empty munitions feed does not include the 2% agent heel.			

3.3.13 CONTINUOUS STEAM TREATMENT OF WOOD, DPE SUITS, AND CARBON

The dunnage to be treated by the continuous steam treater is shown in Table 3-7 and the CST processing rates are shown in Table 3-8.

3.3.14 BATCH METAL PARTS TREATMENT OF BURSTER WELLS AND MISCELLANEOUS PARTS

Table 3-9 shows batch metal parts treatment of burster wells and miscellaneous parts.

3.3.15 MPT AND CST OFFGAS TREATMENT AND CATOX® UNITS

Quench tower sizing based on a gas velocity of 10 ft/sec at actual conditions and a K value of 0.15.

The quench tower high temperature emergency water quench will be sized for the full quench recirculation brine flow rate. Quench tower recirculation brine may require the addition of a defoamer. This will be confirmed during the CST EDS testing program and a recommendation will be made accordingly.

Table 3-7—Dunnage

DPE Dunnage (1)		Wood Dunnage (2)		Carbon Dunnage (3)	
		Munition type	Quantity		
Agent campaign, days (4)	749	155-mm projectile (5)	233,637	No. of Filters	10
Suits per day	12	105-mm projectile	383,418	Carbon per Filter, lbs	13,900
Suits weight, lbs	9.0	4.2-inch mortars	97,106		
		Total	714,161		
DPE weight, lbs	80,892	Wood weight, lbs	1,999,651	Carbon weight, lbs	139,000

Assumptions

(1) DPE suits: average 12 suits per day, 9.0 lb each (average for Tooele operation during year 1999).

(2) Wood: average 2.8 lb per munition (per section J.7 of the ACWA EDS contract).

(3) Carbon: 1 full inventory of the MDB filter bank or 10 filters with 13,900 lb of carbon per filter (to be processed after all contaminated material are processed).

(4) Campaign duration from agent destruction throughput analysis.

(5) Stockpile of 155-mm reduced from 299,554 munitions to 233,637 during pilot test of the facility, per life cycle cost estimate.

Table 3-8—CST Dunnage Processing Rates

CST DPE rate, lb/hr:	15
CST wood rate, lb/hr:	100
CST carbon rate, lb/hr:	300
CST wood/DPE Rate:	
Wood, lb/hr:	85
DPE lb/hr:	15

Table 3-9—Design Feed Rate of Solids Mass to Batch-MPT

Munition Type	Item	lb/Munition	lb/hr
155-mm proj.	Burster Well	2.030	121.80
	Burster Tube	0.420	25.20
	Fuze Well Cup	0.060	3.60
	Lifting Plug	1.750	105.00
Total		**4.260**	**255.60**
4.2-inch mortar	Burster Well	0.770	92.40
	Burster Tube	0.474	56.82
	Fuze	0.782	93.84
Total		**2.026**	**243.10**
105-mm proj.	Burster Well	1.480	177.60
	Burster Tube	0.255	30.60
	Fuze Well Cup	0.060	7.20
	Fuze	1.405	168.56
Total		**3.200**	**384.00**

The MPT and CST CATOX® units will be designed as single catalyst beds (not multiple units). MPT and CST quench towers size based on the larger of the two units. MPT and CST CATOX® units should be sized to accommodate the larger of the two units to facilitate interchangeability of warehouse spare equipment (if required). CATOX® will be sized for a nominal feed airflow rate of 1000 scfm. CATOX® discharge gas temperature must not exceed 1050°F. There will be a maximum of 200°F temperature difference across CATOX®. CATOX® bed will be designed for a pressure drop of 25 inches water. The minimum oxygen concentration in CATOX® discharge gas will be 12% by volume. The CATOX® bed will be provided a minimum of 6 pipe diameters of straight piping/duct upstream and downstream of the catalyst bed.

Introduction of a fine mist of water to quench the CATOX® feed gas is an emergency shutdown measure upon very high CATOX® discharge gas temperature. Under no circumstances is the CATOX® bed to be deluged.

Future designs should consider possibility of using resistance type heaters on the CATOX® feed air stream upstream of the point of mixing with process vent gases. The current EDS WHEAT design employs induction heating on the mixed stream to avoid exposure of the heating coils to corrosives in the process gas.

3.3.16 BIOREACTOR OFFGAS TREATMENT AND CATOX® UNIT

Each ICB™ module (4 ICB™ units) will have a separate CATOX® unit, giving a total of 4 CATOX® treatment trains.

CATOX® will be sized for a nominal feed airflow rate of 6400 scfm. The CATOX® discharge gas temperature not to exceed 1050°F. The minimum oxygen concentration in CATOX® discharge gas will be 12% by volume.

The CATOX® bed will be provided a minimum of 6 pipe diameters of straight piping/duct upstream and downstream of the catalyst bed.

Offgas reheaters to be sized for the full heating load for startup. Normal operating heat load to be based on the operation of the economizer.

3.3.17 BULK CHEMICAL STORAGE

The bulk chemical storage system is designed for minimum of two weeks storage capacity for the chemical consumption, based on operation at 80% of maximum rate or slightly over 11 days of storage. The decon supply tank is sized for the full 14 days. With this basis the bulk chemical storage tanks are sized as follows.

3.3.17.1 Sodium Hydroxide

The 50% sodium hydroxide tank will require a working capacity of 10,000 gallons with a design capacity of 12,600 gallons. The tank will be 12 feet in diameter by 15 feet high, made of stress-relieved carbon steel, and with design conditions of 3-inch water column at 225°F.

The 18% sodium hydroxide tank will require a working capacity of 5,600 gallons with a design capacity of 7,050 gallons. The tank will be 10 feet in diameter by 12 feet high, made of carbon steel, with a 5,600-gallon working capacity, and with design conditions of 3-inch water column at 225°F.

3.3.17.2 Sodium Hypochlorite

The 12% sodium hypochlorite tank will require a working capacity of 8,000 gallons with a design capacity of 10,000 gallons. The tank will be 10 feet in diameter by 17 feet high, made of high density polyethlyene (HDPE) or fiberglass reinforced plastic (FRP), and with design conditions of 3-inch water column at 125°F.

3.3.17.3 Central Decontamination Supply

The decon tank (5.5% sodium hypochlorite) will require a working capacity of 5,600 gallons with a design capacity of 7,050 gallons. The tank will be 10 feet in diameter by 12 feet high, made of high density polyethlyene (HDPE), and with design conditions of 3-inch water column at 125°F.

3.3.17.4 Inorganic Nutrient Supply

The inorganic nutrient tank will require a working capacity of 17,000 gallons with a design capacity of 21,000 gallons. The tank will be 14 feet in diameter by 18 feet high, made of epoxy lined carbon steel or plastic, and will be equipped with an agitator to ensure proper mixing of the nutrients, and with design conditions of atmospheric pressure at 225°F.

3.3.18 DECON SUPPLY AND SPENT DECON CAPTURE/STORAGE SYSTEM

The weekly requirement of decon for the decon shower (5.5 wt% NaOCl) is based on 2 entries of 2 persons per shift, 3 shifts per day, which is 42 entries per week. The actual decon rate will normally be much less, because only 1 or 2 entries per week may be required.

The fresh decon rate is 20 gallons per person per shower. The decon shower rinse water volume is the same as the fresh decon shower volume. Spent decon is the sum of the fresh decon plus the rinse water. The floor drain spent decon is based on 50 gallons per entry, 6 entries per day, plus two 300-gallon major washdowns per week.

The flow rates stated above do not include a safety factor of 1.25. The values used in the M&E balances for unit design rates include this safety factor.

The minimum weekly spent decon quantity is based on 2 entries of 2 persons with equipment decon. This yields approximately 47 gallons per day average of spent decon.

An intermediate decon production rate (between the minimum daily rate and the maximum daily rate) of 363 gallons per day (for the NC) is based on 6 entries per day (40 gallons spent decon per entry) plus 50 gallons spent decon for equipment decon.

The spent decon will be processed through the agent hydrolysis reactors, as needed, and the hydrolysate will be processed in the bioreactors.

3.3.19 TEMPERATURE CONTROL SYSTEM

Heating and cooling is required to bring reaction components up to reaction temperature and to remove heat of the exothermic neutralization reactions that take place in the agent and energetics hydrolysis/neutralization systems. To eliminate the possibility of contaminating the primary cooling or heating utility systems with toxic components of the process streams, secondary re-circulating media are utilized. Due to the temperature range, the fluid used is water.

3.3.19.1 Secondary Heat Transfer Fluid Circulation System: Agent Hydrolysers

The maximum nominal heating duty requirement for the agent hydrolyser heat exchanger is 4.6 x 10^5 Btu/hr. This is the duty requirement for the agent hydrolyser heat transfer fluid (HTF) heater. The design duty includes an additional 20% margin. The design duty is 5.5 x 10^5 Btu/hr. The nominal flow rate of the HTF through the agent hydrolyser HTF heater that is used to heat the agent hydrolyser is 43,000 lb/hr (90 gpm). The inlet and outlet temperatures of the HTF for the agent hydrolyser HTF heaters are approximately 205°F and 215°F, respectively.

The maximum nominal cooling duty requirement for the agent hydrolyser heat exchanger is 4.8 x 10^5 Btu/hr. This is the duty requirement for the agent hydrolyser HTF cooler. The design duty includes an additional 20% margin. The design duty is 5.8 x 10^5 Btu/hr. The nominal flow rate of the HTF through the agent hydrolyser HTF cooler that is used to cool and maintain the agent hydrolyser is 43,000 lb/hr (88 gpm). The inlet and outlet temperatures of the HTF for the agent hydrolyser HTF coolers are approximately 171°F and 160°F, respectively.

The maximum nominal heating duty requirement for the agent hydrolyser jacket is 1.3 x 10^5 Btu/hr. This is the duty requirement for the agent hydrolyser jacket heater. The design duty includes an additional 20% margin. The design duty is 1.6 x 10^5 Btu/hr. The nominal flow rate of the HTF through the agent hydrolyser HTF heater that is used to heat the agent hydrolyser is 61,600 lb/hr (133 gpm). The inlet and outlet temperatures of the HTF for the agent hydrolyser jacket heaters are approximately 204°F and 206°F, respectively.

3.3.19.2 Secondary Heat Transfer Fluid Circulation System: Energetics Neutralization Reactors (ENR)

The maximum nominal heating duty requirement for the energetics neutralization reactor jacket is 1.5 x 10^5 Btu/hr. This is the duty requirement for the ENR HTF heater. The design duty includes an additional 20% margin. The design duty is 1.8 x 10^5 Btu/hr. The nominal flow rate of the HTF through the ENR HTF heater that is used to heat the ENR is 12,500 lb/hr (27 gpm). The inlet and outlet temperatures of the HTF for the ENR HTF heaters are approximately 205°F and 216°F, respectively.

The maximum nominal cooling duty requirement for the energetics neutralization reactor jacket is 0.5 x 10^5 Btu/hr. This is the duty requirement for the ENR HTF cooler. The design duty includes an additional 20% margin. The design duty is 0.6 x 10^5 Btu/hr. The nominal flow rate of the HTF through the ENR HTF cooler that is used to cool the ENR is 12,500 lb/hr (27 gpm). The inlet and outlet temperatures of the HTF for the ENR HTF coolers are approximately 171°F and 167°F, respectively.

3.3.20 UTILITY SYSTEMS

The utility systems listed below are required for the operation of the ACWA WHEAT HD munitions demilitarization facility.

3.3.20.1 Fuel Gas System

Natural gas will be provided by the depot at 35 psig. The gas distribution system will be installed in accordance with applicable requirements of NFPA. See Table 3-10.

Table 3-10—Fuel Gas

Item No.	P&ID No.	Usage Rate (scfd)			Remarks
		Normal	Intermittent	Simultaneous Max.	
200-BOIL-101	APU-02-D-001	193,000		193,000	Boiler No. 1
200-BOIL-102	APU-02-D-002	0	467,400	0	Boiler No. 2 (spare)
					(Intermittent for evaporator startup).
Hot Water Boilers	-	337,000	1,348,000	337,000	Use 25% operating factor.
(Bldg. Heating)					
Total		530,000		530,000	

3.3.20.2 LPG System

The liquid petroleum gas (LPG) system is used as a fuel gas backup system for natural gas. Dilution air is blended with LPG to obtain flow characteristics similar to natural gas. The LPG system consists of an LPG storage tank with LPG capacity of 17,000 gallons, dilution air dryer, LPG/air blender, vaporizer, dilution air compressor, truck-unloading station, and a transfer pump. The LPG storage tank's capacity represents approximately a one-day supply at normal load.

The LPG storage tank is designed in accordance with NFPA 58. The LPG vaporizer is designed to handle a normal demand of 25,772 scfh.

The LPG dilution air compressor is designed to provide 362 inlet cubic feet per minute (icfm) at 100 psig. Dilution air passes through the dilution air dryer and then is mixed with LPG vapor in the LPG/air blender and delivered as fuel gas at 35 psig to the natural gas users. The transfer pump is a positive-displacement type rated at 28-gal/min capacity. The LPG system is designed to meet the requirements of NFPA and OSHA 29 CFR 1910.110.

3.3.20.3 Instrument Air System

The instrument air system (Table 3-11) consists of three 50% reciprocating or rotary screw-type oil-free compressor packages, two air dryer packages (one operating and one standby) with prefilters and afterfilters, and two instrument air receivers (both operating). The compressors are rated for a capacity of 2000 scfm at 125 psi. These compressors are also common to plant air and life support air systems (described in the following sections).

The instrument air is compressed to 125 psig, dried to a -40°F dewpoint, and supplied to instrument air users through a piping distribution network. The instrument air dryers are rated for the full flow and pressure and are designed in accordance with ASME Section VIII. The air dryer regeneration timer is interlocked with the air compressor motor so that the regeneration sequence proceeds only when the air compressor is operating.

Table 3-11—Instrument Air

Item No.	P&ID No.	Usage Rate (scfm)			Remarks
		Normal	Intermittent	Simultaneous Max.	
Instruments	----			2000	
Machinery (& Airlocks)	----			800	
HVAC	----			200	
Total				3000	

The air receiver is sized to provide air to all users in order to perform an orderly shutdown. The air receivers are sized for a 20-minute residence time at the rated flow. The receivers are designed in accordance with ASME Section VIII and are protected by relief valves set at 140 psig.

The air compressors are controlled by step-control regulating suction valve unloaders for loading and unloading. A dual control shuts down the compressors when air demand is low and restarts them when air demand increases. A hand selector switch allows the operator to select either step control or automatic start/stop. A timer prevents the motor from being cycled excessively. If there is no increase in demand, the compressors automatically shut down and are ready to start on demand. The compressors remain off until the pressure in the receiver drops below 100 psig. The receiver pressure is normally maintained at 125 psig.

3.3.20.4 Plant Air System

The plant air system (Table 3-12) is combined with the instrument air system. A 4-inch plant air line is branched off the instrument air line, downstream of the air receivers. Plant air is supplied to the following users:

(1) Sump pumps and other air-driven process pumps
(2) Munitions handling equipment

(3) Utility stations
(4) LPG system emergency dilution air

3.3.20.5 Life-Support System (LSS) Air

The LSS provides primary breathing and cooling air to the DPE wearer (Table 3-13). The LSS air supply system is common to the instrument air system up to the air dryer packages. Downstream of the dryers, a 2-inch line is taken off for the LSS air users. Before going to the end users, the LSS air passes through charcoal and catalyst filters and is collected in an LSS air receiver (sized for 30-minute residence time at 300 scfm). After the receiver the LSS air is cooled down to 65°F before being sent to the end users.

Table 3-12—Plant Air

Item No.	P&ID No.	Usage Rate (scfm)			Remarks
		Normal	Intermittent	Simultaneous Max.	
020-PUMP-104	AAC-01-D-207	20		20	
040-BOX-205	ANE-01-D-460	10		10	Typical of 3; 1 operating
040-PUMP-201	ANE-01-D-461	20		20	
200-PUMP-124/125	ANE-01-D-580	20		20	Total of 2; 1 operating
200-PUMP-123	AAC-01-D-301	20		20	
030-PUMP-131	AAC-01-D-301	20		20	Typical of 8; 1 operating
030-PUMP-132	AAC-01-D-302	20		20	Typical of 7; 1 operating
030-PUMP-133	AAC-01-D-303	20		40	Typical of 22; 2 operating
200-PUMP-122	ANE-01-D-570	20		20	Typical of 4; 1 operating
200-TANK-116	ANE-01-D-570	30		30	Typical of 4; 1 operating
200-TANK-117	ANE-01-D-570	30		30	Typical of 4; 1 operating
Brine Recov. Pkg.	VENDOR P&ID	30		30	
200-PUMP-110	APU-02-D-004	20		20	
110-PUMP-127	ANE-44-D-013		20		
110-PUMP-128	ANE-44-D-014	20		20	
110-PUMP-125	ANE-44-D-015		20		
110-PUMP-126	ANE-44-D-016	20		20	
110-PUMP-122	ANE-44-D-017		20		
090-FILT-101	AAC-44-D-103	20 (X2)		40	Total of 2.
090-PUMP-104	AAC-44-D-102	20		20	
050-PUMP-202	ANE-50-D-560	20		20	Typical of 3; 1 operating
010-WPMD-101	APU-50-D-509/1	0	30	0	
010-PUMP-101	AAC-50-D-107	25 (X2)		50	Total of 2.
050-BOX-202	ANE-50-D-560	10		10	Typical of 3; 1 operating
020-PUMP-108	AAC-01-D-202	20		20	
Utility Stations		0	40 (X4)	160	4 Utility Stations operating.
PMB		30		30	
TOTAL		520		690	

Table 3-13—Life Support Air

Item No.	P&ID No.	Usage Rate (scfm)			Remarks
		Normal	Intermittent	Simultaneous Max.	
				300	
Total				300	

3.3.20.6 LSS Bottle-Filling System

The LSS bottle-filling system is in the Utility Building and consists of a lubricated air compressor package with a purification package and four air cylinders of standard size that provide high-pressure air to charge life-support air bottles that are in storage racks at critical locations within the MDB. The high-pressure air compressor system has an air inlet equipped with a chemical, biological, and radiological (CBR) charcoal filter between two HEPA filters. The LSS bottle filling system provides breathing air for high-pressure backpack bottles, DPE backpack bottles, DPE transport vehicle bottles, and low pressure air for the LSS air station in the DPE support area.

The compressor is rated for a capacity of 5 scfm at 5,000 psig.

The cylinders are manifolded in pairs so that one pair can be charged by the compressor while the other pair is being used to charge the air bottles. The cylinder air pressure is charged to 4,500 psig for air-bottle refilling (with the exception of DPE backpack bottles which are charged at 3,000 psig after a pressure let down valve). Systems operation is by manual control only. Relief valves (set at 5,000 psig and 3,300 psig respectively) are provided to protect the filling system from being overpressured by the compressor.

3.3.20.7 Nitrogen

The liquid nitrogen storage and vaporization system (Table 3-14) consists of a 6,200-gallon liquid nitrogen storage tank, an electric vaporizer, a 150-psig gaseous nitrogen receiver and distribution piping to the users. Liquid nitrogen is delivered to the plant by refrigerated tank truck and pumped into the liquid nitrogen storage tank, which is designed for 5-days storage. The vaporizer capacity is 236 lb/hr to supply the requirements of the users. The nitrogen gas receiver is sized at 1,200 ft^3, which represents a 4-hour reserve of gaseous nitrogen.

Table 3-14—Nitrogen

Item No.	P&ID No.	Usage Rate (scfh)			Remarks
		Normal	Intermittent	Simultaneous Max.	
040-RCTR-101	ANE-01-D-410	120 (X6)		720	Total of 6.
040-TANK-107	ANE-01-D-430	120		120	
076-MPT-101	AAC-01-D-752		50	50	
070-MMC-101	AAC-01-D-708	600		600	
170-TANK-101	AAC-44-D-005	60 (X3)		180	Total of 6; 3 operating.
180-TANK-101	AAC-44-D-105	60 (X1)		60	Total of 2; 1 operating.
200-TANK-104	AAC-44-D-701	120		120	
050-RCTR-101	ANE-50-D-510	120 (X3)		360	Total of 3.
050-TANK-104	ANE-50-D-530	120		120	
010-TANK-101	AAC-50-D-107	120 (X2)		240	Total of 2.
075-CST-121	AAC-50-D-714	600		600	
010-ERD-101	AAC-50-D-601	0	TBD	0	
070-MPT-101	AAC-01-D-702	0	50	50	
Total		3120		3220	

3.3.20.8 Cooling Medium Systems

Cooling systems consist of the following subsystems.

A. Secondary Heat Transfer Fluid (SHTF) systems for Agent Hydrolysers and for Energetics Neutralization Reactors

The SHTF systems are discussed separately in the sub-section preceding this one.

B. Process Cooling Water System

The Combinaire Cooling Tower provides cooling water for various process users at a supply temperature of 66^{o}F and a return temperature of 101^{o}F (Table 3-15). The cooling water pumps consist of one operating pump and one 100% standby spare pump, each designed for a flow rate of 1100 gpm. The total duty of the cooling tower is 17.4 MMBtu/hr.

(1) Cooling water is supplied from the cooling tower at 66^{o}F.

(2) The process cooling water pump rated capacity is 1100 gpm. This flow rate is based on the sum of design duties for all coolers.

(3) The design duty for each of the equipment items is 20% above the nominal duty.

(4) What follows is a detailed listing of the cooling water users.

Table 3-15—Cooling Water

Item No.	P&ID No.	Usage Rate (gpm) Normal	Intermittent	Simultaneous Max.	Remarks
060-EXCH-101	AAC-40-D-602A	57.2 (X4)		228.8	Total of 4
070-EXCH-102	AAC-01-D-706	20.9		20.9	
070-EXCH-103	AAC-01-D-706	14.4		14.4	
080-EXCH-102	AAC-01-D-803	73.3		73.3	
170-EXCH-113	AAC-44-D-006	33 (X6)		198	Total of 6
180-EXCH-107	AAC-44-D-106	3.4 (X3)		10.2	Total of 3
200-COMP-102A	ANE-02-D-201	143		143	
200-COMP-102B	ANE-02-D-202	143		143	
200-COMP-102C	ANE-02-D-203	0		0	Spare
075-EXCH-122	AAC-50-D-717	5.7		5.7	
075-EXCH-123	AAC-50-D-717	0.1		0.1	
085-EXCH-102	AAC-50-D-803	60.0		60.0	
Brine Recov. Pkg.	Vendor P&ID	170.6		170.6	
Total		1068		1068	

C. Chilled Water System

The chiller system provides cooling medium (40% glycol solution) for process streams requiring cooling to lower temperatures (Table 3-16). The chilled water supply temperature is 35°F and the return temperature is 45°F. The duty of the water chiller is 0.44 MMBtu/hr. The chilled water pumps consist of one operating pump and one 100% standby spare pump, each designed for a flow rate of 220 gpm.

Table 3-16—Chilled Water

		Usage Rate (gpm)			
Item No.	P&ID No.	Normal	Intermittent	Simultaneous Max.	Remarks
040-EXCH-107	ANE-01-D-435	37.0		37.0	
040-EXCH-201	ANE-01-D-460	6.5 (X3)		19.5	Total of 3
040-EXCH-202	ANE-01-D-460	6.5 (X3)		19.5	Total of 3
200-EXCH-105	ANE-02-D-206	1.5		1.5	Note 1
050-EXCH-104	ANE-50-D-535	12.8		12.8	
050-EXCH-201	ANE-50-D-560	6.5 (X3)		19.5	Total of 3
020-EXCH-101	AAC-01-D-204	51.3 (X2)		102.2	Total of 2
TOTAL		212		212	
Note 1. Chilled water for Item 200-EXCH-105 is supplied from the HVAC chiller. All other users are supplied from 200-CHLR-101A/B.					

D. MPT/CST Demineralized Cooling Water System

Demineralized cooling water is pumped through a closed loop system to provide cooling medium to the electric coils of the induction heaters used in the energetics rotary deactivators, the MPTs and the continuous steam treater. The demineralized cooling water supply temperature is 90^{o}F and the return temperature is 100^{o}F. The duty of the demineralized water air cooler is 4.4 MMBtu/hr. The demineralized cooling water pumps consist of one operating pump and one 100% standby spare pump, each designed for a flow rate of 900 gpm.

3.3.20.9 Process Water System

The process water system (Table 3-17) consists of two 72,000-gallon carbon steel storage tank with internal epoxy coating and external electric heating jacket, two 100% supply pumps (one operating, one spare) with a rated capacity of 165 gal/min, and distribution piping.

Makeup water to the process water storage tank comes from the demineralized water package. The process water tanks receive recovered water from the Brine Recovery Package. The storage tank capacity is based on having sufficient reserve of process water to operate the plant for 24 hours during a shutdown of the brine evaporator. This is achieved through the combined storage capacity of the two process water tanks. Piping will be extended to utility stations, decon hose stations, decon showers, BCS for process solution dilution, boiler feedwater, pump gland seals, glove boxes, and process water head tanks.

Table 3-17—Process Water

Item No.	P&ID No.	Usage Rate (gpm)			Remarks
		Normal	Intermittent	Simultaneous Max.	
200-TANK-116	ANE-50-D-570	0	8 (X2)	16	Use 2 Decon Showers operating.
		5	100 (Note 1)	5	Makeup to Process
050-BOX-202	ANE-50-D-560	0	2 (X2)	2	Total of 2; 1 operating.
040-BOX-205	ANE-01-D-460	0	2 (X3)	2	Total of 3; 1 operating.
Utility Stations			20 (X2)	20	1 Utility Station operating.
Total		5		45	Note 2.

Notes

1. 100 gpm is required if the evaporator is shut down. Uses 24-hour reserve combined storage in the process water tanks.
2. Demineralized water package unit is designed for 50 gpm.

A hot process water system is also provided to supply hot water at 194^{o}F to both the agent and energetics reactors, as required on a batchwise basis. This system consists of a 15,650-gallon hot process water tank furnished with an internal steam heating coil for heating the process water and maintaining the temperature.

Flow is provided from the process water pumps mentioned above. A small hot water recirculation pump is also provided to maintain the proper temperature in the piping loop to the users.

A. Process Water Tank, 200-TANK-109 A/B

The process water tanks provide water storage for all process requirements, such as boilers, MPT, CST, ICB™, decon preparation, agent hydrolysis, energetics neutralization, WMDM, projectile burster washout and energetics shredder and hot process water. The capacity of each tank is 72,000 gallons with dimensions of 24-ft 0-inch diameter by 24-ft 0-inch high, constructed of epoxy lined carbon steel. Design conditions for the tank are 3-inch WC at 150°F.

B. Hot Process Water Tank, 140-TANK-101 and Hot Process Water Tank Heater, 140-EXCH-101

The hot process water tank provides hot water storage for agent hydrolysis and energetics neutralization. The capacity of the tank is 15,650 with dimensions of 12-ft 0-inch ID by 14-ft 6-inch T/T, constructed of epoxy lined carbon steel. Design conditions for the tank are 165 psig/full vacuum at 350°F. The tank will be equipped with a hot process water tank heater. The heater will be an immersion steam coil rated for 7.0 MMBtu/hr.

3.3.20.10 Steam and Condensate Systems

A. Steam

Steam is used in both the agent and the energetics reactor systems, in the CST and MPT systems, and the hot process water tank heater (Table 3-18).

Table 3-18—50-PSIG Steam

		Usage Rate (lb/hr)			
Item No.	P&ID No.	Normal	Intermittent	Simultaneous Max.	Remarks
140-EXCH-101	ANE-02-D-002	7100		7100	
180-EXCH-104	AAC-44-D-106	165 (X3)		495	Total of 3
170-EXCH-107	AAC-44-D-006	500 (X3)		1500	Total of 6, (Oper. 50% of time).
170-EXCH-101	AAC-44-D-007	145 (X3)		435	Total of 6, (Oper. 50% of time).
075-HEAT-122	AAC-50-D-715	50		50	CST
070-HEAT-103	AAC-01-D-703	30		30	Rotary MPT
076-HEAT-102	AAC-01-D-753	260		260	Batch MPT
Brine Recov. Pkg. 100-PKG-101	Vendor P&ID		7500 (Note 1)		For Startup.
Steam to Deaerator 200-Tank-100		281		281	
Boiler Losses		378		378	
Contingency, 25%		2632		2632	
Total		2632	7500	13161	
Note 1: Capacity for startup of evaporator is provided by the spare process boiler.					

The steam is supplied by two 100% (one operating, one standby), packaged-type, steam boilers designed to use fuel gas (or backup LPG/Air mixture) and be capable of automatic operation.

Each boiler generates 50-psig saturated steam at a design duty of 16.0 MMBtu/hr. The boilers are designed for 60-psig design pressure in accordance with ASME Section I.

A pressure letdown station is used to provide the necessary amount of 10-psig steam for use in the CST and MPT systems. Superheaters are used to take process steam and raise its temperature to approximately 1200°F for use as carrier gas/reactant in the MPT and CST systems.

Demineralized water is used as boiler feedwater. It is deaerated before feeding to the boilers. The deaerator is designed for a capacity of 26,322 lb/hr. The deaerator is designed in accordance with ASME Section VIII. Two boiler feedwater pumps (one operating, one spare) supply water to the boilers at a rated capacity of 61.2 gal/min. Water is chemically treated to control corrosion and scaling. Blowdown from the boilers is piped to the evaporator feed tank.

B. Condensate

A collection system recovers steam condensate from the agent and energetics heat transfer fluid heaters, the agent hydrolyser jacket heaters, the hot process water tank heater, and drip traps. This flow will flash in the deaerator.

3.3.20.11 Demineralized Water Package

A packaged water demineralizer system is provided to supply 50 gpm of demineralized water to the plant (Table 3-19).

The system consists of two units, one operating, and one standby. This allows for vendor removal of the spent unit for regeneration at vendor's facility, while the second unit is in operation.

Most process water used in the plant is recovered in the brine recovery package and routed back to the process water tank. The demineralized water package is used to make up for the various losses of process water (e.g., water contained in offgases) and for such uses as makeup to decon shower process water head tank, makeup to the demineralized cooling water expansion tank, and utility stations.

Table 3-19—Plant Water

Item No.	P&ID No.	Usage Rate (gpm)			Remarks
		Normal	Intermittent	Simultaneous Max.	
200-PKG-101 A/B	AAC-16-D-007	11	50	50	
200-CLTW-101	AAC-16-D-023	30			
200-PUMP-126	AAC-44-D-005		10		NNF
Total		41		50	

3.3.21 WATER BALANCE

The primary purpose of the water balance is to determine the amount of makeup water supply needed for the process portion of the plant.

3.3.21.1 Assumptions and Design Parameters Used in the Water Balance

Water intake into the system (or sources of water gain) and related process parameters:

(1) Caustic import/supply (NaOH) concentration: 50% wt.

50% caustic (NaOH) solution is used in the energetics reactors

(2) Diluted caustic concentration: 18% wt.

50% NaOH is diluted to 18% NaOH solution, which is used for agent hydrolysis, and pH control, of the ICB™ and the quench tower recirculation brine of the MPT and CST offgas treatment systems.

(3) Tetryl neutralization reaction: 1 mol tetryl needs 4.5 mols of NaOH

Energetics (tetryl) neutralization reaction requires three moles of NaOH for each mole of tetryl, producing acetate, formate, ammonia, nitrous oxides and nitrogen.

(4) pH control of agent hydrolysis:

1 mol HCl + 1 mol NaOH = 1 mol NaCl + 1 mol H_2O

In the agent hydrolysis reaction, HCl produced from the reaction of agent and water will be neutralized using NaOH. According to stoichiometry, 1 mole of HCl requires 1 mole of NaOH.

(5) pH control in ICB™: 0.65 lb NaOH/lb TDG

Caustic is used to control pH in the ICB™. This is done by adding 0.65 pounds of NaOH for each pound of thiodiglycol fed to the ICB™.

(6) pH control in MPT:

1 mol HCl + 1 mol NaOH = 1 mol NaCl + 1 mol H_2O

In the MPT, it is assumed there will be a 2% agent heel in the munitions bodies. Part of the agent residue is hydrolyzed in the vapor phase by steam, producing HCl. The HCl is to be neutralized with NaOH.

(7) pH control in CST:

1 mol HCl + 1 mol NaOH = 1 mol NaCl + 1 mol H_2O

In the CST, the DPE case is the only case in which HCl is produced and, therefore, must be neutralized with NaOH.

(8) Decon import/supply (NaOCl) concentration: 12% wt.

(9) Diluted personnel decon concentration: 5.5% wt.

(10) Spent decon amount: 5 lb decon solution/munition round

Imported 12% wt sodium hypochlorite is diluted to 5.5% wt to be used for decontamination. It is given that 5 pounds of decon is required for each round of munition.

(11) Water concentration in inorganic nutrient mixture: 75% wt.

(12) Nutrient amount: 0.0565 lb nutrient/ lb agent

Inorganic nutrients solution has a water concentration of about 75%. It is used in the feed recipe for the bioreactors (ICB™). One pound of agent processed in the system requires 0.0565 pounds of nutrient.

Note: dilution amount (water added) for the above chemicals is considered part of the makeup water supply

Water loss or usage within the system and related process parameters:

(1) Agent hydrolysis:
$1 \text{ mol } S(CH_2CH_2Cl)_2 + 2 \text{ mol } H_2O = 1 \text{ mol } S(CH_2CH_2OH)_2 + 2 \text{ mol } HCl$

Water is consumed in the agent hydrolysis reaction. Each mole of agent consumes two moles of water.

(2) Biomass concentration in ICB™ effluent: 0.05% wt.

(3) Evaporator/Crystallizer filter cake moisture content: 30% wt.

Water entrained in the evaporator/crystallizer (E/C) cake is lost from the system. Water content for the E/C cake is 30%.

(4) ICB™ air flow: 6400 SCFM

(5) ICB™ offgas saturation: 100%

(6) ICB™ minimum temperature: 75°F

(7) Air summer dry bulb design temperature: 97°F

Air winter design temperature: -7°F

Air summer relative humidity: 8%

Air winter relative humidity: 100%

ICB™ offgas water content is based on 6400 SCFM of 100% saturated air exiting the system. Calculations are performed for both summer and winter conditions: summer, with a dry bulb temperature of 97°F and relative humidity 8%, and winter, with a dry bulb temperature of -7°F and relative humidity of 100%. Different ambient conditions result in different moisture holding capacities of the offgas, which affect the amount of water loss from the system.

(8) Agent hydrolyzers offgas is calculated based on reactor size and level fluctuation of the fluid in the reactor.

(9) MPT and CST offgas is based on the reaction inside the MPT (2% agent heel), or CST (DPE, wood or carbon), as well as the energetics rotary deactivator (ERD) and energetics neutralization reactors (ENR).

In the MPT, it is assumed that there will be a 2% agent heel in the munitions bodies. With the presence of steam, part of this agent residue is hydrolyzed in the vapor phase while the other part is reformed. This stream, in addition to the offgas produced in the ERD and ENR, will be sent to the MPT quench tower. As for the CST, it handles three types of material: DPE, wood and carbon. Each of the materials requires different amounts of superheated steam according to the chemistry. This stream will be sent to the CST quench tower. The effluent from the MPT (mixed with the ERD and ENR offgas) and CST varies depending on the various types of feed. Different effluents require different amounts of process water for the quench tower, which in return influence the amount of offgas, and its water content, exiting the system.

3.3.21.2 Water Balance - Transient

ACWA - WHEAT is a "Total Solution" process. No liquid effluent will be discharged from the system. Under normal operating conditions within the climatic design parameters (as described above), makeup water addition is required. The amount of makeup water varies with the variation of recovered water recycled back into the system. This is due to the existence of different scenarios for the overall water balance (i.e. summer or winter, design or normal).

However, conditions do exist which there will be no need for makeup water because excess water will be produced. This condition usually occurs during the summer at high humidity levels (> 90%). The excess water will be recycled back to the storage tank to be used as future makeup water when normal conditions are restored.

Table 3-20 shows the different scenarios of maximum excess water production and the relative humidity percentage point at which excess water production begins. The maximum amount of excess water during worst conditions possible (M60, steady-state, 100% relative humidity, summer, DPE) is 1555 gallons per day. The negative quantities represent excess water production, therefore no makeup water will be needed (i.e. a negative makeup water requirement).

Table 3-20—Water Production

Maximum Excess Water Production (at 100% Relative Humidity)

DPE	Steady State	Design
	gal/day	gal/day
M110	-591	-671
M60	-1555	-867
M2/2A1	-929	-1018

Wood	Design
	gal/day
M2/2A1	-984

Wood/DPE	Design
	gal/day
M2/2A1	-998

Relative Humidity at which Excess Water will be Produced

DPE	Steady State	Design
	%	%
M110	96.0	94.5
M60	89.5	93.0
M2/2A1	94.0	91.5

Wood	Design
	%
M2/2A1	92.0

Wood/DPE	Design
	%
M2/2A1	91.5

From Table 3-21, the maximum amount of makeup water supply needed is for munitions M110 (155 mm) during the summer, at steady-state conditions with munitions feed rate of 37 munitions/hr and the CST processing DPE. This amount is 15652 gallons per day. The minimum amount needed is for munitions M2/2A1 (4.2 inches) during the winter, at peak (design) munitions feed rate of 120 munitions/hr, with the CST processing DPE. This amount is 4628 gallons per day.

Table 3-21—Makeup Water Requirements

DPE	Steady State		Design	
	Summer	Winter	Summer	Winter
	GAL/DAY	GAL/DAY	GAL/DAY	GAL/DAY
M110	15652	6466	13720	4975
M60	15562	5502	13640	4778
M2/2A1	15295	6128	13570	4628

Wood	Design	
	Summer	Winter
	gal/day	gal/day
M2/2A1	13593	4660

Wood	Design	
	Summer	Winter
	gal/day	gal/day
M2/2A1	13590	4648

3.4 SOURCES

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[4] "Description of Proposed Test to Wash-out HD Projectiles and Dispose of Associated Liquid & Solid Wastes at the CAMDS Test Facility," Parsons Infrastructure & Technology Group Inc., ACWA Project Team, October 5, 2000.

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SECTION 4

PROCESS SYSTEMS DESCRIPTION

4.1 MUNITIONS RECONFIGURATION

4.1.1 PROPELLANT AND PRIMER REMOVAL

Reconfiguration of 105-mm projectiles and of 4.2-inch mortars is required to remove propellants and primers. This operation is performed in the propellant reconfiguration room (PRR), which is adjacent to the unpack area (UPA). The operations that constitute reconfiguration are as follows:

(1) Munitions are depalletized by manually cutting metal strapping, removing fiberglass tubes containing projectiles/mortars from wooden boxes, and loading fiber container onto a transfer cart.

(2) Monitor and check that the projectile/mortar is leak free by performing a vapor test prior to its removal from the fiberglass container. This monitoring function is performed inside a glovebox. If a leaker is found, it is isolated from the others and overpacked. The overpacked leaker is transferred to the toxic maintenance area (TMA) for further treatment.

(3) Remove the striker nut, propellant, and ignition cartridge from the 4.2-inch mortar. These operations are performed manually using tools such as a wrench and vise.

(4) Remove the ignition cartridges for 105-mm projectiles using the standard army prime/deprime machine APE 1229M1.

(5) Pack the ignition cartridges in wooden boxes in single layers with fireboard separators between layers and side of the wooden box. A cabinet is provided in the propellant staging room for holding ignition cartridges and primer containers.

(6) Palletize all propellant and ignition cartridge containers and send for storage in an empty munitions storage igloo in the Depot for later processing during the propellant processing campaign.

4.1.2 PROPELLANT AND IGNITION CARTRIDGE PROCESSING

Upon completion of the agent destruction campaign, the propellant and the ignition cartridge from 4.2-inch mortars and 105-mm projectiles will be retrieved from the munitions storage igloo in the Depot for processing.

4.1.2.1 Propellant Processing

The propellant processing will require modification of the burster wash water machine located in the ECR and replacement of existing roller conveyors by belt conveyors. The top of the machine that consists of drum and rotating barrel will be replaced by a propellant receiving hopper located on top of the energetic shredder. All propellants will be transferred from unpacking area to a shredding hopper in the ECR by the modified conveyor system.

Return

The energetic slurry generated by shredding propellants and with the addition of water is pumped to the receiving energetics neutralization reactor located in energetic neutralization room for processing and disposition.

In an alternative scenario propellants can also be manually fed directly into the energetics reactors as it is currently done in the PANTEX test apparatus. The current energetics reactors would need to be modified to accommodate feeding solids in the form of propellant bags and wafers.

4.1.2.2 Ignition Cartridge Processing

The ignition cartridges will be fed in the ERD for deactivation and will subsequently be sent to the batch MPT for further treatment to 5X conditions.

4.2 UNPACK AREA

Palletized munitions are transported from the Depot and stored in the munitions storage building (MSD) located inside the facility. The MSD has a 24-hr storage capacity and has the capability to thaw the munitions, (mustard freeze at temperatures below 58°F). The palletized munitions are transported via stake bed trucks from the munitions storage building (MSB) to the loading/unloading area of the munitions demilitarization building (MDB). The palletized munitions are unloaded by forklift from the trucks and moved into the vestibule area of the MDB for inventory check and inspection prior to moving them into the UPA.

The UPA is sized to provide a minimum 4 hours of munitions staging capability.

There are two munitions loading stations. The palletized munitions are unpacked manually on the pallet-receiving table by cutting the steel strapping. All steel strapping is collected in waste collection boxes for later treatment in the batch metal parts treater. The contaminated wood from the pallets is separated from the noncontaminated wood by visual inspection and moved to the continuous steam treater (CST) area for shredding and treatment.

4.3 PROJECTILE/MORTAR DISASSEMBLY (WPMD)

Reference PFD: AAC-50-F-010 Projectile Disassembly / Burster Washout

Figure 4-1 is a block flow diagram that illustrates the basic activities involved in disassembly of projectiles and mortars.

Projectiles of each caliber and agent fill will be processed in an individual campaign due to equipment tooling and agent monitoring/certification requirements. Standard baseline procedures and equipment will be used to move, unpack and prepare munitions for disposal. The baseline type WPMD machine will remove the nose closure/lifting lug or the fuze (for 105-mm and 4.2-inch). Fuzes with booster cups will be removed and punched by the WPMD to expose the explosive. The 4.2-inch mortar has a burster well that is attached to the fuze by threads. The WPMD will unthread and remove this portion of the assembly and then extract the burster from the burster well. For all other projectiles, the burster in its metal casing will be removed from the burster well by a WPMD station. Bursters are subjected to high-pressure water washout of the explosives in the burster washout machine (BWM). Empty burster casings are sent to a container, located outside the explosive containment room (ECR).

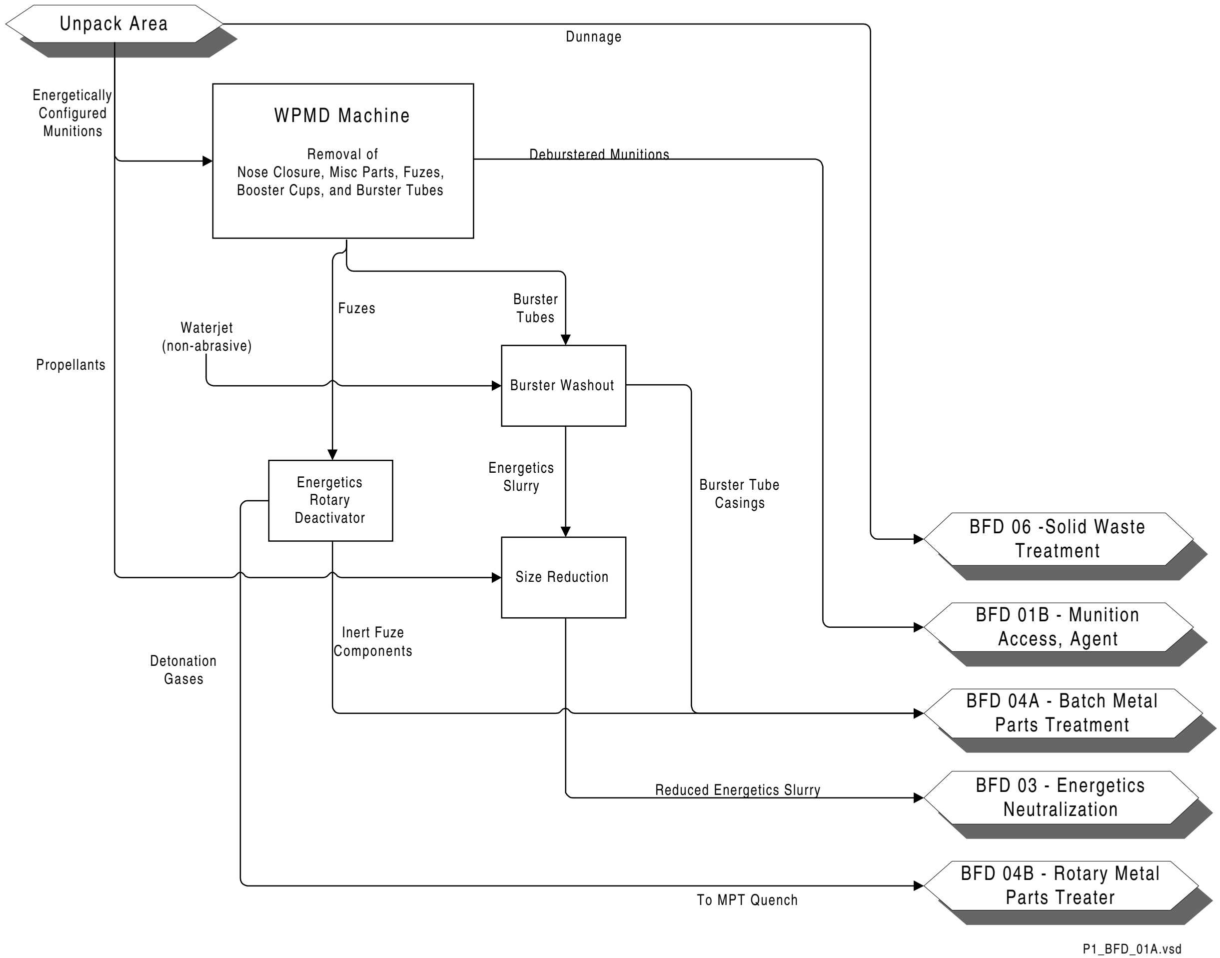


Figure 4-1—ACWA WHEAT Projectile Disassembly

The fuzes and booster cups removed by the WPMD are sent to the energetics rotary deactivator (ERD), which uses induction heating coils to deactivate the energetic component with heat at 650ºF in a nitrogen atmosphere. The container located outside the ECR which receives the empty burster casings also receives the deactivated fuzes and booster cups, and also lifting lugs and miscellaneous parts that follow the same path through the ERD. The same container picks up burster wells further downstream at the WHEAT munitions demilitarization machine (WMDM) and eventually is conveyed and fed to the batch metal parts treater (BMPT) for 5X heat treatment of its contents.

The aqueous energetics slurry generated in the BWM passes through an energetics shredder to prepare a slurry with uniform size solids to facilitate downstream neutralization. The slurry discharges from the shredder to a collecting tank from where it is pumped using air driven double diaphragm pumps to the neutralization reactors. The shredder and collection tank are expected to be physically integrated into the BWM. Energetics slurry volume is kept to a minimum and is not allowed to accumulate within the system. The energetic concentration is limited to 20%.

Deburstered mortars and projectiles are fed to the WMDM in the MDM room.

4.3.1 PROJECTILE/MORTAR DISASSEMBLY MACHINES (010-WPMD-101/102)

The WPMD is an automatic, hydraulically powered machine installed, one in each of the two ECRs, to process all calibers of projectile munitions in order to remove their explosive components. It is identical to the baseline PMD in function; however, the destination of the removed energetic parts is different for ACWA WHEAT. The nose closure parts, fuzes, booster cups and miscellaneous parts are fed to the ERD instead of the (baseline) DFS, and the bursters are fed to the BWM instead of to the baseline burster size reduction machine.

The WPMD is an eight-position, rotating-table machine with five main stations remotely controlled by a programmable logic controller (PLC). (Refer to Figure 4-2.)

The main components of the WPMD machines consist of:

(1) In-feed transfer station (same as baseline)
(2) Nose closure removal station (same as baseline)
(3) Miscellaneous parts removal station (same as baseline)
(4) Burster removal station (same as baseline)
(5) Discharge/output station (modified baseline)
(6) Nose plugs, fuzes, and miscellaneous parts conveyor fed to the ERD (modified baseline)
(7) Burster washout station (modified baseline)
(8) 300-psi air compressor (baseline, outside ECR)

The WPMD performs four basic functions:

(1) Removes nose plugs or nose fuzes from projectiles.
(2) Removes fuze cups, miscellaneous parts, and/or supplementary charges from projectiles.
(3) Removes burster charge from projectiles.
(4) Feeds bursters to BWM for energetics removal.

4.4 ENERGETICS ROTARY DEACTIVATION (010-ERD-101/102)

Reference PFD: AAC-01-F-010 Projectile Disassembly/Burster Washout

The ERD receives fuzes and booster cups removed in the WPMD and de-energizes them in an inert (nitrogen) atmosphere by electric induction heating of the feed material to 650°F. One ERD is located in each of the two ECRs and is coupled with the operation of the WPMD. Each ERD will be 2-ft 6-inches diameter by 6-ft 0-inch long.

De-energized fuzes and booster cups leaving the ERD are sent to the Batch MPT for 5X decontamination. Other munitions components such as lifting lugs and miscellaneous parts are also fed through the ERD. The lifting lugs are removed from 155-mm projectiles; during the 155-mm projectile campaign the ERD acts as a materials handling equipment, and the induction heating coils are not activated.

Vent gases from the ERD are sent to the MPT quench tower.

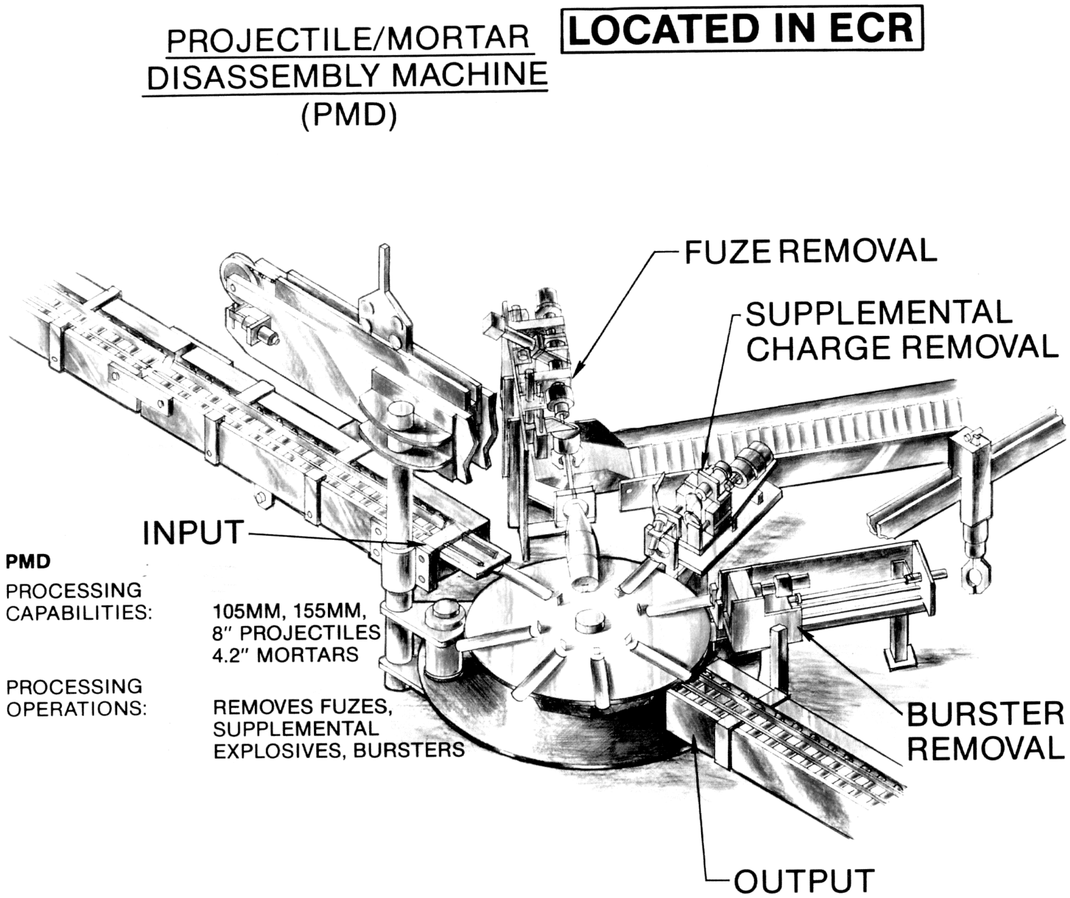


Figure 4-2—Baseline Projectile/Mortar Disassembly Machine

4.5 BURSTER WASHOUT

Reference PFD: AAC-50-F-010 Projectile Disassembly/Burster Washout

4.5.1 BURSTER WASHOUT MACHINE (010-WASH-101/102)

Bursters removed from the 4.2-inch mortar, and the 105-mm and 155-mm projectiles are processed through the BWM to remove the explosive content. (Refer to Figure 4-3.)

Bursters are fed into the BWM at a minimum rate of one per minute for 105-mm projectiles or 4.2-inch mortars and one per 2 minutes for 155-mm projectiles by a pick-and-place machine from the burster discharge conveyor of the WPMD in the ECR. There is one BWM per WPMD in each ECR. Except for the 4.2-inch mortar bursters, the explosive charges are encased in metal tubes whose fuze end provides direct access to the explosive. The 4.2-inch burster tubes are attached to the fuzes, which when taken apart by the WPMD, also provide direct access to the explosives. The end opposite the fuze is the metal sealed end of the tube in all cases.

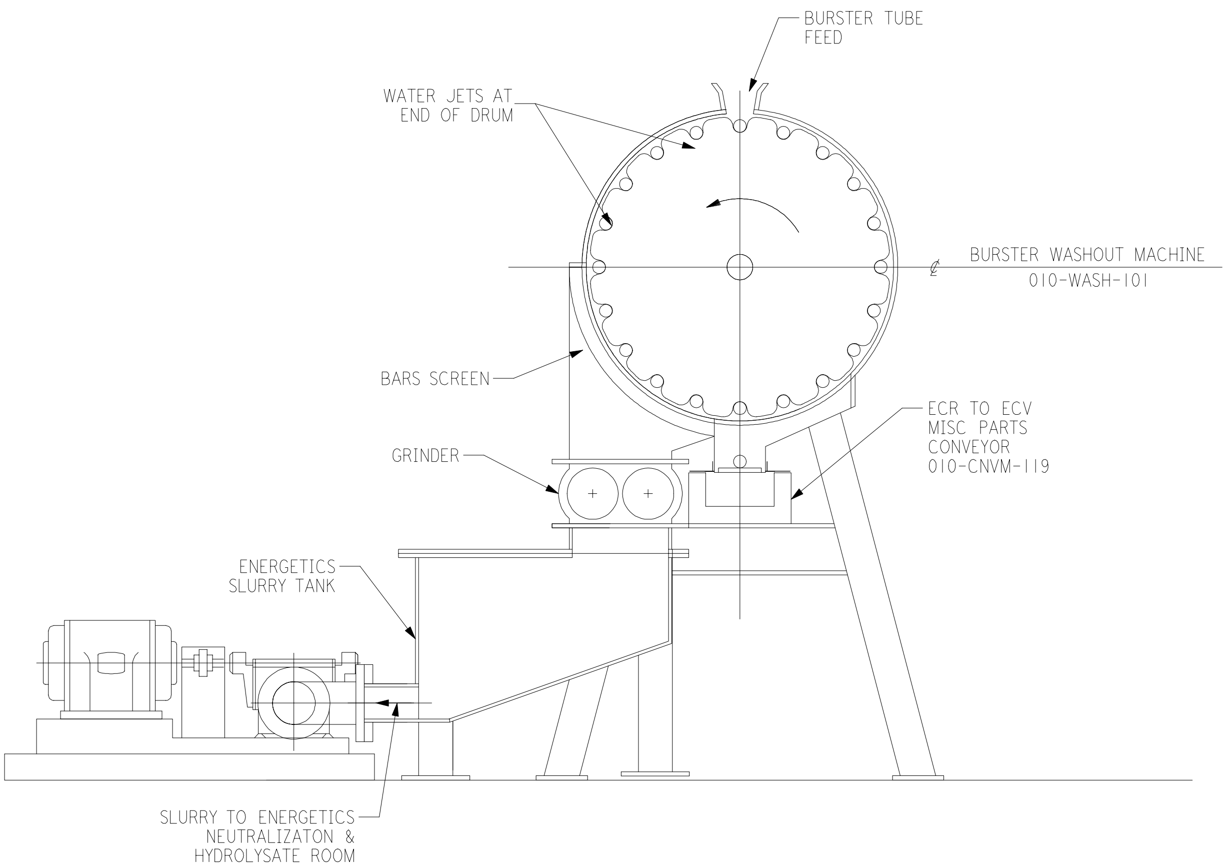


Figure 4-3—Burster Washout Machine (BWM)

The BWM has a rotary carousel with multiple burster holding receptacles. Bursters will be aligned with a multi-nozzle waterjet washout probe on the BWM so that the jet will cut into the explosive charge axially from the open end. The width of the jet is adjusted to obtain maximum coverage of the interior of the burster tube, ensuring that the walls are thoroughly cleaned of explosive. The washout probe is aligned with the open end of the burster and waterjet flow (no abrasive) is initiated at approximately 12,000 psi. The washout water entrains the explosive particles and chunks and washes them clear of the burster casing and washout station spray through a shredder that reduces all particles to less than 1/8-inch diameter to facilitate transport and hydrolysis reaction time. Upon reaching the metal end of the burster tube the waterjet washout probe will be withdrawn. There will be four such wash stations.

Empty burster tubes, although not considered contaminated with agent, are deposited on a conveyor and placed into a batch metal parts treater (BMPT) tray for subsequent 5X heat treatment. The resulting scrap metal is taken to the residue handling area (RHA) for processing to storage.

The water jet high-pressure pump, 010-PKG-101/2/3, is used to supply the required water pressure for the burster washout machine. The pump will be rated for 5 gpm at 12,000 psi and sized for 64.3 BHP and 100 HP.

4.6 MUNITIONS DEMILITARIZATION (020-WMDM-101/102)

Reference PFD: AAC-01-F-020 Projectile Demilitarization

The WMDM is used to drain agent and remove burster wells from the deburstered munitions. The WMDM is unique to the WHEAT process and will be designed to process a maximum of one projectile per minute.

In addition, the WMDM is designed to contain the agent (mustard) effervescent spillage that results when projectile burster wells are pulled. Experience with mustard filled munitions at JACADS has also shown draining to be a problematic operation due to the presence of an unpredictable quantity of degradation products in the form of mustard sludge/solids. (Refer to Figure 4-4.)

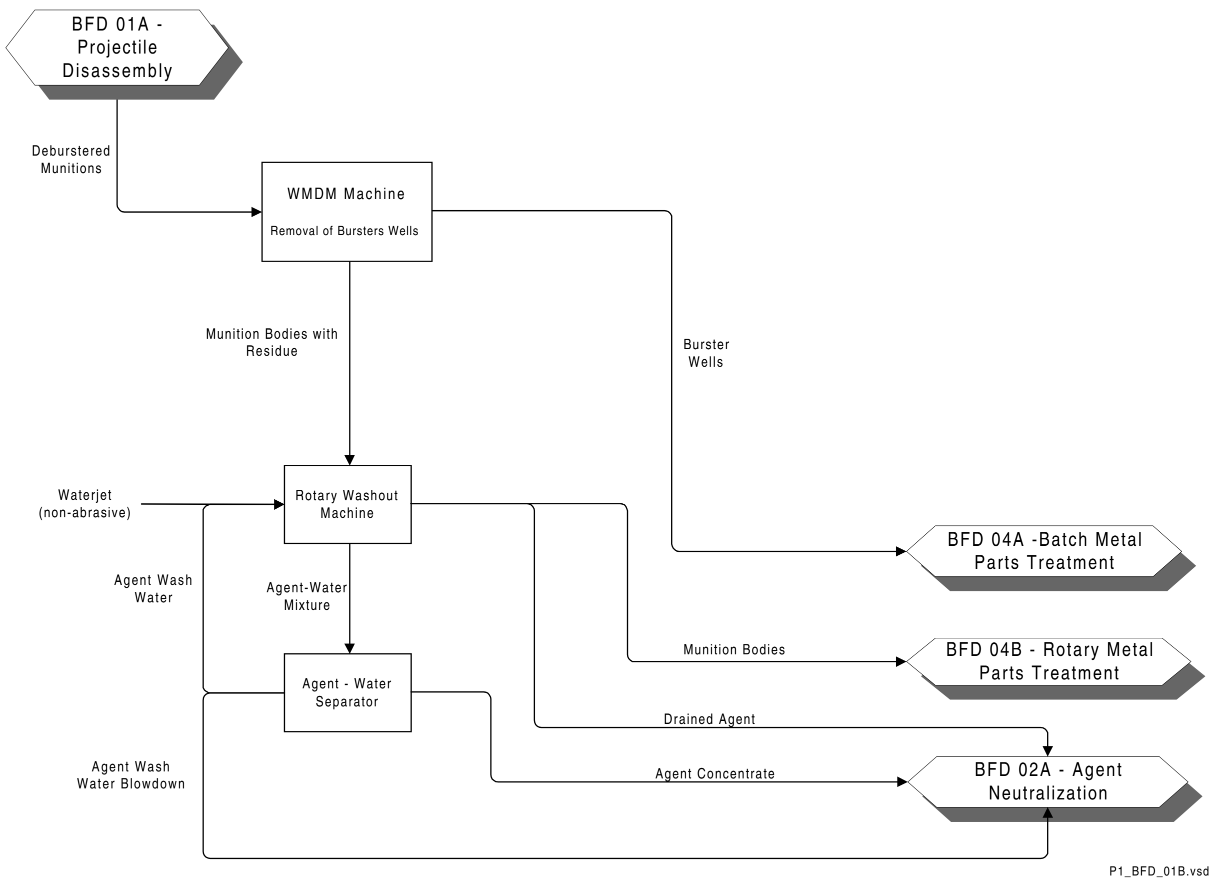


Figure 4-4—Munition Access - Agent

Modifications to the baseline MDM are burster well removal (i.e., pull station), and agent extraction via tilting and draining the munitions, followed by water jet washout of the remaining sludge/heel; in lieu of the baseline MDM suction probe type drain station. (Refer to Figure 4-5.)

The tilt and drain station will collect and transfer drained agent to the agent storage tanks located in the toxic cubicle.

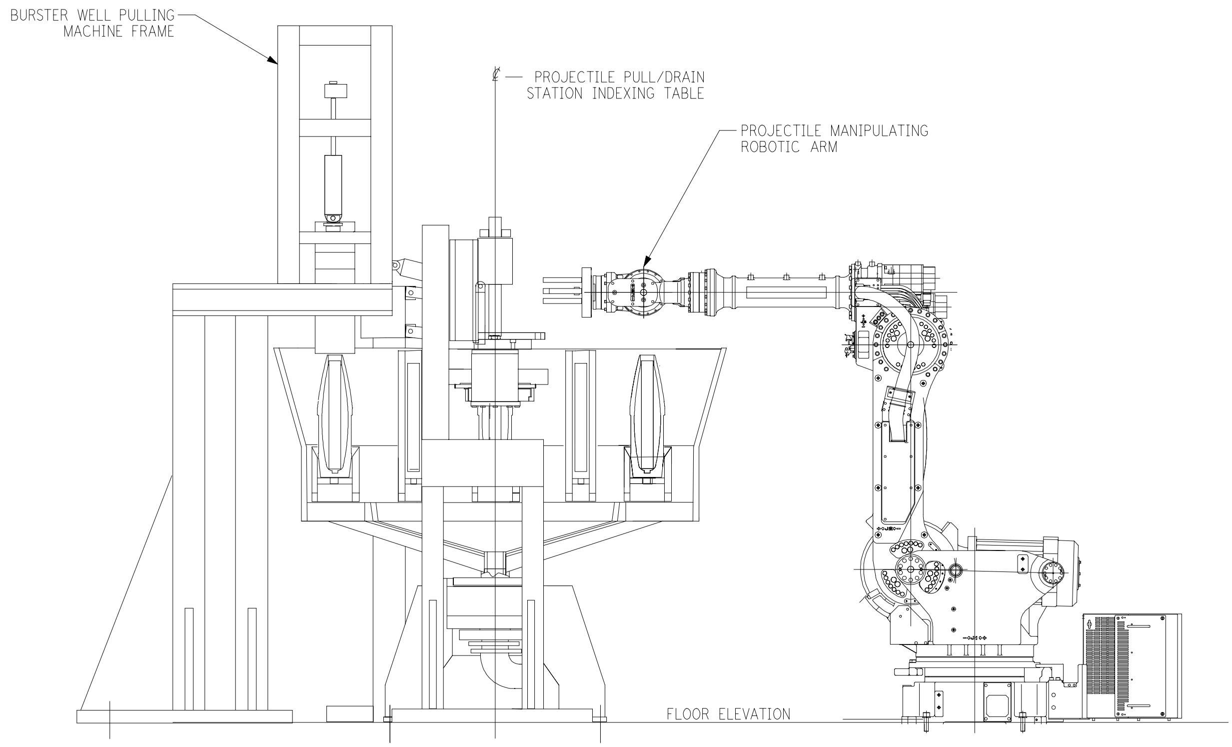


Figure 4-5—ACWA WHEAT Munition Demilitarization Machine (WMDM)

The burster well pull station uses a collet and expander rods similar to the baseline MDM pull device, but it is modified to include the containment/splash guard, cylindrical attachment. The burster wells removed from the munitions bodies are placed in the energetics parts containers for processing in the BMPT.

The WMDM has a cutting station to counter the eventuality of a failed pull operation by cutting through the munition casing wall.

There will be two WMDM units, one per munitions processing line.

4.7 PROJECTILE (ROTARY) WASHOUT MACHINE

Reference PFD: AAC-01-F-020 Projectile Demilitarization

Figure 4-6 shows the projectile (rotary) washout machine.

The solid heel or sludge that remains inside the munition casing is washed out using recirculated wash water through high pressure water jets. The resulting agent washout slurry is allowed to settle into a heavier agent phase and a lighter wash water phase.

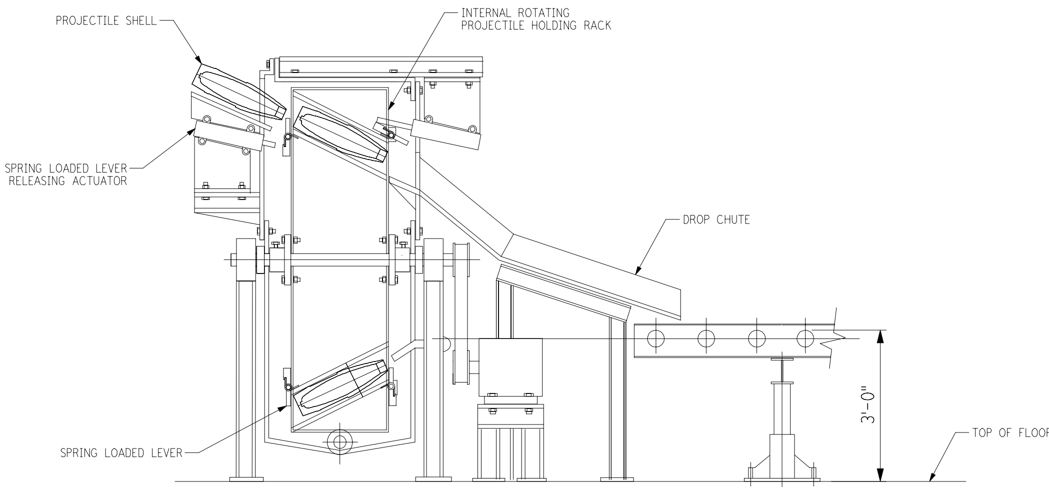


Figure 4-6—Projectile (Rotary) Washout Machine

The lighter phase, consisting of wash water containing dissolved TDG and HCl and entrained mustard, is recycled to the water jet probes of the rotary washout machine as the washing medium. The TDG and HCl are present in the wash water as hydrolysis reaction products. The reaction cannot be prevented from taking place; it can only be slowed down. Keeping the re-circulated washout water temperature low (and the reaction residence time low) can achieve this. Additionally, the presence of chloride ions in the wash water is also expected to slow the reaction. Mustard is only slightly soluble in water. A wash water purge stream will be sent to the agent hydrolysers and mixed with fresh makeup water as feed to the hydrolysers in an approximate ratio of 1:3 (washwater purge: fresh water). The TDG and HCl imported into the hydrolysers is not expected to exert a noticeable influence on the overall hydrolysis reaction time due to the dilution effect of the wash water purge stream with the fresh water.

The heavier phase, an agent (mustard) concentrate of "known" composition is collected and sent to the agent concentrate holding tank (located in the TOX). Subsequently the agent concentrate is fed to the agent hydrolysers. The composition of the agent concentrate is set at 90% (by weight) of HD, as a performance specification for the phase separation step of the washout operation. This performance specification serves the current design effort and is to be verified by testing the agent washout system and the process design modified accordingly.

The optimum temperature for the munitions water jet washout is not yet determined, but the guideline is to be able to dissolve and to rinse the bulk of the mustard components inside the munitions while minimizing chemical reaction (hydrolysis) upon contact between the mustard and water. The lower and upper temperature limits will be 60°F and 110°F; well below 194°F (the optimum temperature for hydrolysis).

Water jet washed munitions (with an assumed maximum 2% agent heel consisting of HD sludge) are next sent on a unit-handling basis to a continuous feed rotary metal parts treater (RMPT) for 5X heat treatment. The washed out munitions will be delivered to a conveyor, and will travel through an airlock to the loading device of the RMPT unit.

There will be two rotary washout machines, one per WMDM (i.e., one per munitions processing line).

The rotary washout machine, 020-RW-101/102, is used to remove residual agent remaining in the munition bodies coming from the munition demilitarization machine. Agent wash water is sent to the agent settling tank and the munition bodies are sent to the RMPT. Two rotary washout machines will be required, the details of which will be determined later.

The agent settling tank, 020-TANK-102/104, is a horizontal vessel used to separate the denser agent from the wash water. Two tanks will be required, each sized for 172 gallons of wash water and 96 gallons of agent concentrate. The vessels will have the following dimensions: 2-ft 6-inches diameter by 10-ft 0-inch long with design condition of atmospheric pressure at 250ºF.

The water jet pump, 020-PUMP-101/110/111, is used to transfer water from the agent settling tank to the water jet package. Three pumps are required (one spare) each rated for 5 gpm, 300 psi, 3-HP and constructed of carbon steel with 12 Cr trim.

The agent water jet high-pressure pump, 020-PKG-101/102/103, recirculates agent wash water to the three water jet probes of the projectile washout system. Three water jet pumps are required, each rated for 25 gpm, 4,000 psig, 100 HP, and constructed of Hastelloy C or equal.

4.8 TOXIC STORAGE

Reference PFD: AAC-01-F-030 Agent Collection/Toxic Storage/Spent Decon

4.8.1 AGENT COLLECTION

Drained agent from the WMDM and agent concentrate (a minimum 90% agent in wash water solution) from the projectile rotary washout machine are stored in the TOX.

The agent holding tank, 030-TANK-101, is a 660-gallon vessel (500-gallon working capacity) made of carbon steel. The service and design of this vessel is identical to baseline CSDP.

The agent concentrate holding tank, 030-TANK-110, is a 660-gallon vessel (500-gallon working capacity) made of carbon steel with epoxy lining. The service and design of this vessel is unique to ACWA WHEAT, though the capacity is identical to baseline CSDP. Unlike the other agent storage tanks in the TOX, 030-TANK-110 is equipped with an agitator to maintain a uniform phase of the product out of the tank to be fed to the agent hydrolysers. Pending the results of agent/projectile washout testing this agitator may be deleted if the agent concentrate proves to be a single phase high agent content liquid.

The agent surge tank (030-TANK-102) is a 1,300-gallon vessel (1,020-gallon working capacity) provided for emergency use either as an emergency overflow from the agent holding tank, the agent concentrate holding tank, or as the holding tank contents in the event of a tank failure in the TOX. The service and design of this vessel is identical to baseline CSDP except for the addition of epoxy lining to the carbon steel shell.

Drained agent and agent concentrate are next sent to be hydrolyzed.

4.8.2 SPENT DECON

The sumps used to collect the spent decon are located in the equipment decon/access airlocks, TOX, ANRs, hydrolysate tank room, MDM area, TMA, ECR, ECR vestibule (ECV), ENR, MDB lab area, MPT room, metal parts treater offgas treatment system (MPT-OTS), CST room, continuous steam treater offgas treatment system (CST-OTS), propellant reconfiguration room (PRR), UPA, [hydraulic equipment room (HER) and compressor], and MPT/CST condensate tank room. Each sump has an actual capacity of 200 gallons. The spent decon is pumped from these sumps by the corresponding sump pumps to the agent neutralization rooms (ANR) spent decon holding tanks. In the TOX, the sump can also be pumped to the agent surge tank in case of an agent spillage.

There are three spent decon holding tanks, 030-TANK-105/6/7. Each tank is a 2,300-gallon vessel (1,855-gallon working capacity) equipped with an agitator. One tank is provided for each ANR. The contents of each tank are sent to the corresponding agent hydrolysis reactor in the corresponding ANR for processing.

4.8.3 MPT/CST CONDENSATE HOLDING TANKS

The MPT/CST condensate holding tank provides storage capacity for condensate from the MPT and CST surge tanks. The combined condensate is collected in batch mode and tested for the presence of HD. If HD is not detected the condensate is sent the agent hydrolysate tank. If HD is detected the condensate is sent to the agent hydrolysers for reprocessing. (Refer to Figure 4-7.)

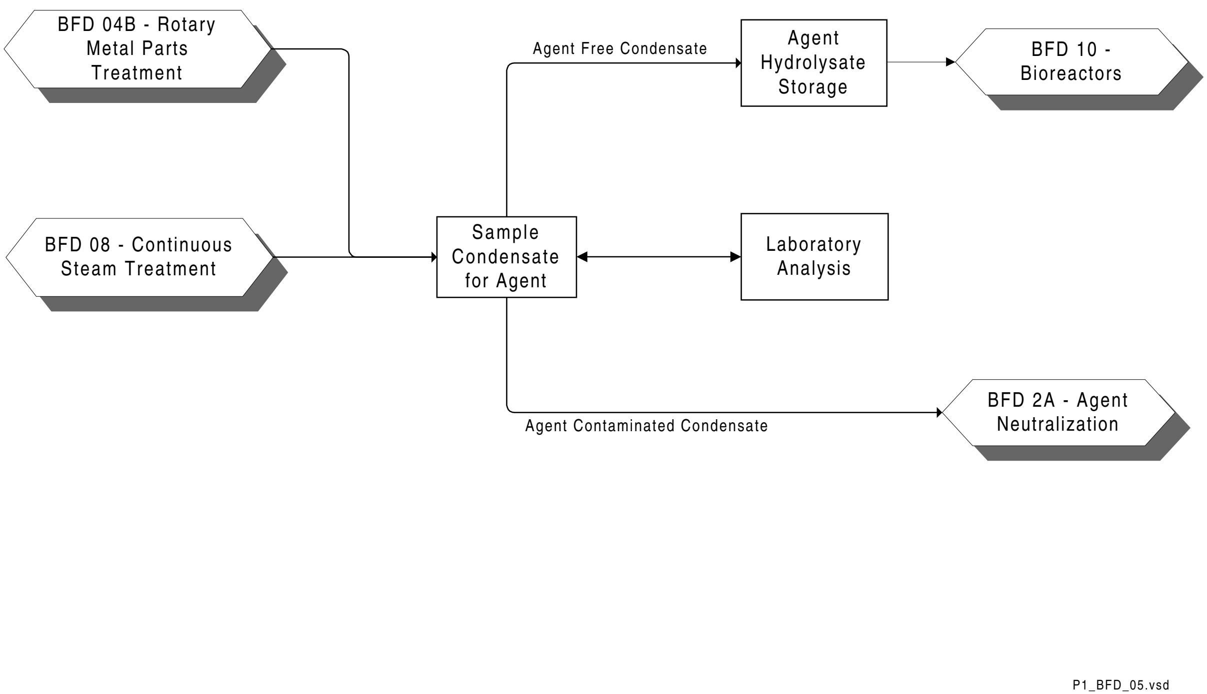


Figure 4-7—MPT/CST Condensate Storage

Two MPT/CST condensate holding tanks, 030-TANK-103/104, will be provided each with 6,800-gallon capacity with dimensions of 12-ft 0-inch diameter by 10-ft 0-inch high, constructed of epoxy lined carbon steel. The design conditions for the tanks are 15 psig, 64-inch water column vacuum at 225ºF.

4.9 AGENT NEUTRALIZATION

Reference PFD: AAC-01-F-040   Neutralization - Agent

The neutralization of agent occurs in three identical agent neutralization rooms (ANR). Each ANR contains two agent hydrolysers (reactors) and one spent decon holding tank. The agent hydrolysers are used for the destruction of agent drained from the WMDM, the agent concentrate from the rotary washout machine, and also for the destruction of agent contained in the spent decon solution. The hydrolyser is also used to destroy agent if detected in the MPT/CST condensate. If required, hydrolyser contents can be transferred to another hydrolyser for further processing. (Refer to Figure 4-8.)

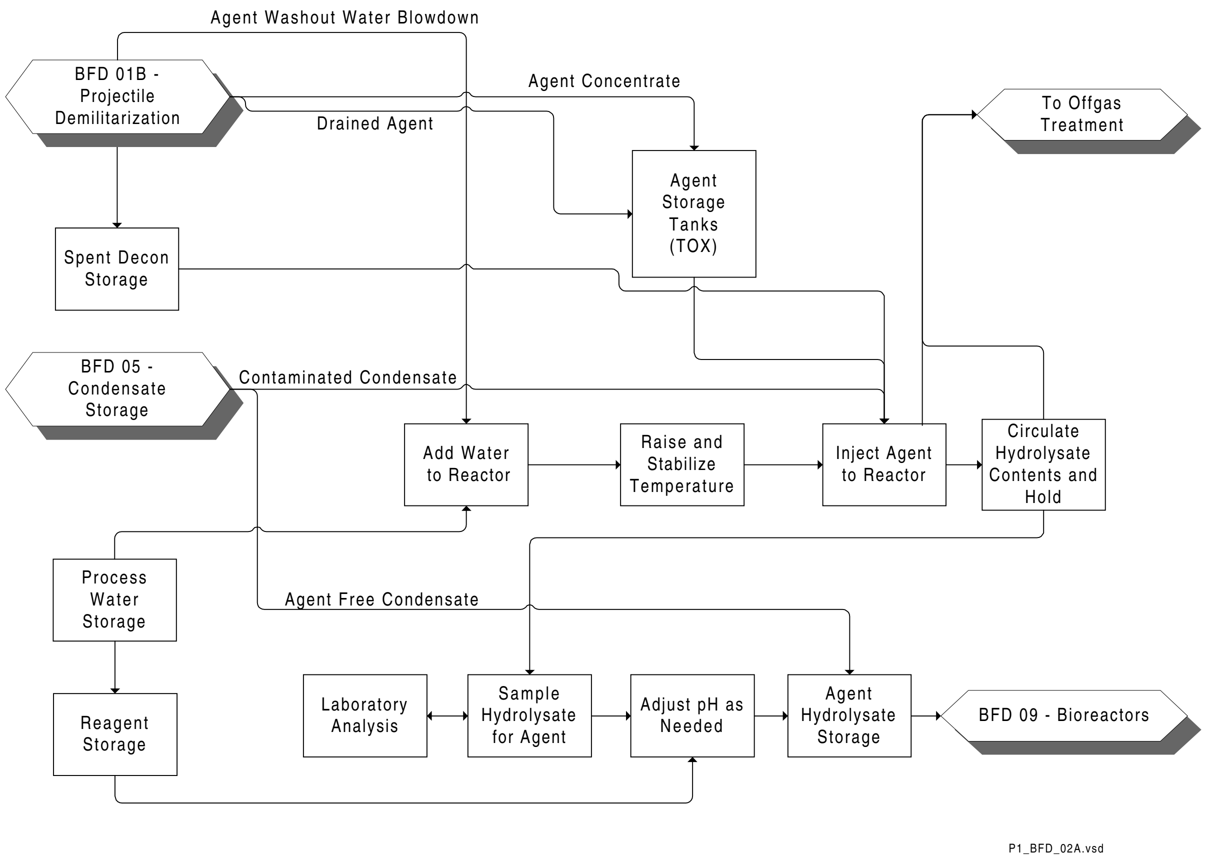


Figure 4-8—Agent Neutralization

Mustard from an agent holding tank in the TOX will be pumped along with hot water through a static mixer eductor, which disperses the agent in the water as droplets roughly 60 microns in diameter. The aqueous dispersion is pumped to a well-stirred 2,520-gallon (1,525-gallon working capacity) made of titanium (palladium modified), hot-water jacketed, reactor partially filled with hot water (194°F). The agent concentration in the reactor is to be approximately 4 wt%. The agent feed rate is controlled to maintain an excess of water, which prevents the formation of sulfonium salts that slow the completion of neutralization and give rise to additional byproducts. As the agent reacts with water, the neutralization reaction produces hydrochloric acid which lowers the pH until the mixture is highly acidic (about pH 2). The reaction time in the vessel, including the hold period for laboratory verification, will be approximately 2 hours 30 minutes (see Table 4-1). The neutralization reaction is exothermic so that heat is removed via a recycle loop with a heat batch exchanger. After the prescribed reaction time, 18% sodium hydroxide is added to adjust the mixture to pH 10-12. This neutralizes the acid and prevents any reformation of the agent. The hydrolysate will be transferred to the hydrolysate storage tank. Table 4-1 shows the overall reaction steps for mustard hydrolysis/neutralization and the time allocated for each step.

Table 4-1—Batch Steps for Neutralization of Drained Agent or Agent Concentrate

Step	Activity	Duration (Hr:Min)
1	Charge the reactor with hot water and agent washwater[(a)]	0:15
2	Allow time for water to reach 194°F	0:15
3	Inject agent into the recirculation loop	0:30
4	Circulate the reactor contents and hold at 194°F	1:15
5	Sample and hold reactor contents to await laboratory results	1:15
6	Add 18 percent NaOH for pH adjustment	0:15
7	Pump the reactor contents to the Hydrolysate Tank	0:15
Total batch time[(b)]		4:00

[(a)]Agent washwater comes from the Agent Settling Tank of the projectile rotary washout machine system (only when the WMDM is in operation). The transfer rate is about 5 gpm.

[(b)]Each agent neutralization reactor is scheduled to perform 4 batches daily. This allows a 2-hour contingency to account for unanticipated delays in laboratory sample processing and effectively making the reactor batch turnaround a 6-hour cycle.

Table 4-2 shows the reaction recipe for mustard neutralization.

Table 4-2—Mustard Neutralization Reaction Recipe

Agent Hydrolysis Reaction	Proportion, wt%
Agent	3.4
NaOH (100 wt%)	1.7
Water	94.9

The recirculation loop is started and the contents of the reactor are heated to 194°F by hot water circulating through the reactor jacket and swept with nitrogen to maintain the reactor pressure at 3 psig (17.36 psia). The reactor is vented to the MPT offgas treatment (CATOX®) system to allow venting of the vapor space during filling operations (except during agent filling) and to reduce the organics in the ventilation system.

After the hydrolyser temperature is established at 194°F, the vent is closed and agent is introduced into the recirculation loop upstream of the static mixer. The static mixer is used to reduce the droplet size and to increase the contact area between the agent and the water in the reactor fluid. In addition, a two-impeller agitator is provided to ensure vigorous agitation inside the reactor. The reactor contents are agitated and temperature is maintained at 194°F throughout the agent addition by the use of water circulating through the reactor jacket. Because mustard is not very soluble in the water phase, adequate mixing is essential for agent destruction. To facilitate agent destruction, the potential for agent entrapment will be minimized. Thus, the piping in the recirculation loop will have no dead legs or pockets and will have minimum distances between the feed points and valves and the static mixers.

The batch cycle for the neutralization of agent concentrate is the same as that for the drained agent neutralization

The spent decon will be pumped from the spent decon holding tanks to the agent hydrolysers, as needed.

The agent hydrolysers, 040-RCTR-101/2/3/4/5/6, are vertical agitated vessels with reaction temperature maintained by heating/cooling water jackets. Six hydrolysers will be provided, each with an overall capacity of 2520 gallons with dimensions of 6 ft-6 inches ID by 8 ft-0 inch T/T, constructed of titanium or Kynar lined carbon steel. Design conditions for the hydrolysers is 150 psig, full vacuum at 250ºF.

4.10 ENERGETICS NEUTRALIZATION

Reference PFD: AAC-50-F-050 Neutralization - Energetics

The energetics neutralization reactors are fed energetics slurry, 50% NaOH and hot process water. The reactor is a vertical agitated vessel with reaction temperature maintained by heating/cooling water jackets. (Refer to Figure 4-9.)

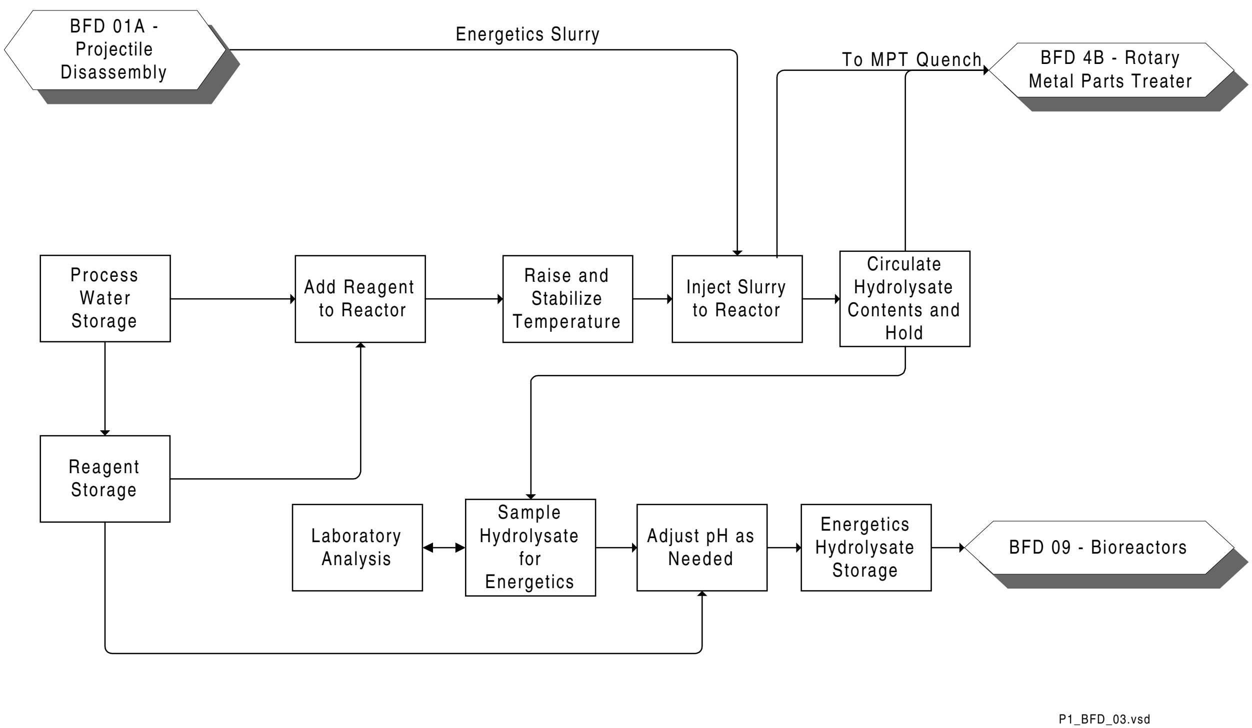


Figure 4-9—Energetics Neutralization

The neutralization of energetics occurs in one cubicle containing three energetics neutralization reactors. The reactors are vented to the MPT quench tower to allow venting of the vapor space and reduce the organics in the MPT offgas treatment system.

Three energetics neutralization reactors, 050-RCTR-101/2/3, will be provided each with a capacity of 300 gallons (200 gallons working capacity) with dimensions of 3-ft 0-inch ID by 5-ft

6-inches high constructed of 304 stainless steel. Design conditions for the reactors are 150 psig, full vacuum at 250°F. The batch steps for the neutralization of the energetics for the different munition are shown in Table 4-3.

Table 4-3—Batch Steps for Neutralization of Burster Energetics

M110 155-mm Projectiles			
Step	Activity	Duration (hr:min)	Notes
1	Fill reactor with water and 50% NaOH and heat to 194°F	0:10	1
2	Load energetics slurry into reactor	8:25	2
3	Allow time to complete the reaction	3:00	3
4	Sample and hold reactor contents to await laboratory results	1:15	
5	Pump the reactor contents to the Energetics Hydrolysate Tank	0:10	
	Total batch time	13:00	
	Maximum number of batches required per day	2.9	4
	Total number of batches available per day	5.5	5
M60 105-mm Projectiles			
Step	Activity	Duration (hr:min)	Notes
1	Fill reactor with water and 50% NaOH and heat to 194°F	0:10	1
2	Load energetics slurry into reactor	6:40	2
3	Allow time to complete the reaction	3:00	3
4	Sample and hold reactor contents to await laboratory results	1:15	
5	Pump the reactor contents to the Energetics Hydrolysate Tank	0:10	
	Total batch time	11:15	
	Maximum number of batches required per day	3.6	4
	Total number of batches available per day	6.4	5
M2/M2A1 4.2-inch Mortars			
Step	Activity	Duration (hr:min)	Notes
1	Fill reactor with water and 50% NaOH and heat to 194°F	0:10	1
2	Load energetics slurry into reactor	12:20	2
3	Allow time to complete the reaction	3:00	3
4	Sample and hold reactor contents to await laboratory results	1:15	
5	Pump the reactor contents to the Energetics Hydrolysate Tank	0:10	
	Total batch time	16:55	
	Maximum number of batches required per day	2.0	4
	Total number of batches available per day	4.3	5

NOTES

1 Temperature rise due to heat of dilution of 50% NaOH to 33% NaOH in this step is 66°F

2 Energetics Slurry composition is 20% (wt) energetics in water.

3 The allocated completion time allows the last drop of energetics slurry to be neutralized. Total reaction time is the sum of steps 2 and 3.

4 Maximum number of batches required per day is based on processing burster energetics slurry at WPMD/burster washout design peak operating rates. The actual number of batches processed per day will be the nearest integer rounded upward.

5 Total number of batches available per day is based on 100% availability of the 2 operating reactors plus the third (stand-by spare) reactor.

Energetics Neutralization Reaction Batch Recipe

Reaction feed component	Proportion, wt%
Energetics (Tetryl or Tetrytol	12.0
Sodium Hydroxide (100% basis)	12.0
Water	76.0

Antifoam addition is provided for the energetics neutralization reactors to prevent foaming.

4.11 HYDROLYSATE STORAGE

Reference PFD:	AAC-01-F-040	Neutralization - Agent
	AAC-50-F-050	Neutralization – Energetics

The hydrolysate tanks are used to separate the upstream batch neutralization processes from the downstream continuous bioreaction process.

4.11.1 AGENT HYDROLYSATE HOLDING TANK, 040-TANK-107

The agent hydrolysate tank is located in the hydrolysate tank room and provides hydrolysate storage for feed to the bioreactors. The storage tank is sized to hold 24 hours agent hydrolysate production at the peak-operating rate of all 16 of the ICB™ units operating at 100% availability. This corresponds to 22 agent hydrolysate batches produced per day for the 4.2-inch mortars.

The agent hydrolysate holding tank is a 42,000-gallon vessel designed to accept hydrolysate from all six agent hydrolysers and agent free outflow from the MPT/CST condensate holding tanks. The tank dimensions are 18-ft 0-inch ID by 22-ft 0-inch high and the tank is constructed of lined carbon steel. Design conditions for the tank are atmospheric pressure at 225°F. The tank is equipped with an agitator to keep the contents of the tanks well mixed. The tank is vented to a condenser to allow venting of the vapor space and reduce the organics in the MPT offgas treatment system.

There is an online chlorine analyzer on the agent hydrolysate outflow stream from the tank. Chlorine is monitored to track the sodium hypochlorite level in the bioreactor feed stream. The hypochlorite source is the spent decon solution (which has been through hydrolysis to destroy residual chemical agent if present). Total organic carbon (TOC) is also monitored in this stream.

4.11.2 ENERGETICS HYDROLYSATE HOLDING TANK, 050-TANK-104

The energetics hydrolysate holding tank is located inside the energetics neutralization room (ENR). The tank is sized based on 40 hours of energetics hydrolysate production from the burster washout operation. This corresponds to 3.6 energetics neutralization batches produced per day for the processing of tetrytol in the 105-mm M60 projectiles.

The energetics hydrolysate holding tank is a 1,600-gallon vessel designed to receive hydrolysate at 194°F from the three energetics neutralization reactors prior to feeding the ICB™ feed tank. The tank is equipped with an agitator to keep the contents of the tank well mixed. The tank is vented to a condenser to allow venting of the vapor space and reduce the organics in the MPT offgas treatment system.

The tank dimensions are 6-ft 0-inch ID by 8-ft 0-inch high, and the tank is constructed of stress relieved carbon steel. Design conditions for the tank are 150 psig, full vacuum at 250°F.

4.12 BIOREACTION

Note: Refer to Appendix B.3, Bioreaction Process Basics, for the theory of bioreaction, design factors, and operating limits.

Reference PFD: AAC-40-F-060 Bioreactors

Figure 4-10 shows bioreactions. Agent and energetics hydrolysate are mixed with a nutrient and additional process water, and then fed into the bottom of the first chamber of the ICB™ vessel. (Refer to Figure 4-11.) Air is also sparged into the bottom of the chamber and the water and air flow concurrently up through the packed bed of ICB™ media. A microbial culture specific to the organic constituents in the feed is established within the ICB™ media where they digest the organics, producing CO_2 and water. Excess air is vented and the water is directed to the bottom of the next chamber. The water continues to flow through the ICB™ in this arrangement, with fresh air sparged into each chamber.

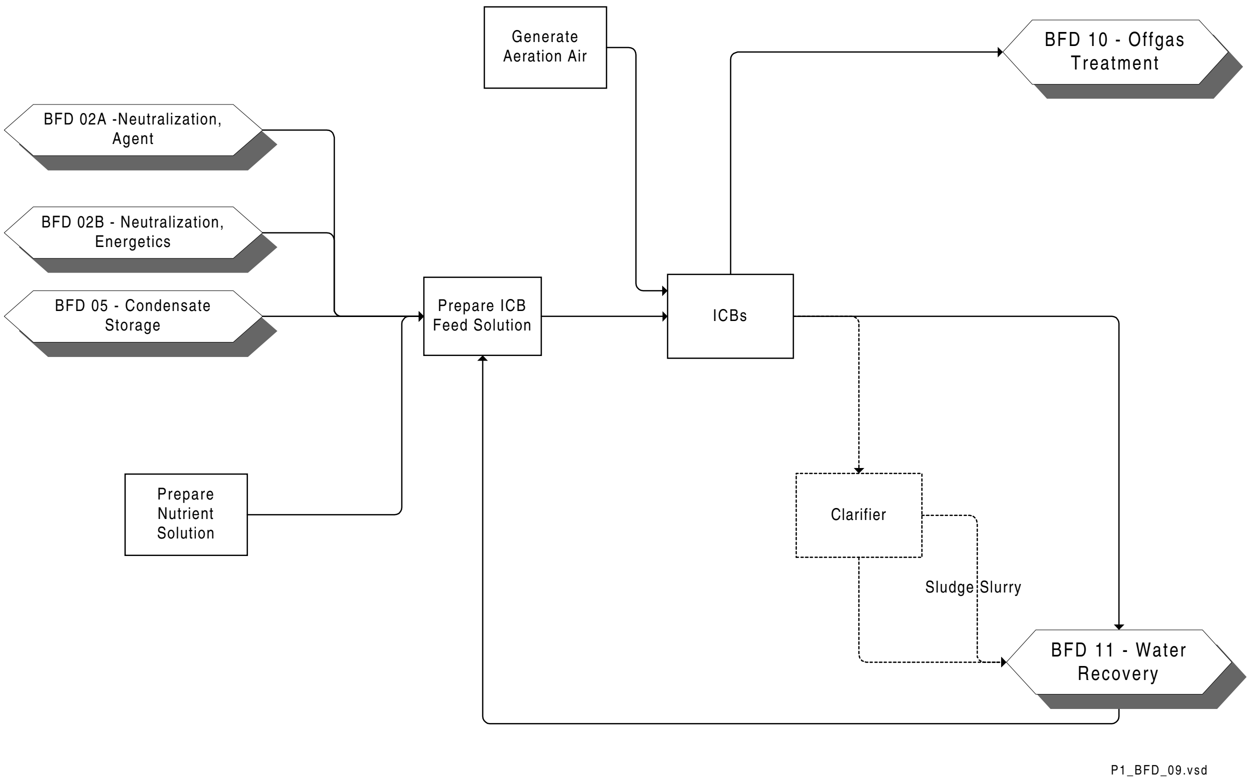


Figure 4-10—Bioreaction

The time taken by the wastewater to flow through the total packed bed volume is called the hydraulic retention time (HRT). It is the time needed for the microorganisms to achieve the desired reduction in the concentrations of the compounds of concern.

Part of the biotreatment operation is effluent flocculation and removal of the biological sludge—the waste product of the biological function in the ICB™. Normally, outflow from the ICB™ is processed through a clarifier in which the biomass present in the ICB™ effluent is removed; however, EDS testing with HD hydrolysate indicated little suspended solids, and that ICB™ effluent does not need to be clarified.

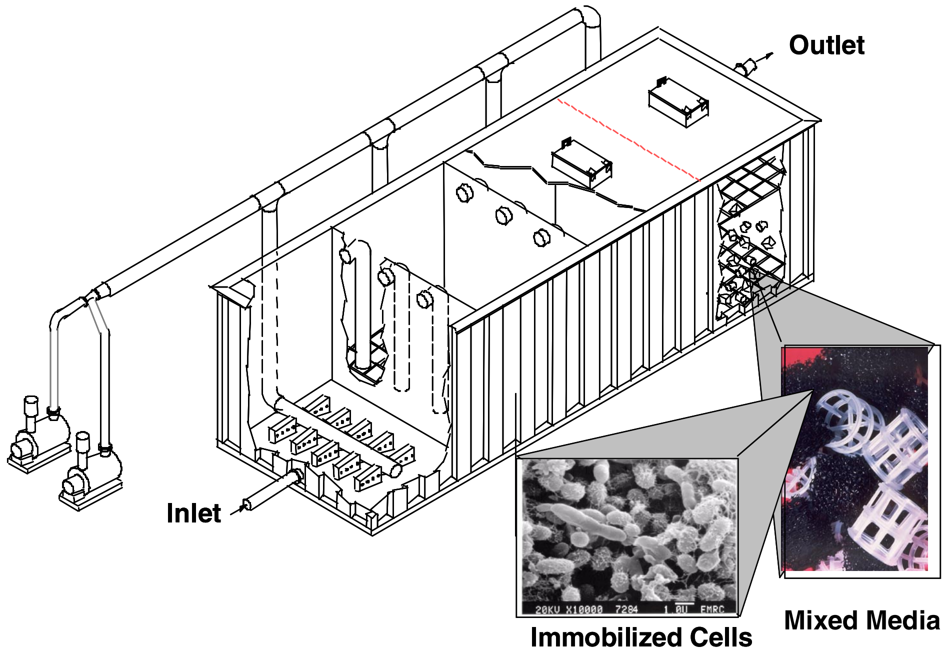


Figure 4-11—Immobilized Cell Bioreactor ICB™

The ICB™ uses a mixture of two very different substrata to immobilize the reactor biomass. One of the immobilizing substrata is a highly reticulated polyurethane foam (in the form of 2-inch blocks). This component provides a high surface area for biomass colonization. Once the bioreactor is fully colonized, these foam blocks are completely filled with biomass to a depth of at least 1 inch. This gives the foam blocks a very high biomass density (>8,000 mg/L MLVSS) and, due to the highly immobilized nature of this biomass, a very long solids retention time (approximately 150 days). One of the major problems encountered by biofilm reactor systems is mass transfer and distribution of air and water through the packed bed as well as the related problem of clogging. When immobilized substrata (packing) are completely colonized and an extensive biofilm begins to bridge the gaps between this packing, clogging can occur which reduces the effective volume of the reactor by creating dead zones with minimal mass transfer and biocatalytic activity. This situation is exacerbated by small sized reactor packing. This problem was addressed in the ICB™ by selecting a relatively large porous packing with a very high internal surface area but also relatively large spacings between the packing components. This was further enhanced by evenly mixing a very open HiFlow plastic support, with the reticulated foam blocks. The biomass concentration on the HiFlow supports is much lower than the foam due to elutriation of excess biomass by hydraulic flow and aeration shear forces. This feature, however, ensures good distribution of both gas and water throughout the packed bed of the ICB™.

The mixed media of the ICB™ system is packed in a compartmentalized bioreactor vessel. Compartmentalization of the vessel produces quasi-plug flow characteristics enabling a higher removal of organic contaminants in a smaller reactor volume.

ICB™ media consists of two major components: (1) flexible, reticulated polyurethane foam, and (2) rigid plastic open structures (HiFlow). Since one component is blended with the other we call this a mixed media system. The ICB™ media contains an evenly distributed mixture of reticulated polyurethane foam and HiFlow in a 1:1 ratio by count.

The HiFlow packing acts as a spacer in the mixed media system and provides a rigid open structure around the foam blocks. Due to the open nature of the spacers, the gas-liquid distribution increases, and the foam bed becomes a lot less compressible. Proper mixing of the components is critical, as improper distribution of HiFlow in the foam bed would tend to cause channeling and result in poor removal rates.

The ideal packing would be a spacer that possesses a minimal surface area and a maximum void space, so that filamentous biological growth cannot plug the spacer and cause channeling and, in turn, result in poor removal.

The ICB™ feed tanks, 060-TANK-101/2/3/4, are used for mixing and also provide storage for agent and energetics hydrolysates, and process water prior to feeding the ICBs. Four agitated tanks will be provided, each with 16,000 gallons capacity with dimensions of 14-ft 0-inch ID by 14-ft 0-inch high, constructed of stress relieved lined carbon steel. Design conditions for the tanks will be atmospheric pressure at 225°F.

The bioreactors, 060-ICBR-101 to -116, will be designed for operation at one atmosphere at 225°F with 5-day residence time. Sixteen ICB™ units (each having the dimensions 10-ft 6-inches wide by 46-ft 6-inch long by 11-ft 0-inch high) of 40,000 gallon capacity each, will be required. The bioreactors are proprietary bioreactors manufactured by Honeywell.

The ICB™ air blowers, 060-BLOW-101/2/3/4/6/7, provide air to the ICB™ modules to ensure proper agitation of the ICB™ contents. Six blowers will be required, one for each ICB™ module (one module consists of four ICBs) and two warehouse spares. Each blower will be designed for a capacity of 6400 scfm at 8 psi and sized for 335 BHP, 400 HP.

The bioreactor offgas knockout pots, 060-SEPA-101/2/3/4, each receive vent gas from each ICB™ module, in addition to the brine reduction system vents.

Each knockout pot will be provided with dimensions of 6-ft 0-inch ID by 8-ft 0-inch high, constructed of carbon steel or high density polyethylene. Design conditions for the pots are 15 psig, 0.5 VAC at 135°F.

ACWA FDS testing indicated the need for a mist eliminator pad for each knockout pot prevent liquid carryover.

The ICB™ effluent pump tanks, 060-TANK-105/6/7/8, provide surge volume for the level control of the ICB™ effluent pumps. Each tank will be provided with 800 gallons capacity with dimensions of 4-ft 0-inch ID by 11-ft 0-inch high, constructed of high density polyethylene. Design conditions for the tanks will be $\pm$30 inches water column at 135°F.

4.13 DEWATERING

Reference PFD:	AAC-40-F-060	Bioreactors
	AAC-44-F-090	Water Recovery

Dewatering facilities for the bioreactors consist of a clarifier, thickener, and solid separation units. ACWA EDS ICB™ testing indicates that the ICB™ effluent has a suspended solids content which is low enough to forgo the clarification/dewatering process step. The deletion of dewatering is a process issue which will be resolved later pending completion of the test, the full evaluation of the test results and the submittal of a formal recommendation. For the time being dewatering has been retained as a component system of the ACWA EDS WHEAT HD munitions processing facility design.

This section covers process description of the units together with a description of their major equipment.

Water from the bioreactors is fed to two clarifiers where suspended materials are separated and collected by a sludge collector rotating at a speed of 0.05 revolution per minute. The clarifiers are built with a concrete floor at a slope of 1:12 and steel walls. Since effluent is not expected to have scum, no skimming device and scum baffle is provided. A scraper type sludge collector is provided to collect the underflow sludge and release it to the thickener intermittently. An Envirex circular type clarifier or equivalent with a diameter of 16 feet or more with water depth of 12 feet is required. The overflow from these units is fed to the evaporator feed tank for further treatment.

The underflow sludge from the clarifiers is fed to two thickener units. Each thickener with a diameter of 6 feet or more is required to provide an underflow of 4% solid content. The thickeners are designed to capture 90% of the suspended solids. The thickened sludge is transferred by pump intermittently to two filter press units for solids removal.

Two filter presses each with a capacity of 12 cubic feet or higher for each cycle is provided for separation of solids. JWI J-Press models or equivalent is required for this duty. The units are designed to dewater the thickened sludge. They are equipped with an automatic air/hydraulic opening and closing device with a closing force of 52 tons, and a semiautomatic air operated plate shifter. This feature eliminates the need for hand cranking and pumping. The cake produced by the press is dropped from the filter press to a dumpster to be transferred out for offsite disposal by trucks.

The overflow from the thickener and filtrate from the filter press are pumped back to the clarifiers.

4.14 BRINE REDUCTION

Reference PFD:	AAC-44-F-100 Sheet 1 of 2	Brine Concentrator
	AAC-44-F-100 Sheet 2 of 2	Evaporator/Crystallizer

4.14.1 BRINE REDUCTION PACKAGE

The brine reduction package consists of a brine concentrator unit, an evaporator crystallizer unit, a solid separation unit and related tankage. This package is provided for recovery of clean water from the bioreactor effluent for re-use in the process unit and for separation of the solids in a pressure filter or a centrifuge for offsite disposal. The brine reduction package is designed for a rate of 100 gpm, based on the rate of bioreactor effluent during the 4.2-inch mortar munitions campaign (the maximum design case), corrected for unit availabilities and other design criteria as explained in section 3.3.11.

The bioreactor effluent is an approximately 2 wt% salt solution, consisting of primarily sodium sulfate, sodium chloride, and sodium monophosphate. The solids leaving the unit contain no free liquid besides the water needed for their crystallization. The recovered water from this unit is reused by the process, mainly in the bioreactor system. The specification for recovered water will be defined at a later date. However, since it will be mainly used as bioreactor dilution water, its solid content can be fairly high. The designed system will produce water with a salt content of less than 250 ppm and is not expected to have any difficulty meeting the requirement. (Refer to Figure 4-12.)

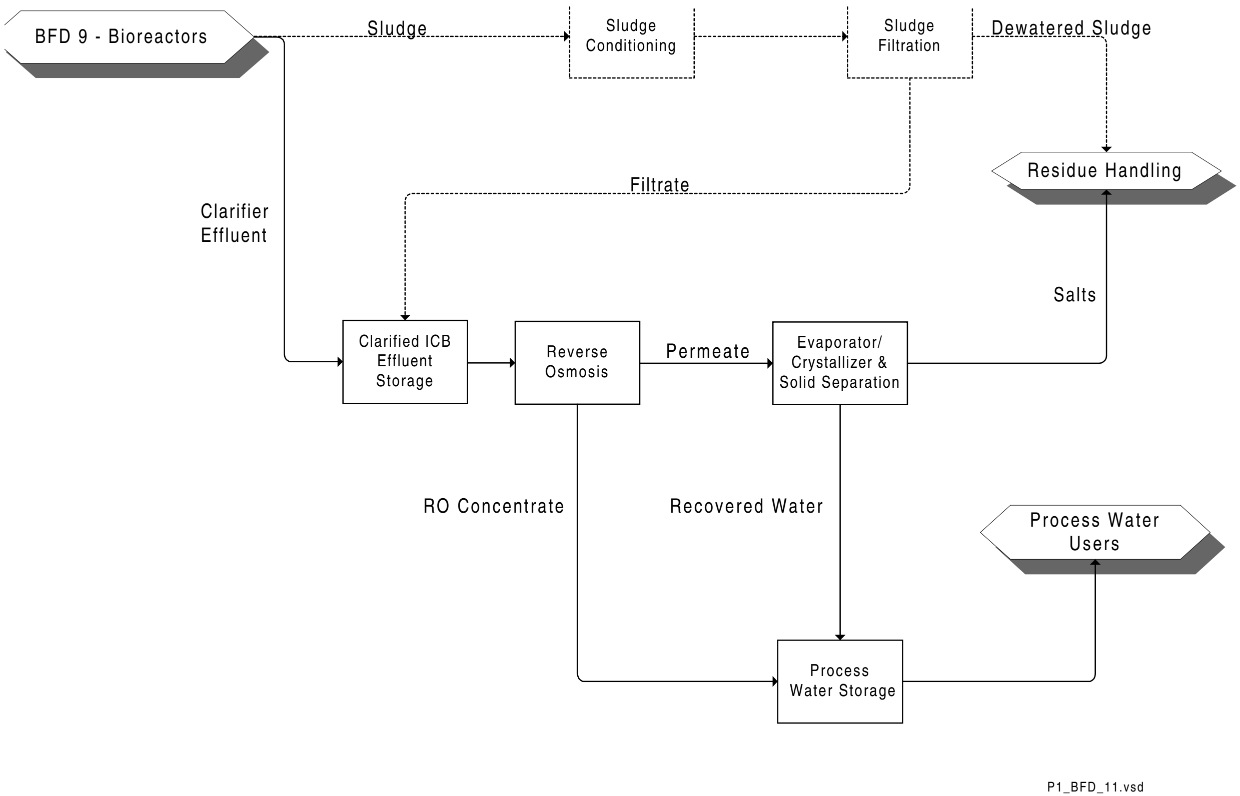


Figure 4-12—Brine Reduction and Water Recovery

4.14.2 BRINE CONCENTRATOR (BC)

The brine concentrator unit is installed to recover 80% of the water available in the brine. The concentrated brine from this unit is fed to an evaporator/crystallizer unit for further processing. (Refer to PFD AAC-44-F-100, sheet 1.)

Acidity of the feed to the unit is adjusted to a pH of 9 to protect the equipment under high temperature and corrosive condition. Bioreactor effluent and the caustics are mixed together by an inline static mixer, upstream of a mixing tank. The contents of the mixing tank are stirred with a mechanical agitator to promote mixing and neutralization. After neutralization in the caustic mixing tank, the bioreactor effluent is heated to approximately 210°F by the evaporator feed heat exchanger. The heat transfer medium for this exchanger is provided by condensate recovered from the evaporator. The condensate from the condensate tank is pumped to the evaporator feed heat exchanger and after being cooled by a water cooler it is sent to the water recovery system.

Feed to the unit after being heated in the feed/product heat exchanger is pumped into a deaerator where air is stripped off, and it exchanges heat with the vapors coming from the condensate tank.

Feed flows from the deaerator by gravity to the evaporator. The evaporator bottom is pumped by the recycle pump to the evaporator condenser where it flashes and exchanges heat with the compressed steam at the top of the evaporator column before returning to the sump. The evaporator is an atmospheric flash tank used for separation of steam from the brine slurry. A high alloy falling film condenser is located at the top of the evaporator to provide heat transfer surface to exchange heat between the evaporator recycle and the compressed steam. The water vapor from the evaporator exits at the top after passing through a mist eliminator pad (or valve trays) that prevents salt carry over. The vapor is conducted to a rotary type vapor compressor. The vapor compressor is a mechanical unit that compresses the water vapor to approximately 15 psig and superheats it by utilizing the heat of compression. The superheated steam is used as the heat transfer medium in the evaporator condenser, where the steam loses its superheat, condenses, and is collected in the condensate tank through a collecting pipe. A pressure controller on the tank vent maintains the tank operating pressure. The tank is connected to the deaerator vessel that condenses some of the vapor released from the tank and combines it with the feed. The remaining vapor that is mainly noncondensible discharge to the building sump.

An antifoam skid is provided for the BC package to prevent foaming in the evaporator.

During startup and cleaning, there is no internal steam available from the evaporator and the compressor cannot be a source of energy to heat the recycle stream from the recycle pump. A source of LP steam should be available during the startup period until the unit comes onstream. This external heat source is not necessary during normal operations.

A side stream from the recycle pump is fed to the evaporator crystallizer unit using the evaporator feed tank as a balance.

The evaporator is connected to the evaporator/crystallizer brine tank for boilout and dumping storage requirement. It is provided to hold the contents of the evaporator and an equal volume of dilution water during the cleaning cycle. The brine concentrator and the evaporator/crystallizer share one brine tank. The brine tank utilization is not going to be more than 10% of the time for each unit.

The major equipment of the unit together with their major characteristics are given below.

4.14.2.1 Caustic Mixing Tank

The caustic mixing tank will be sized for 100 gpm of effluent available from the bioreactor units at approximately 15 minutes residence time. Eighteen percent NaOH solution is to be added to the tank to raise the pH value of the bioreactor effluent to about 9. A feedback control from a pH controller sets the flow and the position of the caustic control valve. The tank will be furnished with a mechanical mixer. The tank will be constructed of carbon steel with proper lining material or equivalent. Its configuration will be either cylindrical with baffles or square.

4.14.2.2 Mechanical Mixers

All mechanical mixers will be constructed of 316L stainless steel (SS).

4.14.2.3 Evaporator Feed Tank

The evaporator feed tank will have a capacity to hold one day of bioreactor production. The tank will be constructed of carbon steel with proper lining material.

4.14.2.4 Condensate Tank

The condensate tank will provide a minimum holding capacity of 15 minutes of average condensate flow. The tank will be constructed of 316L SS.

4.14.2.5 Antifoam Skid

The antifoam skid will be a vendor-designed package including a tank with agitator, a measuring pump and necessary piping.

4.14.2.6 Evaporator

The flash tank will be designed and fabricated for full vacuum service and design pressure specified by the design contractor, normally around 5-10 psig. It is made of 6% moly SS. At the design contractor's recommendation, valve trays or a multisection mist eliminator can be provided at the top of the vessel to minimize the salt carryover to the condensate to guarantee quality of the condensate. The construction material of the shell and trays will be 6% moly SS.

4.14.2.7 Feed Heat Exchanger

The feed product heat exchanger is normally of a plate and frame type with high alloy material.

4.14.2.8 Evaporator/Condenser Assembly

The evaporator/condenser assembly consists of a shell and tube heat exchanger sitting on top of the sump. Depending on its duty there are several hundred titanium tubes with thin walls in the order of 0.027 inch thickness. The tubes are normally 2 inches in diameter and about 30 feet high. The tubes are terminated at each end on a titanium tube sheet. The tube bundle is contained in a stainless steel tube shell. The upper tube sheet forms the floor of the flood box that forms the top of the condenser. Brine from the sump is pumped to the top of the assembly and enters through a brine strainer located in the flood box. From here the brine is distributed evenly down each tube of the condenser in a thin film.

The thin film brine takes the heat of vaporization from the compressed steam on the shell side of the condenser. The condensed steam forms on the outside of the tubes and flows to the bottom tube sheet of the condenser. From where it flows to the condensate tank.

The noncondensed steam and noncondensible gases accompany the condensate to the tank and form a pocket at the top of the tank. This pocket provides stripping steam for the deaerator.

4.14.2.9 Vapor Compressor

The vapor compressor will compress the water vapor from the evaporator to provide additional energy to raise the temperature of the recirculating brine at the evaporator/condenser. The vapor compressor is a positive-displacement, rotary-lobe-type compressor (roots blower or equivalent).

4.14.2.10 Deaerator

The deaerator is a small vessel with a packed bed designed to strip mainly air from the feed to the evaporator. In this vessel feed to the unit enters from the top and any air or vapor accompanying it is stripped off with steam coming from the condensate tank.

4.14.2.11 Pumps

The feed and product pumps are 316L stainless steel. The recirculation pumps and the brine tank pumps are made of high alloy CD4MCu.

4.14.3 EVAPORATOR/CRYSTALLIZER (E/C)

The concentrated brine from the brine concentrator (BC) unit is fed to the E/C unit to recover the remaining water in the brine and to crystallize the solids for dewatering. (See PFD AAC-44-F-100 sheet 2 for reference.)

Feed to the unit is pumped through a feed product heat exchanger to the suction of the recycle pump. In addition to the feed stream the filtrate from the solid separation unit is also pumped to the suction of the recycle pump. The recycle pump circulates the evaporator bottoms through a forced circulation heat exchanger to exchange heat with the compressed steam from the compressor. The recirculating stream reaches the flashing point in the heat exchanger and is flashed after being discharged to the evaporator column. The evaporator is an atmospheric flash tank used for separation of steam from the brine slurry. The steam from the evaporator exits at the top after passing through mist eliminators (or valve trays) that prevents salt carryover. The vapor is conducted to a rotary vapor compressor. The vapor compressor is a rotary lobe type compressor that compresses the water vapor to approximately 15 psig and superheats it. The superheated water vapor is used as the heat transfer medium in the forced recirculation heat exchanger. In this exchanger the steam loses its superheat, condenses, and through a collecting pipe is transferred to the condensate tank. The tank is connected to a vent condenser that condenses most of the vapor released from the tank and returns it to the tank. The remaining vapor that consists of mainly noncondensable gases is discharged to the ICB™ CATOX® system. A pressure controller at the discharge of the vent condenser maintains the condensate tank operating pressure.

An antifoam skid is provided for the E/C package to prevent foaming in the evaporator.

During startup and cleaning, no internal steam is available from the evaporator and the compressor cannot be a source of energy to heat the recycle stream from the recycle pump. A source of LP steam should be available during the startup period until the unit comes onstream. This external heat source is not necessary during normal operations.

A side stream from the recycle pump is fed to the solid separation unit using the slurry tank as a balance storage capacity.

The evaporator column is connected to the brine tank for boilout and dumping storage requirement. It is provided to hold the contents of the evaporator and an equal volume of dilution water during the cleaning cycle. The BC and E/C units share one brine tank. The brine tank utilization is not going to be more than 10% of the time for each unit.

Organics present in the ICB effluent are high boiling point components that are expected to end up in the solid cake produced in the unit. However, for additional safety, the combined vent stream from the E/C unit is directed to the suction of the ICB CATOX® unit. So that any trace of noncondensable organic compounds present in this stream would be destroyed by the CATOX® prior to discharge to the atmosphere.

The major equipment of the unit together with their major characteristics are given below.

4.14.3.1 Mechanical Mixers

All mechanical mixers will be constructed of 316L SS.

4.14.3.2 Condensate Tank

The condensate tank will provide a minimum holding capacity of 15 minutes of average condensate flow. The tank will be constructed of 316L SS.

4.14.3.3 Antifoam Skid

The antifoam skid will be a vendor deigned package including a tank with agitator, a measuring pump and necessary piping.

4.14.3.4 Evaporator Column

The flash tank will be designed and fabricated for full vacuum service and design pressure specified by the design contractor, normally around 5-10 psig. It is made of 6% moly SS. At the design contractor's recommendation, valve trays or a mist eliminator can be provided at the top of the vessel to minimize the salt carryover to the condensate to guarantee quality of the condensate. The construction material of the shell and trays, if any, will be 6% moly stainless steel.

4.14.3.5 Feed Product Heat Exchangers

The feed product heat exchanger is normally of a plate type with titanium material or suitable high-alloy material.

The forced circulation heat exchanger is a shell and tube heat exchanger. The tubes will be made of titanium or suitable high alloy material, and the shell of the exchanger that contains steam and condensate will be made of stainless steel.

The vent condenser is a shell and tube heat exchanger made of stainless steel.

4.14.3.6 Vapor Compressor

The vapor compressor will compress the steam from the evaporator to supply additional energy to raise the temperature of the recirculating brine at the evaporator/condenser and provide a mean to evaporate the steam. The vapor compressor is a positive-displacement, rotary-lobe-type compressor (roots blower or equivalent).

4.14.3.7 Pumps

The feed and product pumps are 316 SS. The recirculation pumps and the brine tank pumps are made of high alloy CD4MCu.

4.14.4 SOLID SEPARATION SYSTEM

The solids dewatering unit will be either a centrifuge, a drum drier type unit, or a plate and frame type filter press, or an automatic pressure filter similar to an Oberlin pressure filter. The solids dewatering unit will be a complete package unit capable of dewatering an average rate of 21,000 lb/day of solids (primarily Na_2SO_4 and Na_2HPO_4 or NaCl) including bound water of hydration. The dewatered cake will not have free liquid and will be suitable for offsite land disposal. The solid separation unit considered for this process at this stage is a pressure filter. The Oberlin or an equivalent pressure filter is common in the industry for separation of solids in water treatment facilities. The system consists of a slurry tank, the pressure filter, an agitated filtrate tank, filtrate pump, and solid cake conveyor. The slurry flows from the slurry tank to the filter, a pneumatic airbag lowers the filter platen against the filter chamber. Platen seals on the perimeter of the compartments form a liquid tight seal around the filter media. Solids bearing liquid is pumped into the platen and forced by the pump pressure through the filter media. The filtered liquid is collected in the lower compartment and drains out to the filtrate tank. The filtrate is collected in the filtrate tank and is returned to the evaporator column, and solid cake is conveyed to a dumpster by a conveyor belt. The solids are stored in industrial bins and are transported by trucks for offsite disposal. A side stream from the filtrate is returned to the solid stream to balance the solids around the filter. Therefore the solids contain about 30 wt% moisture as they leave the filter. The moisture is later on absorbed as hydration liquid as the solids cool down.

An acid injection system has been provided to add concentrated sulfuric acid to the slurry tank. It is intended to reduce pH of the slurry to promote filtration. Based on the test results an acid injection rate of 6-ml per liter of slurry is necessary to produce a cake with 83% concentration. It is expected that a 70% solid concentration will meet the required cake specification. Therefore, lower acid injection rate may be necessary during the operation to achieve the desired cake specification.

4.14.4.1 Slurry Tank

The slurry tank is an agitated small balance tank between the evaporator column and the filtering unit. It is made of high-alloy material (6% moly) and designed to provide about 24 hours of residence time for the E/C slurry flowing to the filter. The assumption is that this time will allow E/C unit to continue operation while repair is being done on the solid separation section.

4.14.4.2 Slurry Pumps

An air-driven, high-alloy slurry pump is installed with spare to transfer slurry to the pressure filter.

4.14.4.3 Filter Structure

The wetted parts of the filter structure will be made of alloys (titanium or Hastelloy C) or can be lined with alloy material. The filter requires no special foundation. Electrical controls are based on either discrete relays with timers or programmable controllers.

4.14.4.4 Agitated Filtrate Tank

The tank will be furnished with a mechanical mixer. The tank will be constructed of alloy material. Its configuration will be cylindrical and will have an equivalent of 15 to 20 minutes of residence time for the filtrate.

4.14.4.5 Filtrate Pumps

A centrifugal high alloy (CD4MCu) filtrate pump with a spare will pump the filtrate back to the suction of the recycle pump.

4.14.5 EVAPORATOR FEED TANK, 090-TANK-101, AND PROCESS WATER TANKS, 200-TANK-109 A/B

Feed and process water tanks for the brine recovery package are designed on the basis of storing at least a day of throughput for the feed tank and 16 hours of production for the process water. The brine reduction package normally has a biweekly boilout period that lasts approximately 16 hours, during which the unit is in total recycle. To have supply of water for the process during that period and to allow the ICB™ unit to operate, and to absorb variations in the throughput of the adjacent units, feed and recovered process water tanks have been provided.

The evaporator feed tank provides storage for 24 hours of evaporator feed rate, or 144,000 gallons of working capacity. The installed tank capacity of the feed tank is 158,000 gallons. It is made with epoxy-lined carbon steel with a dimensions of 35-ft diameter by 24-ft high. The tank will be designed for atmospheric pressure at 225^{o}F.

The recovered water is normally stored in the process water tanks. These tanks have a combined capacity equivalent to a day of BRA production, and are sized for 72,000 gallons each. The material of construction is epoxy lined carbon steel, and the tank dimensions are 24-ft diameter by 24-ft high. The tanks are designed for atmospheric pressure at 225^{o}F.

4.15 ROTARY METAL PARTS TREATMENT

Reference PFD: AAC-01-F-070 Rotary Metal Parts Treatment

The purpose of the rotary metal parts treatment (RMPT) is to decontaminate the empty projectile and mortar shells by heating the shells to 1,000°F and holding them for a minimum of 15 minutes at that temperature. (Refer to Figure 4-13.)

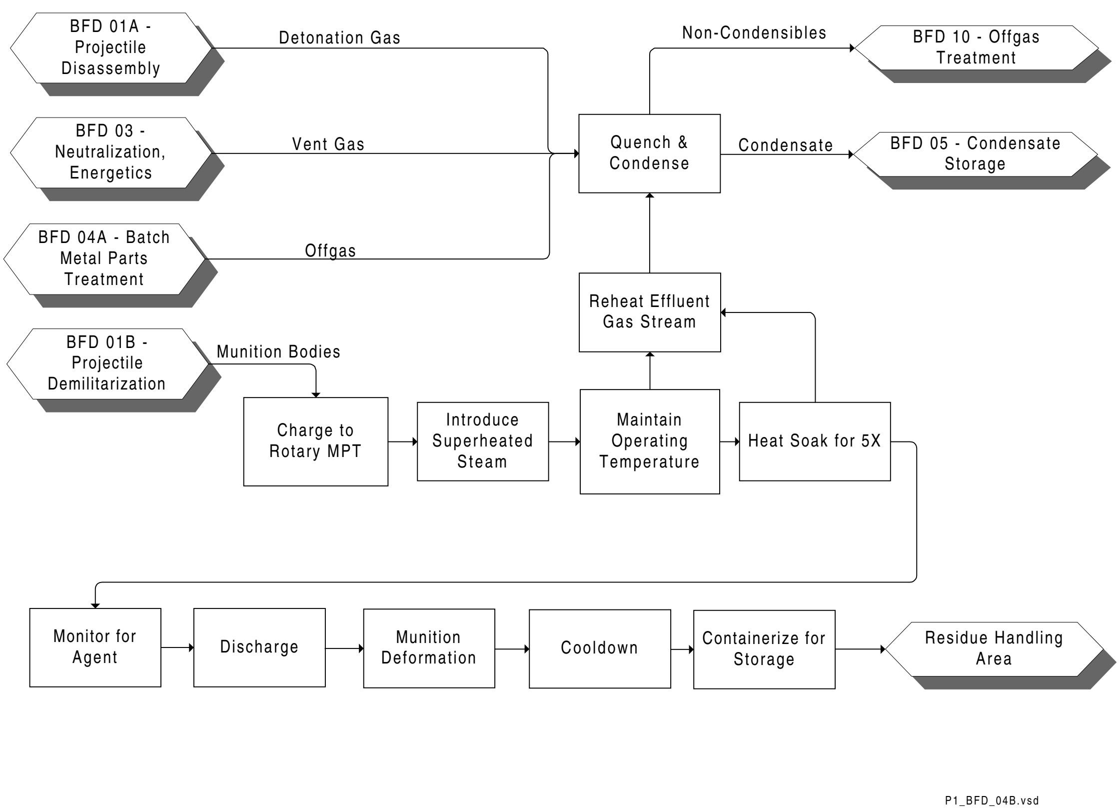


Figure 4-13—Rotary Metal Parts Treatment

The drained and washed munitions from projectile washout are transported by a conveyor system and loaded into the RMPT on a unit feed basis.

The RMPT is heated by using electric induction coils and swept with superheated steam. There will be a vent gas reheater downstream of the RMPT where agent destruction is completed by increasing the temperature of the vent gas to 1,250°F and reforming the agent residual with the steam already present in the vent gas.

Downstream of the reheater, the vent stream, mixed with the vents from the BMPT, ERD and ENRs, will be cooled and condensed, in a quench condenser in contact with a recirculated alkaline brine stream. A purge stream, from the recirculating brine, will be sent to the MPT/CST condensate holding tanks, and from there if agent free to bioreaction via the agent hydrolysate holding tank. If agent is found to be present in the MPT/CST condensate, the latter will first be treated in the agent reactors, where agent destruction will be completed and the resultant hydrolysate sent to bioreaction.

Noncondensable gases will be sent to the CATOX® offgas treatment system dedicated to the MPTs.

4.15.1 ROTARY MPT, 070-MPT-101

The design throughput for the RMPT is 120 rounds/hr for 105-mm and 4.2-inch munitions and 60 rounds/hr for 155-mm munitions. (Refer to Figure 4-14.) The RMPT uses external induction coils as the primary heat source, with a process heat load of 250-kW (installed duty 450 kW), and uses superheated steam as the carrier gas. The dimensions of the RMPT are 4-ft 8-inches ID by 15-ft 7-inches with design conditions of 15 psig/full vacuum at 1,500ºF. The RMPT will be constructed of Hastalloy C-276.

RMPT is a cylindrical structure rotating at a prescribed speed inside of a cylindrical furnace. The cylindrical structure contains 15 cages evenly distributed around a 36-inch outside diameter inner pipe supported and strengthened by baffles.

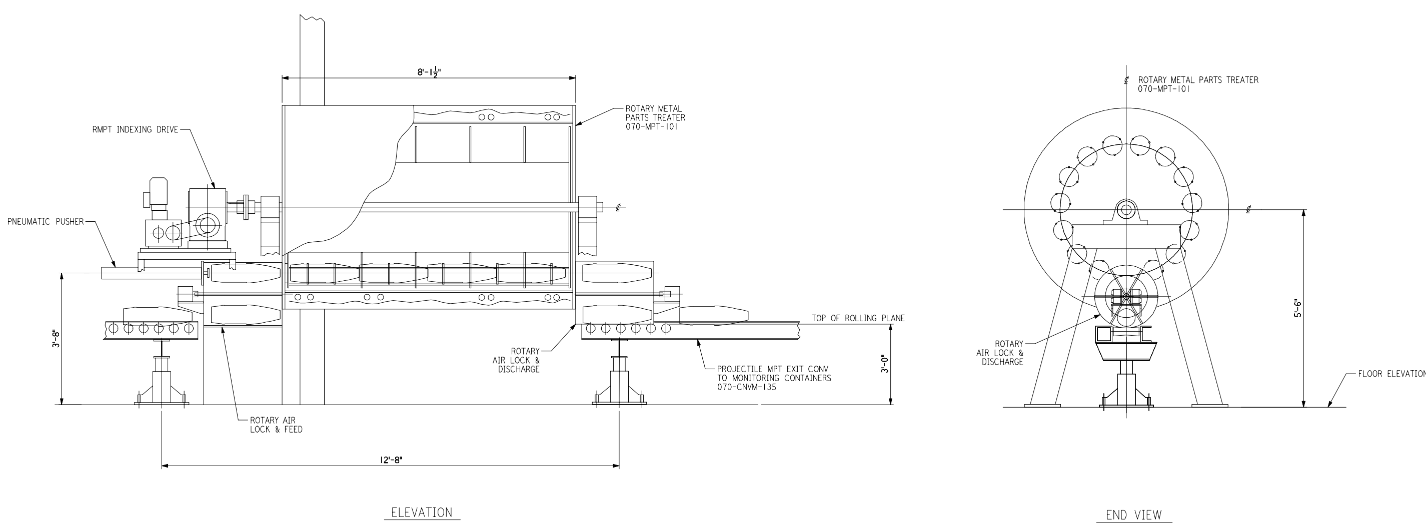


Figure 4-14—Rotary Metal Parts Treater

Munitions loading will be into these cage structures. Each cage is made with three ½-inch diameter stainless steel rods, positioned at a 120-degree angle and parallel in the axial direction. The inside diameter of the cage is determined just to accommodate the munitions or mortars without misaligning or jamming. Different size cages will be used for different munitions and mortars.

The length of the RMPT was determined by performing thermal analyzes. The iteration, while changing the furnace length continued until the process goal was met. The primary process goal was to meet the 5X conditions (15 minutes at or above 1,000°F) for all the munitions treated in the RMPT. Another requirement was to match the throughput rate of the upstream MDB machine. At this point of the process design effort, it is determined that the furnace should accommodate, in a row, ten 105-mm munitions, seven 155-mm munitions, or ten 4.2-inch mortars. The length of the cage is determined at 167 inches and the furnace 187 inches.

The RMPT assembly of cages, baffles, and inner pipe is rotated at a speed determined for each type of munitions: one revolution per 7 minutes and 30 seconds for 105-mm projectiles and 4.2-inch mortars, and 15 minutes for 155-mm projectiles. While the assembly is rotating or indexed at the prescribed speed, one 105-mm projectile or 4.2-inch mortar is loaded every 30 seconds, and one 155-mm projectile is loaded every minute. At the same time as a munition is loaded on the front end, one is discarded at the discharge end of the furnace. Then resulting total residence time for each munition is 75 minutes for 105-mm projectiles and 4.2-inch mortars (or 10 rows or complete revolutions), and 105 minutes for the 155-mm projectiles (or 7 rows/revolutions).

4.15.2 FURNACE WALL AND HEAT SOURCE

The munitions are heated primarily by radiation originating from the cylindrical furnace shell of 54-inches ID and 187-inches long. At both ends of the furnace, there are insulated disc plates equipped with munition/mortar loading and unloading devices.

The furnace wall is first heated by induction power supplied from an radio frequency (RF) generator. Since the load heating is by radiation, certain radiative properties of the furnace material become important parameters. One of these is the emittance. The shell material needs to have high emittance as well as good chemical resistance to corrosion, to resist the acid gases generated during the operation.

The entire furnace wall area needs to be maintained uniformly at 1,250°F. If not, the thermal gradient of the furnace wall will cause an inefficiency due to heat exchange between furnace segments at different temperatures, rather than heat up the munitions.

The RMPT steam superheater, 070-HEAT-103, is used to supply 1,000°F superheated steam to the RMPT. The unit will be a packaged manufacturer's standard unit sized for designed for 25-kW, 15-psig/full vacuum at 1,500°F with a capacity of 15,000 Btu/hr.

The RMPT effluent heater, 070-HEAT-101, is used to heat the RMPT effluent to approximately 1,200°F to ensure total destruction of HD present in the vent gas. The unit will be a manufacturer's standard unit designed for 25-kW, 15-psig/full vacuum at 1,500°F with a capacity of 50,000 Btu/hr and a residence time of 0.5 second.

The MPT quench tower, 070-TOWR-101, receives the heated vent gases from the RMPT, BMPT, ERD and ENRs, and contacts the gases with a recirculating alkaline brine solution and the resultant noncondensable vent gases sent to the offgas treatment CATOX® units. The quench tower will be made of Hastalloy C-276 and designed for a feed rate of 8000 ACFM, 15-psig/full vacuum at 175°F with tower dimensions of 1-ft 6-inches ID by 12-ft 0-inch T/T.

The MPT condensate surge tank, 070-TANK-101, receives the purge stream from the recirculating brine which will be sent to the MPT/CST condensate holding tanks. The tank will be provided with 750 gallons capacity, with dimensions of 4-ft 0-inch ID by 8-ft 0-inch high, constructed of hastelloy C-276 or plastic. Design conditions for the tank are 15 psig, full vacuum at 175°F.

ACWA EDS testing indicated a need for a mist eliminator pad in the MPT condensate surge tank to prevent liquid carryover.

4.16 CONTINUOUS STEAM TREATMENT

Reference PFD: AAC-50-F-075 Continuous Steam Treater

AAC-50-F-120 Contaminated Waste Preparation

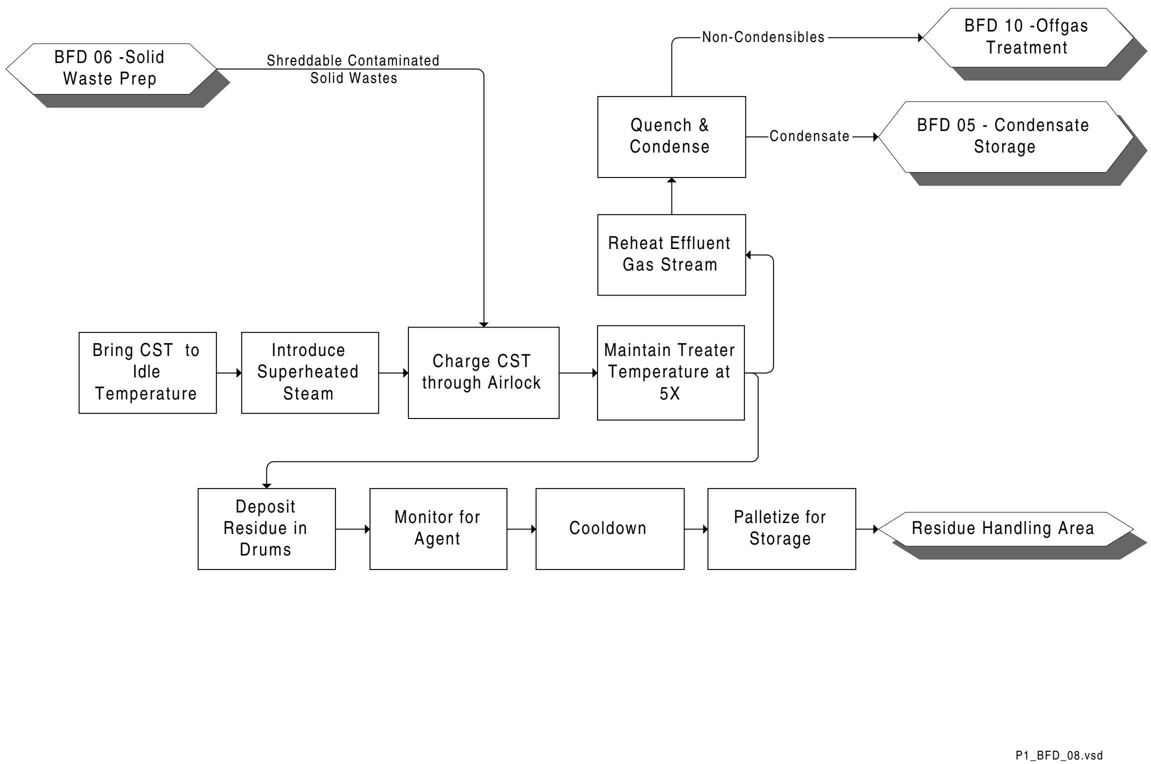


Figure 4-15—Continuous Steam Treatment

The continuous steam treater (CST) system is designed to achieve 5X conditions for plant non-process wastes and dunnage, by heating the materials to 1,000°F and holding at that temperature for a minimum of 15 minutes. Shredded wood pallets, spent activated carbon from the HVAC carbon beds, and shredded plastic (DPE with boots and gloves) will be treated in the CST unit. The CST system operates in a continuous feed mode to decontaminate each feed type. The shredded wood and shredded DPE feeds will be mixed with an aggregate material to add bulk to the feed materials and also to act as a scouring agent for the CST shell.

Feed aggregate/carrier material (crushed tabular alumina or other suitable material) is needed to provide bulk to shredded feedstock such as wood or plastic (DPE). ACWA EDS CST testing will recommend the type and quantity of aggregate and the appropriate feed mixture to aggregate ratios.

The ACWA EDS WHEAT full-scale design for the CST is based on hourly feed ratios based on 100 lb wood:200 lb aggregate; 15 lb DPE:285 lb aggregate; mixed feed at 15 lb DPE:85 lb wood: 200 lb aggregate. Aggregate attrition rate is assumed to be 10% of the feed aggregate. This quantity will be recalculated based on CST testing results. Carbon is fed alone (no aggregate) at 300 lb per hour.

ACWA EDS WHEAT full-scale design is based on CST mechanical design as tested. This design is subject to modification based on CST test results and recommendations for design modifications. Steam feed flow rate is at 50% excess of stoichiometric reaction needs, superheated to 1,000°F. The feed solids must be maintained at 1,000°F for a minimum of 15 minutes. CST vent gases must be heated and maintained at 1,200-1,250°F at the CST effluent reheater for a minimum residence time of 0.5 second.

The CST uses steam as a carrier gas. Prior to commencing the steam treatment, the heating chamber is purged with nitrogen to create an inert atmosphere. Steam is superheated to 1,000°F prior to feeding into the CST chamber.

4.16.1 CST Feed Material

The CST will be used for destroying potentially agent-contaminated waste such as contaminated wood pallets, boxes, DPE suits, and charcoal filters. Most of the waste except charcoal filters will be generated in UPA and PRR. Plastic wrapping will contain the contaminated waste as generated and will be fed to shredders for CST processing.

Metal parts are separated from the DPE suits as the suits are removed and before placing them in overpack bags. The metal parts are then treated through the BMPT.

The other major waste generated will be in the filter area located north of MDB. The spent Contaminated filters as removed will be packaged in the plastic bag and placed in the temporary storage for later CST processing in the MDB.

The waste generated in the TMA due to leaker campaign will be in the form of DPE suits and contaminated wood pallets. This waste will be packaged in plastic bags for transfer to two shredders in feed conveyors.

The bagged contaminated wood pallets and DPE suits will be removed from TMA air lock and loaded on to the motorized pallet trucks and forklifts for transfer through the UPA to two shredders in feed conveyors for processing.

4.16.2 Contaminated Waste Preparation

A typical operating scenario for the CSTR consists of receiving contaminated wood pallets/boxes and DPE suits by forklift/pallet trucks. The plastic suits and wood will be introduced into the shredding room through dedicated airlocks located on the west wall of the CSTR. The two dedicated shredders one for wood and the other for DPE suits will be located in the shredding room. Flexible screw conveyors will transfer the shredded material from the respective shredders to an enclosed belt conveyor through a surge bin/loss in weight feeder system.

All material as being shredded will drop down to the bottom compartment of the shredder along with any minor dust/small particles that may have generated in this operation. The enclosed screw conveyor will transfer shredded material along with settled dust/small particles through a closed conveyor system to the CST. A dedicated dust collection is not necessary for this type of system as very minimal dust is generated in the shredding and settles down along with the larger particles at the bottom of the shredder.

Any metal such as nails generated from the wood shredding operation will be collected and placed in miscellaneous parts container for transfer to the batch MPT for the treatment.

Flex screw conveyor will transfer alumina as aggregate from the storage bin onto the enclosed belt conveyor carrying shredded wood and plastic suits to CST. The material will be dropped into the CST through a double flap gate airlock valve. The mixture will be thermally treated as it moves towards the CST discharge end by the CST auger. The discharged mixture in the form of ash and alumina will be transferred to a classifier for separation by a water-cooled screw conveyor.

The classifier will separate the ash, which will be collected in ash bins through a gravity chute and alumina will directly be deposited in the storage bin for recycle.

4.16.3 CST AND CST OFFGAS TREATMENT

The CST will provide 5X decontamination (1,000°F for 15 minutes) of the dunnage, using external inductive heating and the steam inside. The steam passes through the CST countercurrent to the flow of solid feed; steam enters near where the treated dunnage discharges and exits the near the dunnage feed end.

Solid materials discharged from the CST will be separated into two components: ash (to be monitored and drummed for disposal) and aggregate. The aggregate will be blended with dunnage and will be fed again to the CST.

The largest CST system component is an induction furnace. This is a 300-kW inductively heated horizontal cylinder, approximately 5-ft diameter by 15-ft long. The shell is to be constructed of Hastelloy C-276. Contained within the shell is a rotating, multibladed auger shaft that rotates in a 30-inch diameter trough running the length of the furnace. Material (dunnage plus aggregate) is fed at one end of the furnace. The steam enters the opposite end of the furnace. Feed material transits the length of the furnace in approximately 1 hour (controlled by auger shaft rotation speed and blade pitch). Residual solids exit the furnace through a discharge air lock.

Volatized gases and steam exit the feed end of the furnace and enter an induction re-heater. The re-heater ensures process gases are elevated to approximately 1,200°F with a minimum residence time of 0.5 seconds. Re-heater discharge flow enters the quench tower.

The quench tower receives hot gases from the re-heater and uses evaporative cooling spray to condense steam and reduce process outlet temperature to approximately 150°F. A purge stream, from the recirculating brine, will be sent to the MPT/CST condensate holding tanks, and from there, if agent free, to bioreaction via the agent hydrolysate tank.

The continuous steam treater, 075-CST-121, will accomplish a decontamination level of 5X, 1,000°F maintained for 15 minutes, in shredded contaminated material from wood pallets, DPE suits and spent carbon. The design throughput for the CST will be 300 lb/hr. The MPT uses external induction coils as the primary heat source, with a heat load of 300 kW, and superheated steam as the carrier gas. The dimensions of the CST are 4-ft 8-inches ID by 11-ft 0-inch with design conditions of 15-psig/full vacuum at 1,500°F. The CST will be constructed of Hastalloy C-276.

The CST steam superheater, 075-HEAT-122, is used to supply 1,000°F superheated steam to the CST. The unit will be a packaged manufacturer's standard unit sized for designed for 25-kW, 15-psig/full vacuum at 1,500°F with a capacity of 30,000 Btu/hr.

The CST effluent heater, 075-HEAT-121, is used to heat the CST effluent to approximately 1,200°F to ensure total destruction of HD present in the vent gas. The unit will be a manufacturer's standard unit designed for 25-kW, 15-psig/full vacuum at 1,500°F with a capacity of 24,000 Btu/hr and a residence time of 0.5 second.

The CST quench tower, 075-TOWR-121, receives the heated vent gases from the CST and contacts the gases with a recirculating alkaline brine solution. The quench tower will be made of Hastalloy C-276 and designed for a feed rate of 8000 ACFM, 15-psig/full vacuum at 175°F with tower dimensions of 1-ft 6-inches ID by 12-ft 0-inch T/T.

The vent gas from the quench tower system is further treated in the CATOX® offgas treatment system. (Refer to Section 4.18.)

The CST condensate surge tank, 075-TANK-121, receives the purge stream form the recirculating brine which will be sent to the MPT/CST condensate holding tanks. The tank will be provided with 750 gallons capacity, with dimensions of 4-ft 0-inch ID by 8-ft 0-inch high, constructed of stress relieved carbon steel or plastic. Design conditions for the tank will be 15 psig, full vacuum at 175°F.

ACWA EDS testing indicated a need for a mist eliminator pad in the CST condensate surge tank to prevent liquid carryover. Also testing indicated the need for antifoam addition for the CST quench system to prevent foaming in the quench tower and surge tank.

4.17 BATCH METAL PARTS TREATMENT

Reference PFD: AAC-50-F-076 Batch Metal Parts Treatment

4.17.1 MPT BATCH PROCESS

While the main bodies of 105-mm, 155-mm munitions, and 4.2-inch mortars are processed in the RMPT, the internal parts taken out from these munitions are collected into rectangular boxes and put through batch processes in another MPT. (Refer to Figure 4-16.) These parts are burster wells, burster tubes, fuzes, nose cones, lifting lugs, plugs, etc.

The batch metal parts treater, 076-MPT-101, will accomplish a decontamination level of 5X, 1,000°F maintained for 15 minutes, in burster wells from WMDM, burster tubes, fuzes, booster cups, nose closure plugs and miscellaneous parts from projectile disassembly. (Refer to Figure 4-17.) The design throughput for the BMPT will be three 3-ft by 3-ft by 2-ft containers/batch. The BMPT uses external induction coils as the primary heat source, with a heat load of 450 kW, and superheated steam as the carrier gas. The dimensions of the BMPT are 4-ft 8-inches ID by 11-ft 0-inch with design conditions of 15-psig/full vacuum at 1,500°F.

The BMPT steam superheater, 076-HEAT-102, is used to supply 1,000°F superheated steam to the BMPT. The unit will be a packaged manufacturer's standard unit sized for designed for 50-kW, 15-psig/full vacuum at 1,500°F with a capacity of 138,000 Btu/hr.

The BMPT effluent heater, 076-HEAT-101, is used to heat the BMPT effluent to approximately 1,200°F to ensure total destruction of HD present in the vent gas. Re-heater discharge vent gases are sent to the MPT quench tower. The unit will be a manufacturer's standard unit designed for 50-kW, 15-psig/full vacuum at 1,500°F with a capacity of 94,000 Btu/hr and a residence time of 0.5 second.

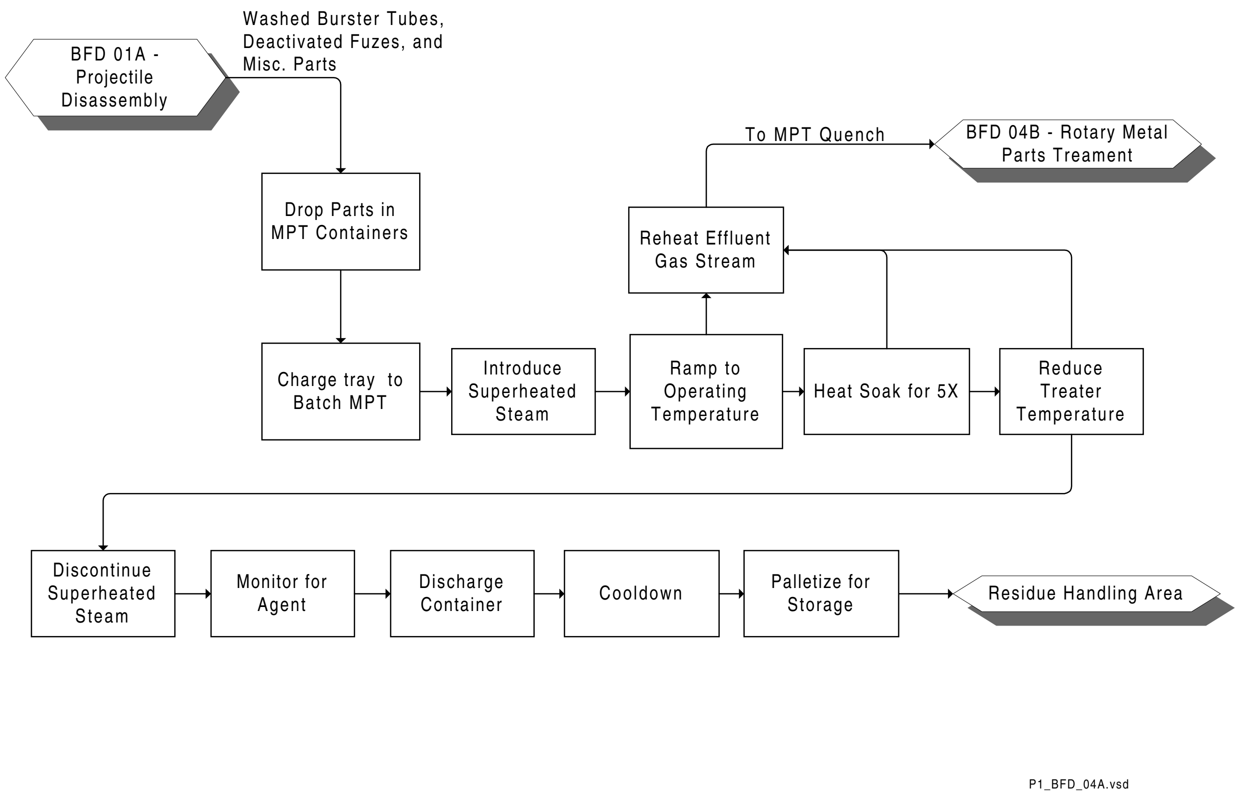


Figure 4-16—Batch Metal Parts Treatment

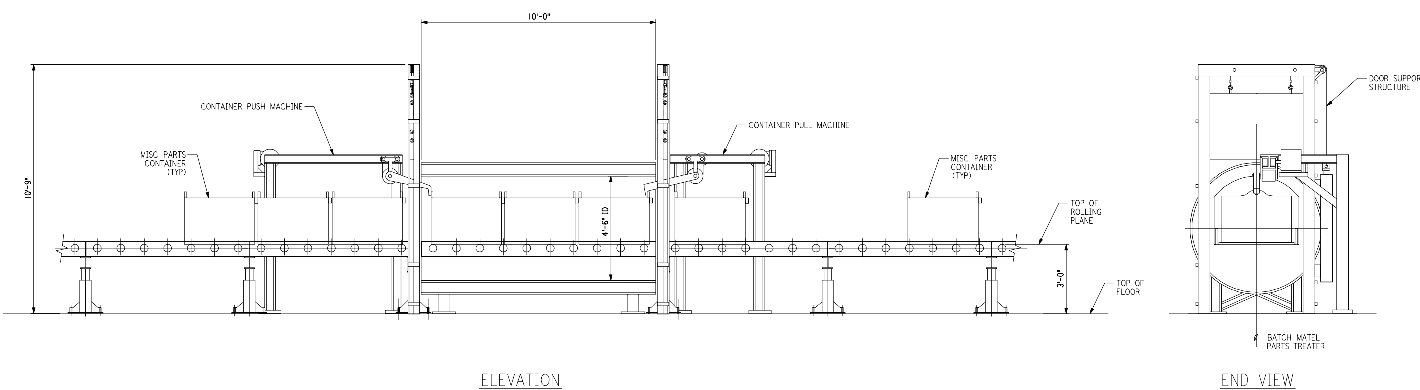


Figure 4-17—Batch Metal Parts Treater

4.18 OFFGAS TREATMENT

Reference PFD:	AAC-01-F-080	Offgas Treatment - MPT
	AAC-50-F-085	Offgas Treatment – CST
	AAC-40-F-087	Offgas Treatment – Bioreactor

The ACWA EDS WHEAT full-scale systems use catalytic oxidation as a localized method of process offgas treatment. There are three systems involved. As illustrated in Figure 4-18, these are the offgas treatment systems for the MPTs, CST and bioreactor process vent gases.

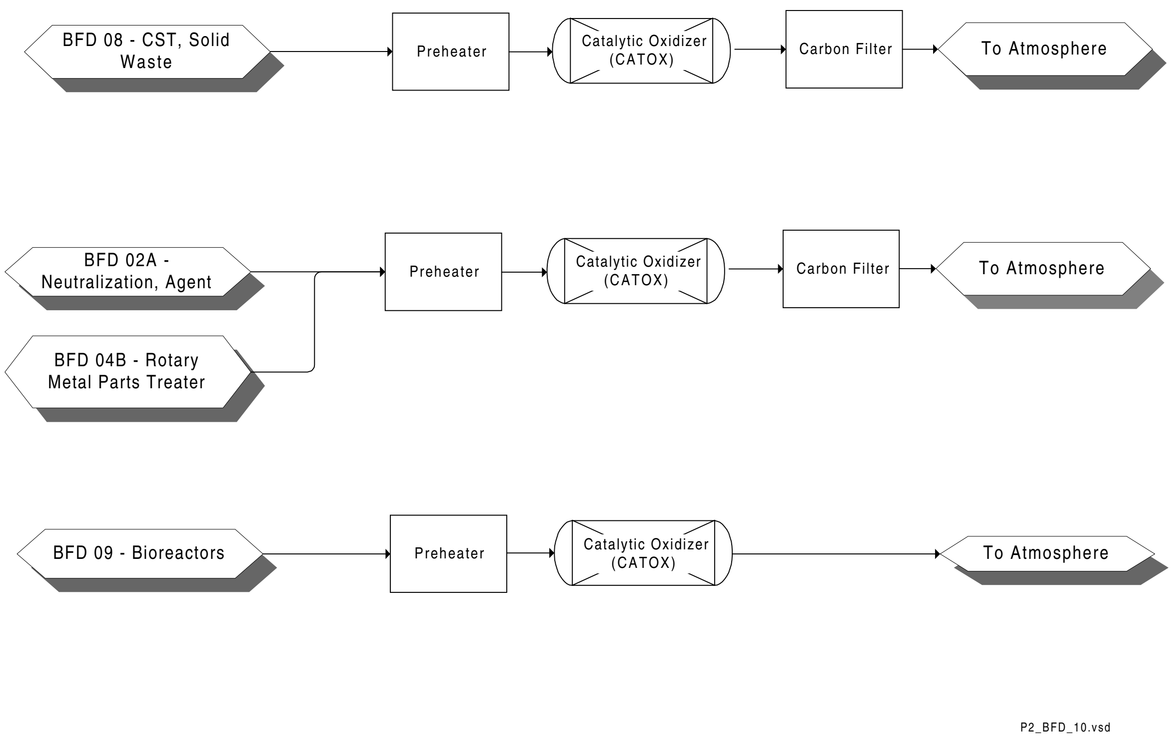
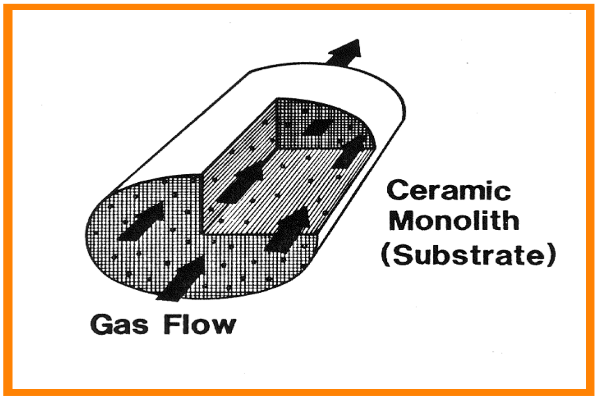


Figure 4-18—Offgas Treatment Systems

Trace pollutants in the process vent streams from the MPTs, the CST, reactors and hydrolysate tank vents, the ERD, and the ICB™ will be removed by catalytic treatment. In theory, the reactant molecules (e.g., VOCs and oxygen) diffuse to the catalyst surface and are adsorbed onto the catalyst. On the catalyst surface, the reactants dissociate into fragments and atoms. Following surface reactions, the end products then desorb from the surface back into the flow stream. Thus, the catalyst facilitates the reaction by providing a low energy pathway for the reaction to occur (in other words, it lowers the activation energy). (Refer to Figure 4-19.)

The catalyst will be supported on straight channel, ceramic monolith substrates that provide higher catalytic efficiencies with minimum pressure drop. Typically, the monolith channels are coated with a high-surface-area inorganic oxide (e.g., Al_2O_3) “washcoat” to improve the dispersion and durability of the active component. The active component is loaded onto the washcoat in an impregnation step.

The catalytic reactor is designed to operate under external mass transfer rate control. That is, the rate of destruction is determined by the rate the reactant molecules diffuse from the bulk flow stream to the surface of the catalyst. The actual surface reaction occurs much faster than the diffusion step. In this way, standard mass transport equations and fluid dynamics can be used to design the catalytic reactor to give a desired conversion and pressure drop for given inlet conditions.



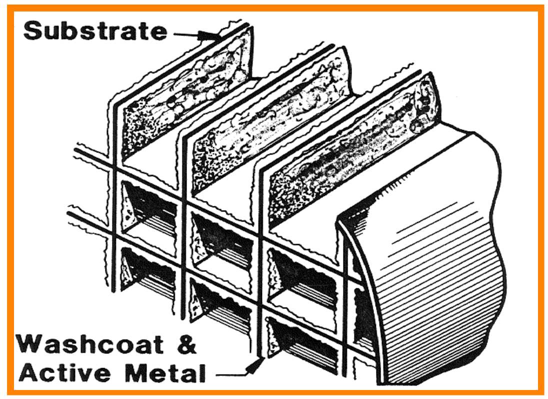


Figure 4-19–Catalytic Oxidizer Cutaway Diagrams

In typical operations, the flow inlet is brought to the desired temperature by heating. This heated air is brought into the catalytic reactor where the trace pollutants are destroyed. The reactor will be composed of a series of monolithic catalyst segments to improve mass transfer properties. The outlet air can then be passed through a heat exchanger to recover some of the energy and then exhausted to the MDB filter system.

The proprietary Honeywell catalyst formulation to be used was developed specifically for its resistance to common catalyst poisons such as halogens, sulfur, and phosphorus. This catalyst has been tested extensively against compounds containing common catalyst poisons, chemical agents and has shown high-destruction efficiencies and durable performance. (ACWA EDS CATOX® HD challenge testing at 10-30 mg HD per cubic meter of air was concluded successfully in October 2000. The test results and lessons learned will be incorporated in full-scale design pending publication of the test report and recommendations.)

The bioreactors will be equipped with their own CATOX® systems. These are not anticipated to ever see agent and are provided solely to deal with any VOCs stripped from the ICB™ feed by the bioreactor aeration or generated by the biota in the reactor. Each bioreactor module (comprising 4 ICB™ units) will be equipped with a dedicated CATOX® offgas treatment system.

The three CATOX® systems operate in the same manner. Incoming air streams are heated electrically to about 800-840°F, to bring the gas streams within the CATOX® catalyst active temperature. This active temperature can be lowered to about 700°F, if upstream process conditions impose a heavier than anticipated organic (or oxidation) load on the CATOX® unit. The maximum sustained operating temperature at the discharge of the catalyst bed is 1,050°F. Operation at temperatures above this will result in gradual loss of catalyst activity and it is to be avoided. Process control systems are in place to stay within the operating limits; these are discussed in subsection 7.2.5, Monitoring and Control Strategy – MPT/CST Offgas Treatment.

The proprietary Honeywell catalytic matrix destroys all organic materials. The bioreactor CATOX® units discharge directly to the atmosphere. The MPT and CST system vent CATOX®

unit(s) discharge to the MDB filter system as a precaution. The MDB filter system discharges to the atmosphere.

The MPT offgas reheater, 080-HEAT-106, takes incoming gases from the MPT agent condensate surge tank vent, the agent hydrolysers, and the agent hydrolysate tank vents and heats the mixed stream electrically (by using electric induction coils) to reduce moisture content and condition the gas streams to the CATOX® operating temperature. The unit is a manufacturer's standard unit sized for 450 kW with a capacity of 1.2 MMBtu/hr and design conditions of 15-psig/full vacuum at 1,000°F.

The MPT offgas CATOX® treater, 080-CATX-101, receive the heated gases from the MPT offgas reheater and through the proprietary Honeywell catalytic matrix destroying residual VOCs and semi-VOCs. The unit has a capacity of 1260 scfm, 25-inch water column pressure drop and dimensions of 2-ft 0-inch diameter by 4-ft 0-inch flange-flange (F/F).

The MPT offgas cooler, 080-EXCH-102, receives the heated air stream from the CATOX® treaters and cools the stream prior to entering the HVAC carbon filters. The cooler will be rated for a duty of 1.2 MMBtu/hr with design conditions of 15-psig/full vacuum at 925ºF (tubes). The tubes of the cooler will be constructed of alloy 20 with a carbon steel shell.

The MPT offgas blower, 080-BLOW-106, transfers the cooled CATOX® exhaust and transfers the gas to the HVAC carbon filters. The exhaust blower will provide enough flow and draw to keep the complete system at a pressure slightly less than ambient. The blower will have a capacity of 1260 scfm and be sized for 72 BHP, 100 HP.

The CST offgas reheater, 085-HEAT-106, takes incoming gases from the CST condensate surge tank and heats the stream electrically to reduce moisture content and condition the gas streams to the CATOX® operating temperature. The unit will be a manufacturer's standard unit sized for 450 kW with a capacity of 1.0 MMBtu/hr and design conditions of 15-psig/full vacuum at 1,000°F.

The CST offgas CATOX® treaters, 085-CATX-101, receive the heated gases from the CST offgas reheater and through the proprietary AlliedSignal catalytic matrix destroys residual VOCs and semi-VOCS. The unit will have a capacity of 1040 scfm, 25-inch water column pressure drop and dimensions of 2-ft 0-inch diameter by 4-ft 0-inch F/F.

The CST offgas cooler, 085-EXCH-102, receives the heated air stream from the CATOX®/CATOX® treaters and cools the stream prior to entering the HVAC carbon filters. The cooler will be rated for a duty of 1.0 MMBtu/hr with design conditions of 15 psig/full vacuum at 925ºF (tubes). The tubes of the cooler will be constructed of 1-1/4 Cr - 1/2 Mo with a carbon steel shell.

The CST offgas blower, 085-BLOW-106, transfers the cooled CATOX®/CATOX® exhaust and transfers the gas to the HVAC carbon filters. The exhaust blower will provide enough flow and draw to keep the complete system at a pressure slightly less than ambient. The blower will have a capacity of 1040 scfm and be sized for 60 BHP, 75 HP.

The ICB™ offgas reheater, 087-HEAT-101/2/3/4, takes incoming gases from the ICB™ modules and brine reduction system vents, and heats the stream electrically to reduce moisture content and condition the gas streams to the CATOX® operating temperature. Four heaters are required; each will be a manufacturer's standard unit rated for 720 kW with a capacity of 2.4 MMBtu/hr and design conditions of 15 psig at 1,000°F.

The ICB™ offgas CATOX® treaters, 087-CATX-101/2/3/4, receive the heated gases from the ICB™ offgas reheater and through the proprietary AlliedSignal catalytic matrix destroys residual VOCs and semi-VOCS. Four CATOX® treaters are required; each unit will have a capacity of 6400 scfm, 25-inch water column pressure drop, and dimensions of 4-ft 6-inch diameter by 4-ft 0-inch F/F.

The ICB™ offgas blowers, 087-BLOW-101/2/3/4, transfer the cooled CATOX® exhaust and transfers the gas to the HVAC carbon filters. The exhaust blowers will provide enough flow and draw to keep the complete system at a pressure slightly less than ambient. Four blowers will be required; each will have a capacity of 6400 scfm and be sized for 200 BHP, 250 HP.

The CATOX® offgas economizers, 087-EXCH-101/2/3/4, are gas-to-gas heat exchangers used to heat the CATOX® feed with CATOX® effluent. Four exchangers will be required; each will be rated for 4.3 MMBtu/hr with design conditions of 75 psig at 1,000°F and be constructed of 1-1/4 Cr - 1/2 Mo carbon steel exposed.

4.19 BULK CHEMICALS STORAGE

The bulk chemical storage system consists of storage tanks for 50% sodium hydroxide, 18% sodium hydroxide, 12% sodium hypochlorite, inorganic nutrients, and decontamination solution (5.5% sodium hypochlorite) with the appropriate unloading stations and transfer pumps.

4.19.1 SODIUM HYDROXIDE

Fifty percent sodium hydroxide is provided to the process from the 50% sodium hydroxide storage tank. The tank receives 50% sodium hydroxide solution from delivery trucks and stores it for use in the neutralization reaction of energetics and for mixing with process water to make 18% sodium hydroxide solution. The 50% sodium hydroxide storage tank will be electrically heat traced to maintain the 50% solution at 80°F to prevent freezing.

Eighteen percent sodium hydroxide solution is stored in the 18% sodium hydroxide storage tank and used in the neutralization reaction of drained agent, pH control in the bioreactors, pH control in the rotary MPT condensate tank and the continuous steam treater condensate tank and for pH control in the brine reduction package. The 18% sodium hydroxide solution is also used as an emergency decon for equipment washdown.

4.19.2 SODIUM HYPOCHLORITE SOLUTION

Twelve percent sodium hypochlorite is provided to the sodium hypochlorite tank. The tank receives 12% sodium hypochlorite solution from delivery trucks and stores it for mixing with process water to make 5.5% sodium hypochlorite solution.

4.19.3 CENTRAL DECONTAMINATION SUPPLY

The 5.5% sodium hypochlorite solution is stored in the decon supply tank. The 5.5% sodium hypochlorite is used for personnel decontamination throughout the facility.

4.19.4 INORGANIC NUTRIENT SUPPLY

Inorganic nutrients are provided to the process from the inorganic nutrient tank. The tank receives inorganic nutrients consisting of ammonia, magnesium chloride, potassium phosphate, diammonium phosphate, and calcium chloride from delivery trucks, and stores it for use in the bioreactors. The inorganic nutrient tank is supplied with an agitator to ensure that a well-mixed solution is fed to the bioreactors.

Fresh decon is transferred from the decon supply tank to the emergency showers. The emergency showers are provided for the equipment decon/access airlocks to the agent neutralization rooms (ANRs) and toxic maintenance area (TMA). After showering with fresh decon, personnel are rinsed with an equal volume of process water. The decon supply and spent decon capture/storage system provides the process water for rinsing personnel after the decon shower. Process water is transferred from the process water tank to the emergency showers. The resulting spent decon is collected in sumps.

4.20 PROCESS SAMPLING SYSTEMS

4.20.1 AGENT NEUTRALIZATION ROOMS

There are three ANR gloveboxes, one for each room. One ANR glovebox will be able to handle samples of hydrolysate taken from each of the two reactors in its room, drained agent from the agent holding tanks, MPT/CST condensate from the holding tanks, and agent concentrate from the agent concentrate holding tank. The other two gloveboxes will only handle samples of hydrolysate from the two reactors in their own ANR. Decon solution (5.5 wt% sodium hypochlorite) is provided to each glovebox for decontaminating the sample cylinders and piping. In addition, process water is provided to each glovebox for washing and rinsing. Plant air is provided for drying and for the auto sampler.

The sample circuit for drained agent from the agent holding tank is a loop from the agent holding tank to the agent sample pump and back to the agent holding tank. A normally closed-side stream connects from this circuit to the sample cylinder in the ANR glovebox. When a sample is required, the side stream is opened and a sample is collected in the sample cylinder. The flow rate for the sample circuit is estimated to be 3.6 gpm. Flow through the sample circuit is continuous while the pump is operating to ensure a well-mixed representative sample of the contents in the agent holding tank. The purpose of this sample is to verify the composition of the agent in the drained agent holding tank, e.g., ferric ion concentration are within limits to prevent corrosion.

The sample circuits from the agent hydrolysers are lines from the pump discharge side of the agent hydrolyser recirculation pumps back to the discharge side of the same pumps, but downstream of the inline mixers. A normally closed-side stream connects from this circuit to the sample cylinder in the ANR glovebox. When a sample is required, the side stream is opened and a sample is collected in the sample cylinder after being cooled by the agent hydrolyser sample cooler. Chilled water provides the cooling. The flow rate for this sample is estimated to be 1.3 gpm. Flow through the sample circuits is continuous while the pump is operating to ensure that a well-mixed representative sample of the contents of the drained agent reactors. The purpose of this sample is to determine the concentration of agent in the agent hydrolysate, to ensure that the hydrolysate meets spec before being pumped to the agent hydrolysate holding tank.

The sample circuit from the MPT/CST holding tank is a line from the pump discharge side of the MPT/CST condensate feed pump back to the suction side of the same pump. A normally closed-side stream connects from this circuit to the sample cylinder in the ANR glovebox. When a sample is required, the side stream is opened and a sample is collected in the sample cylinder.

The flow rate for this sample is estimated to be 1.0 gpm. Flow through the sample circuit is continuous while the pump is operating to ensure that a well-mixed representative sample of the contents of the tank. The purpose of this sample is to determine if there is a concentration of agent in the condensate, in which case the condensate would have to be sent to an agent hydrolyser rather than the agent hydrolysate holding tank.

The sample circuit from the agent concentrate holding tank is a loop from the tank to the sample pump and back to the tank. (Note: The sample pump operates continuously to keep the contents of the agent concentrate holding tank well mixed.) A normally closed-side stream connects from this circuit to the sample cylinder in the ANR glovebox. When a sample is required, the side stream is opened and a sample is collected in the sample cylinder. The flow rate for this sample is estimated to be 1.0 gpm. Flow through the sample circuit is continuous to ensure that a well-mixed representative sample of the contents of the agent concentrate holding tank. The purpose of this sample is to determine the composition of the spent agent concentrate before it is sent to the agent hydrolysers for processing.

Any spills, rinse water, or spent decon resulting from decontaminating any ANR glovebox will gravity drain to the glovebox receiver. The contents of the glovebox receiver are then pumped to the spent decon holding tanks.

4.20.2 ENERGETICS NEUTRALIZATION ROOM

There is one ENR glovebox located in the observation corridor adjacent to the ENR. The glovebox will handle all three samples from the corresponding three energetics neutralization reactors. Decon solution (5.5% sodium hypochlorite) is provided in the glovebox for decontaminating the sample cylinders and piping. In addition, process water is provided to the glovebox for washing and rinsing and plant air is provided for drying.

The sample circuits from the ENRs are lines from the discharge of the energetics neutralization reactor recirculation pumps and back to the suction side of the same pumps. A normally closed-side stream connects from this circuit to the sample cylinder in the ENR glovebox. When a sample is required, the sidestream is opened and a sample is collected in the sample cylinder after being cooled by the ENR sample cooler. Chilled water provides the cooling. The flow rate for this sample is estimated to be 1.3 gpm. Flow through the sample circuit is continuous while the pump is operating to ensure that a well mixed representative sample of the contents of the energetics neutralization reactor. The purpose of this sample is to determine if the energetics hydrolysis reaction is complete, so that the hydrolysate can be pumped to the energetics hydrolysate holding tank. A sample can also be taken and checked for the presence of agent if a leaking munition has been detected.

Any spills, rinse water, or spent decon from the glovebox will gravity drain to the energetics neutralization reactor glovebox receiver. The contents of the glovebox receiver are then pumped to the spent decon holding tanks.

4.21 TEMPERATURE CONTROL SYSTEMS

4.21.1 SECONDARY HEAT TRANSFER FLUID (SHTF) SYSTEM

Reference PFD:	AAC-01-F-170	Sec. Heat Trans. Fluid Circ. Sys.-Agent
	AAC-50-F-180	Sec. Heat Trans. Fluid Circ. Sys.-Energetics

The secondary heat transfer fluid (SHTF) system provides indirect heating and cooling to the reactor systems by preventing plant steam and cooling water systems from direct exposure to the toxic process streams. For operating flexibility and to prevent cross contamination, each agent hydrolyser and ENR has its own independent heat transfer fluid circulation system consisting of an expansion drum, circulating pumps and requisite number of exchangers.

Due to the required temperature range, the fluid used is water. The system is initially charged and subsequently made up with process water. The system is designed to maintain the reactor operating temperature at 194°F. Heating is required initially to bring the reactants to reaction temperature and to maintain this temperature to completion of reaction. Cooling is required to remove heat of the exothermic neutralization reaction.

To prevent leaking of the toxic agents into the heating/cooling services, the pressure of the secondary heat transfer fluid system is designed to be considerably higher than the reactor systems that it serves. This higher pressure is maintained through use of circulating pumps and nitrogen supply on all the expansion drums.

4.21.2 AGENT HYDROLYSER SHTF SYSTEM

The heating/cooling for agent hydrolysers is accomplished by two separate loops: one directly through the hydrolyser jacket, and one indirectly through the hydrolysate recirculation exchanger. These two loops are identical for all reactor units.

The direct heating water for the agent hydrolyser jacket is pumped through a heat exchanger using steam as the heating medium. In case cooling is required, there is a jump-over provision to circulate secondary cooling water through the jacket.

The indirect heating/cooling water for the hydrolysate recirculation exchanger is pumped, by a separate pump, through either a steam heat exchanger to provide heating, or a cooling-water exchanger to provide cooling. A temperature controller on the hydrolyser maintains the hydrolysate temperature by adjusting the flow of heating and cooling water streams through these parallel exchangers.

The heating loop is designed to provide heating water at 215°F. A temperature controller at the outlet of the exchanger controls the flow of steam. The cooling loop is designed to provide cooling water at 160°F. Another temperature controller at the outlet of the exchanger adjusts the flow of cooling water to this exchanger.

4.21.3 ENERGETICS NEUTRALIZATION REACTOR SHTF SYSTEM

Since the ENRs do not have a hydrolysate recirculation loop, the heating/cooling for these reactors is accomplished directly by a single loop through the reactor jacket. Each reactor unit utilizes an identical system.

The heating/cooling water for the reactor jacket is pumped through either a steam heat exchanger to provide heating, or a cooling-water exchanger to provide cooling. A temperature controller on the reactor jacket maintains the jacket temperature by adjusting the flow of heating and cooling water streams through these parallel exchangers.

The heating loop is designed to provide heating water at 216°F. A temperature controller at the outlet of the exchanger controls the flow of steam. The cooling loop is designed to provide cooling water at 167°F. Another temperature controller at the outlet of the exchanger adjusts the flow of cooling water to this exchanger.

4.22 AGENT QUANTIFICATION SYSTEM

Munitions are weighed just prior to entering the WMDM and also prior to entering the deformation machine. The agent removed from munitions is quantified by taking the difference between these two weights and adding an allowance for the burster well weight.

SECTION 5

PROCESS FLOW DIAGRAMS

5.1 PROCESS FLOW DIAGRAMS

Process flow diagrams (PFDs) are included in this section. The PFDs illustrate the major components of each process subsystem in the projected HD munitions destruction facility and are listed as being a system within a processing area or building, including those for the munitions demilitarization building (MDB), the biotreatment area (BTA), and the process auxiliary building (PAB). The PFDs also summarize a condensed form of the heat and material (H&M) balances for these subsystems which, among other data, indicate the design flow rates, the minimum flow rates and their respective munitions campaign cases. Table 5-1 lists the PFDs.

5.2 HEAT AND MATERIAL BALANCE CASES AND EXPLANATION

H&M balances are required for the engineering design of each system. Each balance incorporates the following features:

(1) **Conservation of Mass:** The total amount of any chemical element (e.g., carbon) entering a subsystem as feed must equal the total amount leaving as product. When new compounds form or old ones are neutralized, the quantities of the respective elements involved are simply related in terms of the combining weights, which are simple multiples of the atomic weights. Thus, the formation of 44.0 lb (1 lb-mol) of carbon dioxide (CO_2) requires 32.0 lb of oxygen and 12.0 lb of carbon.

(2) **Thermochemistry and Thermodynamics:** In the neutralization process, heat is released. Chemical reactions, changes in state, and temperature changes are accompanied by the evolution or the absorption of energy, which can be evaluated from fundamental thermochemical and thermophysical data such as heats of formation and enthalpies. The basis of all such calculations is the first law of thermodynamics, i.e., the law of conservation of energy.

(3) **Chemical Reactions:** The agent feed to the hydrolysis reactor comprises a number of chemical components in addition to the agent. These components undergo a number of reactions during neutralization. The basis for the agent neutralization process is that the feed added to the reactor is assumed to react according to the reactions listed in Table 5-2. All reactions are assumed to go to completion. Likewise, the neutralization of energetic feeds are shown in Table 5-2.

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Table 5-1—ACWA WHEAT HD Processing Process Flow Diagram Listing

Drawing Number	Drawing Title/Description
AAC-00-F-001	Legend and Symbols
AAC-50-F-010	Projectile Disassembly/Burster Washout
AAC-01-F-020	Projectile Demilitarization
AAC-01-F-030	Agent Collection/Toxic Storage/Spent Decon
AAC-01-F-040	Neutralization - Agent
AAC-50-F-050	Neutralization - Energetics
AAC-40-F-060	Bioreactors
AAC-01-F-070	Rotary Metal Parts Treatment
AAC-50-F-075	Continuous Steam Treater
AAC-50-F-076	Batch Metal Parts Treatment
AAC-01-F-080	Offgas Treatment - MPT
AAC-50-F-085	Offgas Treatment - CST
AAC-40-F-087	Offgas Treatment - Bioreactor
AAC-44-F-090	Water Recovery
AAC-44-F-100 Sheet 1 of 2	Brine Reduction Package - Brine Concentrator
AAC-44-F-100 Sheet 2 of 2	Brine Reduction Package - Evaporator/Crystallizer
AAC-02-F-110	Bulk Chemical Storage
AAC-50-F-120	Contaminated Waste Preparation
AAC-01-F-130	Residue Handling
AAC-00-F-140	Water balance
AAC-00-F-150	Process Block Flow Diagram
AAC-01-F-170	Secondary Heat Transfer Fluid Circulation System - Agent
AAC-50-F-180	Secondary Heat Transfer Fluid Circulation System – Energetics

Table 5-2—Neutralization Reactions

(1)	$HD + 2H_2O \rightarrow TDG + 2HCl$
(2)	$TNT + 3NaOH \rightarrow$ formaldehyde + formic acid + $N_2O + NH_3 + N_2$
(3)	Tetryl + NaOH $\rightarrow$ acetate + formate + $N_2O + NH_3 + N_2$
(4)	Other organic impurities $\rightarrow$ other organics
(5)	Unknown organic impurities $\rightarrow$ other organics

Where,

HD is agent HD with formula $S(CH_2CH_2Cl)_2$

TDG is thiodiglycol with formula $S(CH_2CH_2OH)_2$

(4) **Microsoft Excel Spreadsheets and Aspen Simulation Software**: If possible, the Aspen Simulation Program Releases 9.3-1 and 10.0-1 are used to help develop H&M balances around specific unit operations. The output from the Aspen simulation models are then input to an overall material balance, which is calculated using Excel. Physical properties of feeds and products are estimated using Aspen software and entered into the Excel spreadsheet.

Once completed, the M&E balances are checked to ensure that the mass entering the system is the same (balanced) as that leaving the system. In addition, the enthalpy (energy) entering the system, including heats of reactions, is the same (balanced) as the enthalpy leaving the system.

Table 5-3 shows the H&M balance cases that comprise the ACWA WHEAT process design for processing HD munitions.

Table 5-3—ACWA WHEAT HD Munitions Processing H&M Balance Cases

Case	Munition	Throughput (munitions/hr)	Dunnage	Throughput (lb/hr)
Design/DPE	M2/2A1	120	DPE (note 1)	15
Design/Wood	M2/2A1	120	Wood (note 2)	100
Design/Wood-DPE	M2/2A1	120	Wood-DPE (note 3)	100
Steady State/DPE	M2/2A1	70.3	DPE (note 1)	15
Design/DPE	M110	60	DPE (note 1)	15
Steady State/DPE	M110	36.6	DPE (note 1)	15
Design/DPE	M60	120	DPE (note 1)	15
Steady State/DPE	M60	120	DPE (note 1)	15

Notes:

1. Total dunnage throughput includes DPE suits and aggregate carrying medium.
2. Total dunnage throughput includes wood and aggregate carrying medium.
3. Total dunnage throughput includes wood, DPE suits and aggregate carrying medium.
4. The Steady State case corresponds to the "Steady State All Systems Go" scenario of the munitions throughput model.
5. For process assumptions and design criteria, refer to section 3.0 of the Process Design Basis Document.

SECTION 6

ENVIRONMENTAL DESIGN BASIS

State, federal, and local environmental regulations and permits provide mandatory criteria for the design of chemical demilitarization facilities. The design for an ACWA chemical demilitarization plant must comply with all applicable local, state, federal, and Army regulations for air quality, water quality, solid and hazardous wastes, noise, and site compatibility. Since this design package for the ACWA project is technology-based and not located at a particular site, state and local regulations and permit requirements are not addressed in this section. This section only provides a brief description of the federal requirements for an ACWA chemical demilitarization plant at an unspecified location.

The major federal environmental statutes that impact the design of a chemical agent demilitarization plant are the National Environmental Policy Act (NEPA), the Clean Air Act (CAA), the Clean Water Act (CWA), and the Resource Conservation and Recovery Act (RCRA).

The administration of federal regulations is often delegated to state agencies, who interpret and implement federal rules, and sometimes add more restrictive requirements. Since no RCRA permit or permit application is currently associated with this project, no attempt has been made here to anticipate specific interpretation of RCRA rules as they may apply to an ACWA chemical demilitarization plant at an unspecified location.

This discussion addresses federal regulatory requirements for design only, and does not describe operational requirements such as training, recordkeeping, inspections, and reporting.

6.1 AIR QUALITY CONSIDERATIONS

6.1.1 FEDERAL REGULATIONS AND PERMIT REQUIREMENTS

Air emissions are regulated under the Clean Air Act (CAA) of 1970, Public Law 91-604; 42 USC 7401, as amended to include the Clean Air Act Amendments of 1990 (CAAA), Public Law 101-549; 42 USC 7401. The CAA gives individual states the authority and responsibility to ensure air quality within their borders.

The CAA is intended to prevent, control, and abate air pollution from stationary and mobile sources. The U.S. Environmental Protection Agency (USEPA) established National Ambient Air Quality Standards (NAAQS), New Source Performance Standards (NSPS) for new facilities, and standards of performance for existing facilities. The CAAA of 1977 further define air quality standards and establish the prevention of significant deterioration program, the new source review regulations, the national emission standards for hazardous air pollutants, and the NSPS.

The CAAA of 1990 established additional requirements for air pollution control. The CAAA mandates the regulation of 189 hazardous air pollutants (HAPS), reduction of vehicle emissions, establishment of maximum achievable control technology (MACT) standards for emission

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control, reductions of industrial NO_x and SO_2 emissions, and establishment of procedures for plan approvals (permitting process).

The CAA imparts wide-ranging requirements on the discharge of pollutants to the atmosphere through 11 separate programs. These programs involve the attainment and maintenance of NAAQS, regulation of mobile sources, control of hazardous air pollutants elimination of acid rain, protection of stratospheric ozone and prevention of global warming, permitting, and enforcement. The NAAQS discussed in Title I of the CAA (Attainment and Maintenance of National; Ambient Air Quality Standards) of the act are not directly related to handling or treating chemical agent. The NAAQS set ambient limits for particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead. These and an additional group of significant pollutants are regulated through a set of programs that maintain ambient standards through permit programs and performance standards for new and modified emission sources. The proposed facility boilers and diesel generators are not large enough to be governed by these standards.

Under Title III of the CAA, the USEPA is setting regulations for hazardous air pollutants mainly within 40 CFR Parts 61-63; 189 compounds have been classified as HAPs. The new regulations will require the review and control of emissions for various source categories based on MACT from major new and modified sources. The new major sources defined under the Title III regulations will emit at least 10 tons/year of one HAP or 25 tons/year of any combination of HAPs. An ACWA chemical demilitarization plant is not considered to be a major source of HAPs.

The requirements for RCRA Subpart CC, Air Emissions Standards for Tanks, Surface Impounds, and Containers (i.e., the air emission standard for hazardous waste), are discussed in Section 6.3. Table 6-1 is a list of federal air quality regulations pertinent to chemical demilitarization plants.

Table 6-1—Federal Air Quality Program Requirements

Requirement	Regulatory Bases
Permit Review Rules	40 CFR Part 70
Emissions Limitations and Standards	40 CFR Part 60, Subpart Dc, 40 CFR Part 60.42c(d)
Compliance Determination Requirements	40 CFR 60, App. A, and 40 CFR 60, Subpart Dc
Note: Resource Conservation and Recovery Act (RCRA) air emission requirements are described in Section 6-3 below.	

Air emissions from the plant will meet the emission levels required by AR 385-61, which are likely to be the same as would be imposed by state air permits. The emissions control systems will meet the removal requirements dictated in a facility's RCRA hazardous waste treatment permit.

Emissions of SO_2, NO_X, and particulate matter (TSP, PM_{10}, and $PM_{2.5}$) would occur from utility boilers and emergency generators. Compliance with fuel oil sulfur content must be demonstrated for the boilers by providing a vendor analysis of the fuel or by analysis per 40 CFR Part 60, Appendix A, Method 19.

Additional pollutants could be emitted from the HVAC system for the munitions demilitarization building (MDB) but will be controlled by carbon filters constructed as part of facility. Emissions from additional plant vehicular traffic are also anticipated. These sources are not expected to affect the attainment of air quality standards.

6.1.2 ENGINEERING DESIGN REQUIREMENTS

Process offgas emissions could potentially contain chemical agent, HAPs, and VOCs. As a result, technology based regulatory standards AR 385-61 for chemical agent and 40 CFR 264 Subparts CC for HAPs and VOCs must be met. Fugitive process emissions from processes containing at least 10% organics will be controlled in accordance with 40 CFR Subpart BB. Process emissions from processes treating or storing surety-level chemical agent must meet Army requirements in AR 385-61 and as specified in a facility's RCRA permit. The Army has set source emission limits and permissible exposure limits in AR 385-61 as shown in Table 6-2.

Table 6-2—Source Emissions Limits and Permissible Exposure Limits for H, HD, and HT from AR385-61

Item	Airborne Exposure Limit (Permissible Exposure Limit) (mg/m^3)	
	Maximum Allowable Concentration[a]	Time Weighted Average (TWA)
Allowable Stack Concentration	NA	0.03 mg/m^3 - 1-hour TWA
Non-agent Worker and General Population	0.003 mg/m^3	0.0001 mg/m^3 - 72 hour TWA
Unmasked Worker	0.003 mg/m^3	0.003 mg/m^3 - 8 hour TWA
Air Supplied Respirators	0.003 mg/m^3	NA
[a]The maximum allowable concentration refers to maximum exposure concentration for any duration of time.		

Process emissions containing VOCs must meet the following RCRA regulatory requirements. RCRA (40 CFR 264) Subpart CC requires that tanks containing liquids with more than 500 ppm volatile organics be closed pressure tanks or covered tanks venting to a closed offgas treatment system with a minimum 95% removal efficiency. Emissions from process tanks in the AWCA MDB will be directed under negative pressure to activated carbon filter system for overall reduction of VOCs by greater than 95%. This vent treatment system must meet the requirements of 40 CFR 264, subpart CC, air emission standards for tanks. For tanks downstream of treatment systems that reduce the concentration of volatile organics in the liquid stream to less than 100 ppm VOC, control of VOCs is not required.

For nonprocess emissions from classified areas of the MDB, the building interior acts as a closed vent system for toxic area processes and equipment fugitive emissions. The air emissions from the toxic cubicle and other classified areas will be controlled by the cascade negative pressure

HVAC system of the MDB and treated in a multibank activated carbon filter system before release.

Utilities will include small package boilers for process water and steam and for emergency power diesel generators. Emissions of SO_2, NO_X, and particulate matter (TSP, PM_{10}, and $PM_{2.5}$) can occur from utility boilers and emergency generators. These nonprocess sources will be permitted and will be designed and operated under the air pollution control requirements of an individual state and the CAA.

Emissions from vehicular traffic also contribute to overall air emissions at the plant. The combined emissions from these sources are not expected to affect the attainment of air quality standards. The aggregate of all facility process and nonprocess emissions will be less than deminimis levels precluding applicability of New Source Review (NSR) requirements and stringent controls under the CAA.

The stacks for treated offgas will be of a sufficient height so that ground level concentrations of HAPs will not exceed 95% of permissible exposure limits.

Chemical agent monitoring will be provided using Automatic, continuous air monitoring system (ACAMs) and depot area air-monitoring system (DAAMS). The low-level ACAMS system detects chemical agent at concentrations below the permissible exposure level which allows immediate corrective action before a health hazard occurs. The DAAMS collects air over periods of 1 to 12 hours, with subsequent laboratory analysis for long-term documentation and ACAMS results validation. The monitors and analytical procedures verify compliance with applicable stack, workplace emission, and ambient standards and provide emergency warning. The air monitoring system will be located in process and nonprocess vents and the control room. Sampling ports will be located in each exhaust stack and between selected activated carbon filter banks and ducts. In addition air will be monitored at ambient stations throughout the work area. Monitoring of nonagent process emissions will be in accordance with RCRA requirements, and sampling ports will be located on exhaust stacks.

6.2 WATER QUALITY CONSIDERATIONS

6.2.1 FEDERAL REGULATIONS AND PERMIT REQUIREMENTS

The Water Pollution Control Act, as amended by the Clean Water Act (CWA) (PL 95-217; 33 USC 1251) of 1977 (with further amendments through 1987) restores and maintains the chemical, physical, and biological integrity of the nation's navigable waters. The CWA provides a wide range of requirements and restrictions; it (1) requires control of toxic chemicals at industrial sites through best management practices; (2) revises the Federal Water Pollution Control Act, requiring all municipal and industrial waste water to be treated before being discharged into waterways; and (3) applies to alternative technologies to the extent that any wastewater may require treatment or other disposition.

The CWA eliminates the discharge of pollutants into navigable waters and achieve water quality levels protective of human health and the environment. The CWA established a permit program that regulates point source discharges of pollutants to U.S. waters through the issuance of National Pollutant Discharge Elimination System (NPDES) permits. The USEPA implements and enforces the NPDES program unless a state is authorized to do so. In authorized states, NPDES permits are issued in accordance with procedures and standards at least as stringent as federal requirements and with USEPA oversight.

Title III of the CWA, Standards and Enforcement, contains language on effluent limitations in Section 301(f) specific to chemical agent. It states that "it shall be unlawful to discharge any radiological, chemical, or biological warfare agent, any high-level radioactive waste, or any medical waste, into the navigable water."

The CWA provides protection for the nation's wetlands from filling, dredging, and other alteration. Section 404 of the CWA (33 USC 1344) authorizes the Army Corps of Engineers to regulate the discharge of dredged or fill material into U.S. waters. The CWA defines U.S. waters as navigable waters, their tributaries, adjacent wetlands, and other waters and wetlands where degradation or destruction could affect interstate or foreign commerce. Section 404(b)(1) Guidelines (40 CFR Part 230) are the federal environmental regulations for evaluating the filling of navigable waters and wetlands. The guidelines restrict discharges of dredged or fill material where less environmentally damaging, practicable alternatives exist.

Table 6-3 lists federal regulations governing water and wastewater issues at an ACWA chemical demilitarization plant.

Table 6-3—Federal Water Quality Program Requirements

Requirement	Regulatory Bases
Water quality standards for surface and ground waters	40 CFR 130 to 131; 33 USC 26-1312 to –1314
Spill reporting, containment, and response	40 CFR 300; 33 USC 26-1321
NPDES programs and requirements	40 CFR 122 to 125; 33 USC 26-1342
Stormwater runoff from construction and industrial Activities	33 USC 26-1329
Chemical testing of industrial wastewater	40 CFR 136
Provisions related to the filling and dredging	CWA, Sections 401 and 404; 33 USC 26-1344

The NPDES program is an EPA-administered permit program covered under the CWA. The program was initiated to ensure that any direct wastewater discharge does not endanger the quality of the receiving body of water. Under NPDES permit requirements, the Army must demonstrate that any liquid discharge from the demilitarization process meets minimum requirements for pollution discharge levels. The NPDES permit is issued for the release of treated wastewater into an installation's wastewater treatment system. An NPDES discharge permit is required for discharge from an industrial facility to the STP by means of a sanitary sewer system. NPDES permitting will be in accordance with the federal Clean Water Act and site-specific implementation by the individual states. Federal regulation 40 CFR 122.4(f) states that no NPDES permit shall be issued for the discharge of any chemical or biological warfare agent. Also, a permit is required for connection to an installation's sewer system governed by 40 CFR 122.

6.2.2 ENGINEERING DESIGN REQUIREMENTS

The ACWA chemical demilitarization plant is zero discharge system with no discharge of process wastewater from the demilitarization process. A small quantity of nonprocess wastewater such as noncontact cooling water blowdown or boiler blowdown will be discharged to the evaporator feed tank consistent with the zero discharge concept. Sumps in the MDB will be directed to the process system for treatment. As a zero discharge plant, no discharge standards, performance criteria or permits apply.

The civil design of the demilitarization plant will control storm water runoff and minimize storm run-on from off-site. The design will prevent contact of hazardous materials with storm drainage to eliminate the potential for contamination of stormwater.

Sanitary sewage from workers will be forwarded to the installation central wastewater treatment through a sewer interconnection at the chemical demilitarization plant.

6.3 HAZARDOUS WASTE CONSIDERATIONS

6.3.1 FEDERAL REGULATIONS AND PERMIT REQUIREMENTS

Federal requirements for hazardous waste management for design and operation of an ACWA chemical demilitarization facility are governed by the Resource Conservation and Recovery Act (RCRA) (PL 94-580; 42 USC 6901, 1976), as amended by the Hazardous and Solid Waste Amendments of 1984. Federal regulations defining what materials constitute hazardous or solid wastes and detailing proper methods for their transportation, treatment, storage, disposal, and overall management are contained in regulations under RCRA authority contained mainly in 40 CFR Parts 260-281. Hazardous wastes are defined and regulated by RCRA, which considers a waste hazardous if it is reactive, ignitable, corrosive, or toxic, or if it is otherwise listed as a hazardous waste.

RCRA regulates hazardous waste generation, storage, and destruction. Owners or operators of facilities that generate, treat, store, or dispose of hazardous waste must obtain an operating permit as required under RCRA. This permit ensures that the owner and operator of the proposed facility can safely manage the hazardous waste being stored in the facility.

A RCRA Part B permit will establish the terms and conditions for the operation and hazardous waste management activities at each ACWA chemical demilitarization facility. This permit implements and incorporates the RCRA requirements and regulatory basis summarized in Table 6-3.

Under RCRA 40 CFR 266 Subpart M, Military Munitions, a munition becomes a solid waste when it is "removed from storage in a military magazine or other storage area for the purpose of being disposed of, burned or incinerated, or treated prior to disposal." Simply stated, the feed material (munitions) to a chemical demilitarization plant is categorized under Subpart M as hazardous waste. Under RCRA, hazardous wastes must be treated, stored, or disposed of at a RCRA-permitted hazardous waste facility. Consequently, a chemical demilitarization facility is classified as a RCRA treatment, storage, and disposal facility (TSDF) subject to the provisions of 40 CFR 264, which sets standards for hazardous waste treatment, storage, and disposal facilities.

Subpart J of 40 CFR 264 regulates tank systems used to store and treat hazardous waste. The regulations include general design standards for tanks and requires secondary containment for tank systems except for tanks located indoors holding wastes with no free liquids, tank systems including sumps which serve as secondary containment, or drip pads. Secondary containment systems must be designed and operated to hold at least 1005 of the volume of the largest tank, designed and operated to prevent run-on or infiltration of precipitation unless there is a sufficient additional volume in the secondary containment to handle a 25-year, 24-hours storm event, have a sloped bottom properly designed, and have a leak detection system. In addition, secondary containment of tank ancillary equipment (e.g., pipe, valves, and pumps) must also be provided except for aboveground welded piping that is visibly inspected daily.

Facility standards for miscellaneous units (40 CFR Subpart X 264.600) specify general performance requirements for this class of treatment, storage, and disposal facility. Subpart X requires that miscellaneous units be located, designed, constructed, operated, maintained, and closed in a manner protective of human health and the environment. This entails the prevention of release of materials to the air, surface water, groundwater, or soil. Specific permit terms are determined on a case-by-case basis.

Subparts AA, BB, and CC of 40 CFR 264 regulate air emissions from process vents, equipment leaks, and tanks (and other containment devices), respectively. For RCRA regulated facilities, organic vapor emissions from hazardous waste treatment, storage and disposal areas must be controlled. Subpart AA pertains to distillation, fractionation, thin-film evaporation, and other processes not related to ACWA. Subpart BB applies air emissions from hazardous waste systems processing materials containing over 10% by weight or organics. Subpart BB details performance standards for pumps, compressors, valves, pressure relief devices, sampling systems, test methods, and recording/recordkeeping requirements which partly depend on the type of organic being treated.

Subpart CC, promulgated December 6, 1994 and revised November 25, 1996, applies air emissions from hazardous waste tanks, surface impoundments, and containers handling wastes with at least 500 ppmw of volatile organics. For tanks, these regulations require the control of emissions to 95% removal, the use of pressurized tanks with no emissions, or no emissions control for biological treatment tanks with at least a 95% volatile organic biodegradation efficiency. These regulations do not apply to tanks in a series of tanks once the wastes have been treated so that the concentration of volatile organics is less than 100 ppm (volatile organics have either been removed or destroyed). Dilution is not considered treatment. The regulations provide formulas to determine whether the quantity of volatile organics is reduced sufficiently.

In December 1994, new land disposal restriction regulations were implemented which dictate universal treatment standards (UTS) that certain hazardous wastes must meet before land disposal. Depending on the hazardous waste classification, different treatment standards now apply but are subject to change under proposed future regulations.

Federal regulations 40 CFR 271 and Section 3006 of RCRA authorize states to administer a hazardous waste management program in lieu of the federal program, including administration of most of the Hazardous and Solid Waste Amendments (HSWA). Table 6-4 lists federal regulations governing hazardous waste issues at an ACWA chemical demilitarization plant.

Table 6-4—Federal Regulatory Requirements for Hazardous Waste Management Program

Requirement	Regulatory Bases
Identification and listing of hazardous wastes	40 CFR 261, Subparts A, B, C, D, and Appendices I, II, III, VII, VIII, IX and X and 40 CFR 266.202, Subpart M, Munitions Rule.
Standards for owners and operators of hazardous waste treatment, storage and disposal facilities	40 CFR 264, Subparts A, B, C, D and E
Facility and site closure and post-closure	40 CFR 264, Subpart G
Use and management of containers	40 CFR 264, Subpart I
Tank systems	40 CFR 264, Subpart J
Land disposal systems	40 CFR 268
Corrective action for solid waste mgmt. units	40 CFR 264, Subpart S
Air emission standards for equipment leaks	40 CFR 264, Subpart BB
Air emission standards for tanks, surface impoundments, and containers	40 CFR 264, Subpart CC
Hazardous waste permit programs	40 CFR 270.41, 270.42, 270.43, and 270, Subparts A, B, C and D
Inspections and investigation	40 CFR 270.30(i)
Miscellaneous units	40 CFR 264, Subpart X

Delisting of hazardous wastes under RCRA is an admistrative petition process in which a waste is declared a nonhazardous material after being properly treated (subject to rigorous technical and performance standards). The delisted material can then be managed and handled as nonhazardous. Delisting requires an applicant to demonstrate that the waste stream to be delisted is successfully treated in the permitted hazardous treatment unit and does not exhibit the characteristics of the permitted waste form. When a demilitarization waste is properly treated and delisted, it is no longer considered a chemical warfare agent or hazardous waste.

For an ACWA demilitarization plant, the optimal location in the liquid process system for delisting under RCRA is at the discharge of the ICB unit and before the evaporator/crystallizer (E/C). For solid waste generated from the RMPT, BMPT, and CST, the best location for delisting this material is at the discharge of each of these process units. To achieve delisting of 5X munitions scrap metal, 5X residue from the CST and BMPT, and salt and brine from the E/C, an ACWA demilitarization facility must be constructed and operated to meet the technical requirements for treatment for delisting. When a waste material is delisted, the process units and tanks downstream of the delisting point (the ICB™ units), such as the E/C and process water tank, are exempt from 40 CFR 264 Subpart CC requirements, in accordance with 40 CFR 264.1082(c)(2)(ii).

Army Regulation AR 385-61 sets standards for handling, monitoring, personal protective clothing, and treatment and disposal of agent contaminated wastes. The 1X/3X/5X standards are described in the Department of the Army Pamphlet 385-61, Toxic Chemical Agent Safety Standards, March 1997, and summarized as follows:

- **1X Wastes —** A single "X" indicates an agent contaminated waste is not decontaminated or the item has been partially decontaminated of the indicated agent. Further decontamination processes are required before the item is moved or any maintenance or repair is performed without the use of chemical protective clothing and equipment.

- **3X Wastes —** The symbol "3X" indicates that the item has been surface decontaminated and bagged or contained in an agent-tight barrier. Testing or monitoring inside the headspace of the containment barrier (bag) must verify that concentrations are below 0.003 mg/m^3 for H, HD or HT for an item to be considered 3X. Waste items that are decontaminated to the 3X level have been successfully landfilled at RCRA-permitted land disposal TSDF facilities in the past.

- **5X Wastes —** The symbol "5X" indicates that a waste is decontaminated completely by subjecting the waste to temperatures above 1000^{o}F for a 15-minute holding period. The Army then consideres these wastes to be free of agent and eligible for release for general use or sold to the general public. A 5X condition must be certified by the commander or his designate. An article in 5X condition still must be delisted under RCRA before it can be handled and disposed of as nonhazardous. The ACWA RMPT, BMPT, and CST are designed to achieve 5X condition (1000^{o}F for 15-minute holding period) for wastes being treated.

6.3.2 ENGINEERING DESIGN REQUIREMENTS

6.3.2.1 Environmental Requirements for Hazardous Waste Munitions and Storage Units

Hazardous waste munitions and explosives storage units must be designed and operated in accordance with Title 40 CFR, Part 264 Subpart EE, Hazardous Waste Munitions and Explosives Storage. Hazardous waste munitions and explosives storage units must be designed and operated with containment systems, controls, and monitoring that minimize the potential for detonation or other means of release of hazardous waste, hazardous constituents, hazardous decomposition products, or contaminated runoff to the soil, groundwater, surface water, and atmosphere. Storage units must provide a primary barrier, which may be a container (including a shell) or tank, designed to contain the hazardous waste. The waste and containers stored outdoors must not be in standing precipitation.

A secondary containment system must be provided to ensure that any released liquid wastes are contained and promptly detected and removed from the waste area. Alternatively, a vapor detection system may be provided that ensures that any released liquids or vapors are promptly detected and an appropriate response taken (e.g., additional containment such as overpacking or removal from the waste area). The system must also provide monitoring and inspection procedures that ensure the controls and containment systems are working as designed and that releases affecting human health or the environment are not escaping from the unit.

Depending on explosive hazards, hazardous waste munitions and explosives may also be managed in other types of storage units, including containment buildings, tanks, or containers.

Hazardous waste munitions and explosives may be stored in one of the following storage areas:

- Earth-covered magazines (igloos) must be constructed of waterproofed, reinforced concrete or structural steel arches, with steel doors that are kept closed when not being accessed. They must be of sufficient length and thickness to support the weight of any explosives or munitions stored and any equipment used in the unit. They must provide working space for personnel and equipment and withstand movement activities that occur in the unit. Igloos must be located and designed to minimize the propagation of an explosion to adjacent units and to minimize other effects of any explosion.

- Aboveground magazines must be located and designed to minimize the propagation of an explosion to adjacent units and to minimize other effects of any explosion.

- Outdoor or open storage areas must be located and designed to minimize the propagation of an explosion to adjacent units and to minimize other effects of any explosion.

6.3.2.2 Environmental Requirements for Tanks and Vessels

All tanks and vessels that store hazardous materials will comply with 40 CFR, Part 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, Subpart J, Tank Systems. A tank system is a hazardous waste storage or treatment tank and its associated ancillary equipment and containment system.

Hazardous wastes or treatment reagents must not be placed in a tank system if they could cause the tank, its ancillary equipment, or the containment system to rupture, leak, corrode, or otherwise fail. Appropriate controls and practices to prevent spills and overflows from tank or containment systems include spill prevention controls (e.g., check valves, dry disconnect couplings), overfill prevention controls (e.g., level sensing devices, high level alarms, automatic feed cutoff, or bypass to a standby tank), and maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation.

Tank systems for storing or treating hazardous waste must have sufficient structural integrity and be acceptable for storing and treating hazardous waste. The foundation, structural support, seams, connections, and pressure controls (if applicable) must be adequately designed and the tank system have sufficient structural strength, compatibility with the waste to be stored or treated, and corrosion protection to ensure that it will not collapse, rupture, or fail.

For new tank systems or components in which the external shell of a metal tank or any external metal component of the tank system is in contact with soil or water, a corrosion expert must determine the factors affecting the potential for corrosion; the type and degree of external corrosion protection needed to ensure the integrity of the tank system; corrosion-resistant materials of construction such as special alloys or fiberglass reinforced plastic; corrosion-resistant coating (such as epoxy, fiberglass, etc.) with cathodic protection (e.g., impressed current or sacrificial anodes); and electrical isolation devices such as insulating joints, and flanges.

The practices described in the National Association of Corrosion Engineers (NACE) standard, Recommended Practice (RP-02-85), Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems, and American Petroleum Institute (API)

Publication 1632, Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems, may be used, where applicable, as corrosion protection guidelines for tank systems.

For underground tank system components that may be adversely affected by vehicular traffic, design or operational measures must protect the tank system against potential vehicle damage. Design considerations must ensure that tank foundations maintain the load of a full tank; tank systems are anchored to prevent flotation or dislodgement where the tank system is placed in a saturated zone or is located within a seismic fault zone; and tank systems withstand the effects of frost heave.

The design of tank systems must ensure that proper handling procedures are adhered to in order to prevent damage to the system during installation. Before covering, enclosing, or placing a new tank system or component in use, a qualified installation inspector must inspect the system for the presence of any of the following items:

- Weld breaks
- Punctures
- Scrapes of protective coatings
- Cracks
- Corrosion
- Other structural damage or inadequate construction/installation

All discrepancies must be remedied before a tank system is covered, enclosed, or placed in use.

Tank systems or components that are placed underground and backfilled must be provided with a backfill material that is noncorrosive, porous, and homogeneous, and tank systems must be installed so that the backfill is placed completely around the tank and compacted to ensure that the tank and piping are fully and uniformly supported.

Tanks and ancillary equipment must be tested for tightness before being covered, enclosed, or placed in use. If a tank system is found not to be tight, all repairs necessary to remedy the leak must be performed before the tank system is covered, enclosed, or placed into use.

Ancillary equipment must be supported and protected against physical damage and excessive stress due to settlement, vibration, expansion, or contraction. The piping system installation procedures are described in API Publication 1615 (November 1979), Installation of Underground Petroleum Storage Systems, or ANSI Standard B31.3, Petroleum Refinery Piping, and ANSI Standard B31.4, Liquid Petroleum Transportation Piping System, may be used, where applicable, as guidelines for proper installation of piping systems.

The type and degree of corrosion protection will be recommended by an independent corrosion expert to ensure the integrity of a tank system during its use. The installation of a field fabricated corrosion protection system must be supervised by an independent corrosion expert to ensure proper installation.

To prevent the release of hazardous waste or hazardous constituents to the environment, secondary containment must be designed, installed, and operated to prevent any migration of wastes or accumulated liquid out of the system to the soil, groundwater, or surface water at any time during the use of the tank system.

Secondary containment must be able to detect and collect releases and accumulated liquids until the collected material is removed. Secondary containment systems must be constructed of or lined with materials compatible with the wastes in the tank system and must have sufficient strength and thickness to prevent failure owing to pressure gradients (including static head and external hydrological forces), physical contact with the waste to which it is exposed, climatic conditions, and the stress of daily operation (including stresses from nearby vehicular traffic).

Secondary containment systems must be placed on a foundation or base capable of supporting the system and resistant to pressure gradients above and below the system, and be capable of preventing failure due to settlement, compression, or uplift. Secondary containment must be provided with a leak-detection system designed and operated to detect the failure of the primary or secondary containment structure or the presence of any release of hazardous waste or accumulated liquid in the secondary containment system within 24 hours. Containment will be sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation.

Secondary containment for tanks must include one or more of the following devices:

- A liner (external to the tank)
- A vault
- A double-walled tank
- An equivalent device as approved by the USEPA

External liner systems must be designed or operated to contain 100% of the capacity of the largest tank inside its boundary. Liner systems must be designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event. Liner systems must be free of cracks or gaps, and designed and installed to surround the tank completely and to cover all surrounding earth likely to come into contact with the waste if it is released from the tank (i.e., able to prevent lateral and vertical migration).

Tanks containing no free liquids situated inside a building having an impermeable floor are exempt from secondary containment requirements. Tanks and sumps that are part of a secondary containment system for primary tanks systems do not require further additional secondary containment.

Vault systems must be designed to contain 100% of the capacity of the largest tank inside their boundary and to prevent run-on or infiltration of precipitation into the secondary containment system. The exception is when the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event. Vaults must be constructed with chemical-resistant water stops at all joints and be provided with an impermeable interior coating or lining that is compatible with the stored waste and that will prevent permeation of the waste into the concrete. For ignitable or reactive wastes, vaults must be provided with a means to protect against the formation and ignition of vapors within the vault. Vaults must be provided with an exterior moisture barrier or otherwise be designed to prevent migration of moisture into the vault if the vault is subject to hydraulic pressure.

Double-walled tanks must be designed as an integral structure (i.e., an inner tank completely enveloped within an outer shell) so that any release from the inner tank is contained by the outer shell. If constructed of metal, the tank must be protected from corrosion of the primary tank interior and corrosion of the external surface of the outer shell. Double-walled tanks must be provided with a built-in continuous leak detection system capable of detecting a release within 24 hours. The provisions outlined in the Steel Tank Institute (STI) Standard for Dual Wall Underground Steel Storage Tanks may be used as guidelines for aspects of the design of underground steel double-walled tanks.

Ancillary equipment for double-walled tanks must be provided with secondary containment (e.g., trench, jacketing, double-walled piping) except for:

- Aboveground piping (excluding flanges, joints, valves, and other connections) that are visually inspected for leaks daily

- Welded flanges, welded joints, and welded connections, that are visually inspected for leaks daily

- Sealless or magnetic coupling pumps and sealless valves, that are visually inspected for leaks daily

- Pressurized aboveground piping systems with automatic shut-off devices (e.g., excess flow check valves, flow metering shutdown devices, loss of pressure actuated shut-off devices) that are visually inspected for leaks daily.

6.3.2.3 Environmental Requirements for Containment Buildings

Containment buildings that house storage or treatment units must comply with 40 CFR Part 264, Subpart DD, Containment Buildings. Containment buildings must comply with the following design standards. The containment building must be completely enclosed with a floor, walls, and a roof to prevent exposure to the elements (e.g., precipitation, wind, run-on) and to ensure containment of managed wastes. The floor and containment walls, including the secondary containment system if required, must be designed and constructed of materials of sufficient strength and thickness to support themselves, the waste contents, and any personnel and heavy equipment in the building, and to prevent failure due to pressure gradients, settlement, compression, or uplift, physical contact with the hazardous wastes; climatic conditions; and the stresses of daily operation, including the movement of heavy equipment within the unit and contact of such equipment with containment walls. The building must be designed with sufficient structural strength to prevent collapse or other failure. All surfaces to be in contact with hazardous wastes must be chemically compatible with those wastes.

Standards established by professional organizations generally recognized by the industry such as the American Concrete Institute (ACI) and the American Society of Testing Materials (ASTM) will be used to meet structural integrity requirements.

If appropriate to the nature of the operation, an exception to the structural strength requirement may be made for lightweight doors and windows that meet these criteria if they provide an effective barrier against fugitive dust emissions and the building is designed and operated in a fashion that ensures that wastes do not actually come in contact with these openings.

Incompatible hazardous wastes or treatment reagents must not be placed in the building or its secondary containment system if they could cause the containment building or secondary containment system to leak, corrode, or otherwise fail.

The containment building must have a primary barrier designed to withstand the movement of personnel, waste, and handling equipment in the unit during its operating life and appropriate for the physical and chemical characteristics of the waste to be managed.

For a containment building used to manage hazardous wastes containing free liquids or treated with free liquids (the presence of which is determined by the paint filter test, a visual examination, or other appropriate means), a primary barrier must be designed and constructed of materials to prevent the migration of hazardous constituents into the barrier and a liquid collection and removal system to minimize the accumulation of liquid on the primary barrier of the containment building. The primary barrier must be sloped to drain liquids to the associated collection system. Liquids and waste must be collected and removed to minimize hydraulic head on the containment system at the earliest practicable time.

A secondary containment system includes a secondary barrier designed and constructed to prevent migration of hazardous constituents into the barrier and a leak detection system able to detect failure of the primary barrier and collect accumulated hazardous wastes and liquids at the earliest practicable time.

The requirements of the leak detection component of the secondary containment system are satisfied by installing a system that is, at a minimum, constructed with a bottom slope of 1% or more and is constructed of a granular drainage material with a hydraulic conductivity of $1x10^{-2}$ cm/sec or more and a thickness of 12 inches (30.5 cm) or more, or constructed of synthetic or geonet drainage materials with a transmissivity of $3x10^{-5}$ m^2/sec or more.

Treatment areas in the building must be designed to prevent the release of liquids, wet materials, or liquid aerosols to other portions of the building. The secondary containment system must be constructed of materials that are chemically resistant to the waste and liquids managed in the containment building and of sufficient strength and thickness to prevent collapse under the pressure exerted by overlaying materials and by any equipment used in the containment building. Containment buildings can serve as secondary containment systems for tanks placed within the building under certain conditions. A containment building can serve as an external liner system for a tank, provided it meets the requirements for secondary containment of tanks and vessels listed in Section 3.2.3.2.

All containment buildings must use controls and practices to ensure containment of the hazardous waste. The building must have a primary barrier free of significant cracks, gaps, corrosion, or other deterioration that could cause hazardous waste to be released from the primary barrier. The level of the stored/treated hazardous waste inside the containment walls must not exceed the height of the containment wall. Tracking hazardous waste out of the containment by personnel or by equipment must be prevented. Fugitive dust emissions must be controlled so that openings (doors, windows, vents, cracks, etc.) exhibit no visible emissions. In addition, all associated particulate collection devices (e.g., fabric filter, electrostatic precipitator) must be operated and maintained with sound air pollution control practices. This state of no visible emissions must be maintained effectively at all times during routine operation and maintenance, including when vehicles and personnel are entering and exiting the unit.

For containment buildings having areas both with and without secondary containment, measures must be taken to prevent the release of liquids or wet materials into areas without secondary containment.

6.4 NEPA CONSIDERATIONS

6.4.1 APPLICABLE REGULATIONS

Large federal projects such as chemical demilitarization projects must comply with the provisions of NEPA (Public Law 91-190, as amended by Public Laws 94-52 and 94-83). NEPA procedures are implemented by regulations (40 CFR 1500—1508) developed by the President's Council on Environmental Quality. These procedures and the NEPA process are incorporated into Army Regulation 200-2. A NEPA review is conducted to ensure that environmental factors are given adequate consideration early in the decision-making process. The NEPA process provides federal agencies with the information needed to weigh the significance of the environmental impacts of a proposed action against those of other alternatives before making a decision to implement the proposed action.

Section 102(2)(C) of the public law requires that an environmental impact statement be "included in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment." An ACWA chemical demilitarization plant meets this definition, and therefore an EIS is required. Because the Chemical Stockpile Disposal Program is national in scope, both programmatic (CSDP) and site-specific regulations must be prepared.

6.4.2 DESIGN INPUT TO NEPA DOCUMENTS

NEPA requires design input into the EIS including emission sources, location, quantity and characterization, mitigating design measures to environmental impacts, emission control system information, and commitment of natural resources. This design document is intended to provide sufficient information for the ACWA technology to meet the technology design input needs of an EIS. Site-specific design information regarding implementation of the technology at a particular location is not provided here.

SECTION 7

PROCESS CONTROL

7.1 INSTRUMENTATION DESIGN CRITERIA

The overall control system philosophy is described in AAC-00-I-001, Control System Philosophy.

In general, all field instruments will comply with the Department of the Army specification CEGS-13405, Process Control, and guidance from CEHND-1110-1-1, Engineering Guidance Design Manual For Architect-Engineers.

7.1.1 INSTRUMENT GENERAL ELECTRICAL REQUIREMENTS

Electrical and electronic instruments will be designed to operate in the proximity of high voltage electrical equipment and portable radio transmitters. All instruments will be insensitive to interference by radio frequency (RF) or electromagnetic (EM) waves.

Field wiring, trays, conduit, and junction boxes will in general conform to the practices outlined in API RP552 and will be segregated by signal type as follows:

(1) Process Control

(2) ESD

(3) Agent Monitoring

(4) CCTV

(5) Fire Protection

(6) HVAC

Smart field instruments will use 4-20 mA signals with a superimposed digital communication protocol. However, prior to the start of detail design, the system contractor will consider the feasibility of using Foundation Field Bus H1 or H2 for field instrument signal wiring and modify the design accordingly if deemed safe and cost effective.

Where practical, ESD shutdown signals will be derived from analog transmitter signals.

Devices with nonstandard signals, e.g., thermocouples, RTDs, etc., will typically be supplied with smart transmitters to convert the output to 4-20 mA.

As a minimum, instrument cabinets and consoles (including equipment located in the CCR) will be designed to meet NEMA 4 requirements and will be supplied with sealed cable entries to prevent the ingress of water from the firewater system.

7.1.2 INSTRUMENT GENERAL INSTALLATION REQUIREMENTS

Where practical, ESD sensors and taps to the process (root valves and tubing or thermowells) will be separate from the BPCS sensors.

In general, all pressure sensing process tubing will be supplied with a piping root valve and a secondary tubing valve with vents and drains, i.e., manifold valve.

As a minimum, all instrument tubing will be 316LSS with 316LSS double ferrule compression fittings.

In general, all control valves, level instruments, and flow elements will be supplied with block and bleed valves to facilitate maintenance.

In general, all in-line instruments will be flanged with a minimum trim material of 300 series stainless steel, e.g., 1 ½ inch flanged 316SS thermowells. The system contractor will confirm material compatibility with the process.

Each ACAM will be supplied with an associated DAAM. System contractor will determine the final DAAM count and location.

7.1.3 SPECIAL INSTRUMENT REQUIREMENTS FOR TOXIC AREAS

Placement, installation, and wiring of instruments will give consideration to reduce frequency and duration of entry into the Category A, B or A/B areas.

Field instruments and enclosures installed in the toxic area will be suitable for decontamination process, i.e., washed with a decontamination solution without damage.

Where practical, mounting brackets for instruments and valve accessories will be fabricated from stainless steel.

Where allowed by the NEC code, plug-in type connectors for limit switches and instruments will be used.

7.1.4 ADDITIONAL INSTRUMENT REQUIREMENTS

In general, all transmitters will be supplied with integral LCD indicators.

The use of mercury switches is prohibited.

Noncontact type flow (magnetic, coriolis, etc.) and level sensors (radar, vibrating fork, etc.) will be considered for agent bearing fluids, corrosive fluids, or where solid build-up/entrapment is a concern, e.g., hydrolysate or brine services. For control valve applications in these services, pinch type valves will be considered where allowed by the piping specification.

7.1.5 CONTROL VALVE AND ON-OFF VALVE REQUIREMENTS

Valves will be compatible with service requirements and will conform to the following industry standards when applicable: ANSI/FCI 70-2, API STD 598, API STD 602, ASME B1.20.1, ASME B16.34, ASME B16.5, ASME B16.10, ASME B31.3, MSS SP-72, and MSS SP-80.

7.1.5.1 Materials of Construction

Valve body and trim materials will be equal to or better than the materials listed in the piping specifications. The general valve construction will meet or exceed the piping specification. As a minimum, the valve trim (including plug, cage, ball, disc, stem, etc.) will be 300 series stainless steel and will be selected to meet the worst-case process condition of the line. The valve material inspection requirements (including special cleaning and internal material smoothness requirements) will meet or exceed all requirements of the piping specification.

Generally, all in-line valves will be of flanged or lugged body single-flange design. Where permitted by the piping class specification, screwed connections will be permissible for regulators 1 inch and smaller.

7.1.5.2 Control Valve Sizing

Control valves will be sized per ISA S75.01 or the selected supplier's method so that at normal flow, no more than 70% of the valve capacity is exceeded.

The valve noise level will be limited to a maximum of 85 decibels (dBA) at any point within 3 ft upstream or downstream of the valve. In general, valve noise will be treated at the source and the use of acoustic insulation for noise abatement will be avoided.

7.1.5.3 Valve Accessories

Where practical, actuators will be designed to use a spring force to achieve the specified valve failure position. Actuator sizing will be based on the maximum valve differential pressure with a minimum air pressure of 70 psig. Actuators for isolation service (e.g., on-off valves, 3-way divert valves, etc.) will be sized with a 1.3 minimum safety factor.

If deemed cost effective, "Smart" valve positioners with 2-wire type 4-20 mAdc input with full-duplex digital communication ability will be used for control valves.

All isolation valves will be furnished with two independent hermetically sealed, heavy-duty, adjustable limit switches. Limited switches will be connected to the control system for positive feedback on the valve position.

Where deemed safe, control valves will be installed with a control valve manifold (block and bypass valves) or be provided with a handwheel.

7.1.6 RELIEF VALVE REQUIREMENTS

Relief valves will be compatible with service requirements, and as a minimum, will conform to the following industry standards as applicable: API RP520; API RP521; API STD 526; API STD 527; API STD 620; API STD 650; API STD 2000; ASME SEC I; ASME SEC VIII D1; and ASME SEC VIII D2. Relief valves will be sized per the applicable API or ASME code, and stamped accordingly.

7.1.6.1 Materials of Construction

Valve body and trim materials will be equal to or better than the materials listed in the piping specifications. The general valve construction will meet or exceed the piping specification. As a minimum, the valve trim will be 316SS stainless steel. The valve material inspection requirements (including special cleaning and internal material smoothness requirements) will meet or exceed all requirements of the piping specification.

Generally, all relief valves will be flanged. Where permitted by the piping specification, thermal relief valves may be 3/4-inch NPT inlet by 1-inch NPT outlet.

7.1.6.2 Relief Valve Accessories

Lifting levers will be supplied as required by the applicable code.

Unless required by code, test gags will not be permitted.

For fouling or corrosive services, relief valves with bellows will be supplied with auxiliary balancing pistons.

In general, pilot operated relief valves will limited to clean, noncorrosive gas services.

7.1.6.3 Relief Valve Installation

Unless prohibited by code, locked open block valves will be installed on the inlet and outlet of all relief valves. Exceptions will be on the inlet of relief valves which can be removed with minimal operational impact or on the outlet of relief valves which discharge directly to atmosphere. A 3/4-inch vent/drain valve with plug will be supplied between the relief valve and block valve.

7.2 MONITORING AND CONTROL STRATEGY

The WHEAT monitoring and control strategy is based primarily on the existing, methods, and systems used in CSDP and NECDF. All control elements and instruments will be standard industrial hardware with field proven high reliability and robust components. The general instrument design criteria are detailed in Section 7.1.

The facility will be provided with a control system composed of the basic process control system (BPCS), emergency shutdown system (ESD), and equipment PLCs. The BPCS is composed of microprocessor-based controllers for monitoring and controlling the process. A separate dedicated safety system comprising of PLCs or microprocessor-based controllers will provide the protective logic and shutdown functions for the facility. Where practical, redundant process trains will be assigned to separate BPCS controllers and the safety system PLCs/controllers. In addition, a process data acquisition and recording system (PDAR) will be provided to track munitions, perform leak detection based on level/flow data, inventory bulk chemicals, track utility consumption, and monitor overall agent/energetic neutralization performance. The overall control system is further described in Control System Philosophy document AAC–00-I-001.

The following paragraphs outline the conceptual WHEAT control strategy and basis of design. The main plant shutdowns are outlined in the piping & instrumentation diagrams (P&IDs), i.e., the shutdown block P&IDs.

7.2.1 MUNITIONS RECONFIGURATION, PROJECTILE/MORTAR DISASSEMBLY, BURSTER WASHOUT AND MUNITIONS DEMILITARIZATION

The control strategies for munitions reconfiguration and projectile/mortar disassembly are adapted from baseline material handling equipment, e.g., conveyors, pick-and-place machines, PMD, etc. The control system uses automated, sequence-enabled functions typical of industrial mechanical operations. Positive feedback from position and speed switches ensures that the operational sequence is correct. Automatic continuous air-monitoring system (ACAMS) will be provided at the WHEAT projectile and mortal demil machine (WPMD) to ensure that agent contaminated materials are decontaminated, in the rare event (1/10,000) of encountering a leaker during the burster removal operation.

The burster washout machine is a new machine with sequence-enabled functions similar to a baseline projectile and mortal demil (PMD) machine. Position switches are used to ensure that the correct sequence of operations is maintained. Analog controls are mainly simple level and flow loops.

The washout controls consist of a water jet day tank level control loop, minimum flow recycle for pump protection, and the sequenced washout nozzle functions. Flow control for the washout nozzles is not required since the nozzle itself functions as a restrictive orifice.

After the burster washout, the washed-out energetics are shredded and mixed with a constant water flow to form a slurry. The slurry then flows into the energetics slurry tank where the density of the energetic slurry is controlled by adding plant water. To ensure that the mixture is nonexplosive, energetics concentration must be maintained to less than 20% by weight. A level controller maintains tank level by reducing the slurry tank pump speed when low low level is detected.

7.2.2 PROJECTILE DEMILITARIZATION AND AGENT WASHOUT

The control strategy for the WMDM and the rotary washout machine is similar to that used for the baseline PMD machine, i.e., sequence-enabled functions with position switches used to confirm the correct operational sequence.

Besides the sequential controls, the WMDM has a single control loop in which the drained agent pump speed is controlled by reservoir level. A standard industrial robot is used to load the rotary washout machine with munitions from the WMDM.

The rotary washout machine is where the munitions are washed in several stages with sequenced-enabled washout nozzles by using process water and recycled agent wash water. The process and agent wash water analog controls consist of a water washed storage tank and agent settling tank level control loops, minimum flow protection for the jet pumps, and booster pump. Flow control for the washout nozzles is not required since the nozzle itself functions as a restrictive orifice.

The agent/water washout is collected at the bottom of the rotary washout machine where a level controller maintains the level by reducing the washed agent and water booster pump speed when low level is detected. From the rotary washout, the washed-out agent and water are separated in the agent settling tank using a weir and interface level control. The agent concentrate pump speed is modulated to ensure that the agent/water interface is below the weir, i.e., that only the agent wash water overflows the weir.

The settling tank agent wash water is pumped at a fixed rate through a recycle line back to the agent settling tank. The remainder of the agent wash water is sent to the agent hydrolysers or to the agent water jet, high-pressure pumps. Prior to the agent water jet, high-pressure pumps, the agent wash water temperature is controlled by a heat exchanger with temperature control of the chilled water supply to the exchanger. The temperature is controlled to minimize hydrolysis at higher temperatures and to prevent crystallization at lower temperatures.

7.2.3 CONTAMINATED WASTE PREPARATION, CST, AND ERD

The key CST control parameters for proper degradation of any residual agent are residence time and temperature. Typically, to attain 5X thermal decontamination conditions, the treated material will be heated to about 1000°F for 15 minutes. Superheated steam is added to the treater to assist in the degradation of any agent present. The material leaving the CST is screened to remove fines and oversize particles and to ensure that the aggregate size separated out for recycling is within the size specification (for the proper suspension of the contaminated material in the CST).

The main process control loops associated with the CST are controls for heater temperature and steam flow. The remainder of the treater control system consists of automated, sequence-enabled functions and interlocks to safely operate the treater, e.g., heater interlocks, airlock permissives, motor interlocks, position/level switches to prevent jamming, etc.

Treater operations will be interlocked with upstream contaminated waste preparation equipment and downstream 5X residual handling equipment to ensure that the overall integrated process is within normal bounds (i.e., the associated upstream conveyors, shredders, and other machinery are stopped if the treater stops, and the treater stops if the associated downstream material handling equipment goes off-line). In addition, weigh stations are integrated with the feeders to ensure that the CST is not overcharged with contaminated materials.

In general, the controls for the ERD are similar to those for the CST. This equipment deactivates energetics thermally and not through agent destruction. Consequently, residence time is the only control parameter as long as deactivation temperature is attained. Steam is not required.

7.2.4 BATCH/ROTARY METAL PARTS TREATMENT AND RESIDUE HANDLING

The key rotary metal parts and batch metal parts for proper degradation of any residual agent are residence time and temperature. Typically, for total agent destruction, the treated material will be heated to about 1000°F for a minimum of 15 minutes. Superheated steam is added to the treater to assist with the degradation of any agent present.

The main process control loops associated with the treaters are heater temperature and steam flow. Emergency pressure control is also provided to ensure that the treaters are not overpressured during shutdown. The remainder of the treater control system consists of automated, sequence-enabled functions and interlocks to safely operate the treater, e.g., heater interlocks, airlocks/doors, permissives, motor/pusher interlocks, position switches to prevent jamming, etc.

Treater operations will be interlocked with upstream and downstream equipment to ensure that the overall integrated process is within normal bounds (i.e., the associated upstream conveyors and machinery are stopped if the treater stops, and the treater stops if the associated downstream material handling equipment goes off-line).

For the batch metal parts treatment (MPT), an agent monitor is provided to ensure that the batch is decontaminated. Similarly, agent monitoring stations are provided on the discharge of the rotary MPT.

7.2.5 MPT/CST OFFGAS TREATMENT

The MPT and CST offgas treatment systems use the same control system strategy that consists of a few standard control loops. The controls are divided into two systems: the quenching of the treater offgas and the CATOX®.

The effluent vapors out of the inductive heated treaters (rotary-MPT, batch-MPT, and CST) are heated to higher temperatures to complete destruction of any residual agent in the treater offgas prior to quenching. Each effluent vapor heater is controlled based on the heater discharge temperature.

The processing of offgas by the quench tower and surge tank is similar to baseline. Quench water is maintained using flow control of the quench water recirculation. To protect the quench recirculation pumps, the quench water to the MPT/CST condensate holding tanks flow control can be overridden to provide minimum recirculation flow.

As the quench water scrubs the offgas, the water becomes acidic. The pH control at the condensate surge tank is used to neutralize the spent quench water by adding NaOH to form brine. To limit salt concentration, density controls set the water purge rate, which affects the surge tank level. Should the quench water spray nozzles become plugged with salt, the offgas leaving the quench tower will increase in temperature and activate the backup quench water nozzle.

The quench tower and surge tank levels are interdependent, i.e., set by the relative elevation of the two vessels. Level, as measured at the surge tank, is controlled by the fresh water makeup at the quench tower.

The offgas from the quench tower and other process units are combined in a header to the CATOX® unit. Flow through the CATOX® system is maintained by a variable speed blower, which controls the header pressure.

Based on an O_2 analyzer, air is mixed with the offgas to maintain a minimum 12% oxygen composition at the CATOX® outlet. The minimum oxygen level in the CATOX® outlet gas is used to maintain the proper operation of the CATOX®, and to prevent an explosive mixture from forming when the air is initially mixed with the quench tower vent gas.

For the proper operation of the CATOX®, the CATOX® outlet temperature is maintained between 900 to 1050°F. The two parameters used for the CATOX® temperature control are CATOX® heater duty and air addition. Normally, modulation of the CATOX® heater duty provides sufficient temperature control of the system. However, due to the thermal mass of the heater, this control is relatively slow, and a process upset may require an increase in the airflow to prevent overtemperature. As a final protection, the quench water system will operate on an emergency shutdown caused by high high CATOX® outlet temperature.

The efficiency of conversion of the hydrocarbons to acceptable gas composition for discharge to the atmosphere by the CATOX® is monitored with agent and gas composition on-line analyzers. In addition, differential temperature across each CATOX® is monitored to ensure that the CATOX® is operating within design parameters.

Similar to furnace controls, the heaters will be provided with startup purge interlocks.

7.2.6 TOXIC ROOM

The agent holding tank, concentrated agent holding tank, and agent surge tank process monitoring and control system approach is basically identical to the baseline facility. The control system ensures that overflows from the agent holding tank and concentrated agent holding tank are diverted to the agent surge tank.

The spent decon control system is essentially identical to the baseline facility and is composed of automated, sequence-enabled functions to start/stop sump pumps. The control system also ensures that the spent decon holding tanks are not overfilled.

7.2.7 AGENT HYDROLYSIS

The agent hydrolysis process monitoring and control system approach is based on the ABCDF agent neutralization systems.

The agent hydrolyser operation is regulated by using a batch control strategy.

The operator initiates the agent hydrolyser operation by selecting the recipe via two key switches on the operator console. The first keyswitch selects the fluid to be processed, i.e., agent, agent concentrate, spent decon, agent condensate, or transfer (transfer fluid from another reactor). For spent decon, agent condensate, or transfer, the control system will prompt the operator to enter the agent and chloride concentration based on laboratory analysis, then calculate the proper dilution ratio for the recipe.

The second keyswitch selects the mode of operation. With this keyswitch, the operator has complete control of the hydrolysis process and initiates each stage of the recipe in sequence. The operator selects the mode, the control system requests operator confirmation to start, and upon confirmation, automatically performs the requested batch sequence.

7.2.7.1 Charge

Per the selected recipe, the control system will charge the hydrolyser with hot process water and a fixed charge of agent wash water. Upon clearing of the low level interlocks, the agitator and recirculation pump are started and temperature and pressure controls are initiated.

Hydrolyser temperature controls consist of two separate systems: jacket temperature and re-circulation heat exchanger controls. The jacket temperature control supplies heating only and is used to assist in the initial heating of the batch to the 194°F reaction temperature. The recirculation heat exchanger controls are used to maintain the reaction temperature with split range control of the hydrolyser HTF cooling and heating valves to maintain the hydrolyser contents at 194°F.

The pressure controls are designed to maintain the hydrolyser under a nitrogen blanket between 3 and 18 psig. When the hydrolyser is empty, the pressure is maintained at approximately 3 psig of nitrogen. As the hydrolyser is charged, the pressure is allowed to increase to 18 psig, at which point a vent control valve will maintain the hydrolyser pressure. In essence, allowing the hydrolyser to pressure up during a batch minimizes the vapors sent to the offgas system.

On completion of the charge sequence, the operator is prompted to switch to “Agent Addition.” For agent and agent concentrate addition, both the agitator and recirculation pump must be running.

7.2.7.2 Agent Addition

Per the recipe, add the agent bearing fluid and maintain the hydrolyser at 194°F. Upon completion of the batch residence time, prompt the operator to “Hydrolyser Test.”

7.2.7.3 Hydrolyser Test

The operator places the hydrolyser on hold and takes a manual sample for lab analysis. In this mode, agitation, recirculation, and temperature/pressure control are maintained. Upon lab confirmation of the successful batch processing, the operator proceeds to the pumpout mode. Should lab analysis indicate further processing is required, the operator could manually add water, continue processing the batch, and later re-sample the hydrolyser. Another option is for the operator to transfer the batch to the other hydrolyser sharing the neutralization cubicle for reprocessing.

7.2.7.4 Pumpout

In this mode, the control system automatically adjusts the batch pH to approximately 12 (or less). The recirculation flow is then diverted to the agent hydrolysate holding tank. The recirculation pump is equipped with a variable speed motor, which normally operates at high speed to provide adequate circulation and pumpout flows. But when low liquid level is reached during pumpout, the recirculation pump is switched to low speed to allow complete drainage of the hydrolyser without endangering the pump. Upon completion of the pumpout sequence, the hydrolyser is purged and automatically isolated, and all controls are deactivated.

7.2.7.5 Transfer

Upon selection of the transfer mode, the control system will prompt the operator to:

- Enter the agent and chloride concentration of the transfer fluid
- For the second reactor, select Transfer as the fluid type and start the charge operation

The control system will automatically start the fluid transfer between the hydrolysers after the operator commands the second hydrolyser for "Agent Addition." After completion of the Transfer sequence, the first hydrolyser is automatically isolated and all controls deactivated. However, if the transfer operation is interrupted before the first hydrolyser is fully emptied, the control system will automatically switch the hydrolyser to recirculation while maintaining temperature/pressure control. If required, additional water can be added by operator command.

The operator can intervene at any time to bring a valve under direct manual control. However, the safety PLC will guard against any incorrect valve line-ups based on the recipe stage or activated shutdown interlocks.

At all times, the safety PLC will guard the hydrolysers against overpressure, high high level, high high temperature by automatically isolating the hydrolyser from the energy source. Where isolation is critical, double block valves will be supplied.

The agent addition into the hydrolyser will be controlled to limit the temperature rise in the event of a total loss of cooling incident. For this purpose, redundant on-line flow elements are provided to meter the agent. Having proven the hydrolyser contents agent free by laboratory analysis, there is little likelihood of an agent release to the agent hydrolysate holding tank and ICBs.

The agent hydrolysate holding tank control system consists a simple vent pressure control and a cascaded level/flow control of the tank discharge. The control system also includes a minimum recycle flow loop to help maintain the agitation of the hydrolysate and provide low flow protection to the agent hydrolysate pumps. The pH control at the agent hydrolysate holding tank is not required since the hydrolysate pH has already been adjusted at the hydrolysers.

7.2.8 ENERGETICS NEUTRALIZATION

In general, the energetics neutralization process monitoring and control system is a simplified version of the agent hydrolyser operation.

The ENR operation is regulated using a batch control strategy.

The operator initiates the reactor operation by selecting the recipe via two key switches on the operator console. The first keyswitch selects the fluid to be processed, i.e., energetics or transfer (transfer fluid from another reactor). For the transfer operation, the control system will prompt the operator to enter the energetics concentration based on laboratory analysis of the batch, then calculates the proper dilution ratio for the recipe.

The second keyswitch selects the mode of operation. With this keyswitch, the operator has complete control of the neutralization process and initiates each stage of the recipe in sequence. The operator selects the mode, the control system requests operator confirmation to start, and upon confirmation, automatically performs the requested batch sequence.

7.2.8.1 Charge

Per the selected recipe, the control system will charge the reactor with process water and sodium hydroxide to the vessel to make between 1.5 and 3.0 molar NaOH solution. Upon clearing of the low level interlocks, the agitator and recirculation pump are started and reactor main control loops are initiated (i.e., pH, temperature and pressure).

Reactor temperature controls consist of jacket cooling/heating only. The reactor contents are maintained at 194°F with split range control of the reactor HTF cooling and heating valves.

The pressure controls are designed to maintain the reactor under a nitrogen blanket between 3 and 18 psig. When the reactor is empty, the pressure is maintained at approximately 3 psig of nitrogen. As the reactor is charged, the pressure is allowed to increase to 18 psig, at which point a vent control valve will maintain the reactor pressure. In essence, allowing the reactor to pressure up during a batch minimizes the vapors sent to the offgas system.

On completion of the charge sequence, the operator is prompted to switch to "Energetics Addition." For the addition of the energetics fluid, both the agitator and recirculation pump must be running.

7.2.8.2 Energetics Addition

Per the recipe, add the energetics bearing fluid. The reactor contents temperature is maintained at 194°F. Upon completion of the batch residence time, prompt the operator to "Reactor Test."

7.2.8.3 Reactor Test

The operator places the reactor on hold and takes a manual sample for lab analysis. In this mode, agitation, recirculation, and temperature/pressure control are maintained. Upon lab confirmation of the successful batch processing, the operator proceeds to the pumpout mode. Should lab analysis indicate further processing is required, the operator could manually add water and sodium hydroxide, continue processing the batch, and later re-sample the reactor. Another option is for the operator to transfer the batch to one of the other two reactors.

7.2.8.4 Pumpout

In this mode, the recirculation flow is diverted to the energetics hydrolysate holding tank. The recirculation pump is equipped with a variable speed motor that normally operates at high speed to provide adequate circulation and pumpout flows. But when low liquid level is reached during pumpout, the recirculation pump is switched to low speed to allow complete drainage of the reactor without endangering the pump. Upon completion of the pumpout sequence, the reactor is purged and automatically isolated, and all controls are deactivated.

7.2.8.5 Transfer

Upon selection of the transfer mode, the control system will prompt the operator to:

- Enter the energetics concentration of the transfer fluid
- For the second Reactor, select "Transfer" as the fluid type and start the charge operation

The control system will automatically start the fluid transfer between the reactors after the operator commands the second reactor for "Energetics Addition." After completion of the transfer sequence, the first reactor is automatically isolated and all controls deactivated. However, if the transfer operation is interrupted before the first reactor is fully emptied, the control system will automatically switch the reactor to recirculation while maintaining temperature/pressure control. If required, additional water can be added by operator command.

The operator can intervene at any time to bring a valve under direct manual control. However, the safety PLC will guard against any incorrect valve line-ups based on the recipe stage or activated shutdown interlocks.

At all times, the safety PLC will guard the reactors against overpressure, high high level, high high temperature by automatically isolating the reactor from the energy source.

The energetics hydrolysate holding tank control system consists a simple vent pressure control and a cascaded level/flow control of the tank discharge. In addition, discharge flow is limited so that the ratio of agent–energetic hydrolysate is normally limited to 20–1 (20—5 max ratio for short durations) on hydrolysate. The control system also includes a minimum recycle flow loop to help maintain the agitation of the hydrolysate and provide low flow protection to the energetics hydrolysate pumps.

7.2.9 SECONDARY HEAT TRANSFER FLUID

The secondary heat transfer fluid system acts as a barrier between the potentially agent contaminated hydrolysers/reactors and the plant utilities (steam and cooling water). Each hydrolyser/reactor system has its own heat transfer fluid (HTF) loop that operates continuously at a relatively high pressure to ensure that any leaks at the hydrolysers/reactors will drain into the hydrolyser/reactor. The controls are essentially identical to those provided on NECDF, i.e., pump minimum flow control and temperature control of the hot/cold HTF loops. The optimum hydrolyser/reactor reaction temperature is maintained by split range control of the hot and cold HTF flows.

7.2.10 BIOREACTION, WATER RECOVERY, AND ICB™ OFFGAS

In general, the bioreactor process is stable, reliable, and extremely robust. The biomass can tolerate large operating margins in the hydrolysate feed rate, aeration, and temperature. The biomass can withstand the total loss of feed or air for extended periods with minimal impact. For optimum operation, the temperature for the biomass feed is maintained between 75°F and 115°F. Except for the feed/water dilution controls, the principal control loops are simple level, flow, pressure, and pH control.

To ensure proper dilution, both the agent and energetic hydrolysate ICB™ feed concentrations are measured at the MDB with on-stream analyzers. The accuracy of the on-stream analyzers can be verified by comparison with the data collected from the lab analysis of the hydrolyser/reactor batches. The control system then uses the flow and concentration data for both streams to calculate the hydrolysate concentration of the combined agent/energetic stream feeding the ICB™ feed tanks.

At each ICB™ feed tank, the combined hydrolysate feed flow with the calculated agent/energetic concentration is used to determine the dilution water and inorganic feed requirements. The typical water dilution is 40:1. Should the on-line TOC analyzer on the ICB™ feed tank effluent indicate high TOC, the control system will compensate by cutting back on the hydrolysate feed to the tank. The ICB™ feed tank level is maintained by cascade control of the four flow control loops which maintain the equal loading of the four ICBs. The ICB™ feed pumps have a minimum flow recycle loop.

The ICB™ aeration rate is maintained using flow control to vary the ICB™ air blower speed. ICB™ pressure is maintained by controlling the ICB™ offgas blower speed. Water knocked out in the bioreactor offgas K.O. pot is gravity fed back to the feed tank.

Each ICB™ cell has pH control to ensure optimum water acidity for the biomass.

Water from the ICBs overflows to the ICB™ effluent pump tank where level is maintained using cascade control of the effluent pump flow control. The ICB™ effluent is then mixed with the effluent from the other three ICB™ trains and flows into the two clarifier/dewatering trains.

The clarifier dewatering filters and evaporator crystallizer process control designs use standard industrial control strategies that are typical in mining and sewage treatment facilities, e.g., level controls.

The ICB™ hydrolysate destruction efficiency is monitored with TOC on-line analyzers on each ICB™ train effluent liquid stream. On high TOC levels, the suspected ICB™ train is automatically shut-down and isolated. An additional safety factor is that all ICB™ effluent water is recycled via the brine reduction unit. Consequently, there is little likelihood of contaminated water reaching the environment.

The ICB™ offgas control system consists mainly of shutdowns and run permissives as shown on the shutdown block diagrams. In addition to the ICB™ offgas blower speed control described above, the only control loop the ICB™ offgas system has is the ICB™ offgas reheater temperature control.

7.2.11 MPT/CST CONDENSATE STORAGE

The MPT/CST condensate holding tank controls consist of interlocks to ensure that only one tank is on line to receive condensate. The off-line tank will typically be in recirculation using the common MPT/CST condensate feed pumps. After lab analysis confirms that the off-line tank is agent free, the operator switches from recirculation to pump out the condensate to the agent hydrolysate storage tank. If agent is detected, however, the operator will divert the condensate to an agent hydrolyser.

7.2.12 LAB WASTE TANKS, SUMPS, SPENT DECON

The monitoring and control of the spent decon, lab waste tanks, and sumps are based primarily on the strategy, methods, and systems used in NECDF.

7.2.13 BULK CHEMICAL STORAGE (INORGANIC NUTRIENT, 50% NAOH, 18% NAOH, SODIUM HYPOCHLORITE, AND DECON)

The monitoring and control of the bulk chemical storage is based primarily on the strategy, methods, and systems used in NECDF. Controls for inorganic nutrient storage and sodium hypochlorite tanks are also modeled after NECDF.

7.2.14 UTILITIES

The monitoring and control of the utility systems are based primarily on the strategy, methods, and systems used in CSDP and NECDF or as determined later by the packaged equipment vendor.

SECTION 8

MATERIALS SELECTION

8.1 MATERIALS SELECTION CRITERIA

ACWA WHEAT provides a process of destruction of chemical mustard (HD) agent and energetics associated with various munitions. Water/caustic based hydrolysis reactions are used. The process involves total destruction of agent and clean-up of all reaction products to safe levels.

Processing of mustard (HD) by 194°F hydrolysis reactions produces hydrochloric acid and thiodiglycol.

Throughout these materials selection comments, process descriptions are included. These descriptions are much simplified and are used only for the most general guidance for materials selection.

Plant life is two to three years. When possible, materials are selected with this life in mind. However, where stream purity or lack of suitable material is a problem, more resistant materials are selected.

Materials are selected based on the current process schemes. Refinements in the process will result in materials changes, which will be incorporated in the next engineering phase.

Materials are mentioned by trade name (Hastelloy, Durichlor, etc.) for simplicity. For design, such trade names will not be used and materials will be referred to and specified using Universal Numbering System (UNS) members.

Exchangers are called out using specific materials. These materials are for exchanger process fluid side. (For shell and tube exchangers, if process is on the tube side, the shell side will often be carbon steel).

Corrosion allowances are not detailed here. However, in general, for carbon steel, 1/8-in. will be used. For high alloys, 1/32-in. will be used.

ACWA-WHEAT process equipment and piping is reasonably small. In a later engineering phase, upgrading of some materials may be sensible. This would reduce the number of piping classes and reduce the number of varieties of pumps and valves, simplifying procurement and sparing requirements.

Most heating is by induction or water jacket.

Many equipment items are unique to the process. Materials selection will be by the supplier, based on data-sheet and expected process conditions. Supplier recommended materials and design will require careful review.

Process Flow-Diagrams (PFDs) list equipment in a very general way-pump, condenser, blower, etc. Materials are specified for these items. In some cases, selection of an item will eventually

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be based on an industry standard with only limited allowable materials availability. In such cases, materials changes will be required.

8.2 MATERIALS SELECTION BASIS

8.2.1 WATER

(1) Most process water is deionized or of high purity. Such water is very corrosive to carbon steel. If carbon steel is used, the water purity will quickly drop. Stainless steel is specified for this water to maintain purity.

(2) Process tap water. Carbon steel is specified.

(3) Condensate-pure. Stainless steel is specified.

(4) Condensate (caustic or neutral) brine. Carbon steel is specified. If required by caustic or temperature level, stress relief is specified.

8.2.2 STEAM

Conventional industrially used materials are specified.

8.2.3 AGENT

Use carbon steel, smooth, if required. (If agent is water contaminated, see Hydrochloric Acid).

8.2.4 HYDROCHLORIC ACID

Streams handling hydrochloric acid liquid are specified using plastic, plastic-lined carbon steel or Hastelloy C-276 or C-22. Polypropylene lined carbon steel piping is an economical choice. Tanks, pumps, valves, equipment will have to be suitably lined carbon steel or Hastelloy C. (C-22 is somewhat more resistant to HCl corrosion than C-276).

8.2.5 AGENT HYDROLYSIS

Corrosion tests have recommended only three materials for contact with agent hydrolysis fluids during the reaction: titanium, zirconium and Kynar lined carbon steel. To use titanium, a suitable level of oxidizing impurity (such as ferric ion) must be present. To use zirconium; no oxidizing impurity can be present. Kynar is not sensitive to oxidizing impunity. (Polypropylene was also suitable). Palladium modified titanium is specified, along with plastic lined pipe (Polypropylene). The palladium alloy is less sensitive to oxidizing impurity level than pure titanium.

8.2.6 THIODIGLYCOL (TDG)

TDG is produced in the agent hydrolysis reaction. Corrosion test results indicated the following as suitable materials for contact with TDG:

Temperature of 194°F, any pH. Polypropylene lined carbon steel piping. Metallic materials should be titanium.

Temperature 130°F – 150°F. Plastic lined carbon steel piping and Hastelloy C-276 or C-22 metallic materials.

Temperature less than 78°F, pH caustic or neutral. Carbon steel or stainless steel.

Temperature less than 78°F, pH less than 4. Hastelloy C or plastic lined carbon steel.

8.2.7 SODIUM HYDROXIDE

50% strength, carbon steel, stress relieved. Heating coils (immersed) should be Nickel 200.

18% strength above 140°F, carbon steel, stress relieved.

18% strength below 140°F, carbon steel

8.2.8 CATOX® EXIT GAS

CATOX® exit gases have a temperature of 900°F. 1 ¼ Cr – 1 Mo. carbon steel is suitable at this temperature. For condensers in this gas, if $S0_2$ is present, Alloy 20 is suitable. Alloy 20 will withstand any condensing sulfur acids. Alloy 20 is also used for the blower. Carbon steel is suitable for the cooled gas, but if cooling water is expected to fail, stainless steel should be used.

8.2.9 SODIUM HYPOCHLORITE

Sodium hypochlorite is best stored in high-density polyethylene tanks and handled in plastic lined carbon steel. Durichlor 51 pumps are suitable.

8.2.10 DECON/SPENT DECON

Use plastic lined carbon steel piping or plastic. Durichlor 51 pumps and Alloy 20 agitators are suitable. Tanks may be plastic or lined carbon steel.

8.2.11 DUPLEX STAINLESS STEEL

Duplex stainless steel (such as UNS 31803) is suitable for certain brines at elevated temperatures. They are corrosion resistant and available.

8.2.12 ENERGETICS

Tetryl is TNT in a binder. According to corrosion test data, tetryl slurry and hydrolysis are suitably handled in 304 or 316 stainless steel.

8.3 MATERIALS SELECTION ACWA – WHEAT

8.3.1 PROCESS WATER

Through out the facility, process water is used. In almost all cases, process water is deionized water or condensate. Such deionized water (DI) is very corrosive to carbon steel. Therefore, this deionized process water is carried in lined carbon steel or stainless steel piping. Tanks and equipment are plastic, lined carbon steel or stainless steel. Actual individual materials selections are based on item size and materials availability.

8.3.2 PROJECTILE DEMILITARIZATION (AREA –020, -030)

Projectile Demilitarization involves drainage and collection of agent (HD, Mustard) from projectiles, then water washout of the drained projectiles to remove remnant agent, corrosion products etc. Then washout slurry is collected; the water is separated and used again in washout.

Corrosion guidelines for materials selection are as follows:

(1) Drained agent is not very corrosive and can be piped, pumped and stored using carbon steel equipment.

(2) Agent washout water and agent/water/debris systems are highly corrosive. The water contains substantial amounts of hydrochloric acid (HCl) and any materials in

contact with washout water or slurry must be resistant to HCl. Such materials are plastics, plastic lined carbon steel, Hastelloy C-276 and Durichler 51.

The rotary washout machine must be supplied with process-liquid wetted parts resistant to HCl corrosion. Washout slurry piping should be plastic-lined carbon steel. Pumps should be Durichlor 51 or Hastelloy C. Storage tanks for the washout water storage should be lined carbon steel. Any tanks for storing or separating agent slurry should be Hastelloy C-276. Tanks storing agent should be carbon steel. If water may be present, the bottom part of the tank where the water layer will form should be lined or coated. (Possibly with an epoxy phenolic). If the agent contains a water emulsion or gel that will not easily separate out, the tank should have wetted all surfaces plastic lined or be made from Hastelloy C-276.

In the next engineering design phase, solid plastic on fiber-reinforced plastic (FRP) tanks should be considered for handling agent, agent slurry, and washout water. Safety and reliability of plastic tankage has been a concern.

8.3.3 SPENT DECON (AREA – 030)

Spent decon consists of sodium hypochlorite (bleach), sodium hydroxide, water and small amounts of salts resulting from decon operations. Tanks and piping for spent decon should be plastic (such as high density polyethylene-HDPE) or plastic lined carbon steel. Metal parts for agitator should be Alloy 20. Pumps for spent decon should be Alloy 20 on Durichlor 51.

8.3.4 AGENT HYDROLYSIS (AREA – 040)

Agent is broken down (hydrolyzed into simpler chemicals in a stirred, heated reactor at 194°F. While the hydrolysis reaction is preceding a side stream of reacting product is withdrawn and pumped through an exchanger. Agent, agent slurry, projectile washout water, etc. are added to the hydrolyser with hot water. The reaction proceeds at 194°F, producing high concentrations of HCl and other breakdown products (such as thiodiglycol -TDG-, etc.). At the end of the reaction, the hydrolysite pH is adjusted using sodium hydroxide to near neutral. The hydrolysite is then transferred from the hydrolyser to a holding tank.

Corrosion studies have been made modeling the hydrolysis reaction. Only three materials are recommended:

(1) Titanium

(2) Zirconium

(3) Kynar

Titanium is suitable only if oxidizing impurities are in the reacting solution (Ferric ion is a suitable oxidizing impurity and should be present in amounts of 100 to perhaps 400 ppm depending on operating conditions). If suitable oxidizing impurity is not present, rapid corrosion of the titanium is possible.

For zirconium to be corrosion resistant, there must be no oxidizing impurities. With oxidizing impurities, zirconium corrodes rapidly during hydrolysis. Kynar lining is not sensitive to oxidizing impurity level.

Oxidizing impurities will be present in the solutions (ferric ion from agent sludge corrosion washout). Therefore, zirconium is not suitable. Titanium modified by alloying with palladium is less sensitive to oxidizing impurity levels then chemically pure titanium and the palladium-modified titanium was selected as the most suitable material for the hydrolyser, agitator and hydrolyser exchanger. The hydrolyser recirculation pumps are titanium. The recirculation (194°F) piping is plastic lined carbon steel.

A Kynar-lined carbon steel hydrolyser is also suitable from a corrosion standpoint. This is a reasonably small, vigorously stirred reactor with external water jacket. Whether the Kynar-lined would prove reliable should be addressed in the next engineering phase. (In any case, agitator, exchanger, pump and mixer should be titanium.

8.3.5 HYDROLYSIS OVERHEAD GASES (AREA – 40)

Overhead gases from the hydrolyser and hydrolysite storage tank are sent to offgas treatment (area – 80). These gases are at 194°F carrying some water, traces of agent, nitrogen. Carbon steel is suitable.

8.3.6 AGENT HYDROLYSATE (AREA – 040)

Agent hydrolysate is produced in the hydrolyser. As produced, the hydrolysate has a very low pH, due to HCl. The hydrolysate is neutralized using sodium hydroxide. Neutralized hydrolysate contains thiodiglycol (TDG), NaCl, water, plus small amounts of other compounds. TDG can be very corrosive. Standard corrosion data do not provide information on TDG, but the hydrolysis corrosion tests provide guidelines for the TDG containing hydrolysate. These guidelines were followed in materials selection for hydrolysate.

For hydrolysate with TDG:

(1) T: 194°F – Use plastic lined carbon steel pipe at any pH. Metal parts should be titanium.

(2) T: 100-150°F – Use plastic lined carbon steel pipe. Metal parts should be Hastelloy C-276 or Hastelloy C-22. Tanks may be solid metal or lined. (Titanium is also suitable at this temperature).

(3) T: 77-100°F – pH caustic or neutral) – Carbon steel is suitable. Pumps may be carbon steel or duplex stainless steel.

Process changes may result in hydrolysate temperature changes. Whatever the hydrolysate temperature, the above guidelines are used for materials selection.

Hydrolysate is sent to ICB™ Feed (Area 60)

8.3.7 METAL PARTS TREATMENT – AGENT (AREA 70)

Munitions bodies from the Rotary Washout Machine are loaded into an induction heated treater. The bodies are held in the treater for sufficient time at 1000°F. Remnant agent is broken down into HCl (about 20%), TDG, H_2O, SO_2, etc. gases. These gases are sent to a secondary induction heated unit, where they are heated to 1200°F. Gases exit this unit at 1200°F (perhaps even hotter) and are reducing in character with H_2, CO, etc. The gas has H_2O, HCl (wet HCl), TDG, SO_2, CO_2, etc. Because these two units are induction heated, their skin temperatures would be expected to be higher than the internal gas temperature. (The secondary heater may have a 1500°F metal shell temperature). These gases are sent to a quench tower, where they are quenched at using a caustic scrubbing solution. Overhead quench gases are sent to offgas treatment and the quench liquid to agent condensate storage. The treated munitions bodies are sent to cool and be deformed.

The Metal Parts Treater (1000°F) and the secondary heater pose special and difficult materials selection problems. A combination of wet HCl, wet SO_2, steam and reducing conditions plus the unknown effects of TDG while heating the gases to 1000°F or 1200°F rules out use of most metallic materials. Ceramic linings or solid ceramics may not be thermal shock resistant for induction heating. Hastelloy C-276 has been selected for these two items, plus associated hot piping. Final materials choice, however, will have to await currently on-going pilot plant corrosion testing of potentially suitable materials.

8.3.8 OFFGAS TREATMENT – MPT (AREA 80)

This area takes accumulated offgases through a reheater, then a Honeywell CATOX® Unit. The treated gases emerge at 900°F; go through a cooler, then a blower to the carbon filters. The treated gases have water, SO_2, CO_2, etc. The cooler should be Alloy 20 to avoid sulfur acid corrosion. The blower should be Alloy 20. Piping downstream of the CATOX® Unit should be 316 SS or Alloy 20 (in case of cooling water failure).

8.3.9 BULK CHEMICAL STORAGE (AREA 110)

(1) Inorganic Nutrients may be handled in lined carbon steel tank or plastic tank using carbon steel piping.

(2) Sodium Hypochlorite is stored in a HDPE plastic tank and handled in plastic lined pipe. Durichlor 51 is suitable for the pump.

(3) 50% Sodium Hydroxide is handled in stress relieved carbon steel tanks, pumps and piping. Tank heating coil is nickel. For 18% sodium hydroxide, carbon steel is suitable. No stress relief is needed.

8.3.10 BIOREACTORS (AREA 60)

Here agent and energetics hydrolysates are sent through a bioreactor for clean up. Agent hydrolysate, because of its high temperature requires Hastelloy C-276 or plastic lined carbon steel piping. Energetics hydrolysate uses carbon steel. ICB™ feed tank is lined, stress relieved carbon steel with a Hastelloy C-22 agitator. ICB™ feed pumps are Hastelloy C. The ICB™ feed exchanger is Hastelloy C-22. The exchanger cools the feed so that downstream carbon steel equipment and piping are suitable. Equipment and piping downstream of the bioreactor are carbon steel or plastic.

8.3.11 OFFGAS TREATMENT: BIOREACTOR (AREA 87)

Offgases from the bioreactor contain small amounts of VOCs, etc. and water. Temperature is 77°F. These gases are handled in carbon steel and sent to the ICB™ CATOX® Unit. Gases leaving the CATOX® are clean, at 900°F. Metal materials in contact with the 900°F gases should be 1 ¼ Cr. – ½ Mo. carbon steel. When the gases are cooled to 450°F, carbon steel is suitable. (Stainless steel may also be used for these streams).

8.3.12 WATER RECOVERY AND SLEDGE COLLECTION (AREA 90)

Here, water and clarifier sludge effluent from the bioreactors is further treated. Water treatment chemicals are handled in stainless steel or plastic. Equipment and piping is carbon steel. Thickeners are cement lined.

The process make up water uses stainless steel. The recovered water tank is epoxy-lined carbon steel.

8.3.13 EVAPORATOR/CRYSTALLIZER (AREA 100)

The evaporator/crystallizer will be supplied as a packaged unit. Materials should be selected by the supplier based on process design. Selected materials should be reviewed and approved by the design engineer.

8.3.14 PROJECTILE DISASSEMBLY/BURSTER WASHOUT (AREA 010)

Here, energetics are removed from munitions and energetics are washed from the boosters with water and slurried. The main energetic material is Tetryl. Process water lines, energetics washout and energetics slurry contacting pipes and equipment are stainless steel. (Mainly type 304 or 316). Equipment and piping must be suitable for handling explosives. The energetics slurry is sent to energetics neutralization.

8.3.15 ENERGETICS NEUTRALIZATION (AREA 50)

Energetics slurry, consisting of water and Tetryl (TNT plus binder), is sent to the Energetics Hydrolyser. 50% sodium hydroxide is mixed in. The energetics are reacted at 194°F. Caustic brine is produced, containing $Na\ N0_{2,}$ sodium acetate, sodium formate, ammonia, etc. This hydrolysate brine is not very corrosive. Materials testing for the hydrolysis of tetryl in caustic indicates that 304 stainless is suitable.

Type 304 stainless is specified for pipe bringing in the energetics slurry and for the energetics hydrolyser. Stress relieved carbon steel is used for the 50% caustic. If an exchanger is needed for the energetics hydrolysis, it should be type 316 stainless steel.

Stress relieved carbon steel is used for energetics hydrolysate piping and hydrolysate tank. Stress relief is needed for carbon steel at these temperatures and caustic concentrations. Overhead gases are handled in carbon steel piping. Hydrolysate pumps are 304 stainless. The energetics hydrolysate tank vent condenser is duplex (UNS 31803) stainless steel.

8.3.16 CONTINUOUS STEAM TREATER (CST) (AREA 75)

Shredded PVC, chipped wood, spent carbon, etc. are destroyed in this unit. These materials are continuously fed into an induction heated, steam treater. Steam temperature is 1000°F. The treater is heated to maintain this 1000°F temperature. PVC, wood, etc. reacts with the 1000°F steam and breaks down. PVC forms hydrochloric acid; wood yields acetic, formic and other organic acids, turpentine, tars, etc. The resulting gases are reducing in nature, with $H_{2,}$ CO, etc. These gases are sent to a secondary, induction heated heater where they are heated to 1200°F. The 1200°F gases are sent to a quench tower, where they are quenched with a caustic quench. Gases are sent to offgas treatment and CST condensate/quench to an area-30 condensate storage tank.

If anything selecting suitable materials for the CST and CST Effluent Heater is even more difficult than for the MPT (see comments, paragraph 7). Hastelloy C-276 has been selected for both items, but final materials selection will have to await pilot plant test results.

Quench tower is Hastelloy C-276. Piping leaving the quench tower is carbon steel. Carbon steel pipe hotter than 140°F should be stress relieved. (The quench fluid in a caustic brine). The CST quench recirculation cooler is stainless steel. CST condensate surge tank is stress relieved carbon steel or plastic. The CST condenser is duplex stainless steel. CST quench pump is carbon steel.

8.3.17 METAL PARTS TREATMENT – ENERGETICS (AREA 76)

Various metal parts associated with energetics are treated in a 1000°F induction heated steam treater. Gases from this treater are reheated to 1200°F, and then sent to the MPT quench tower (Area-70).

Materials selected are Hastelloy C-276 due to possible agent in the last campaign.

8.3.18 OFFGAS TREATMENT – CST (AREA 85)

Materials for the 900°F gases may be 1 ¼ Cr – ½ Mo. carbon steel. Cooled gases and blower should be carbon steel. If cooling water failure is a concern, use stainless steel throughout, with Alloy 20 blower and cooler.

SECTION 9

OVERALL FACILITY DESCRIPTIONS

9.1 FACILITY DESIGN OVERVIEW

The ACWA WHEAT facility is designed to handle an alternative process to the baseline incineration. The selected process is the hydrolysis of HD or HT in water at low temperature (<200°F) and low pressure (<20 psig) to produce reaction products that are biodegradable, and can readily meet all applicable regulatory requirements. This WHEAT process eliminates almost all airborne emissions, and produces biomass which can be disposed of with minimal risk to public safety.

The facility design will utilize baseline incineration technology, equipment design and baseline risk assessment techniques wherever possible. Design will meet all applicable federal, state and military codes and regulations for facility construction including information contained in the U.S. Army's *Design Criteria Handbook for Chemical Agents and Munitions Disposal Facilities*.

The baseline facility has been modified to accommodate the WHEAT process. Numerous baseline buildings have been modified or deleted and new buildings have been added. Table 9-1 identifies the WHEAT buildings and their status versus the baseline buildings.

Table 9-1—WHEAT Facility

Baseline Building	WHEAT Facility
Container holding building (CHB)	Deleted – replaced by a munitions storage building (MSB)
Munitions demilitarization building (MDB)	Modified 1-story versus 2-story in baseline
Pollution abatement system (PAS)	Deleted
Process and utility building (PUB)	Replaced by NECDF baseline utility building (UB) and new process auxiliary building (PAB)
MDB HVAC exhaust filters (FIL) and monitor house	Modified
Personnel and maintenance building (PMB)	Identical
Entry control facility (ECF)	Identical
Chemical laboratory (LAB)	Identical (LAB processes conducted will be different)
None	New, Biotreatment Area (BTA)
Process support building (PSB)	Identical

The proposed site layout for the ACWA WHEAT facility is shown in Figure 9-1.

Return

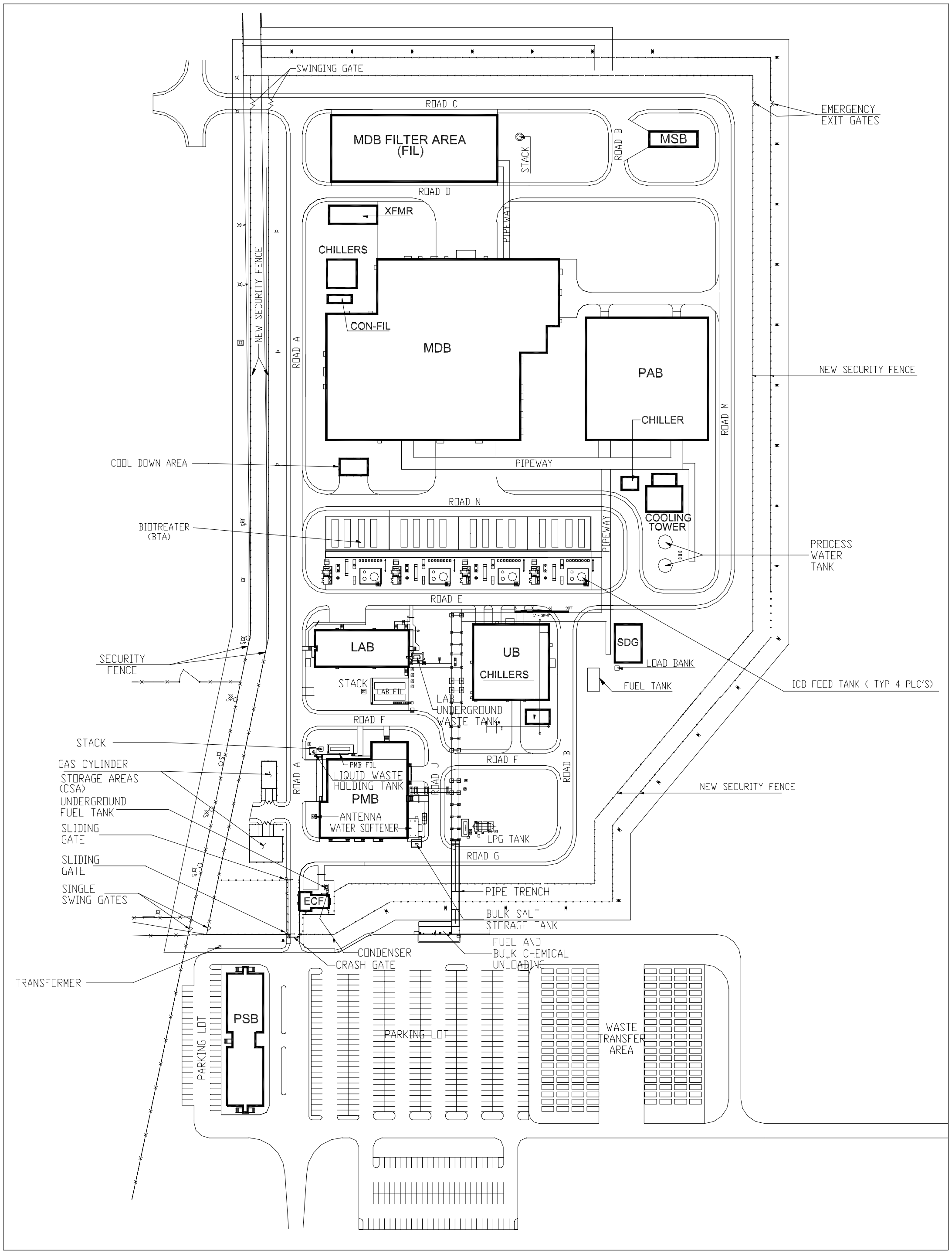

Figure 9-1—ACWA WHEAT Site Layout

9.2 BASELINE BUILDINGS

9.2.1 MDB HVAC EXHAUST FILTERS (FIL)

The FIL contains carbon filtration, all welded inlet and exhaust ductwork, and an adjacent exhaust stack. The stack elevates the discharge above ground level to escape building wake effects, and allow dispersion of the filtered exhaust. The filter units are located on an on grade slab.

The baseline filters are modified to expand the baseline capacity from 100,000 scfm to 160,000 scfm of air. The FIL contains a total of twelve carbon filter trains, ten of which are in normal operation. One filter unit is considered on stand-by and one can be down for maintenance.

9.2.2 PERSONNEL AND MAINTENANCE BUILDING (PMB)

The personnel and maintenance building is identical to the baseline building. It houses lunch rooms, showers, and locker rooms. The demilitarization protective ensemble support area (DSA) where the personnel will suit on the demilitarization protective ensemble (DPE) is also part of the PMB. The DSA includes DPE suit sealing equipment, lockers, toilets, facilities for refilling DPE respirator packages, and storage areas for cotton goods and boots. Included here is separate office space for treaty compliance inspectors. Further, the PMB contains routine maintenance facilities, repair shops, stores areas, and facility medical area. Administrative offices are located within the repair shops and medical area. The PMB is a pre-engineered modular wood frame building. An ambulance entrance with canopy roof will also be provided.

9.2.3 ENTRY CONTROL FACILITY (ECF)

Personnel and systems provided to monitor and control physical access to and egress from the overall facility are housed in the entry control facility. This building is identical to the baseline building. The structure is located at the entry point into the plant complex, between the two levels of security fencing. The ECF is of reinforced concrete construction with adequate viewing capability, such as bullet protective windows and video, to monitor both the plant perimeter and the controlled-access routes into and out of the plant. The ECF is manned 24 hours a day, 7 days a week. The complex has one sally port, with inner and outer gates to process vehicles; personnel pass through, a lobby with on turnstile and an identification and metal detection check to enter the site. Vehicle gates in the sally port are electrically operated from the ECF. Personnel gates and turnstiles have electrical release or operating mechanisms controlled from within the facility. The building has protected gun ports, bullet-resistant windows, badge exchange passthrough, office, ready room, toilet room, mechanical rooms, monitor/control room, and an emergency generator for perimeter lighting, security functions, etc. An adjacent underground fuel oil tank supports operations of the emergency generator. Telephone communications are provided to the installation security offices in the event of a security incident or threat.

9.2.4 CHEMICAL LABORATORY (LAB)

A single story laboratory building is required to support the necessary process monitoring, and air monitoring of the facility. It is intended that portions of the laboratory used for activities similar to the CSDP baseline be replicated. The laboratory will be configured, staffed and equipped to ensure compliance with agent treaty requirements, occupational exposure, and environmental emission criteria. There will also be laboratories for liquid and solid sample preparation and analysis, environmental analysis, instrument monitor support, agent standards and quality control. Type of equipment to be operated include fume hoods, pH meters, gas chromatographs, atomic emission spectrometers, titrators, IR analyzers, mass spectrometers, liquid chromatographs, filtrators, and deionized water stations. Emergency showers and eyewash stations will be provided for each laboratory. Industrial liquid waste from all laboratories is collected in an underground chemical waste tank set in a concrete pit outside the laboratory and is pumped to waste tank truck for disposal.

9.2.5 PROCESS SUPPORT BUILDING (PSB)

The PSB is identical to the baseline building, a single story building, modular wood frame mobile structure supported on concrete piers. The structure consists of two wings joined by a common shared utility module containing foyer, toilet facilities, janitor closet, and vestibules. One wing houses the government staff, and the other wing houses the operating contractor's employees. Each wing contains offices, open work space, meeting/lunch rooms office equipment, and a record keeping area.

9.2.6 UTILITY BUILDING (UB)

The Utility Building is similar to the UB in the NECDF. The UB contains the facility boiler systems (process and HVAC boilers), boiler makeup water treatment system, air compressors and receivers for the plant air system, the instrument air system, and the life support system (LSS).

The UB has two electrical equipment rooms, which contain 4,160V and 480V switchgear, motor control centers, and local distribution panels. The facility main utility power circuit breakers and transformers will be located outside the building.

9.3 NEW BUILDINGS

The following buildings are new or heavily revised baseline buildings in order to support the WHEAT technology.

9.3.1 MSB

Because the HD and HT agents have a lower lethal value than other chemical agents processed in the baseline facilities, the requirement for the use of containers to transport munitions from the Chemical Depot to the facility and storing munitions onsite has been waived for this project. Consequently the CHB has been deleted and replaced by an MSB. The MSB is a standard earth-covered army bunker 25 ft x 80 ft. It is sized to provide 24-hour onsite munition storage which will allow continuous operation of the facility even though the transport of munitions from the munition depot to the facility is prohibited at night.

9.3.2 MDB

The MDB is an approximately 118,000-ft^2, one-story, noncombustible industrial steel frame over a concrete floor slab-on-grade construction. The MDB houses the basic process equipment and control systems necessary to disassemble and drain munitions and other liquid and solid waste, decontaminate munition bodies and other metal items, and destroy agent and energetics. The facility also provides critical services to the personnel operating and maintaining the process equipment. Table 9-2 lists the major functional operations of the MDB.

Table 9-2—MDB Operations

Operation	Function
Munitions processing	Prepare munitions for agent destruction and decontamination
Agent hydrolysis	Hydrolyze agent, decon solution, CST & IIPT condensate, agent concentrate, and agent wash water
Energetic hydrolysis	Hydrolyze energetics
Nonprocess waste treatment	Decontaminate nonprocess waste
Offgas treatment	Decontaminate offgas
Process control, personnel, and maintenance areas	Provide operation, maintenance, and personnel support

The following hazard categories (Table 9-3) have been defined to characterize the risk associated with the processing of chemical agent.

Table 9-3—Hazard Categories

Hazard Category	Description
A	Areas that have a high probability of contamination, either agent liquid or vapor (negative pressure related to atmosphere).
A/B	Areas with a high probability of agent vapor contamination and under certain process operating conditions assumed to be contaminated with liquid agent (negative pressure relative to atmosphere).
B	Areas with a high probability of agent vapor contamination resulting from routine operations (negative pressure).
C	Areas with a low probability of agent vapor contamination (negative pressure).
D	Areas that are unlikely to ever have agent contamination (atmospheric pressure).
E	Areas kept free from any chance of agent contamination barring a major event (positive pressure).

Walls, floors, ceilings, and all penetrations of Category A, A/B, B, and C areas are sealed to prevent migration of agent in liquid or vapor from/to other areas. These areas also have specialized materials applied to all building surfaces because of the possible presence of agent and subsequent decon solution exposure. All equipment and area layouts conform to the human factors engineering (HFE) requirements for personnel in demilitarization protective ensemble (DPE). All rooms are sized to accommodate the equipment housed in them with allowances made for equipment access. Category A, A/B, and B areas are also sized to allow DPE access.

Refer to Appendix E "Safety Design Requirement Manual" for further details.

9.3.2.1 Munitions Processing

Areas in the MDB that prepare the explosives, agents, and munitions for destruction and decontamination consist of the following activities, equipment, and vehicles.

A. Loading Area. Munitions are received at the MDB from the MSB using forklifts or directly from the Chemical Depot. Forklifts are used to transfer the munitions to the unpack area (UPA) in the MDB.

B. Unpack Area (UPA). The area classification of the UPA is Category C. The palletized reconfigured munitions are unpacked and transported by conveyor to the next stage of processing in the explosive containment vestibule (ECV). Contaminated dunnage is processed using the continuous stream treater (CST). Noncontaminated dunnage is transported back to the depot for later processing after the agent destruction campaign. Equipment airlocks between the UPA and the ECV maintain a negative pressure in the ECV, allow passage of munitions for further processing, and prevent spread of potential contamination.

C. Propellant Reconfiguration Room (PRR). The area classification of the PRR is Category C. The boxed nonreconfigured munitions are first processed through the PRR, where the propellant and igniter are separated from the 105-mm projectiles and the 4.2-in. mortars. The munitions are placed on a cart for transport during the reconfiguration process and, upon completion of the reconfiguration, are brought back to the UPA to be loaded onto the conveyors feeding the ECR. The dunnage is processed identically to that originating in the UPA. The propellant is boxed and sent back to the depot for processing after the agent destruction campaign.

D. Explosive Containment Vestibule (ECV). The area classification of the ECV is Category A/B. All munitions pass through the ECV on conveyors. From the ECV, munitions are transferred to one of two explosive containment rooms (ECRs). The ECV is sized to house the munitions and transporting and handling equipment. Access is provided for personnel in DPE suits.

E. Explosive Containment Room (ECR). The area classification of the ECR is Category A/B.

All munitions that contain energetic material are processed in one of the two ECRs for safety. Fuzes are removed from the munitions, deactivated in the energetic rotary deactivator (ERD), and conveyed to a small part collection basket outside the ECR. Bursters are also separated from the munitions and placed in a burster washout machine (BWM) where the energetic materials are removed and pumped as water slurry to the energetic neutralization system. After the energetic materials have been removed, projectiles are transferred via the ECV to the multipurpose demilitarization machine room, where the agent is removed. The ECR is designed to totally contain blast pressures, fragmentation, and release of chemical agent in the event of an accidental detonation during munition processing. Each ECR houses identical munitions processing equipment.

F. Multipurpose Demilitarization Machine Room (MDMR). The area classification of the MDMR is Category A. The MDMR is the area in which agent is removed from projectiles. After removing the burster well that is placed in the small part collection basket, the agent is drained from the munitions and pumped from the MDMR to the toxic room (TOX). The munitions are placed in the rotary washout machine, which uses high-pressure water to remove the remaining agent. The washwater and agent are separated, the water is recycled, and the agent concentrate is pumped to the TOX. The remaining metal casings are conveyed to the rotary metal parts treater (R-MPT) for decontamination. The small parts baskets are collected and conveyed to the batch metal parts treater (B-MPT).

G. Metal Parts Treatment Room (MPTR). The area classification of the MPTR is Category B. The washed munition bodies are introduced one at a time into the RMPT from the MDMR. The RMPT treats the munitions to a 5X level of decontamination and acts as airlock between the MDMR and the MPTR. Because it is impossible to monitor and verify complete agent destruction in the MPT before releasing the 5X munitions to the MPTR, the room is designated Category B. Monitoring boxes are provided to allow the residence time required for the ACAMS monitoring cycle. After agent destruction is verified, the munitions are conveyed through the airlocks to the residue handling area (RHA). The baskets containing small metal parts are introduced batch-wise in the B-MPT for 5X treatment. After treatment, the content of the B-MPT is monitored for agent and sent to the RHA. Offgas from both R-MPT and B-MPT is sent to the offgas treatment system.

H. Residue Handling Area (RHA). The area classification of the RHA is Category D. The 5X munitions are deformed by a hydraulic press mounted on the discharge conveyor and placed in a roll-off container for proper disposal. After the roll-off container is filled, it is moved into a fenced cooldown area just outside the building before it is transferred to the waste transfer area outside the facility. Small parts from the B-MPT are placed in another roll-off container for disposal.

9.3.2.2 Agent Processing

A. Toxic Room (TOX). The area classification of the TOX is Category A. The TOX contains the storage tanks for the neat agent and agent concentrate which are pumped from the MDMR. The agent is then pumped to the agent neutralization room (ANR) for destruction.

B. Agent Neutralization Room (ANR). The area classification of the ANR is Category A. Agent drained from the munitions is pumped from the storage tanks in the TOX to the agent hydrolyzers in the ANR. Agent is mixed with reagent (hot water) in a static mixer at the inlet of the reactor vessel, ensuring thorough mixing and dispersal of the agent into small droplets to promote reaction efficiency. The vessels are filled with the mixed agent/reagent stream and agitated for an appropriate time to ensure the destruction of the agent. After sampling for completeness of hydrolysis, the contents are pH adjusted and pumped to the hydrolysate storage tank in the hydrolysate tank room. The tank serves as a storage buffer for the biotreater unit.

Each ANR contains a storage tank that receives spent decon from collection sumps located throughout the MDB. The spent decon is then pumped from the storage tanks to the agent hydrolyzers for destruction.

C. Hydrolysate Tank Room (HTR). The area classification of the HTR is Category C. The hydrolysate storage tank in the HTR collects the agent-free hydrolysate from all agent hydrolyzers and the agent-free condensate from the MPT/CST condensate holding tanks. The hydrolysate is then pumped to the bioreactor feed tanks. Offgas from the hydrolysate storage tank is condensed and sent to the OTR.

9.3.2.3 Energetics Processing

A. Explosives Containment Room (ECR). The area classification of the ECR is Category A. Energetic materials are removed from the bursters in the ECR by high-pressure water jet pumps. The energetics slurry is then pumped to the energetics hydrolyzer located in the energetics neutralization room.

B. Energetics Neutralization Room (ENR). The area classification of the ENR is Category C. The energetics slurry is pumped from the ECR to one of the energetics hydrolyzers, where it is mixed with reagent (NaOH + hot water) in the appropriate amounts and mixed to promote hydrolytic reaction. Energetics hydrolysate is pumped to the energetics hydrolysate storage tank after sampling and determination that energetic materials no longer exist in the batch. At this point, the hydrolysate is pumped to the bioreactor feed tanks where additional nutrient is added to support the biota in the bioreactor. Offgas from the energetics hydrolyzers is sent to the OTR.

9.3.2.4 Nonprocess Waste Treatment and Offgas Treatment

A. Waste Shredding Room (WSR). The area classification of the WSR is Category B. The dunnage to be treated is placed on one of the airlock conveyors leading to the WSR. The agent-contaminated wood and DPE dunnage is shredded, metered, mixed with aggregate/carrier material, and fed to the CST through an enclosed conveyor.

B. Continuous Steam Treater (CST). The area classification of the CST is Category C. The CST hydrolyzes and treats the dunnage to a 5X level of decontamination. The ash and oversized materials are separated from the aggregate/carrier material and disposed of as 5X waste. The aggregate/carrier material is recycled to the WSR. The offgas from the CST is treated using a catalytic oxidation process before it is merged with the HVAC system.

C. Offgas Treatment Room (OTR). The area classification of the OTR is Category C. The process offgases from the rotary and batch metal parts, agent and energetics reactors, ERD and hydrolysate tanks and the offgas is treated using a catalytic oxidation process, then cooled before being merged with the building exhaust system.

D. Condensate Tank Room (CTR). The area classification of the CTR is Category C. The condensates from the CST offgas system and the MPT offgas system are collected in condensate tanks. The condensate tanks are tested for agent and pumped to the agent hydrolysate tank or processed through the agent reactors.

9.3.2.5 Process Control, Personnel, and Maintenance Areas

Areas in the MDB that house the process support and facilities equipment are discussed in the following subsections.

A. Toxic Maintenance Area (TMA). The area classification of the TMA is Category A. The TMA is used for maintenance of agent-contaminated parts and equipment.

B. Hydraulic Equipment Room (HER). The area classification of the HER is Category C. The HER houses the power units, reservoirs, hydraulic valve manifold, heat exchanger, and pumps for the hydraulically operated equipment used to process munitions in the ECR and MPB.

C. Electrical Rooms (ERs). The area classification of the ERs is Category D. The ERs contain switchgear, MCCs, and panelboards in a central location. The ERs also contain the rectifiers, chargers, inverters, and associated panels to keep the batteries charged and to distribute UPS power as needed for critical electrical loads. Two UPS systems, separated by a firewall, provide a reliable, redundant power supply for the MDB.

D. Battery Rooms (BRs). The area classification of the BRs is Category D.

The battery room contains the batteries needed for the parallel, redundant UPS systems.

9.3.2.6 Mechanical Equipment Room (MER)

The area classification of the MER is Category D. The MER houses the HVAC air-handling equipment to ventilate the process area. The associated chillers are located on a pad outside of the building. This room also contains the air-handling equipment for maintaining the positive control room (CON) environment. The filters and chillers for the CON are located on pads outside the room.

9.3.2.7 Control Room Area (CRA), Communications Room (COM), and Engineering Maintenance Room

The area classification of the CRA is Category E. The CRA on the first floor provides central control for all process-related and communications activities and houses the various process monitor stations and control consoles. The engineering/maintenance area serves as a central area for maintenance activities in the MDB. The COM houses the master public address (PA) console and the building radio system console. Common walls between the engineering/maintenance area, multipurpose room, shift operator’s office, and CRA have glass windows providing visibility to the operator consoles.

9.3.2.8 Observation and Multipurpose Room

The observation and multipurpose room functions as a reception area for visitors to the MDB.

9.3.2.9 Process Data Acquisition and Recording (PDAR) Room

The PDAR room houses the network servers and data storage devices.

9.3.2.10 Observation Corridor (OBV)

The area classification of the OBV is Category C.

Observation corridors on the first and second floors are used to monitor process activities and to observe personnel working in DPE. Observation windows are situated to provide unobstructed views of process areas (except in the ECRs).

9.3.3 BIOTREATMENT AREA (BTA)

The solutions from the hydrolysate storage tanks are pumped via an ICB™ feed tank to the bioreactors located in the BTA. The ICB feed is made up in feed tanks where agent hydrolysate and energetics hydrolysate are combined in a prescribed ratio (munition dependent) and diluted with recycled process water. Nutrient solutions are pumped from the bulk chemical storage system and added to the solution downstream of the feed tank. The nutrient mixture consists primarily of agricultural chemicals in water solution.

A total of sixteen bioreactors are provided in four independent modules. Each module consists of an ICB™ feed tank, four bioreactors, control systems, air blowers, and CATOX® unit. The bioreactor modules are arranged for parallel flow. The bioreactors flow is continuous (24 hours per day, 7 days per week).

9.3.4 PROCESS AUXILIARY BUILDING (PAB)

The PAB is an a Category D building that houses all process utilities that support the operation of the MDB.

Liquid effluent from the bioreactors in the BTA is flocculated and clarified (sludge removed) prior to being treated by an evaporator/crystallizer unit to remove dissolved salts. The water is recovered for reuse and the salts and suspended solids are collected, dewatered and the dried cakes are containerized for disposal.

The bulk chemical for process use and decontamination are stored in tanks surrounded by containment walls. The chemicals are pumped and distributed to all users and utility stations where required.

The secondary heat transfer systems provide the heating and cooling duties to the agent and energetics reactors. Maintaining an operating pressure above the reactors' operating pressures provides separation between agent-containing systems and the steam and cooling water systems.

The PAB has two electrical equipment rooms which contain 480V switchgear, motor control centers for both the PAB and the BTA, and local distribution panels.

SECTION 10

FACILITY DESIGN CRITERIA

10.1 CIVIL

10.1.1 SITE

The site encompasses 27 acres inside the perimeter fence. The site is flanked by Block G on the west, open areas on the north and east, and parking and waste transfer areas on the south.

10.1.2 ROADS

Roadways will be designed for use by vehicles with American Association of State Highway and Transportation Officials (AASHTO) designations of P, SU, BUS, WB-40, AND WB-50. Except for the patrol road, all roads consist of two 10-ft-wide lanes with 6-ft-wide gravel shoulders.

10.1.3 BUILDINGS

Buildings that do not contain explosive materials will be separated from the explosive storage buildings by a 200-ft intraline distance (excluding buildings with limited explosive inventory such as MDB with a maximum of 4 hrs inventory). Fire clearance separations between the new buildings will be maintained in accordance with MIL-HDBK-1008B.

10.1.4 UTILITY SYSTEMS

The firewater and process water distribution system will be designed to meet the design potable water plus process demand of 290 gpm together with the firewater demand of 2790 gpm. All the process water is sent through a water softener and then through a distribution system independent of the firewater system.

10.1.5 SANITARY SEWER SYSTEM

The gravity sewer system will be designed in accordance with TM 5-814-1.

10.1.6 STORM DRAINAGE

Drainage from inside the site will be directed away from structures and will be sent offsite to an interface outside the fence, at which point another contractor will design the storm drain system to a discharge point. The site underground storm drains will be designed for a 25-year storm frequency.

10.1.7 FENCING

The perimeter security fencing will be designed in accordance with Army Regulation (AR) 50-6-1 and will be located parallel to the roads—30 ft from the edge of the pavement in most cases. The two 7-ft chain link fences, topped with six strands of barbed wire, are 30 ft apart.

10.2 ARCHITECTURAL

10.2.1 BUILDING CONSTRUCTION

The facilities will be of one-story, noncombustible industrial type steel frame over concrete floor slab on grade construction. The building exteriors will be insulated composite metal wall panels and roof panels, and the roofs will slope 1-1/2 inches per foot.

10.2.2 AREA SEPARATION WALLS

The facilities will have area separation walls according to occupancy classifications set forth in the Uniform Building Code. See architectural floor plans for locations.

10.2.3 FIRE RATED WALLS AND OPENINGS

Fire rated walls will be located where required in the facilities according to the requirements in the Uniform Building Code and will bear the proper fire ratings. Openings in the fire rated walls will comply with the Uniform Building Code. See architectural floor plans for locations of fire rated walls and fire protection ratings.

10.2.4 TOXIC AREAS

Interior walls of toxic areas will be coated with specialized materials to facilitate wash down in the event of contamination. Emergency exit and entry doors will be located in the adjacent observation corridors to meet Life Safety Code requirements.

10.2.5 EMERGENCY EGRESS

Emergency exit doors and door components will be provided throughout the facilities in accordance with the Uniform Building Code and NFPA 101.

10.2.6 NOISE

Increases in ambient noise will occur from construction activities and increased traffic volume. Worker safety is of primary concern onsite, whereas public safety is the concern for offsite areas. Noise levels will meet the requirements of the U.S. Occupational Safety and Health Administration (OSHA) (Department of Labor Occupational Noise Exposure Standard, Code of Federal Regulations (CFR), Title 29, Chapter XVI, Part 1910, Subpart G, June 28, 1983) and the Department of the Army (Hearing Conservation Program, Regulation 385-1-89, January 19, 1983, and Technical Bulletin, Hearing Conservation, TB-MED-501, March 1980) relating to onsite worker safety and offsite public safety.

These documents establish the emission noise limits for Army material and prescribe testing requirements and measurement techniques for determining conformance to the limits herein. This standard applies to the design of all new systems, equipment, and facilities that emit acoustic noise to personnel areas.

The maximum allowable noise level intensity for personnel exposure will be less than 85 dBA during an 8-hr period. Unprotected personnel exposure to impulsive or impact noise will not exceed 140 dBA peak sound pressure level. The Control Room will be designed for a maximum ambient noise level of 65 dBA. A maximum 75 dBA level will be applied to process areas in which personnel are working and communication is required for safe performance of work tasks.

10.3 STRUCTURAL

The characteristics of the site are listed below:

(1)	Soil bearing capacity (allowable static bearing capacity for lightly loaded willow spread footings or continuous foundations):	
	Mat foundations (subgrade modulus):	100 pci
	Continuous footings:	2.1 kips/ft^2
	Spread footings:	2.5 kips/ft^2
	Differential settlements:	0.75 inch
(2)	Water table (normal groundwater elevation):	10–15 ft below existing grade
(3)	Precipitation (snow) Ground snow load:	10 psf (based on ASCE 7)
(4)	Basic wind speed:	90 mph at ground level (3-sec gust) (based on ASCE 7)
(5)	Seismic criteria:	See Appendix D

10.3.1 STRUCTURAL LOADS AND LOAD COMBINATIONS

All structures, structural loads, and load combinations will be governed by TI 809-01, Load Assumptions for Buildings, except as noted below:

(1) ASCE 7, Section 2, Combinations of Loads, will be used.

(2) Wind and snow loadings will be applied in accordance with ASCE 7, using the requirements of TI 809-01.

(3) Seismic loading will be applied in accordance with TI 809-04 (see Appendix D for seismic criteria).

10.3.1.1 Dead Loads

The weight of the member itself and all permanent construction including walls, floors, roofs, ceilings, and fixed service equipment will be considered dead loads. An allowance for routed mechanical, piping, HVAC, and electrical equipment of 20 psf will also be included on the roofs except for those of modular wood structures.

10.3.1.2 Live Loads

Minimum uniformly distributed live loads will be as follows:

(1)	Roofs:	20 psf or ASCE 7
(2)	Platform and work area:	100 psf
(3)	Light storage:	125 psf
(4)	Heavy storage:	250 psf
(5)	Office:	50 psf
(6)	Dining/meeting rooms:	100 psf

(7)	Laboratory:	125 psf
(8)	Toilet areas:	60 psf
(9)	Mechanical and electrical rooms:	150 psf
(10)	Stairs, fire escapes, corridors, and exits:	100 psf
(11)	Slab on grade:	250 psf or fork lift truck, 6-kip capacity (HS20-44 capacity in designated areas)

Additional live loads due to portable equipment (e.g., lifting hoists and portable jacks) will also be considered. The magnitude of these loads will be based on manufacturers' recommendations.

10.3.1.3 Snow Loads (based on ASCE 7)

Ground snow load: 10.0 psf for all buildings (importance factors 1.2 for MDB, LAB, PAB, and UB, and 1.0 for all others; exposure factor 1.0)

The appropriate factors will be used for built-up snow load and drifting.

10.3.1.4 Wind Loads (based on ASCE 7)

(1) Basic wind speed (3-sec gust): 90 mph (importance factors 1.15 for MDB, PAB, UB, and LAB; 1.0 for all others)

(2) Exposure classification: C

10.3.1.5 Seismic Loads (based on TI 809-04)

See Appendix D for seismic criteria and loads.

10.3.1.6 Impact Load

The impact load will be defined as an equivalent static force caused by a moving object. As a minimum, dynamic load factors (DLFs) will be as described in industry standards such as AASHTO, AISC, ASCE 7, or as required by the equipment manufacturer.

10.3.1.7 Thermal Load

The thermal load will be defined as those forces caused by a change in temperature. Such forces will include those caused by piping expansion or contraction.

10.3.1.8 Erection Load

The erection load will be defined as temporary forces caused by the erection of structures or equipment.

10.3.1.9 Blast and Fragment Loads

The blast and fragment loads due to an accidental explosion will be considered in the Explosion Containment Room (ECR) of the Munitions Demilitarization Building (MDB). The ECR will be designed to totally contain blast pressures, fragmentation and release of chemical agent in the event of an accidental detonation during munitions processing. It is estimated that maximum explosive value of the munitions processed in ECR in terms of equivalent TNT is approximately 4 pounds. This amount is based on the Safety Design Requirements Manual (Engineering Design Study), June 2000, prepared for the ACWA project. For structural design purposes, a minimum safety factor of 1.2 is required per Army Design Manual TM 5-1300. Thus rounding off to the nearest whole number, an equivalent TNT of 5 pounds will be used for the ECR design. The minimum standoff distance of the above equivalent TNT charge will be assumed at 6 ft from the walls and 3 ft above the floor for the design of structural and mechanical components of ECR.

Three munitions (105-mm/M60, 155-mm/M110, and 4.2-inch/M2A1) configuration and characteristics will be used to develop the fragment design criteria. The design fragments for these three munitions will be determined based on the guidance of Reference HNDM-1110-1-2 or test data of similar munitions or other appropriate references. For each design fragment, the fragment characteristics (size, weight and velocity) will be calculated or provided.

See Section 10.3.3.8 for blast and fragmentation design methods.

10.3.2 MATERIALS

(1) Structural steel: ASTM A36/A36M
ASTM A53, Grade B (steel pipe)
ASTM A500, Grade B (structural tubing)
ASTM A572, Grade 50 (high strength)

(2) Cast-in-place concrete: 4,000 psi minimum, 28-day compressive strength

(3) Concrete masonry units

(a) Hollow load-bearing units: ASTM C90
(b) Nonload-bearing units: ASTM C129
(c) Mortar: ASTM C270 (Type S)

(4) Concrete reinforcing steel: ASTM A615, Grade 60

(5) Welded wire fabric: ASTM A185

(6) Roof deck: Galvanized metal, ASTM A446, Grade A

(7) Floor deck: Galvanized metal, ASTM A446, Grade A

(8) Bolts, nuts, and washers

(a) High-strength

1. Bolts: ASTM A325 SC, Type 1
2. Nuts: ASTM A563, Grade A, Heavy Hex
3. Washers: ASTM F959 (Load Indicator)
ASTM F436 (Hardened Washer)

(b) Unfinished

1. Bolts: ASTM A307, Grade A
2. Nuts: ASTM A563, Grade A, Heavy Hex
3. Washers: ASTM F844

(9) Filler metal: AWS D1.1, including Table 10.1.1, E70XX Electrodes

(10) Pipe handrail and posts: 1½-inch IPS, ASTM A53, Type E or Type S, Grade B, rails and posts

(11) Floor grating: ASTM A569 steel, galvanized (unless otherwise noted)

10.3.3 DESIGN METHODS

(1) Concrete: Ultimate strength method

(2) Structural steel: Strength Method Using Load and Resistance Factor Design

Allowable Stress Method (ASD) an alternative to LRFD in accordance with AISC or TI

10.3.3.1 Concrete Structures

Concrete structure design will be based on the applicable sections of TI-809-02 and ACI 318. Reinforcement detailing and placement, including concrete protection for steel reinforcement, will conform to ACI 315 and 318, except that the minimum cover will be increased to 3 inches where concrete is exposed to immersion or other corrosive conditions. Such bars will be coated with epoxy. Formwork will be designed and constructed to ensure that the finished concrete members will conform accurately to the required dimensions, lines, and elevations. Precast concrete will be used only where it is necessary to attain close tolerances, minimum warpage, and a high-quality finish.

10.3.3.2 Steel Structures

Steel structure design will be based on TI 809-04 and the applicable sections of FEMA 302 and the AISC Manual of Steel Construction, LRFD, including AISC Seismic Provisions for Structural Steel Buildings.

10.3.3.3 Foundation Design

The foundations will be designed in accordance with the approved geotechnical reports and CEHND 1110-1-1. The foundation type and design must satisfy the limiting deflections required to ensure the proper performance of the building superstructure. Differential settlements will be in accordance with the recommendations of the geotechnical report or will be limited to L/600-L/1000, L/360-L/600, and L/200-L/360 for rigid, semirigid, and flexible systems, respectively, where L is the distance between the points in question.

Heavy vibration-producing equipment, such as air compressors, centrifuges, filter presses, chillers, fire pumps, and engine/generator sets, will have separate, isolated foundations. Other equipment will be provided with the appropriate vibration isolators. Nonvibrating equipment will be mounted on concrete housekeeping pads at least 6 inches above the finished floor elevation.

10.3.3.4 Masonry Walls

Masonry walls will be designed in accordance with TM 5-809-3 and ACI 530.

10.3.3.5 Lateral Walls

Exterior walls will be designed to withstand wind or seismic lateral loads while spanning vertically from floor to floor (or roof) or horizontally between columns, pilasters, or intersecting walls. The wall load will be determined from the worst possible combination of exterior and interior wind pressures (either inward or outward) or lateral seismic loads. Interior partitions will be spanned either horizontally or vertically. If interior partitions are spanned vertically, they must be supported at the top by the roof or floor framing.

Interior partitions will be designed to withstand a minimum lateral pressure of 5 psf for drywall and 10 psf for concrete masonry walls. Lateral seismic loads for both interior and exterior walls will be determined in accordance with TI 809-04.

10.3.3.6 Steel Stud Walls

Steel studs may be used with gypsum board or plaster for interior partitions. Steel stud shear walls will be designed in accordance with TI 809-07. Connections to the building frame at the top steel stud walls will allow independent movement of the frame, both vertically and longitudinally, to prevent loadbearing shear wall action.

10.3.3.7 Firewalls

The foundations for firewalls must be designed for the imposed loads. The lateral design load for firewalls will be a minimum of 10 psf. Where all (or a portion) of the wall is exposed to exterior wind loads, the design load will be increased accordingly.

10.3.3.8 Blast and Fragmentation Design of ECR

All structural and mechanical (blast doors, blast valves, and HVAC system) components of ECR will be designed to resist the blast pressure and fragment loads produced due to accidental explosion as defined in Section 10.3.1.9.

The blast design of the structural components will be in accordance with the requirements of TM 5-1300. The structural design acceptance criteria for ductility ratio (μ) and support rotation (θ) will not exceed the following values for various components.

Component	μ	θ (degrees)
Reinforced concrete structural components	6	1
Blast doors	1	1
Steel Plates	5	2
Steel beams	3	1

The thickness of various components will be sufficient to prevent penetration, perforation and scabbing for various design fragment criteria as established in Section 10.3.1.9. For the design guidance thickness of various components to prevent fragment penetration, perforation and scabbing, references DOE/TIC-11268 and SWRI-6714 or other appropriate references can be used.

For the design of mechanical components, Reference HNDM-1110-1-2 is recommended. Other appropriate references can also be used.

10.3.4 STEEL BUILDING FRAMING SYSTEM

The design will be in accordance with the AISC Manual of Steel Construction and TI-809-02, as applicable by TI 809-04. For purposes of design, assume columns of rigid frames to be fixed at the foundation. Bolted connections may be used for vertical load-carrying frames. Welded connections should be used for moment-resisting frames. However, high-strength bolted connections may be used for moment-resisting frames if economy will result or if needed for ease of construction. The design and construction of joist girders will be in accordance with CEHND 1110-1-1 and the SJI standard specification.

All vertical and horizontal bracing connections will be designed for the loads indicated on the drawings. Beams that are part of bracing systems will be connected for axial force in addition to shear connection. Beams greater than 10 ft long will have standard framed beam connections designed for the full shear capacity of the member in accordance with AISC specifications for structural steel joints. At least two bolts will be provided for beams and channels.

All structural bolts will be a minimum of 3/4-inch diameter and will conform to specifications for high-strength bolts for structural steel joints ASTM A325. Installation of high-strength bolts will conform to AISC specifications for structural joints using ASTM A325 bolts. All structural welding and welder qualifications will conform to the requirements of the AWS D1.1 Code for structural welding. All weld sizes will be at least the minimum required in accordance with AWS D1.1. Weld electrodes for structural welding will be low-hydrogen E70XX. All anchor bolts will conform to the specifications of ASTM A307 for carbon steel externally threaded standard fasteners. All anchor bolts will be hot-dipped or mechanically galvanized.

10.3.5 ROOFS

Composite metal panel roofing will be used for pre-engineered steel framed structures and for the MDB, PAB and UB. Structural framing for low-slope roofs will be designed to minimize deflection (to eliminate ponding) and to ensure that positive drainage is maintained. Flat valleys between drains are unacceptable. Lightweight insulating concrete will not be used for roof fill over composite metal roof decks.

Metal roofs will conform to the requirements of TI-809-02 and TI 809-29. The steel roof deck design will conform to the following requirements:

(1) Shear diaphragm design will conform to the requirements of the Steel Deck Institute (SDI) Diaphragm Design manual.

(2) The minimum thickness for roof decking will be 22 gauge.

(3) Where steel joists or light trusses are provided to support the metal roofs, a supplementary lateral bracing system will be provided for the top chord of the joists (or trusses).

10.3.6 RETAINING WALLS AND OTHER EARTH-RETAINING STRUCTURES

Lateral earth pressures on walls of below-grade structures or retaining walls will be based on the recommendations of the geotechnical report as noted in Section 10.3.10.3.

Surcharge loads will be included, where applicable. Acceptable practice is to design retaining walls for the following criteria:

(1) Resultant vertical loads fall within the middle third of the base.
(2) Bearing pressure at the toe must not exceed the allowable bearing pressure.
(3) Safety factor against overturning and sliding for wind must be at least 1.5 and 1.0 for seismic loading.

10.3.7 MONORAIL DESIGN

In addition to the AISC requirements, monorail beams will be designed for a maximum bending stress of $f = 12{,}000/(ld/bt) \leq 17{,}600$ psi based on the rated capacity of the hoist plus 25% impact and full dead loads for vertical loads and 20% of rated capacity plus 25% impact for horizontal loads. Vertical deflections will be limited to L/800. Impact loads will be omitted in deflection calculations. Beams will also be checked for a maximum overload of 2.75 times the rated hoist capacity at 75% of the yield stress.

An I beam with a horizontal channel on top may be used for all but very short spans. The hangers and system supporting the monorail beam will also be designed for a crane load of 2.75 times the rated hoist capacity but at normal AISC allowable stresses. Knee braces will be provided, where applicable. Field connections will be ASTM A325 bolted connections.

10.3.8 PREENGINEERED METAL BUILDINGS

Pre-engineered metal buildings are economical and suited for most buildings not requiring a custom design. The MDB, PAB, UB and the entry control facility (ECF) will be custom designed. Pre-engineered metal buildings will be designed in accordance with the requirements of TI -809-02. The following considerations apply to all pre-engineered buildings:

(1) Foundations will be designed by the SC and will be shown on the engineering drawings used for construction.

(2) The building supplier will be allowed minor variations in building dimensions to accommodate off-the-shelf designs.

(3) All loads required for the design of the building frames will be specified, including wind, seismic, and crane loadings.

(4) Applicable pre-engineered building notes will be added on the construction drawings.

(5) The design analysis prepared by the Contractor will include the following information:

   (a) Manufacturer's pre-engineered building calculations, including foundation loads.

   (b) Professional Engineer (PE)-stamped structural certification of design criteria compliance from the pre-engineered building manufacturer.

   (c) PE-stamped drawings from the pre-engineered building manufacturer.

10.3.9 TRAVELING CRANE RUNWAY GIRDERS

Crane runway girder loads will be based on ASCE 7. Adjustable bolted connections will be used to fasten rails to girders. Welded connections are not permitted. Runway girders may be designed as either simple or continuous members subject to the following limitations:

(1) Continuous girders will not be used where significant unequal foundation settlement is likely to occur. Where foundations are other than shale or hard rock, check anticipated differential settlement so that the difference is limited to 0.003 L between adjacent supports.

(2) Limit live load deflection at the mid-span to L/800.

(3) For continuous girders, limit the ratio of the length of the adjacent spans to 2:1.

(4) Connect the ends of simply supported girders so that the ends can rotate under vertical loading.

10.3.10 GEOTECHNICAL CRITERIA

10.3.10.1 Soil Characteristics

The allowable net static soil bearing capacities are assumed to vary from 2100 lb/ft^2 for continuous foundations to 2500 lb/ft^2 for the spread foundation. The differential settlements should be limited to 0.75 inch using the above soil bearing values. The mat foundations will be designed using 100-pci vertical subgrade modulus.

10.3.10.2 Foundation Types

Foundations will be spread footings, grade beam system, or mat foundation, except for foundations for large tanks on the ground, which will be supported by mat foundations or structural slabs on ring walls.

10.3.10.3 Foundation Considerations

Groundwater elevations are assumed to vary from 10 to 15 ft from existing grade elevations. Seasonal variations in rainfall and other factors may appreciably alter the depth of the ground water elevations.

All foundations will extend a minimum of 3-ft 0-inch below grade for possible frost considerations.

Footings will be proportioned to minimize the differential settlement under the service load. The service load will be taken as the dead load plus the live and/or snow load.

10.4 MECHANICAL

10.4.1 HVAC

The purpose of the HVAC system is to provide ACWA with highly reliable controlled air environments to suit many variable and diverse critical requirements. The HVAC system is vital for orderly and safe facilities operation. It provides for controlled air temperature and pressure as well as flows of tempered air to keep contaminants within special confining areas. The system objective is to minimize the spread of contamination and protect the equipment/building areas and the site environs from exposure. Facility operations involve the use of electronic control, monitoring, and communications systems that require tempered air environments for stability, accuracy, reliability, availability, and long life. To the maximum extent possible, the facility will be designed to provide agent confinement through the effective use of physical separation between toxic and nontoxic areas and through the use of a ventilation system design that incorporates progressive negative differential pressures. The building design must also facilitate the HVAC design goals with airtight construction and appropriate airlocks.

Where systems or components are shown to be critical to safety, the systems will be designated as essential or critical as identified on the MEL and will comprise redundant systems, components, and/or power supplies. These systems or components will not be subject to the same single-point or common-mode failure. The required HVAC systems will comprise an array of air intakes, air-handling units, air distribution ductwork systems, cooling and heating systems, automatic control dampers, volume dampers, control systems, exhaust air filter systems, and exhaust stack, all custom designed to support the mission requirements.

10.4.1.1 Agent Contamination Containment

For facility design, operational purposes, and personnel protection during operations, hazard and ventilation categories and concentration limits have been established based on the degree of hazard existing for a worker. This indicates the potential exposure possible in the working areas and predicts the likelihood of chemical warfare agent (CWA) being present. HVAC systems will be designed to implement and conform to these criteria.

The ACWA areas are categorized to designate the potential for agent contamination. These categories are defined as Category A, A/B, B, C, D, and E as shown in Table 9.3.

These classifications will determine the type and magnitude of contamination control measures required in a particular area.

Category A, A/B, B, and C areas will be maintained under negative pressures in a cascade arrangement with Category A being the most negative and Category C the least negative. Category D will be at ambient pressure. The process area with the greater probability of contamination will be maintained at a lower pressure than an adjacent area with a lower probability of contamination so that filtration is always from a lesser area to a higher probability-of-contamination area. Category E areas will be supplied with air filtered through a carbon bed for removal of any atmospheric agent contamination and maintained under positive pressure with respect to the ambient pressure.

10.4.1.2 Toxic Area Ventilation Systems

A. General Requirements

Work areas where agent may be present will be provided with an appropriate ventilation system that will fulfill the following requirements:

(1) Collect and exhaust agent vapors from the work area.

(2) Provide mixing of air that is essential for point sampling and monitoring of agent concentrations.

(3) Provide a relatively negative pressure within the work area to prevent the exfiltration of agent aerosols, vapors, and gases to an area of lesser contamination probability.

(4) Filter the air that is released to the atmosphere through high-efficiency particulate air (HEPA) and carbon filters.

B. Cascade Ventilation System

A cascade ventilation system that fulfills the following requirements will be used to serve the Category A, A/B, B, and C process areas:

(1) The ventilation system will include balancing and isolation dampers with a fail-safe design to preclude the reverse flow of ventilation air and isolate toxic areas in the event of the loss of adequate airflow. Isolation dampers will be of the round butterfly valve type and bubble tight to 4 in. wg.

(2) Ductwork exposed to agent-contaminated air, either internally or externally, will be round and airtight. Duct seams and joints for exterior installations will be fully welded. Ductwork will be designed to withstand the maximum positive or negative

pressures to which it could be exposed during normal operations or upset conditions in the space served.

(3) The minimum transport velocity in the duct sections that handle contaminated air should be sufficient to entrain toxic agent aerosol particles ranging from 0.1 to 100 microns. A minimum velocity of 1,800 ft/min (taken from the Design Criteria Handbook) is required, except for small ducts of 4-inch diameter or less where velocity will produce excessively turbulent flow.

(4) Duct penetrations through walls, floors, and ceilings separating ventilation categories will be totally sealed to prevent leakage. A seal with hydrostatic integrity and chemical resistance to agent and decontamination solution will be used. With metal walls, a companion flange that is fully welded to the duct, bolted and gasketed, and/or is fully welded to the penetrated member can be used.

(5) A 6-inch minimum clearance will be provided between ducts and ceiling, wall, or floors to facilitate decontamination of areas and ductwork exteriors in Category A, B, and C areas.

(6) The cascade system will supply 100% outside air and 100% exhaust. Air will be supplied primarily to Category C areas. The air will then be transferred to areas with successively more contamination potential using balancing dampers to achieve the required pressure differentials. The total amount of air exhausted from the process area of the munitions demilitarization building (MDB) will be controlled automatically to maintain the desired airflow.

(7) Airflow from one area to an adjacent area will be controlled through sized openings. Air velocities (capture air velocities) through these openings, and room-to-room air velocity across openings (where no airlock is present) will be a minimum of 150 ft/min (taken from the Design Criteria Handbook).

(8) The criteria used to determine the inside design conditions for the cascade ventilation system are listed in Section 10.4.1.8. Relative humidity will not be controlled, except as a result of dehumidification at the supply air cooling coil.

(9) The ducts entering and leaving the Category A, A/B spaces will avoid liquid agent transfer by sloping downward to the Category A area. Baffles, louvers, or duct direction changes will be used to prevent possible flows of decontamination solution from a contaminated area to a cleaner area.

(10) Filter units for ventilation air will consist of a series arrangement of particulate roughing filter, HEPA filter, six carbon adsorption banks, and a final HEPA filter. The arrangement of units will permit access for maintenance and the ability to monitor for agent between the carbon banks and at the filter stack.

(11) The exhaust system will be provided with variable-frequency/speed motor fans to compensate for loading the filters and to provide the minimum design airflow.

(12) The exhaust filter system will incorporate isolation dampers both upstream and downstream of the filters. The dampers will automatically close airtight if there is a loss of airflow in the system.

(13) The ventilation air exhaust fan will be located downstream of the filter system. If the fan is mounted externally on a separate skid from the filter unit, the fan will have flexible connections in suction and discharge ducts for vibration isolation. The maximum noise level at any point within 3 ft of the exhaust fan will be no greater than 85 dBA.

(14) Instrumentation will be provided to monitor and control the airflow through the filter system. The instrumentation will provide a means to monitor an overall pressure drop as well as the pressure drop across each filter element. The instrumentation will also control flow through the filter system at specified levels as a function of pressure drop.

(15) Differential pressure or airflow gauges with appropriate alarms will be used to verify and signal proper ventilation conditions throughout the facility. Instrumentation outputs will be connected to the facility control system to show the overall facility ventilation status within the central control room area (CRA).

(16) The ventilation system exhaust stacks will release the effluent at an elevation that prevents recirculation into the low-pressure zone induced over a building by wind flow. If exhaust is discharged vertically, the stack will be provided with a trapped drain at the stack base. Exhaust stacks will extend at least 6 ft above the roof of the tallest building in the immediate area.

(17) Vestibules, which serve as a buffer between the Category D areas or between the outside and Category C areas, will be ventilated in accordance with standard industrial practice. Vestibules also serve to prevent ventilation upsets in process areas due to wind pressure on exterior doors.

(18) Airlocks will be used as transitions between areas of differing air pressure and to prevent the spread of contamination. Airlocks, which are used primarily for process-related operations and equipment movement, will be ventilated at a rate appropriate to their category designations (refer to Table 10-1).

(19) When a Category A airlock is egressing personnel or material, a timed purge cycle will be implemented. In this cycle, the ventilation airflow rate for the airlock will be sufficient to achieve two complete air changes within 2 minutes, before allowing persons to exit. The airflow change rate for an airlock when not in use will be the same as that provided for process areas of the same contamination category. Airlock doors will be provided with power assist for opening against differential pressures higher then 0.25-inch wg.

(20) Personnel airlocks associated with passage between Category A and B areas and between Category B and C areas will have interface air velocities of 150 ft/min and a two-air change purge of each airlock between successive openings of airlock doors during an egress. Interlocks will be installed to control the purges and to ensure that both doors are never open at the same time. A manual override system will be provided for emergency egress. Interlocks will also be provided for doors associated with Category D vestibules and areas where opening of more than one set of doors might result in a loss of the integrity of the Category C area boundary.

(21) The Category A, A/B, B, and C personnel airlocks and decontamination rooms used for transit between clean and contaminated work areas have a cascaded airflow from the cleanest to the most contaminated areas. The resistance to airflow must be adequate to maintain space pressure within the ranges stated in Table 10-2 (taken from Design Criteria Handbook).

(22) All ventilation airflow to airlocks will be supplied from building areas of lower probable contamination levels and exhausted to areas of higher probable contamination. All air supply and exhaust fixtures will avoid dead spaces by air diffusion and purging.

(23) The cascade ventilation will be designed to accommodate accurate and representative agent monitoring. The miniature automatic continuous air monitoring system (ACAMS) includes the area and in-duct sampling points that must be placed in locations that will provide reliable data on agent concentrations. ACAMS sampling points will also be located in the filter housings to detect agent breakthrough.

(24) Ducts penetrating security exclusion boundaries will be provided with internal protective grillwork in accordance with AR 190-59, Chemical Agent Security Program. Pressure drops associated with this grillwork must be accounted for properly in the duct sizing calculations.

(25) Duct penetration through the explosive containment room (ECR) will be designed to withstand blast loading and overpressures from the maximum credible event in the ECR, without shearing, rupturing, or leaking.

(26) All conduits, piping, ducts, and sewer lines traversing the facility areas must be designed to preclude reverse flow or infiltration of hazardous materials and/or ventilation air to areas of lesser probability of contamination. Consideration must be made for leaktightness, redundancy, and isolation control.

(27) Duct penetrations through walls, floors, and ceilings separating ventilation categories will be totally sealed to prevent leakage. A seal with hydrostatic integrity and chemical resistance to agent and decontamination solution will be used. With metal walls, a companion flange full welded to the duct, bolted and gasketed, and/or full welded to the penetrated member can be used.

(28) Areas that might be isolated during a malfunction of the HVAC or during fire conditions must be vented properly to prevent overpressurization and possible structural damage to the toxic area walls, floors and ceilings. The preferred approach is to use ungasketed fire dampers on the exhaust from a Category A area. This configuration will allow the room to vent directly to the cascade ventilation exhaust system, even with closure of the area fire dampers. In the event of fire in one of the fire zones, the fire dampers will isolate the normal ventilation flow path to these areas. Area relief dampers or automatic bypass dampers will be provided to ensure continuous airflow through the other process areas. Fire dampers on the supply and transition ducts will be of the gasketed type to limit the spread of smoke.

(29) Airflow volumes through individual supply and transition ducts should be reduced to prevent significant pressure transients from occurring in the event of inadvertent

closure of isolation or fire dampers. The system should comprise many zones in parallel rather than in series to reduce the severity of possible inadvertent isolation transients. To this end, main supply ducts feeding more than one parallel zone will be routed so that large isolation dampers or fire dampers are not required.

Minimum air exchange rates are presented in Table 10-1 (taken from Design Criteria Handbook). The priority of ventilation criteria, if it is not possible to meet all, will be as follows: capture velocity, pressure differential, and air changes.

Table 10-1—Ventilation Rates

Category	Air Changes (hr)
A (work areas)	20
A/B	20
A (airlocks)	60
B (work areas)	10
B (airlocks)	30
C (work areas)	6
C (airlocks)	30
D work areas with engineered exhaust systems	6
Other D work areas	Ventilation per American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 62
E work areas	Positive pressure, ventilation per ASHRAE Standard 62, (20 cfm per person)

Table 10-2—Pressurization

Category	Inch wg
A	–0.75 to –1.50
A/B	–0.75 to –1.50
B	–0.50 to –0.60
C airlock	–0.35
C work area	–0.25
D work area with engineered exhaust systems	–0.10 to –0.20
Other D work areas	Atmospheric
E work areas	Positive with respect to atmosphere +0.10 to +0.20

10.4.1.3 Process (Nontoxic) Building Ventilation Systems

Ventilation systems for Category D equipment rooms will be designed in accordance with standard industrial practice. ASHRAE Standard 62 will be followed for minimum ventilation rates based on cubic foot per person or foot squared, as required. Air change rates will be adequate to limit inside temperatures to 10°F above ambient temperatures during summer operations, while maintaining essentially atmospheric pressure in the areas served. Spaces will be heated to a minimum of 50°F during winter operations. Equipment room ventilation systems will be independent of the cascade ventilation system.

10.4.1.4 Control Room HVAC system

The system will maintain proper positive pressure relationship between the areas served with respect to the toxic process areas of the MDB, and provide (by means of particulate and absorption filtration) a safe environment for personnel operating the facility, in the event of an accidental release of chemical agent. This configuration allows for a safe shutdown of the facility. The system will maintain temperature and humidity conditions as required by the control and data processing equipment. The Control Room air conditioning system will be fed from the essential (emergency) power system.

10.4.1.5 Electrical Equipment Room HVAC Systems

These systems will normally be air conditioned in accordance with ASHRAE 62 guidelines and will be maintained at a maximum temperature of 95°F to increase the operating life and reliability of electrical equipment. Battery and uninterruptible power supply (UPS) areas will be maintained at 75°F in summer and winter to ensure that the electrical equipment will perform at the rated capacity. Battery areas will be exhausted directly to outside areas to preclude buildup of hydrogen, which occurs during charging.

10.4.1.6 Personnel Area HVAC Systems

These areas will be provided with HVAC consistent with usage to provide for comfort and indoor air quality in accordance with ASHRAE 62.

10.4.1.7 HVAC Instrumentation and Controls

The control system will be an integrated system of centrally controlled manual, semiautomatic, and automatic controls with remote monitoring of system status. The hazardous and critical nature of the demilitarization facility requires this approach for operational safety.

Control systems will be as simple as possible to ensure reliability, while meeting design requirements. The systems will provide for automatic compensation to meet load changes and conserve energy. Limit controls and safety controls will be included to achieve fail-safe operations and are to permit override by operating personnel, when required. Controls may be pneumatic or electric.

10.4.1.8 Plant Interior Design Conditions

(1) Summer indoor design conditions, maximum temperatures

- (a) Toxic and process spaces with personnel: 60° to 85°F
- (b) Unoccupied toxic process areas: 100°F

(c)	Unoccupied nontoxic process areas:	102°F (or 10°F above design dry bulb)
(d)	MDB lab area:	75°F ±2°F
(e)	Control Room:	75°F ±2°F
(f)	Control Room relative humidity:	50%
(g)	Battery rooms:	75°F
(h)	UPS rooms:	75°F
(i)	Mechanical Equipment Room (MER):	102°F (10°F above ambient)
(j)	Electrical rooms:	95°F
(k)	Standby generator rooms:	102°F standby 120°F operating
(l)	Toilets:	transfer air
(m)	Offices, lunch rooms, lockers, etc.:	75°F

(2) Winter indoor design conditions, minimum temperatures

(a)	Toxic and process spaces with personnel:	60°F
(b)	Unoccupied process areas:	50°F
(c)	MDB lab area:	65°F–70°F
(d)	Control Room:	75°F ±2°F

(3) Winter indoor design conditions (Category D)

(a)	MER:	50°F
(b)	Unoccupied process areas:	50°F
(c)	Electrical rooms:	50°F
(d)	Battery rooms:	75°F
(e)	UPS rooms:	50°F
(f)	Toilets:	no heating, transfer air
(g)	Offices, lunchrooms, lockers, etc.:	65°–70°F

(4) Margins of safety used during detailed design

The margin of safety used during detailed design will be 20% and will be applied when calculating heat releases and heat losses. Cooling and heating airflow rates are then calculated without safety margins. Margins of safety are not used to determine airflow rates based on air change rate or capture velocity. They are not applied when calculating cooling or heating water flow rates for building heating and cooling cases.

10.4.2 PLUMBING SYSTEMS

The design analysis describes the general plumbing systems (including any potable and industrial water and any sanitary and waste required for MDB) from a point of connection 5 ft outside the structure.

These systems are designed in accordance with the latest editions of all pertinent codes, guides, and regulations of:

(1) Military documents
(2) Federal and state regulatory agencies
(3) National Standard Plumbing Code (NSPC)

10.4.2.1 Potable Water

The potable water is supplied from the site water main from a point of connection 5 ft outside the structure. The system is designed for a minimum of 25 psi at the highest, most remote outlet. The potable water is supplied to all plumbing related fixtures and industrial water to the laboratory areas.

The hot water is provided from electrical storage-type water heaters equipped with 7-day time clock control and circulating pumps, where necessary.

10.4.2.2 Industrial Cold and Hot Water

The industrial cold and hot water system serves the laboratory sinks, cup sinks, deionization units, and dishwasher.

10.4.2.3 Emergency Showers

Multiple "point of use" mixing valves are located at the emergency showers/eyewash and eyewash stations, mixing potable cold and hot water as needed to provide a tepid water supply for emergency use. This provision ensures a hygienic water system to keep the bacterial contamination to a minimum.

The emergency shower/eyewash equipment water output will be restricted and limited by a flow control device to a maximum of 20 gpm. These restrictions ensure the proper performance of the eyewash when both devices are used simultaneously. All emergency shower/eyewash stations shall be equipped with a flashing light that actuates on use of the equipment.

10.4.2.4 Sanitary Facilities

The sanitary facilities are based on the minimum occupant requirements for industrial use, including water closets, urinals, lavatories, service sinks, laboratory plumbing fixtures, equipment, and emergency showers/eyewash stations.

All plumbing fixtures and mechanical equipment drain by gravity to the site sanitary sewer system at an interface connection 5 ft outside the structure. Each plumbing fixture is vented through individual vents collected and vented through the roof.

10.4.2.5 Laboratory Waste

The laboratory waste drains by gravity within a crawl space through a trench into a waste storage tank onsite and all pertaining vents are connected to the mechanical exhaust.

10.4.2.6 Plumbing Fixtures

The plumbing fixtures include wall-mounted water closets, wall-mounted urinals, lavatories, service sinks, and electric water coolers.

10.4.2.7 Specialty Items

Compressed gases are supplied to the NMR and MDB laboratory areas. Each gas is hard-piped throughout the building. The pressure at the delivery points for helium, nitrogen, and air will be 80 psi (minimum); for hydrogen, 60 psi. The gas cylinders are located near the area of use and run through the crawl space to the point of use.

Spare cylinders are stored in a dedicated area. Compressed air is provided by the plant air system.

10.5 ELECTRICAL

10.5.1 LOAD CLASSIFICATIONS

During normal plant operation all loads are powered by utility power brought onsite from an offsite substation via cables in underground duct banks. In the event of a "loss of utility power," essential and critical loads of the plant are powered by onsite generators. In the event of a total "loss of all utility and onsite ac power," critical loads are powered by the battery-backed UPS power. Plant loads are classified as follows:

(1) **Utility Loads** are nonessential loads normally powered by utility power and are not required to operate subsequent to a "loss of utility power" event. Utility loads are all station loads not specifically identified as Essential or Critical and are, therefore, not required for verification of safe suspended plant operations.

(2) **Essential Loads** are loads normally powered by utility power, but are required to operate subsequent to a "loss of utility power" event. These loads are powered from a diesel generator-backed bus and are, therefore, repowered automatically following starting and connection of the diesel generator power. Generally, essential loads will be the following:

   (a) Emergency lighting system
   (b) Uninterruptible power supplies (UPSs)
   (c) Control room HVAC system
   (d) Electrical area ventilation system
   (e) Cascade ventilation system
   (f) Fire detection and protection systems
   (g) Diesel generator auxiliaries and battery charger
   (h) Battery chargers for switchgear control power
   (i) Process loads (pumps, valves, etc.) required to be energized to ensure safe suspended operation
   (j) Emergency building heating
   (k) Security systems

(3) **Critical Loads** are loads normally powered by utility power, but are required to operate uninterrupted subsequent to a "loss of utility power" event. These loads are continuously powered from an uninterruptible power supply during and subsequent to a "loss of utility power" event. Generally, critical loads will be the following:

(a) Agent monitoring instrumentation (ACAMS)
(b) Controls
(c) Communications systems
(d) Alarms and annunciators
(e) Control room lighting
(f) Miscellaneous loads identified as critical loads (e.g., air lock doors)

10.5.2 General Basis of Electrical Design

One 115-kV utility power line will be feeding an outdoor switchyard and substation consisting of two 115-kV circuit breakers, two 115-kV: 4160V power transformers (each with secondary neutral grounding resistor) and one outdoor 4160V double-ended switchgear. Two 4160V feeder breakers, one from each side of the tie-breaker, will be assigned for the facility load. Separate Train A and Train B underground duct bank will be provided from these feeder breakers to the battery limit of the facility.

The duct bank will be extended inside the battery limit to a double-ended main 4160V switchgear lineup with a normally open tie-breaker. Bus A and Bus B of the main switchgear are considered Train A and Train B. Four 4160V motor control centers will be provided to handle the 4160V loads.

Three 4160V standby emergency diesel generators will be provided. One diesel generator will be connected to each bus of the main 4160V switchgear,

Five double-ended 480Y/277V switchgear lineups, each with a normally open tie-breaker, will be provided. Bus A and Bus B of each switchgear will be considered Train A and Train B.

In the event of total loss of utility power, plant operation will be suspended. The standby diesel generators will start automatically and will provide power to the main 4160V switchgear within 10 seconds after receipt of start signal. This will provide the facility operating personnel with the ability to power the required equipment and instrumentation necessary to allow an orderly shutdown and to verify that the suspension of operations has occurred in a safe manner. The diesel generators will have the capability of being paralleled with either utility power supply.

A UPS system will provide power to 480Y/277V and 208Y/120V critical loads that cannot tolerate power interruption or require reliable and regulated ac power.

10.5.3 Available Power Supplies

The following power supplies will be available via the facility electrical distribution system:

(1) 4160V, 3 phase, 60 Hz
(2) 480Y/277V, 3 phase, 60 Hz
(3) 208Y/120V, 3 phase, 60 Hz

Electrical equipment voltage ratings are given in Section 7.

10.5.4 Backup Power Supplies

10.5.4.1 Emergency Standby Diesel Generators

Three standby diesel generators will be provided, each with its own 4160V switchgear to form one 4160V essential switchgear. The 4160V essential switchgear will be connected to each bus of the main 4160V switchgear to supply essential loads in the event of loss of utility power.

Upon receiving the automatic start signal, the diesel generator will assume loads within 10 seconds. Following restoration of utility power, the generator will automatically synchronize with the utility source and transfer the loads to the utility power. These generators will be able to synchronize with each other and with the utility source.

10.5.4.2 Uninterruptible Power Supply

UPS systems will provide regulated battery backup power for sensitive electrical and all instrumentation equipment. The UPSs will also provide power to loads that ensure safe suspended operations and cannot tolerate power interruption, even during the time it takes the diesel generators to start and come on line.

One redundant facility UPS system will be provided for the entire plant in the Electrical Room of the MDB. The UPS system batteries will have a 45-minute duty cycle and will provide power for all critical loads in the facility.

10.5.5 ELECTRICAL LOADS

10.5.5.1 Motor Ratings

Motor ratings will be as follows:

(1)	Motors larger than 150 HP:	4,000V, 3 phase, 60 Hz
(2)	Motors ½ HP to 150 HP:	460V, 3 phase, 60 Hz
(3)	Motors less than ½ HP:	115V, 1 phase, 60 Hz

10.5.5.2 Ratings of Instrumentation and Control Devices

Instrumentation and control circuit devices will be rated at 115V, single-phase, 60-Hz and at 24 Vdc as required.

10.5.5.3 Ratings of Other Electrical Equipment

Ratings of other electrical equipment will be as follows:

(1)	Power receptacles:	480V, 3 phase, 60 Hz
(2)	Lighting fixtures:	480V, 277V, 120V, 1 phase, 60 Hz
(3)	Convenience receptacles:	120V, 1 phase, 60 Hz

Note: UPS and variable frequency drive (VFD) equipment will include filters to limit the harmonic currents to within the 5% limit specified in IEEE-519.

10.5.5.4 4160V Switchgear

The 4160V switchgear lineups will be located in the following areas:

Tag Number	Service	Location
31-SWGR-201A/B	Substation 4160V Switchgear A/B	Electrical Substation
02-SWGR-201A/B	Main 4160V Switchgear A/B	Utility Building (UB)
10-SWGR-201A	Generator 4160V Switchgear A	Standby Diesel Generator (SDG1)
10-SWGR-201B	Generator 4160V Switchgear B	Standby Diesel Generator (SDG2)
10-SWGR-201C	Generator 4160V Switchgear C	Standby Diesel Generator (SDG3)

The electrical substation is provided outside the facility fence line to receive incoming power at 115 kV from the utility company. 4160V feeder circuit breakers will supply essential and nonessential power to 4160V motor control centers, 4000V motors (200 HP and larger) and to 480V switchgear lineups (through their respective 4160V: 480Y/277V transformers).

The main 4160V switchgear located in the Utility Building (UB) will supply power to 4160V motor control centers, 4000V motors (200 HP and larger) and all 480V switchgear lineups in the facility.

The two 4160V switchgear lineups located in the standby diesel generator buildings (SDGs) will include 4160V load bank and generator protection and controls.

The switchgear lineups will be indoor, heavy-duty, metal-clad types with horizontal drawout vacuum circuit breakers.

A 125-Vdc battery system consisting of battery charger, batteries, and dc distribution panelboard will be provided for each 4160V switchgear location for switchgear control power. The batteries will be valve-regulated lead acid (VRLA) types.

10.5.5.5 4160V Motor Control Centers

The 4160V motor control center lineups will be located in the following areas:

Tag Number	Service	Location
01-MCC-201A/B	4160V MCCs A/B	Munitions Demil Building (MDB)
44-MCC-201A/B	4160V MCCs A/B	Process Auxiliary Building (PAB)

4160V motor control centers will be powered from the main 4160V switchgear in the UB. Large non-motor loads and motors, 200 HP and larger, will be supplied from the 4160V motor control centers. Fused vacuum contactors with required protection will be provided at the 4160V motor control centers for these loads.

10.5.5.6 480V Switchgear

The 480V switchgear lineups will be located in the following areas:

Tag Number	Service	Location
01-SWGR-301A/B	480V Switchgear A/B	Munitions Demil Building (MDB)
01-SWGR-302A/B	480V Switchgear A/B	MDB Chillers (located in PEPC-1A/1B)
02-SWGR-301A/B	480V Switchgear A/B	Utility Building (UB)
23-SWGR-301A/B	480V Switchgear A/B	MDB Filters (located in PEPC-1A/1B)
44-SWGR-301A/B	480V Switchgear A/B	Process Auxiliary Building (PAB)

All the 480V switchgear lineups will be provided with ventilated dry transformers rated 4160V: 480Y/277V, 3-phase, 4-wire, 60 Hz with secondary neutral solidly grounded.

The switchgear lineups will be indoor, metal-enclosed types with horizontal drawout air circuit breakers. Feeder circuit breakers will supply essential and nonessential motor control centers and motors 100 HP and larger, up to (but not including) 200 HP.

The switchgear circuit breakers will have adjustable long-time, short-time or instantaneous and ground trip functions. Breakers will be electrically operated for manual control in local mode and for automatic control in remote mode.

A 125-Vdc battery system consisting of battery charger, batteries, and dc distribution panelboard will be provided for each 480V switchgear location for switchgear control power. The batteries will be valve-regulated lead acid (VRLA) types.

10.5.5.7 480V Motor Control Centers

The 480V motor control center lineups will be located in the following areas:

Tag Number	Service	Location
01-MCC-301A/B	480V MCC A/B	Munitions Demil Building (MDB)
01-MCC-302A/B	480V MCC A/B	Munitions Demil Building (MDB)
01-MCC-303A/B	480V MCC A/B	Munitions Demil Building (MDB)
01-MCC-304A/B	480V MCC A/B	Munitions Demil Building (MDB)
01-MCC-305A/B	480V MCC A/B	Munitions Demil Building (MDB)
01-MCC-306A/B	480V MCC A/B	Munitions Demil Building (MDB)
01-MCC-310A/B	480V MCC A/B	For MDB CHIL & FIL (in PEPC-1A/1B)
02-MCC-301A/B	480V MCC A/B	Utility Building (UB)
02-MCC-302	480V MCC	Utility Building (UB)
10-MCC-301A/B/C	480V MCC A/B/C	Standby Diesel Gens (SDG1, SDG2, SDG3)
43-MCC-301A/B	480V MCC A/B	For Biotreaters & Bioreactors (in PAB)
44-MCC-301A/B	480V MCC A/B	Process Auxiliary Building (PAB)
44-MCC-302	480V MCC	Process Auxiliary Building (PAB)

Essential and nonessential 480V motor control centers will be located throughout the facility and will be powered from the 480V switchgear lineups. The 480V motor control centers will distribute 480V power to power distribution and lighting panels; 480V non-motor loads and motors less than 100 HP will be supplied from the motor control centers. Short-circuit and overload protection will be provided for all motor and non-motor loads. Motor circuit protection (MCP) will be provided for all motor loads.

10.5.5.8 Standby Diesel Generators

Three standby diesel generators (SDGs) will be provided to supply power to the facility essential loads. The SDGs will be rated 4160V, 3-phase, 60-Hz, wye-connected, low-resistance grounded with 0.8 power factor. Each SDG will be stand-alone located with its respective 4160V generator switchgear and 480V motor control center (for auxiliaries) in its own dedicated prefabricated electrical power center (PEPC).

The SDGs and associated generator 4160V switchgear lineups will be supplied via common supplier. A multifunction protection package will be provided for each generator to include under/over frequency, undervoltage, overvoltage, negative sequence, reverse power, overcurrent, ground, loss of field, synchronization as a minimum.

Each diesel generator will have a dedicated electric starting system with black-start capability and will include batteries and battery charger. The batteries will be VRLA types.

A panel will be provided in the control room to monitor the status of the diesel generators.

The facility control system will initiate the following actions upon loss of utility power:

(1) Lock out the main 4160V switchgear circuit breaker.
(2) Shed loads.
(3) Start the diesel generator(s).
(4) Connect the diesel generator(s) when rated frequency and voltage are attained.
(5) Connect essential loads.

A dedicated PEPC-1A/1B electrical package will house the Train A and Train B 480V switchgears and 480V MCCs for the MDB filters and MDB chillers. The PEPC will be a stand-alone unit complete with auxiliary equipment such as HVAC equipment, battery charger unit, fire protection, power panels, lighting panels, etc.

10.5.5.9 Uninterruptible Power Supply

Two UPS systems will be provided to supply regulated power to critical ac loads. The UPSs will be powered from essential 480V buses. Each UPS will be sized to carry total connected critical load and will consist of an inverter, charger, UPS static transfer switch, bypass static transfer switch, manual maintenance bypass transfer switch, batteries and battery racks.

The battery charger will be capable of charging the batteries from discharge to 90% full charge within the specified time interval not to exceed 10 times the nominal discharge time, while supplying power to the inverter simultaneously.

Batteries will be sized to supply critical loads upon loss of all ac power (i.e., utility and diesel generator power). The batteries will be VRLA sealed types.

10.5.5.10 Metering and Alarms

A. Switchgear

A voltmeter and ammeter will be provided at each 4160V switchgear main circuit breaker. A voltmeter will be provided for each 4160V switchgear bus. An ammeter will be provided at each 4160V feeder breaker feeding 4160V: 480Y/277V transformer for 480V switchgear.

A voltmeter and ammeter will be provided at each 480V switchgear main circuit breaker. A voltmeter will be provided for each 480V switchgear bus.

B. Standby Diesel Generators

The following meters will be provided, as a minimum, at each standby diesel generator control panel:

(1) Ammeter
(2) Voltmeter
(3) Frequency meter
(4) Wattmeter
(5) Hour meter

Local and remote alarms and status indications will be provided for each standby diesel generator.

Remote alarms and indications will be extended to the control room.

C. Uninterruptible Power Supply

The following meters will be provided at each UPS:

(1) dc ammeter
(2) dc voltmeter
(3) ac ammeter
(4) ac voltmeter
(5) Frequency meter

Local and remote alarms and indications will be provided for each UPS. Remote alarms and indications will be extended to the control room.

D. Facility Metering

Revenue billing metering will be provided at the main 115-kV utility lines outside the facility. Facility metering will be provided at each building for power monitoring.

10.5.5.11 Cable Routing

Cables will be routed separately according to service and insulation class as follows:

(1) 4160V power cables (5000V Insulation Class)
(2) Other power cables (600 Insulation Class)
(3) Control cables (600 Insulation Class)
(4) Instrument cables (300V Insulation Class)

Cables to essential redundant equipment will be separated by train designation.

Cables between buildings will preferably be run in cable trays installed in above-grade pipe racks or sleeper ways. Cables between buildings will be allowed to run in underground duct lines only in absence of pipe racks or sleeper ways. Cables within buildings will be run in cable trays and/or conduits. Generally, EMT will be used in buildings except where rigid steel may be required for strength or by code. Cable trays and/or EMT will not be allowed in toxic areas A, A/B, or B.

Cables will be run in cable trays in nontoxic areas with the exception of loads that terminate in toxic areas. Cable routing in toxic area will maximize the use of large flat surfaces by routing cable/conduit behind walls or in adjacent corridor areas to the greatest extent possible.

All cables and conduits/wires throughout the facility will be given unique tag numbers.

10.5.5.12 Grounding

A. System Grounding

The neutral of the electrical distribution system will be low-resistance grounded at the 4160V secondary of the main transformers and the 4160V standby diesel generators. The 480V systems will be solidly grounded at the secondaries of 4160V: 480Y/277V transformers for the 480V switchgear lineups.

B. Equipment Grounding

All noncurrent-carrying metallic parts that might accidentally become energized (motor frames, transformer enclosures, raceways, etc.) will be connected to the grounding system through a separate ground wire or by using the ground wire installed in cable or raceway.

A separate facility instrument ground system will be provided as required by the BPCS/PLC vendors.

C. Facility Ground Electrode

The facility grounding electrodes will consist of 10-ft-long, ¾-inch-diameter copper-clad ground rods. The ground rods will be located adjacent to the building foundations. The rods will be interconnected with the counterpoise grounding conductors.

10.5.5.13 Lightning Protection

The building lightning protection systems will meet the requirements of NFPA 780. Buildings and structures will be protected against lightning with interconnected roof-mounted air terminals. Down-conductors will be used to connect the lightning protection system to the facility ground electrode.

All conductors and air terminals will be copper. Conductor inline splices and taps will be made with compression fittings. All underground electrical connections and connections to structural steel members will be made with exothermic welds.

Exterior ductwork, not shielded by other objects, will be provided with direct stroke protection. Exposed metal piping (located on pipe racks, etc.) will be grounded before entering the building.

The lightning protection grounding system will be connected to the electric power system-grounding electrode. The minimum burial depth for the lightning protection grounding system will be 2 ft.

10.5.5.14 Surge Protection

Cascaded transient voltage surge suppression (TVSS) will be provided from the 115-kV level down to and including all essential and critical buses and equipment.

The TVSS system will meet the requirements of the following standards:

(1)	IEEE-1100-1992	Recommended Practice for Power and Grounding Sensitive Electrical Equipment
(2)	IEEE-C62.41-1991	Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits
(3)	FIPS-Pub 94-1983	Guidelines on Electrical Power for ADP Installations
(4)	UL-1449-1996	Standard for Safety Transient Voltage Surge Suppressors, Second Edition

All TVSS devices will be UL listed.

Metal oxide surge arresters will be provided at the 115-kV incoming line, at the 115-kV side of the main transformers, and at each 4160V switchgear lineup. The surge arresters will be connected to the facility ground electrode.

TVSS will be provided for all PLCs, UPSs, communication circuits and other critical electrical equipment.

10.5.5.15 Facility Lighting

Facility lighting will generally be powered from a utility nonessential power source. In the event of loss of utility power, reduced lighting levels will be maintained throughout the facility via standby diesel generator-backed essential buses.

Full lighting levels will be maintained in specific areas such as the Control Room and electrical equipment areas. Twenty-five percent of the lighting in the Control Room will be powered from the UPS system.

Lighting levels will generally be maintained in accordance with the IES Handbook.

Battery-pack lighting will be used in the following areas to provide egress lighting in the unlikely event of loss of all facility ac power (utility and standby generators) and during the period (10 seconds) it takes for the standby diesel generators to start:

(1) Electrical equipment rooms
(2) Standby diesel generator buildings
(3) At all equipment locations required for safe plant shutdown
(4) All facility egress routes

All battery-pack lighting will have a duration of 2 hours.

10.5.5.16 Communications

Several communications systems will be provided for the facility.

The telephone system will be used among the various facility buildings. The major equipment located in the Personnel Maintenance Building (PMB) will include a private automatic branch exchange and main distribution frame. Telephone sets will be located throughout the facility. Besides the standard telephone, a point-to-point hot line telephone system will be used for the Entry Control Facility (ECF), Munitions Demilitarization Building (MDB), PMB, Base Commander's Office, and Base Site Security/Command Center.

A public address and paging system will provide public address and emergency messages. The system will include distinctive tone coded signals for agent and security alarms.

A dedicated radio system will be provided to rapidly establish voice communication among DPE personnel and personnel in the Control Room.

A multichannel support radio system will also be provided for security, operations and emergency response communication.

An airlock intercom system will be provided for DPE personnel in the A and B airlocks to personnel in C areas.

A medical area intercom system will be provided for 2-way communication between medical attendants and personnel involved in decontamination incidences (before entering the medical facility and while in the decon area).

10.5.5.17 Security

The facility security system design will meet the requirements of AR 190-59, Chemical Agent Security Program.

Two continuous lines of perimeter intrusion detection systems (IDSs) will be provided to detect unauthorized entry along the site perimeter. All storage rooms, areas, structures or buildings in which chemical agents are stored will be protected with interior IDSs to detect the physical opening of any entryway.

A CCTV surveillance system will be provided between the two facility security perimeter fences.

Security lighting will be provided between the two security fences, along the 30-ft clear zone on each side of the fences and the exteriors of buildings that contain a chemical agent.

The Entry Control Facility (ECF) will normally be powered from essential bus. In the event of loss of utility power, the ECF will be powered via facility standby diesel generator (SDG). The ECF will also contain a dedicated security diesel generator to power the station security loads in the event of loss of all facility power (i.e., utility and SDG power).

The security diesel generator will be sized to carry all security loads such as:

(1) Communications systems
(2) IDS
(3) Security lighting
(4) Security surveillance system
(5) Access control and alarm system
(6) HVAC for ECF

A battery-backed power supply will be provided to power IDS equipment, security alarms and communications in the event of loss of all ac power. The battery will be sized for 4 hours at the lowest expected ambient temperature. The battery charging system will be sized to fully recharge the batteries within 12 hours.

10.5.5.18 Closed Circuit Television (CCTV) System

A CCTV system will provide control room personnel with remote viewing of hazardous operations in toxic A and B areas. The system will also provide video recording of the camera data. Each camera will have pan, zoom and tilt features remotely controlled from the Control Room Area (CRA). The cameras will be protected from the effects of agent and decontamination solutions.

10.5.5.19 Electrical Enclosures

Placing electrical equipment in toxic areas and potentially toxic areas will be avoided when possible. When electrical equipment (e.g., motors, panels, lighting fixtures, etc.) is required in these areas, their enclosures will be suitable for decontamination washdown requirements. Generally, motors will be totally enclosed fan cooled (TEFC). Panelboard enclosures will be NEMA 4 or 4X and lighting fixtures will be enclosed and gasketed.

10.6 FIRE PROTECTION

10.6.1 FIRE SUPPRESSION

Special consideration is required for the fire suppression systems used in various areas of the building. A combination of fixed fire suppression systems, fire hose connections and portable fire extinguishers will be used to provide in-depth defense. Fixed fire suppression systems selected for each area will be based on the type of hazard, the category of the area, the impact on facility operation and the potential for release of agent. The fixed fire suppression systems provided as part of the fire protection design will be wet pipe sprinkler systems, preaction sprinkler systems, ultrahigh-speed deluge systems, high-speed deluge systems, and dry chemical systems.

10.6.1.1 Wet Pipe Sprinkler Systems

Wet pipe sprinkler systems will consist of normally closed head sprinklers. For water to discharge from the wet pipe sprinkler system, the thermal links holding a plug in the sprinkler must melt. The melting of the fusible link will result in the discharge of water from that, and only that, sprinkler head. Flow switches and isolation valve tamper switches will be electrically monitored. In areas in which there is a possibility of contamination, curbs will be provided to contain the water for subsequent disposal. The areas in which a wet pipe sprinkler system is to be used will be defined in the Fire Protection Design Analysis Report.

10.6.1.2 Preaction Sprinkler Systems

Preaction sprinkler systems will consist of normally closed head sprinklers. The systems will employ a piping network containing low-pressure air. The system piping will be supervised by monitoring this low-pressure air. The low-pressure air will be provided from the facilities instrument air system. This type of fire suppression system reduces the chance of accidental discharge by requiring two independent actions prior to the discharge of water. These actions are the opening of the preaction valve from an indication of fire from a detection system and the melting of the fusible link in the sprinkler head due to heat from the fire.

Thermal detectors are the detector of choice for the contaminated areas since they can withstand the decontamination process. Photoelectric smoke detectors are the choice for the areas in which contamination is not a possibility. Provisions will be included for manual actuation of the preaction valve. The melting of the fusible link will result in the discharge of water from that, and only that, sprinkler head. The detection system, the flow switches and isolation valve tamper switches will be electrically monitored. In areas in which there is a possibility of contamination, curbs will be provided to contain the water for subsequent disposal. The areas in which a preaction sprinkler system is to be used and the type of detection used will be defined in the Fire Protection Design Analysis Report.

10.6.1.3 Ultrahigh–Speed Deluge Systems

In most deluge systems, the nozzles are open. In the case of ultrahigh-speed deluge systems, these nozzles will be sealed. The closure devices for the deluge system nozzles will be rupture discs. The piping distribution network will be full of water. However, the piping network will not be pressurized. The area of coverage of these systems will be the high-risk process operations, and not the entire room area. Activation of this system will be by cross-zoned UV/IR optical detectors. Using UV/IR optical detectors will decrease the response time of the system while cross zoning will reduce the chance of accidental discharge of water. Once two cross-zoned UV/IR optical detectors indicate a fire condition, an electrical signal will be sent to an explosive squib located inside the deluge valve. Once detonated, the deluge valve will open. The discharge of water from the nozzles is a result of the increase in the water pressure in the piping network.

The reaction time for this type of system will be 100 milliseconds or less. The UV/IR optical detection system and the isolation valve tamper switches will be electrically monitored. In areas in which there is a possibility of contamination, curbs will be provided to contain the water for subsequent disposal. The areas in which the ultrahigh-speed deluge systems are to be used will be defined in the Fire Protection Design Analysis Report.

10.6.1.4 High-Speed Deluge System

In most deluge systems, the nozzles are open. In the case of high-speed deluge systems, these nozzles will be sealed. The closure devices for the deluge system nozzles will be rupture discs. The piping distribution network is full of water. However, the piping network will not be pressurized. The area of coverage of these systems will be the high-risk process operations, and not necessarily the entire room. Activation of this system will be by cross-zoned UV/IR optical detectors. Using UV/IR optical detectors will decrease the response time of the system while the cross zoning will reduce the chance of accidental discharge of water. Once two cross-zoned UV/IR optical detectors have indicated a fire condition, an electrical signal will be sent to an explosive squib located inside the deluge valve. Once detonated, the deluge valve will open. The discharge of water from the nozzles is a result of the increase in the water pressure in the piping network.

The reaction time for this type of system will be 500 milliseconds or less. The UV/IR optical detection system and the isolation valve tamper switches will be electrically monitored. In areas in which there is a possibility of contamination, curbs will be provided to contain the water for subsequent disposal. The areas in which high-speed deluge systems are to be used will be defined in the Fire Protection Design Analysis Report.

10.6.1.5 Dry Chemical Systems

Automatic, dry chemical systems will be used if required for flammable liquid fires based on the fire hazards analysis. The systems will be designed as local application systems to protect specific hazards. The systems will be actuated by UV/IR optical detectors, rate compensated thermal detectors, or manually. Special consideration will be given to the design for maintenance and operation in potentially contaminated areas and in accordance with project decontamination requirements.

10.6.1.6 Standpipe System

A Class I standpipe system will be provided to ensure the coverage of all areas for which a 150-ft hose line cannot reach. Only hose valves will be provided. There will be no provision for the permanent storage of hose at these locations. Due consideration for the potentially contaminated areas, access to the hose valve, egress routes to the area and the number of doors through which the hose must be pulled will be used to determine hose valve locations.

10.6.1.7 Portable Fire Extinguishers

Portable fire extinguishers will be located throughout the facility. Fire extinguishers will be selected and located based on the fire hazards, the area category, the equipment in the area, and normal access and egress routes.

10.6.1.8 Fire Protection Water Supply

The facilities will have an underground fire main that provides a source of water for yard hydrants and internal fire suppression systems. Yard fire hydrants will be located around the facility for use by the fire brigade. The fire main and water supplies will be sized to provide simultaneous peak firewater, potable water and process water demands for the buildings and site. The water supply will be from an offsite water supply by others.

10.6.2 FIRE DETECTION

The facility will be provided with a proprietary fire detection system designed in accordance with NFPA 72. This system will have a central fire alarm control panel located in the MDB Control Room. The central fire alarm control panel will have a graphical display to assist in identification and response by facility operators. The fire alarm system will show the status of the fire detection system and have a printer to provide a permanent record of all changes in alarm status. The system will also have alarm notification devices. Audible devices will be placed throughout the facility; visual alarms may be required in high noise areas. Automatic smoke, optical and thermal detectors will be located throughout various parts of the facility.

Fire detectors will be installed in accordance with NFPA 72. The type of detector used in a given location will be based on the fire hazards in the area, the area contamination category, the function of the detector and the potential for false alarms. The detectors will be capable of withstanding the decontamination procedures in those areas in which contamination is of concern. The type of detection system used in various parts of the facility will be determined in the Fire Protection Design Analysis Report.

Category A, A/B, B and C areas will use detectors compatible with program decontamination requirements, such as completely sealed thermal or optical detectors. Where occupancies are more suitable to detection by smoke detectors these units will be appropriately shielded.

A linear thermal detection system will be provided in the HVAC filter units to detect a fire originating from inside these units. Two set points will be associated with this system. The first is a high alarm with a set point of 190ºF. The second is the high high alarm set at 275ºF. Upon an indication of fire the isolation dampers on both sides of a filter unit will close, isolating the affected filter unit from the rest of the exhaust filtration system.

Automatic smoke detectors will be located in the HVAC ductwork.

10.6.3 LIFE SAFETY

Life safety will be a prime consideration. Fire barriers, fire detection/alarms, fire suppression systems and facility evacuation routes will be designed to provide protection and evacuation of facility personnel. Doors, stairs, corridors and walls will be arranged in a building to facilitate evacuation. Exit routes will be clearly marked and provided with emergency lighting. Emergency egress routes will comply with AMCR 385-100. NFPA 101 will be used for further guidance. In hazardous operating areas, the exits will be within 25 ft of the personnel working station. Travel to the nearest exit passageway will not exceed 100 ft. Exits from Category A, A/B, B and C areas will be a minimum of 42 inches wide to accommodate personnel wearing DPE. Emergency exits will be provided from Category A, A/B, B and C areas to observation corridors or through airlocks to the outside.

SECTION 11

FACILITY DESCRIPTION

11.1 OVERVIEW

The site is flanked by Block G on the west, by open areas on the north and east, and by the parking and waste transfer areas on the south. The site encompasses 27 acres inside the perimeter security fence. A water storage tank, pump house, and step-down substation are located outside the east security fence. Parking for the ACWA WHEAT facility is provided outside the security fence adjacent to the personnel support building (PSB).

11.2 SITE

11.2.1 FACILITY SITING

The facility is an industrial complex designed to destroy/decontaminate all components of the assembled chemical weapons containing mustard. The facility will have nine buildings, outside tanks, and new infrastructure (road, parking, fencing, etc.).

The space between buildings will provide open areas in accordance with good land-use planning. Fire clearance separations between the new buildings will be maintained in accordance with MIL-HDBK-1008B. Buildings that do not contain explosive materials will be separated from the explosive buildings by at least the appropriate distances as defined in AMC-R385-64.

11.2.2 ROADS, ACCESS DRIVES, AND PARKING AREAS

The geometric design of all roads, streets, and access drives will conform to the applicable portions of Technical Manual (TM) 5-803-5, TM 5- 822-2, and U.S. Army Corps of Engineers Division, Huntsville (CEHND) 1110-1-1. The desirable maximums (e.g., slopes and grades) in the documents will not be exceeded without government approval.

All roads (except the patrol road) will consist of two 10-ft-wide lanes with 6-ft-wide gravel shoulders. These roads will contain only munitions convoy traffic or patrol vehicles. The patrol road is a 12-ft-wide lane with a 4-ft-wide gravel shoulder. All site roads are categorized as Class E. These plant roads are located within a built-up area of installations and will meet the requirements of TM 5-822-2, Table 1-2.

Parking for personnel is adjacent to the PSB outside the ACWA WHEAT security fence. Access to the site will be from the south via a new road designed by another contractor. Munitions are transported directly from Block G to the ACWA WHEAT site via a new interconnecting road at the northwest corner of the site.

Site roads will be designed in accordance with the pavement structural design provided by CEHND and the following criteria:

(1) Vehicle types: designation (TM 5-822-2, Table 3-1) P, SU, Bus, WB-40, WB-50, and forklifts.

(2) Axle loads of vehicles: HS 20.

Return

(3) Traffic marking: in accordance with TM 5-822-2.

(4) Pavement Type: Portland cement concrete will be used for the bulk and chemical and fuel unloading area, truck parking areas, and other areas subject to high wheel loads. The design will be in accordance with TM 5-822-6. Asphalt concrete paving will be designed to the requirements of TM 5-822-5.

(5) Grade restrictions: Grades will be designed to accommodate the expected types of vehicular traffic and their associated characteristics in accordance with TM 5-822-2, Table 1. Maximum grade for munitions hauled by truck will be 6% and 3% for forklift travel.

(6) Curb and gutter: Curbing will be placed adjacent to the sidewalk at the sally port.

(7) Road classification: Class E (minimum) open rural area in accordance with TM 5-822-2.

(8) Design life: As established by the CEHND-provided pavement structural design.

The design of pedestrian walks will comply with TM 5-803-5, TM 5-822-2, and criteria presented herein. Walks paralleling buildings will be located beyond the eaves drip line and at least 5 ft from the foundation. Walks paralleling parking areas will be at least 6 ft wide and will abut the back of the curb.

11.2.3 GRADING

Grading at the site will consist of overland sheet flow toward swales along the roads and ultimately into each catch basin. Gradients for roads, streets, and access drives will be as outlined in TM 5-822-2. Pavement grades in parking areas will provide positive surface drainage with 1% minimum slope in the direction of the drainage and:

(1) Slope in the direction of parking 1½% maximum.

(2) Slope perpendicular to direction of parking 5% maximum for bituminous or concrete surfaces and 3% for other surfaces.

The grades of walks will be in accordance with TM 5-803-5, Chapter 8.

Steps in walk should be avoided, but when used will comply with TM 5-822-2.

11.2.4 STORM DRAINAGE

The design of the storm drainage facilities will be in accordance with TM 5-820-4 except as modified or supplemented by the criteria. Design of drainage structures, culverts, pipes, etc., will be for a minimum of HS 20.

Runoff from drainage areas of 640 acres or less will be determined by the use of the modified rational formula as defined in the CEHND 1110-1 and TM 5-820-4 (this TM limits the rational method to 640 acres or less).

For drainage areas larger than 640 acres, the runoff will be determined by the unit hydrograph method as defined by Franklin F. Snyder (TM 5-820-4). The design storm frequency will be the 25-year storm for roads.

A subsurface drainage piping system will be used for the surface stormwater runoff to be conveyed from the site. The storm drain system will interface 30 ft beyond the outer fence, at which point the another contractor will divert the flow to the natural drainage course.

The drainage system layout will be designed to best meet the operational requirements of the facility. The system will be as economical as practicable, taking into consideration topography, ultimate development of the drainage area, and coordination with offsite storm drain prepared by another contractor.

The gradient will be a minimum of 0.3%. Coefficient of roughness, "n," and maximum permissible velocities for various surfaces are listed in TM 5-820-4.

Except as otherwise noted, storm runoff will not be concentrated on asphalt pavement; if possible, concentrated flow will be allowed to flow only on concrete paved surfaces, including curb and gutters, concrete swales, or concrete channels.

The gradient for culverts will be a minimum of 0.3%. Concrete headwalls, end sections, and /or erosion protection at outfalls will be provided for all culverts.

Whenever possible, pipe crowns will be matched in elevation. Profiles of pipes should show all existing and new underground utilities and pertinent surface features. The minimum gradient will be 0.3%, and piping will be designed to provide a minimum velocity of 2 fps and limit outfall velocities to nonerosive values (4 to 6 fps depending upon soil types). If nonerosive velocities cannot be attained, erosion protection will be provided.

The design of surface inlets and curb inlets will be in accordance with TM 5-820-4. The minimum pipe size will be 12 inches, unless the pipe is a part of the roof drain system, in which case the size of laterals and collector pipes will be 6 inches.

11.2.5 LOOPED FIREWATER/POTABLE AND PROCESS WATER DISTRIBUTION NETWORK

This distribution system will be designed to meet the design potable water plus process demand of 290 gpm together with the firewater demand of 2,790 gpm. The system will be designed in accordance with TM 5-813-5. All process water will be sent through a water softener, then through a distribution system independent of the firewater distribution system. A minimum design pressure of 70 psi is required at the building connection for fire sprinklers, design requirements of 2,800 gpm at 90 psi at the site boundary were established by another contractor. Pipes within the site will be sized to maintain a maximum velocity of 5 fps in the network so that polyvinyl chloride (PVC) pipe can be used.

11.2.6 SANITARY SEWER SYSTEM

A gravity sewer system will be designed in accordance with TM 5-814-1. The sewer system will meet the following specifications:

(1) Minimum pipe size will be 6 inches in diameter.

(2) Design velocity will be minimum of 2.0 fps at the average daily flow rate and a minimum velocity of 2.5 fps at the peak flow rate.

(3) Manholes will be located at change of slopes, direction, or every 300 ft.

(4) Cleanouts will be provided at changes in direction and building connections.

(5) Laterals and mains will be designed to flow at depths not exceeding 80% of full depth.

(6) Gravity sewers are generally designed to maintain subcritical flow conditions in the pipe throughout the normal range of design flows.

11.2.7 FENCING

The perimeter security fence will be designed in accordance with the requirements of Army Regulation (AR) 50-6-1 and will be located parallel to the roads and 30 ft from the edge of the pavement in most cases. The two 7-ft-high chainlink fences, topped with six strands of barbed wire, are 30 ft apart. A clear zone extending 30 ft on each side of the fences will be in accordance with AR 50-6-1. The clear zone will be covered with light colored gravel or crushed rock and will maintain a maximum grade of 6% with a terrain variation of ±2 inches. The clear zone outside the outer fence can be used as a security patrol road. Inside most of the site, an access road is adjacent to the fence and clear zone. The sally port will be provided with sliding gate, and a crash gate in front of the outer gate.

11.2.8 SERVICE AREAS

Bulk chemicals and fuel will be delivered to an unloading area outside the security fence. Other supplies for the facilities will be delivered to the site by truck, entering the site through the sally port. Waste generated by the facility will be removed by truck. Parking for miscellaneous vehicles will be provided at the ECF, PMB, and LAB.

11.2.9 HANDICAPPED ACCESSIBILITY

The site will not be designed for access by the handicapped because of the hazardous nature of ACWA-EDS operations.

11.2.10 LANDSCAPING

No irrigation will be provided for the site. Only native grasses will be used for erosion control.

11.2.11 SIGNAGE

Signage will be in accordance with AR 50-6-1.

11.2.12 ELECTRICAL

11.2.12.1 General

A. Powerline

The estimated electrical power load for the ACWA WHEAT will be about 15 MVA. This power must be brought to a point 30 ft outside the facility security fence. The power is required to be extended to the demilitarization site by cables in underground ductbanks. The power must have adequate voltage regulation to hold the service voltage to ±5% of nominal value over a load range of zero to full capacity.

B. Coordination with Utility Agencies

Extensions and connections for the electrical system are to be coordinated with the local utility company. Telephone service extensions and connections are to be coordinated with the local telephone company.

C. Metering Requirements

The facility electrical power is to be metered. Metering for electrical power is to be located at each facility building.

11.2.12.1 Electrical, Exterior

A. Existing High Voltage Service

A 115-kV transmission line is in the vicinity of the site. The line is to be extended by the utility company to a new dead-end structure to be located in a fenced area outside the facility.

B. New Services

A new substation is to provide power at 4160V to the facility load. The substation is to be located in the fenced area outside the facility.

(1) The substation is to include dead-end structure, motorized 115 kV switches, 115-kV SF6 circuit breakers, 115 kV: 4160V power transformers with load tap-changer, neutral grounding resistors and a 4160V switchgear in an outdoor walk-in enclosure complete with metering, protection, and battery system.

(2) Estimated load for the facility is about 15 MVA.

(3) Emergency power for IDS and perimeter security lighting is provided from the emergency generator in the ECF. Essential (emergency) power for the process systems is provided by three emergency generators located in the SDGs.

C. Lighting

Lighting intensity is accordance with Architectural and Engineering Instructions Design Criteria, except as noted below.

(1) **Intensity:** The intensity at the entrance to buildings has at least 1.0 foot-candle horizontal illumination, 6-inch (minimum) above-grade level at the door, using high-pressure sodium lighting fixtures.

(2) **Security:** For security lighting the intensity is 0.5 foot-candle horizontal illumination, 6-inch above-grade level, 30 ft outside the outer fence, per AR 190-59. Only lighting from high-mast light poles located inside the security fence may be used to meet the security lighting requirements. Lights produce the required foot-candle output within 3 minutes after power is applied. Maximum-to-minimum light ratio does not exceed 6:1. To view the area beyond and within the perimeter and along the approaches to the facility, surveillance CCTV cameras are installed on light poles with monitors in the ECF. The CCTV camera on the security gates are monitored in the ECF.

(3) **Emergency:** For emergency lighting, the normal commercial power supply is backed up by an emergency power from the emergency generator located in the ECF.

(4) **Lighting Fixtures and Switch Location:** Fixtures for general yard illumination are mounted on high-mount (approximately 80 ft above grade level) masts supporting clusters of luminaries. Switching is automatic, controlled by a master photocell, with a manual override at the ECF.

(5) **Streets:** Street lighting is provided in accordance with TM 5-811-1.

(6) **Obstruction:** Obstruction lights are provided, where required, in accordance with FAA regulations.

(7) **Warning:** Warning signs placed outside and perpendicular to the outer security fence are illuminated by the general (yard) lighting. Lighting at the gates is in accordance with AR 190-59.

Grounding and lightning protection will be as follows:

(1) **Plant Ground:** A ground system is provided for each building consisting of copper-clad steel rods connected together with soft-drawn copper cable. Each building perimeter ground system is connected to the site perimeter ground or to the perimeter ground system of an adjacent building in two places. The grounding system is in accordance with AR and DA Pam 385-64 and DOD 6055.9-STD.

(2) **Lightning Protection:** Lightning protection applies to all buildings in accordance with NFPA 780 and DOD 6055.9-STD. Resistance-to-ground does not exceed 10 ohms.

D. Standby Diesel Generator

The standby diesel generators (SDGs) provide essential power for the facility essential loads. The SDGs are self-contained, fully automatic, complete with controls, above-ground fuel day tanks, starting circuitry and accessories, matching diesel engines and brushless alternating current generator packages capable of auto "black" start and parallel operation in isolated mode and with commercial power source.

11.2.13 BTA

The biotreatment equipment shelter is an approximately 250-ft^2, 12-ft-high, pre-engineered steel frame open structure (no walls) over a concrete floor slab-on-grade construction. The roof is composite metal panels with a slope of 1½ inch/ft. The roof covers the entire equipment area and overhangs 1 ft beyond the edge of the concrete slab. These are four biotreatment equipment shelters in the biotreatment area [one shelter per four immobilized cell bioreactor (ICB) units].

11.3 MSB

The MSB is a 25-ft by 80-ft standard Army earth-covered bunker per U.S. Corps of Engineers drawing 33-15-74.

11.4 MDB

11.4.1 ARCHITECTURAL

11.4.1.1 Building Description

The MDB is an approximately 118,000-ft^2, one-story, noncombustible industrial-type steel frame over a concrete floor slab-on-grade construction. The exterior envelope of this building is composed of insulated composite metal wall panels and roof panels over a custom-engineered steel frame, and the roof has a slope of 1½ inch/ft. Interior walls and ceilings for toxic areas (contamination Categories A, A/B, and B) are custom-engineered poured-in-place concrete to establish the required fire ratings.

The interior walls, floors, and ceilings in the contamination Category A, A/B, B, and C areas are coated with specialized materials to facilitate washdown in the event of contamination and have a 2-hr fire rating where fire separation walls are required. Interior walls in nontoxic areas have gypsum wallboard on metal studs to achieve the proper fire ratings where required or metal panels on steel framing where fire rating is not required. Walls, floors, ceilings, and all penetrations of Category A, A/B, B, and C areas will be sealed with Chemical Stockpile Disposal Program (CSDP)-accepted methods and materials to prevent the migration of liquid or vapor agent to adjacent areas.

All equipment and area layouts conform to the human factors engineering (HFE) requirements for personnel wearing demilitarization protective ensembles (DPEs). All rooms are sized to accommodate the equipment housed in them and to allow equipment access. Category A, A/B, and B areas are sized to allow DPE suit access.

11.4.1.2 Area Separations

The MDB is subdivided into fire area separations according to occupancy classifications to reduce the floor areas to below the allowable floor area set forth in the Uniform Building Code (UBC) in all cases. Table 11-1 shows the subdivision and classification of the specific areas. Where fire separation walls terminate at the underside of the roofing systems, the termination will meet the requirements of the UBC (1997), Section 504.6.4.

11.4.1.3 Toxic Areas

Toxic areas are maintained under negative pressure by the cascade ventilation system to safeguard against agent release. Observation corridors are provided for observation of all toxic areas. Access to toxic areas is provided by airlocks equipped for DPE decon, monitoring, and doffing. This access follows the convention for cascaded ventilation systems used by the baseline CSDP. Additional doors with panic bars and automatic door closures without airlocks are provided for emergency egress to meet life safety code requirements.

11.4.1.4 Essential Spaces and Systems

Major portions of the MDB are allocated to house mechanical and electrical systems, control system instrumentation and heating, ventilating, and air-conditioning (HVAC) systems that directly affect the munitions process and agent destruction operations. Plumbing (including emergency decon and rinse water tanks) are provided at all personnel access air locks. The agent and energetics neutralization areas house the process equipment necessary to receive and neutralize the chemical agent. Mechanical support systems, including HVAC decon solution supplies and life support air distribution, are also housed in this structure. Equipment and components are located outside Category A areas to facilitate maintenance and monitoring.

11.4.1.5 Area Contamination Categories

Table 11-2 describes the contamination categories in the specific areas within the MDB.

11.4.1.6 Building Construction Materials

Functional and operational requirements dictate that the primary construction material for the MDB is a custom-designed steel framed building.

Table 11-1—Building Classifications (based on UBC 1997 Edition)

Building	Floor Area (ft^2)	Occupancy Group	Construction Type	Fire-resistant Exterior Wall	Allowable Floor Area (ft^2)	Allowable Floor Area Increase (ft^2)	Allowable Stories[a]	Fire Suppression System[b]	Handicap Accessible	Construction Material
MDB (comprising contiguous buildings as listed below)										Custom-designed steel-framed building with composite roof and wall panel.
ANR	10,581[c]	H-7	II-N	NR	12,000	0	2	E	NR	Concrete walls and ceiling.
CRA	9,157[d]	B	II-N	NR	12,000	24,000	2	B,E	NR	Composite building panel, gypsum board on steel stud.
CTR/HTR	8,575[d]	H-7	II-N	NR	12,000	0	2	E	NR	Concrete walls and ceiling.
ECR	1,888	H-2	II-N	NR	3,700	0	1	C,E	NR	Blast-resistant concrete wall and ceiling.
ECV	5,180	H-7	II-N	NR	12,000	24,000	2	A,E	NR	Concrete walls and ceiling.
ENR/HER/OTR	10,104	H-7	II-N	NR	12,000	0	2	A,F,E	NR	Concrete walls and ceiling, CMU, and composite building panel.
ER	6,021[d]	F-2	II-N	NR	18,000	36,000	2	B,E	NR	Composite building panel and CMU.
MDM/MPT	8,592[d]	H-7	II-N	NR	12,000	0	2	F,E	NR	Concrete walls and ceiling.
MER	6,910	F-2	II-N	NR	18,000	0	2	E	NR	Composite building panel and CMU.
MLA	6,552[d]	H-7	II-N	NR	12,000	0	2	E	NR	Composite building panel, gypsum board on steel stud.
PRR	2,787	H-2	II-N	NR	3,700	0	1	B,C,D,E	NR	Concrete walls and ceiling.
TMA	4,384	H-2	II 1 hr	1 hr	5,600	0	1	A,E	NR	Concrete walls and ceiling.
TOX	2,970	H-2	II-N	NR	3,700	0	1	E	NR	Concrete walls and ceiling.
UPA/CST	14,058[d]	H-7	II-N	NR	12,000	24,000	2	A,B,E	NR	Concrete walls and ceiling.
PAB	45,909	F-2	II-N	NR	18,000	36,000	2	B,E	NR	Custom-designed steel-framed building with composite roof and wall panel.

[a]Notes:
1. NR – Non-rated or Not required.
2. Refer to UBC 1997 Edition, Table 5-A, for exterior wall and opening protection.
3. Refer to UBC 1997 Edition, Table 5-B, for basic allowable building heights and allowable floor area.
4. Refer to UBC 1997 Edition, Table 6-A, for fire-resistive requirements for types of construction.
5. Refer to architectural drawings for location of 2-hr fire-rated area separation walls.

[b]Fire Suppression Legend:
A wet pipe sprinkler system
B preaction fire suppression system
C ultra-high-speed fire suppression system
D high-speed fire suppression system
E portable extinguishers
F detection only

[c]Largest cumulative area including corridors from ANR 1/2/3.
[d]Cumulative area including adjacent corridors and support spaces.

Legend:
ANR agent neutralization rooms
CMU concrete masonry unit
CRA control room area
CST continuous steam treater
CTR condensate tank room
ECR explosive containment room
ECV explosive containment vestibule
ENR energetics neutralization system
ER electrical room
HER hydraulic equipment room
HTR hydrolysate tank room
MDB munitions demilitarization building
MDM munitions demilitarization machine
MER mechanical equipment room
MLA MDB laboratory area
MPT metal parts treater
NR not required
OTR offgas treatment room
PAB process auxiliary building
PRR propellant reconfiguration room
PTA parts transfer area
TMA toxic maintenance area
TOX toxic room
UPA unpack area

Table 11-2—MDB Area Contamination Categories

Area	Category
Agent neutralization rooms (ANRs)	A
Decon access air lock	A
Munitions demilitarization machine room (MDMR)	A
Toxic maintenance area (TMA)	A
Toxic room (TOX)	A
Explosion containment rooms (ECR)	A/B
Explosion containment vestibules (ECV)	A/B
Parts transfer area (PTA)	A/B
Metal parts treater room (MPTR)	B
Waste shredding room (WSR)	B
Condensate tank room (CTR)	C
Continuous steam treater (CST)	C
Energetics neutralization room (ENR)	C
Hydraulic equipment room (HER)	C
Hydrolysate tank room (HTR)	C
MDB laboratory area (MLA)	C
Observation corridor	C
Offgas treatment room (OTR)	C
Propellant reconfiguration room (PRR)	C
Unpack area (UPA)	C
Battery rooms (BRs)	D
Electrical equipment rooms (ERs)	D
Mechanical equipment room (MER)	D
Residue handling area (RHA)	D
Vestibules	D
Control room area (CRA)	E

A. Floors

All building floors are constructed of reinforced concrete. Floor slabs and curbs in the Category A, A/B, B, and C areas are to be monolithically poured, whenever possible. Construction, contraction, and expansion joints are kept to the minimum number possible. Water stops are required.

B. Exterior Walls and Roof

Exterior walls: Insulated composite wall panels fixed on steel girts and a steel tube subframe system.

Roof: Insulated composite roof panels fixed on steel beams and purlins framing system. Gutters and flashing are fabricated in accordance with Sheet Metal and Air Conditioning Contractors National Association (SMACNA) requirements. The MDB does not have parapets. Rooftop mechanical equipment is avoided in toxic areas. If necessary, equipment is mounted on platforms with a sufficient clear area to the composite roof panel. Elevated catwalks will be provided.

C. Interior Walls and Ceilings

Interior walls and ceilings in the following areas are engineered poured-in-place concrete to establish the required fire ratings for the ANR, CTR, ECR, ECV, ENR, HTR, MDMR, MPTR, PRR, TMA, TOX, and the UPA.

Interior walls: Interior walls in nontoxic areas have gypsum wallboard on metal studs or concrete masonry unit (CMU) walls to achieve the proper fire ratings where required or composite metal panels on steel framing where fire rating is not required.

Ceiling: Ceilings in Category A corridors, airlocks, gloveboxes, and areas where chemical agents are processed are exposed concrete with height adequate to clear equipment and personnel, and have a 7-ft 6-inch minimum clearance height. Ceilings in Category C corridors, toilet rooms, locker rooms, and janitor rooms are gypsum board on metal channels. Ceilings in Category D and E areas are suspended acoustical tiles. Showers and toilet areas are 8-ft high (minimum). The BR, CST, ER, HER, MER, and OTR have no ceiling. All ceilings systems are noncombustible.

D. Fire-rated Walls

Fire-rated area separation walls separate the portions of a building or occupancies into fire separation areas according to hazard classification to reduce the floor areas to below the allowable floor area set forth in the UBC (Table 5-B).

Fire-rated walls separate other areas within portions of the building.

E. Roofs

Insulated composite metal panel roofing will be used on all buildings unless special functional or safety considerations dictate the use of another roofing system. The minimum roof slope will be 1½ inch/ft. Standing seam metal roofs, steel roof decks (with either single-ply elastomeric ethylene propylene diene monomer (EPDM) roofing or structural lightweight concrete) and concrete roof decks (either precast or cast-in-place) will not be used unless the structural or functional considerations for this type of design dictate the roofing system.

To the extent possible, roofs will be provided over spill containment areas to direct the flow of rain water from these areas. This roofing will segregate rainwater runoff from process wastewater and will minimize the size of the industrial wastewater treatment facility.

11.4.1.7 Finishes

In general, all exposed surfaces on nuts, bolts, screws, etc., in areas of the MDB with a probability of agent liquid or vapor contamination will be caulked with silicone caulking.

A. Floors

Floor surfaces in toxic process areas (Category A, A/B, B, and C areas) will be sealed and coated with nonporous materials resistant to HD, HT, and decon solutions. The surface material will have a nonskid finish.

Floor slabs in Category D and E areas will be a standard float, trowel concrete surface with nonskid epoxy coating or vinyl composition tile finish.

The control room, instrumentation equipment room, and offices in the control room area (CRA) will have raised access floor system with factory finish.

Toilet areas will have an easy-to-clean, impervious finish.

In Category A, A/B, B, and C process areas where contaminated washdown is performed, or where secondary containment systems are provided, the floor will be sloped toward collection sumps (with permanently installed sump pumps). Floor drains are permitted in personnel showers and toilet areas only.

Except for cast-in-place concrete walls, all walls in Category A, A/B, and C areas are on concrete curbs.

All doors in Category A, A/B, B, and C areas are set on a 6-inch-high curbed opening.

B. Exterior Walls

Exterior walls are prefabricated, factory-finished insulated composite metal panels.

Joints and metal panel seams have an effective seal to maintain a pressure differential.

Walls with void spaces between the surfaces are prohibited in process areas.

Interior surfaces of exterior wall systems in Category A, A/B, B, and C areas that are subject to agent and decon solution have special coatings.

All exterior walls are set on 6-inch-high concrete curbs above the finished floor slab level.

C. Interior Walls and Partitions

All wall finishes in toxic process areas (Category A, A/B, B, and C areas) will be sealed and coated with nonprocess material resistant to HD, HT, and decon solutions. All wall construction and materials (including finishes) will comply with the mandatory and advisory sections of AMC-R 385-100.

Interior wall surfaces in Category D and E areas will have paint finish.

D. Ceilings

All ceiling finishes have a standard, light-colored, nonglare finish.

Finishes must be smooth and impervious.

Ceilings in Category A, A/B, and B areas will be sealed and coated with nonprocess material resistant to HD, HT, and decon solutions.

11.4.1.8 Windows

All windows in MDB process areas have shatter-resistant dual-pane allyl-diglycol carbonate clear plastic, sealed in place with structural glazing beads. Airtight glass-to-wall seals that are resistant to agents and decon solutions are provided. Windows in fire-rated walls have fire-rated steel shutters actuated with electrothermal detectors on both sides of the wall or by the area fire detection system in the event of a fire. All windows into the TMA and the agent and energetics neutralization rooms are resistive to intrusion and penetration in accordance with AR 190-59. Anodized aluminum windows will be specified in all areas of the facility, unless otherwise noted.

Observation windows will provide a clear line-of-sight visibility to all parts of the room. Windows in area containing chemical agent will follow the security requirements of AR 190-59.

Skylights are not permitted.

Windows will be no smaller than 24 inches by 36 inches in even foot modules and will fit into the wall system used. Windows in stock sizes will be used wherever possible. To achieve the maximum functional value, glazing should allow for viewing while seated and/or standing. Therefore, the sill elevation will be at least 2 ft 4 inches above the finished floor for safety, energy conservation, and reduced maintenance. As a minimum, window and opening sizes will meet NFPA 101 life safety code requirements. Glazing and/or doors will be provided in walls at adequate intervals for firefighting access. Refer to NFPA 80 for additional criteria. The actual sizes are determined during final design.

Areas where indirect lighting is possible will be provided with windows if the areas are located on an exterior wall (e.g., CRA offices). All process areas and rooms (e.g., ANR, ENR, TMA, TOX, MDMR and MPTR) are areas in which natural lighting is not permitted; no exterior windows will be provided in these spaces. Window locations will be finalized during final design.

Window lights are replaceable from outside of Category A areas wherever possible.

11.4.1.9 Doors

A. Door Types

Exterior doors: Unless otherwise specified, all exterior doors are insulated and open in the direction of egress and have position switches. All doors requiring an opening force of 30 lb or more will have power-assisted operators, regardless of location or function. Emergency exit doors will have remote alarms where indicated on the security drawings. The position switch on all exterior doors signal the control room to monitor the status of each door. The compressed air system storage capacity gives sufficient reserve for 5 minutes of service. The electric control, alarms, and exit lights are connected to the uninterruptible power supply (UPS).

Interior doors: Personnel doors are fully insulated to eliminate internal void spaces. Hollow metal door frames in all Category A, A/B, and C areas will be filled with foam or cement grout. All doors have a shatter-resistant vision panel. Vision panels in the TMA, the agent and energetics neutralization rooms (ANR and ENR), and the toxic room doors are no larger than 9 inches by 9 inches and resist intrusion and penetration in compliance with AR 190-59. All process area doors have a position switch to signal the control room.

Metal doors: Metal doors will be of 16 ga seamless, and will be reinforced, drilled, and tapped to receive hardware. All exterior doors or doors connecting a heated or air-conditioned room with a nonheated or nonair-conditioned room will be insulated with a minimum "R" value of 8. Door frames for hollow metal doors will be 16 ga welded steel construction with the appropriate jamb anchors for the wall assembly. Construction will be in accordance with Steel Deck Institute (SDI)-100. Face panels for exterior doors will have a hot-dipped commercial zinc coating G60 (Type III Exterior Heavy Duty). For doors to mechanical or switchgear rooms and maintenance shops, where the plan of the area will allow, the door will swing 180º to a wall-mounted door holder, top and bottom. Locks, closers, weatherstripping, etc., will be selected to be compatible with the above requirements. Thresholds and rain drips will be provided at all exterior doors. Weatherstripping will be specified for all exterior doors.

Blast-resistant doors: Blast-resistant doors in the ECRs will be custom designed to resist blast pressures, fragmentation, and the release of chemical agent in the event of an accidental detonation during munitions processing. Panic exit devices will be provided on all blast-resistant doors.

All interior doors that require an opening force of 30 lb or more will have power-assist operators, regardless of location or function. Interior emergency doors also have position switches and remote alarms in the control room only.

All personnel doors, equipment doors, and emergency doors located in Category A, A/B, B, and C areas are equipped with perimeter gaskets at head, jamb, and sill to withstand the room differential air pressure, and those in Category A, A/B, B, or C areas have special coatings to resist agent and decon solutions. Doors in Category D and E areas are subject to differential pressures will meet these gasket requirements.

All personnel and equipment doors located in Category A, A/B, B, and C areas are equipped with magnetic interlocks to prevent the simultaneous opening of two or more doors serving the same room. Magnetic interlocks are activated when a door position switch signals the control system and are released when the open door is closed. Release of the magnetic interlock for Category A, A/B, and B airlocks is delayed 120 seconds when exiting from toxic work areas to provide at least two air changes in that airlock before exiting to a lower category area. Emergency release buttons are provided to override the 120-second delay. Emergency doors are not equipped with magnetic interlocks and do not activate interlocks on other doors. The air supply to the power-assist operators is turned off by a solenoid valve when the magnetic interlock is activated.

Electric door controls, alarms, and exit lights are connected to the UPS.

B. Door Sizes

Building doors are 3 ft 6 inches wide by 7 ft high (internal dimensions) in DPE access areas and in other areas as indicated on the architectural drawings.

Double-leaf doors are a pair, each 3 ft by 7 ft.

Equipment doors are double leaf, 5 ft by 10 ft. With a single-person access (42 inches by 7 ft) door in one leaf.

All other single-leaf doors are 3 ft wide unless a larger size is required for the safe passage of equipment and materials.

Large doors for truck access and similar purposes will be roll-up steel doors. All roll-up steel doors will be provided in accordance with the appropriate CEGS and will be electrically operated. The minimum size of rolling steel or hinged doors will be 10 ft 0 inch high by 12 ft 0 inch wide. No folding doors will be used.

C. Door Location

Personnel exit doors comply with requirements of AR 190-59, DA PAM 385-64, and 29 CFR 1910, Subpart E.

D. Other Requirements

All doors in the secured agent storage area perimeter will resist intrusion and penetration in compliance with AR 190-59.

All airlock doors will meet operational and HFE design requirements.

Doors and airlocks will be gasketed to provide a tight seal using materials that resist chemical agent absorption and are compatible with decon solutions.

DPE hose penetration seals will be provided in all Category A, A/B, and B airlock doors for double-door airlocks or door frames for single airlocks in accordance with HFE requirements.

Equipment doors and removable panels will be provided as required by building equipment access.

11.4.1.10 Door Hardware

All hardware will conform to the applicable American National Standards Institute (ANSI)/ Builders' Hardware Manufacturers Association (BHMA) standards. All hardware will be appropriate for heavy industrial applications. Stainless steel hardware will be used in highly corrosive areas.

A. Panic Hardware

Personnel emergency doors will open in the direction of egress and will be furnished with panic hardware specified to operate with no more than 15 lb force in accordance with National Fire Protection Association (NFPA) 101. Emergency exits designated "ED" have no exterior hardware. Emergency doors designated "EE" have a pull handle and key cylinder to retract the latch bolt on the less toxic side.

All panic hardware will be Underwriters Laboratories (UL) approved and will be installed in accordance with all appropriate life safety codes and ANSI A156.3. Pulls will be 1 inch in diameter, 8 inches center to center, and of stainless steel. Push plates will be of stainless steel. No latches, locks, panic bar latches, or any other device that would slow or inhibit egress from a building will be used on doors of buildings. Door pulls will be installed only on the exterior of one door of the building, preferably a door with an employee at or near it most of the time. Push plates will be installed on the interiors of these doors. Magnetic plates or spring-loaded roller snap latches can be used to secure exterior doors against wind loads. Door stops will be cast aluminum with rubber bumpers.

B. Automatic Door Closers

Automatic door closers will be UL approved with an adjustable hydraulic back check and will be capable of opening 180 degrees. Closers for outswinging exterior doors will have parallel arms or will be top-jamb mounted. Full-mortise, high-frequency, stainless steel hinges with ball bearings and nonremovable pins will be installed in explosive and/or corrosive environments. Standard steel hinges will be used in all other buildings. The number and size of hinges supplied will be appropriate for the type and size of the door, as determined by the hinge manufacturer's printed recommendations.

C. Locks

Locks will be furnished with the manufacturer's standard construction key system with cylinders that have removable cores. Cylinders will have seven pins and will be fitted to the locksets without adapters. Permanent keys will be sent by the lock manufacturer directly to the Contracting Officer by registered mail or another approved means. The lock manufacturer will provide three change keys per lock and six sets of all master keys, as well as additional replacement cores and keys equal to 10% of the total. The contractor will provide key cabinets suitable for the storage of all facility keys. Disassembly of knobs or locksets will not be required to remove the core from the lockset. A building master keying system is required for each building in the facility.

All bored locks will conform to ANSI A115.2 and ANSI A156.2, Grade 1. Mortise locks will conform to the requirements of ANSI A115.1 and ANSI A156.13, Grade 1. Manual flush bolts will be of the mortise type conforming to ANSI A156.16, Type L14081. Automatic flush bolts will be of the mortise type conforming to ANSI A156.3, Type 25, and will be installed with the appropriate strike. Dead bolts will be brass with a 1-inch throw and a heavy-duty tubular lock. Dead bolts on exterior exit doors will be components of mortise locksets that have anti-panic operation.

D. Special Security Requirements

Hardware complies with security requirements of AR 190-59.

E. Other Information

Any door or frame that requires DPE hose penetration entry airlocks contains a DPE hose passthrough device. Hardware surfaces are free of corners, sharp edges, and protrusions to avoid possible damage to DPE suits. Lever handles are required for locksets, latchets, and the exterior side of exit devices (panic bars) in all process areas that require protective clothing for operating personnel. All lever handles will have a return of approximately 1/2 inch off the door frame to prevent snagging the protective clothing.

11.4.1.11 Acoustical Treatment

All acoustical materials are fire resistant.

11.4.1.12 Sound Control

The noise level of the MDB rooms will be limited to acceptable levels as shown in Table 11-3.

11.4.1.13 Lighting

Interior architectural lighting will be specially selected and coordinated for entries and lobbies. Lighting at major cross-corridor intersections, lobbies, directory locations, and other main circulation points will be selected as functionally necessary.

Exterior architectural lighting will be provided where functionally required for public entries, safe walkway access, service entries, and security. The fixture selection and location will provide for low maintenance and low consumption of energy (energy efficient).

General illumination levels will conform to the recommendations of the Illuminating Engineering Society (IES) lighting handbook as modified by the Architectural and Engineering Instruction AEI Design Criteria and TM 5-811-1. If an intensity greater than 75 footcandles is required for a particular item, the additional footcandles will be provided by localized (supplementary) illumination. Exit and emergency lighting normally will be provided as required by NFPA 101.

11.4.1.14 Handicap Accessibility

Handicap accessibility is not required in the MDB.

Table 11-3—MDB Sound Control Schedule

Area/Room	45 dBA	65 dBA	85 dBA
Unpack area (UPA)	—	—	—
Explosive containment vestibule (ECV)			X
Explosive containment room (ECR)			X
Propellant reconfiguration room (PRR)	—	—	—
Continuous steam treater & offgas treatment room (OTR)			X
Energetics neutralization room (ENR)			X
Hydraulic equipment room (HER)			X
Offgas treatment room (OTR)			X
Electrical room (ER)		X	
Multipurpose demilitarization machine room (MDMR)			X
Metal parts treater room (MPTR)			X
Toxic maintenance room (TMA)	—	—	—
Agent neutralization room (ANR)			X
Toxic room (TOX)			X
Observation corridors		X	
Access corridors		X	
Valve galleries		X	
Decon airlock		X	
Glovebox vestibule		X	
MDB laboratory (MLA)		X	
Toilet and locker rooms (lab area)		X	
Supervisor's office (lab area)	X		
Electrical room (lab area)		X	
Vestibules and corridors (lab area)	—	—	—
Doffing and decon shower airlock (lab area)	—	—	—
Janitor's room (lab area)	—	—	—
Control room area (CRA)		X	
Offices (control room area)		X	
Telecommunications room (CRA)		X	
Engineering maintenance room (CRA)		X	
Observation and multipurpose room (CRA)		X	
Toilet rooms (CRA)		X	
Instrumentation equipment room (CRA)		X	
Vestibules and corridors (CRA)	—	—	—

11.4.2 STRUCTURAL

11.4.2.1 Foundations

The allowable net static soil bearing capacities are assumed to vary from 2100 lb/ft^2 for continuous foundations to 2500 lb/ft^2 for spread foundations. The differential settlements should be limited to 0.75 inch using the above soil bearing values. The foundations are spread footings, grade beams or mat foundations. The foundations extend a minimum of 3 ft–0 inch below finished grade for possible frost considerations.

The groundwater table is assumed to vary from 10 to 15 ft from existing grade elevation.

11.4.2.2 Roof and Exterior Wall Framing

The building roof system consists of a complete load-carrying steel space frame consisting of purlins, beams, girders and columns. The lateral wind and seismic load of the building roof is carried to the vertical load resisting system through rigid horizontal bracing system.

The exterior walls consist of steel composite panels supported by evenly spaced girts system.

11.4.2.3 Floor System

All building floors are constructed of reinforced concrete. The floor slabs and curbs in room Category A/B and C areas are placed monolithically. The floor of the MDB building consists of cast-in-place 8-inch concrete slab on 6-inch granular capillary system with 10-mil polyethylene vapor barriers except for TOX cubicle and ECR room. ECR and TOX cubicle floors consist of mat foundation for controlling agent contamination and for ECR blast design.

11.4.2.4 Lateral Load Resisting System

Lateral forces due to wind and seismic loads for the main structure are resisted by vertical steel concentric braced framed system. However, the lateral load resisting system for the agent hydrolysis and spent decon cubicles and the ECR room consists of concrete shear wall.

11.4.3 HVAC

11.4.3.1 Cascade Ventilation System

A. Air Supply Units

Five outside air supply/air-handling units are provided for the MDB toxic and laboratory areas, four operating and one standby. Air is taken directly from the outside through an air-tempering hot water coil with face and bypass damper. The air is then passed through media particulate filters rated at 30% and 85%, based on ASHRAE Standard 52. Next, the air is heated by a hot water coil or cooled by chilled water to the desired discharge temperature. Variable-speed centrifugal fans are used to overcome the pressure drop through the coils, filters, and ductwork to move the air to the various Category C and D areas of the MDB.

The system is started manually at the main operator console in the CRA. Interlock logic prevents more than the prescribed number of units in the system from being operated at one time. In a loss of airflow in an operating supply unit, a low-limit flow transmitter signals an alarm at the main operator console and resets the interlock logic so that the standby fan can be started automatically. Upon fan startup, the low flow logic is overridden for a period of time sufficient to allow the fan to reach full rotation speed. When a supply fan system is selected to run, its discharge isolation damper opens fully. A position switch is then closed, allowing the fan to start. This damper remains closed whenever its fan is not running. The chilled water coil and hot water coil control valves for the main supply units are modulated in sequence through a controller-sensing supply air temperature. A differential pressure gauge is provided at each filter section of each air supply unit to monitor filter loading. These pressures are monitored both locally and at the main operator console, where high-pressure alarms are also provided.

Additional air handling units are provided in areas with high equipment heat loss during operation to maintain design air temperatures.

B. Exhaust Air Filtration Units

The site filtered ventilation system will be similar to that used for CSDP sites already constructed as well as those under design development. Twelve exhaust/filtration trains are provided, 10 operating, one assumed to be undergoing maintenance, and one standby. Exhaust air is ducted from the MDB through a manifold, then to each operating unit where the air passes through a series of filters. The first bank, a media particulate filter with a rate of 85% based on ASHRAE Standard 52, removes any gross particulates present. The second bank, a HEPA filter, removes fine particles down to about 0.3 micron in size. An activated carbon bank is next and is used to remove airborne agent. The second through sixth activated carbon banks are backup to avoid bypassing the agent to the atmosphere when the absorptive capacity of the preceding carbon bank is reached. The final bank, another HEPA filter, is used to collect any fine particles that erode from the carbon filters.

A centrifugal exhaust fan in each unit serves as the prime mover of exhaust air and maintains a negative pressure in the MDB process areas. A flow element in the fan inlet controls a variable-speed motor according to variations in airflow through the filter unit. The variable-speed motor compensates for differential loading of the filters during their service life. The filtered exhaust air is discharged to the atmosphere through a stack.

Each filter unit is started manually at the main operator console. Interlock logic prevents more than the prescribed number of units from being operated at one time. In a loss of airflow in an exhaust filtration unit, a low-limit flow transmitter signals an alarm at the main operator console and resets the interlock logic so that a standby unit can be started. When any exhaust/filtration unit is selected to run, its inlet and outlet isolation dampers open fully. Position switches on these dampers then close, allowing the fan to start. These dampers remain closed when the unit is not running. If loss of airflow is detected in an exhaust/filtration unit, a standby unit is automatically reset to run.

Each exhaust/filtration unit is equipped with a flow-measuring station in the fan inlet. Airflow is maintained at a constant rate as the filters load by adjusting the exhaust fan motor speed automatically as follows: The flow-measuring station senses a reduced airflow rate and its transmitter sends a signal to the fan's speed control drive. The controller increases the fan speed to maintain the required airflow rate. The fan speed may also be manually adjusted (locally or remotely) from the main operator console.

Each medium (i.e., noncarbon) filter is equipped with a differential pressure gauge to monitor filter loading. In addition, a differential pressure gauge is provided to monitor loading of the entire filter train as a unit. These pressures are monitored locally and at the main HVAC control console, where high-pressure alarms are also provided.

Each exhaust/filtration unit has a bypass duct with a normally closed isolation damper. When the unit undergoes maintenance, both inlet and outlet isolation dampers close and the isolation damper on bypass duct opens to maintain negative pressure inside the unit under maintenance. The bypass duct and isolation damper are sized to provide a capture velocity of 100 fpm through a door, which may be opened for maintenance on the filter unit. The outside air passes through the open door and goes through the bypass duct into the intake exhaust manifold of the operating filter units.

A vacuum-relief damper is provided in the exhaust system to ensure that the pressure differential does not cause structural damage in the building. A pressure drop and transient analysis will be required to determine the physical location of the pressure elements and the set points to control this relief damper.

If the ACAMS, which are sampling between the first and second banks of the carbon filters, detect an amount of agent in excess of its set point, an alarm is transmitted to the main operator console. The operator initiates the switchover function and monitors the sequence for shutting down the particular unit and starting the standby unit. The redundant chemical analyzers are provided at the second and third, third and fourth, and fourth and fifth banks of carbon filters, as well as at the common exhaust discharge stack to warn of agent bypass in the event that a filter unit-mounted analyzer fails.

11.4.3.2 Control Room HVAC System

The control room ventilation system serves the control and instrumentation rooms and supporting areas. It provides human comfort, maintains proper positive pressure relationship between the areas served with respect to the toxic process areas of the MDB, and provides (by means of particulate and absorption filtration) a safe environment for personnel operating the facility, in the event of an accidental release of chemical agent. This configuration allows for a safe shutdown of the facility.

The general design of the control room area (CRA) is recirculating with approximately 20% outside air. Air is supplied to the control room and its support areas. Some air is transferred through the spaces to the various storage areas and toilet rooms before being exhausted to atmosphere. The remainder of the air is returned to the supply air unit.

The operating system consists of the outside air filter unit and three air-handling units (two operating and one standby). Each operating unit is selected at the main operator console. In loss of airflow in the fan or fans intended to be operating, a low-limit flow transmitter signals an alarm at the main operator console. Upon fan startup, the low-flow logic is overridden for a period of time sufficient for the fan to reach full rotational speed.

An outside air filtration unit is provided to treat outside supply air entering the space. During normal operation, outside air enters the system through a weatherproof louver and is drawn through a demister and heater to the filtration unit, passing through a series of six filter banks (35% prefilters, 85% filter, HEPA, carbon, carbon, and HEPA). The demister and electric heating coil reduce relative humidity on incoming air to 70%, based on the worst case and assuming the outdoor air is saturated at 80°F. The electric heating coil is controlled by a humidistat. The air is discharged from the filter unit by a pair of centrifugal fans (one in operation and one standby) with variable-speed control, and the air is mixed with the control room return air. Air is then drawn through the two operating air-handling supply units sized for

50% of the required capacity (the third 50% unit is standby). An unfiltered bypass is provided around the filtration unit to provide fresh air when the filter is not available during maintenance.

Each supply air-handling unit consists of a 30% filter, cooling coil, heating coil, and a centrifugal fan with variable-speed control, which delivers the conditioned air to the control room, instrumentation room and supporting areas. A humidifier is provided in the duct serving the control room area to maintain the 50% relative humidity, as required.

When a fan is selected to operate, its discharge isolation damper opens fully. An end switch is then closed allowing the fan to start. These dampers remain closed whenever the fan is not running. The cooling coil and heating coil water control valves are normally controlled from a temperature sensor located in the control room. If the relative humidity in the control room drops below the set point of the humidistat located within the space, the humidifier control valve opens and remains so until the correct humidity level is reached.

The filter unit and air-handling supply units are equipped with flow-measuring stations that control the variable-speed fans to maintain constant airflow in the system.

Each particulate filter is equipped with a differential pressure gauge to monitor filter loading. In addition, a differential pressure gauge is provided to monitor loading of the entire filter train as a unit. These pressures are monitored both locally and at the main operator console where a high-pressure alarm is also provided.

11.4.3.3 Process (Nontoxic) Support Area Ventilation

The ventilation systems that serve the nonagent support areas (Category D) of the MDB including the MDB lab supporting area, housing nontoxic portions of the process are served by independent air-conditioning units.

The room summer and winter design conditions are as noted in Section 10.4.1.8.

11.4.3.4 Battery Rooms

Battery rooms will be provided with cooling and heating from an HVAC unit, to maintain summer and winter design conditions as noted in Section 10.4.1.8. A minimum of six air changes per hour will be provided to control hydrogen buildup during battery charging. 100% exhaust will flow directly to the outside. Unit heaters located in battery areas and other areas with potentially explosive fumes are explosion-proof and spark-resistant. Exhaust fans have explosion-proof motors and spark-resistant bearings.

11.4.3.5 Electrical Equipment Rooms

Electrical equipment will be heated and cooled by dedicated HVAC units. Areas that contain essential and critical electrical systems that are segregated by train have dedicated HVAC systems segregated by electrical power train. Hot water and chilled water lines are not routed inside the electrical areas.

11.4.3.6 Personnel Areas

Personnel areas will be heated and cooled by rooftop or central HVAC units as required for comfort.

11.4.3.7 Mechanical Equipment Rooms

The MERs will be ventilated in summer by dedicated roof ventilators and heated in winter by unit heaters. A small amount of supply air from the cascade system will provide tempered air.

11.4.3.8 Chilled Glycol-Water Systems

The MDB HVAC chilled glycol-water system consists of three 50% chillers (two operating and one standby). Three 50% chilled glycol-water pumps (two operating and one standby) are provided to operate with the chillers. At one time any two chillers and any two pumps will operate. The third chiller and a pump are standby. Chilled water (40% propylene glycol-water) is circulated to the cooling coils associated with the cascade system air handling units, control room system air handling units, and the cooling only recirculating air handling units located in the process areas with high heat loss. The leaving and entering chilled water temperature is 45 to 55°F, respectively.

Each chiller and the pump can be started manually at the main HVAC control console or locally. If a pump intended to operate fails, a flow switch at its discharge alarms the condition at the main HVAC control console. This system is fed from the essential (emergency) power.

11.4.3.9 Water Heating System

Hot water for space heating is provided from the central hot water boilers supply system located in the UB building. In addition to the hot water coils in the air handling units, unit heaters are provided in the required location with local manual start and space mounted thermostats.

11.4.4 PLUMBING

A plumbing system as specified in Section 4.4.2 will include potable and industrial water, sanitary facilities, emergency equipment, laboratory waste, and compressed gas.

11.4.5 ELECTRICAL

11.4.5.1 Electrical Equipment Rooms

Category D areas in the southeast corner of the building are provided to house the electrical equipment associated with the MDB. 4160-V MCCs, 480-V switchgear, 480-V motor control centers (MCCs), distribution panels, UPS equipment with batteries, 125-VDC system with batteries and lighting panelboards are located in these areas. Train A electrical equipment is segregated from Train B equipment by 2-hr rated fire barriers. The batteries in the battery racks and associated equipment are indicated Train A and Train B rooms.

The 4160-V MCCs and 480-V switchgear/MCCs will supply the MDB electrical load. The UPS power will be distributed to the MDB UPS load and to the UPS panels in other areas/buildings such as utility building (UB), MDB filter area (FIL), and process auxiliary building (PAB).

11.4.5.2 Functional and Operational Characteristics/Requirements

Lightning protection required: An integrally mounted system consisting of air terminals, down conductors, ground connections, and grounding are provided for the MDB in accordance with NFPA 780.

Emergency standby power: The emergency power system consists of redundant feeders from SDGs. The SDGs can supply 100% of the essential load and critical load in case of a commercial power outage.

Critical power: The power supply for all critical loads is provided by a parallel redundant UPS system.

Electronic shielding: Not applicable.

Security systems: Yes, in accordance with AR 190-59.

Other special systems: No special requirements.

11.4.5.3 Power

Four 4160V feeders provided at the MDB boundary extend into the MDB electrical rooms. Two 4160V MCCs and two 480V switchgear, for Train A and Train B, are provided. The 4160V feeders are terminated in the respective equipment located in separate rooms. 4160V MCCs are provided to supply 4160V power to large loads.

For utilization and distribution of power, 480-V, 3-phase, 4-wire, 60-Hz switchgear (including dry power transformers) and MCCs are provided. The 480V MCCs are located in electrical rooms and in Category D process areas in the MDB.

For loads requiring 208Y/120V system, 208Y/120V, 3-phase, 4-wire, 60-Hz panelboards are provided and located in electrical rooms and in strategic locations in the MDB.

Utilization Voltages: Voltage ratings for equipment is as follows:

(1)	Motors larger than 150 HP:	4000-V, 3-phase
(2)	Motors ½ HP to 150 HP:	460-V, 3-phase
(3)	Motors less than ½ HP:	208-Y/120-V, single phase
(4)	Lighting:	277-VAC
(5)	Receptacles:	480-V and 208-Y-120-V
(6)	Controls:	120-VAC
(7)	Instrumentation:	120-VAC

11.4.5.4 Lighting

Intensity: Complies with IES and Architectural and Engineering Instructions Design Criteria, except as shown in Table 11-4.

Fluorescent and high-intensity discharge: Fluorescent, high-pressure sodium vapor or metal halide lights are used for shop lighting. Fluorescent lights are used in office areas. High-power factor and, where required, high-temperature ballasts are specified.

Incandescent: No special requirement.

Recess: May be employed in the CRA and support areas.

Surface or pendant-mounted fixtures: No special requirement.

Night lighting: No special requirement.

Emergency and protective lighting: All exit and directional signs are placed on battery packs. Emergency lighting in Category A, A/B, B and C process areas is connected to critical circuits; emergency lighting in maintenance, support, and nonessential areas may be battery-type fixtures with automatic switching on power failure. Minimum required lighting in the central control room is placed on UPS. Lights are provided outside each exterior door.

Additional information:

(1) Light switches are provided in all nontoxic rooms.
(2) Lighting design in toxic areas considers maintenance needs (lamp replacement); where possible, lamp replacement is accomplished from outside the room to avoid the need for special suits and gloves. No PVC or aluminum conduit is used in these areas.
(3) Table 11-4 lists the specific task illumination requirements.

Table 11-4—Specific Task Illumination Requirements

Work Area or Task Type	Minimum[a] (fc)
General work and handling (DPE support area)	75
Areas requiring CCTV	75
Control Room Operations:	
Console surfaces	50
Panels, front/rear	50/30
Computer operations	100
Recording	75
Transcribing and tabulation	100
Circuit diagrams	100
General office work	70
Ambient lighting	50
Reading dials, gauges, meters and scales	50
Benchwork, medium detail (DPE support area)	75
Inspection work and testing	100
Repair work, general	50
Storage, live medium (DPE storage area)	53
Corridors, stairways, and passageways	20
Emergency lighting	3

[a]Where ambient lighting does not meet minimum footcandle requirements to perform tasks, supplementary lighting is provided. In areas requiring CCTV, light-to-dark ratio does not exceed 6 to 1.

11.4.5.5 Communications

The following systems relate to the MDB facility communications system:

(1) Telephone
(2) Two-way radio
(3) Radio paging
(4) Hot line
(5) Intercom
(6) Local area communications Network
(7) Security CCTV
(8) Process control CCTV
(9) Alarm systems – fire and security

(10) Data transmission

(11) Specialized communications (DPE)

(12) Telecopy (facsimile)

(13) Public address system

(14) Communications cable system

(15) IDS cable system

(a) **Telephone system:** A telephone system is provided throughout the building (nontoxic areas) and in the communications room of the MDB. Telephone stations are also provided in the DSA, control room and all observation areas. Telephone stations are not provided in Category A, A/B and B areas.

(b) **Public address system:** A separate multizoned EPABX-driven 70.7-V line public address system is provided. All 70.7-V speaker lines are in a separate conduit. Low-level amplifier drive lines are on dedicated telephone wires.

(c) **CCTV system:** Conduit is provided between remote-controlled waterproof camera locations throughout the facility and the main control room of the MDB. Exact locations will be determined when final layout is determined.

11.4.5.6 Specialty Items

Grounding and lightning protection:

(1) A lightning protection system in accordance with NFPA 780 and grounding system in accordance with AR and DA Pam 385-64 is provided for the MDB. In wash down areas, the ground wire is installed in conduits. Separate grounding systems are provided for instrumentation, connected to the overall grounding system at one point.

(2) Exterior overhead pipes that enter the building are grounded and, at a point external to the building, bonded to the building grounding system. Metal stacks are grounded. Metal doors, panels, stairs, ladders, etc. are grounded.

(3) The ground loop counterpoise has test points to permit additional equipment to be grounded after the building is erected. The counterpoise loop encircles all facility buildings.

Special controls and lighting: All power-operated doors throughout the functional areas of the MDB have position switches with dry contacts to indicate the closed or open position of the door. Wiring is provided between these contacts and the indicators located in the central control room and ECF where the door position is indicated.

Intrusion detection systems (IDSs): Space for intrusion detection systems is provided in accordance with AR 190-59. Specific criteria will be developed based on the site security design review.

Power system overview: Electrical systems for the MDB are classified into three categories in terms of reliability and availability of power required:

(1) **Utility load system:** This system provides power to all nonessential, essential, and critical loads.

(2) **Essential load system:** This system provides power to all loads required for safe shutdown of MDB functions such as support for essential loads that can be interrupted for short periods of time. The required power for this system is provided by SDGs.

(3) **Critical load system:** This system provides power through a UPS, to all critical loads that cannot be interrupted for any length of time. Such loads are computer systems, control room emergency lights, communications, agent monitoring and instrumentation. A parallel redundant UPS system, with 45-minute battery backup time, will provide reliability for the critical load system.

Instrumentation/Controls: A control system takes care of all unusual electrical conditions such as partial and complete power outage, loss of feeder and power transformer, etc. The control system is capable of remote and centralized control commanding closing/opening of breakers/contactors in switchgear/MCCs and transferring electrical loads in response to each unusual condition.

Electric heat tracing: Electric heat tracing is provided where utilities are exposed to freezing weather at connection to the MDB.

Other:

(1) Receptacles are provided in accordance with CEHND-1110-1-1. Receptacles in wash down areas are equipped with corrosion-resistant and waterproof covers and do not contain aluminum.

(2) Welding outlets are provided in the toxic and nontoxic areas close to major equipment and vessels. Welding outlets in wash down areas are equipped with corrosion-resistant and waterproof covers and do not contain aluminum.

(3) Power supplies and controls are provided for all facility-provided equipment including cranes, monorails, etc. Fail-safe system features are used in the design of all process control, HVAC, fire alarm, cranes, and other critical installed building equipment.

(4) Equipment mounting bases (pads) for transformers, switchgears, MCCs, etc., are provided.

(5) NEMA 4X enclosures and equipment not containing exposed aluminum are specified in all Category A, A/B and B areas.

(6) All electrical equipment such as pull and junction boxes, terminal boxes, conduit couplings, fittings, junctions or conduit located in areas that are subject to decon solution wash down are potted with an appropriate material (e.g., RTV or equal) prior to assembly and closeout.

(7) Wall penetrations for power, control, and alarm wiring are provided throughout the toxic areas.

(8) Conduits entering toxic areas are configured with appropriate seal fittings on the lower classification side of the wall to prevent the transmission of toxic material.

(9) Toxic and/or Hazardous Locations:

(a) For room category classifications, see Area Classification Drawings.

(b) Panelboards, circuit breakers, switches, etc. are located outside toxic areas and hazardous areas.

11.4.6 FIRE PROTECTION

The building will be provided with several wet-pipe sprinkler fire suppression systems, several pre-action systems, ultrahigh-speed deluge systems, and several high-speed deluge systems. The activation of the pre-action systems will be by means of photoelectric smoke detectors or thermal detectors as appropriate. The activation of the ultrahigh-speed and high-speed deluge systems will be by ultraviolet/infrared detectors. For the types of fire suppression systems and their method of activation by room, refer to the Fire Protection Design Analysis Report.

A linear thermal detection system will be provided in the HVAC filter units to detect fires originating from within the units.

11.5 PAB

11.5.1 ARCHITECTURAL

11.5.1.1 Building Description

The PAB is an approximately 46,000-ft^2, one-story, noncombustible industrial-type steel frame over a concrete floor slab-on-grade construction. The exterior envelope of this building is composed of insulated composite metal wall panels and roof panels over a custom-engineered steel frame, and the roof has a slope of 1½ inch/ft.

11.5.1.2 Fire-rated Walls

The PAB has two electrical equipment rooms (1 and 2). The perimeter walls of the electrical rooms and the ceiling slab will be of 2-hr fire-rated construction.

11.5.1.3 Floors and Floor Finishes

The floor is constructed of reinforced concrete. Construction and expansion joints are kept to the minimum number possible. Floors in the diked tank and pump areas slopes to sumps. The slope is a minimum of 1/8 inch/ft. Waterstops are required.

In the area surrounding the sodium hydroxide (NaOH) storage tanks, the joints between floors and walls are covered with sealant tape and sealed with an elastomeric one-compound type material that conforms to Federal Specification TT-S-1543, Class A.

The floor finish will be standard float trowel and broom finish. In the area surrounding the NaOH storage tanks, the finish is a special coating with a nonskid finish. This finish will be applied to all concrete floor and wall surfaces, including tank and pump pads.

The mezzanine (platform floor) is constructed of fiberglass grating supported by steel beams and columns.

11.5.1.4 Walls

Exterior walls: Prefabricated, factory-finished composite insulated metal panels over steel framing set on concrete curbs.

Interior walls and partitions: 8-inch-thick reinforced concrete masonry units set on concrete curbs.

Removable panels: Provided for equipment access close to the equipment wherever possible.

A 2-hr fire-rated wall is required to separate the ERs from the process equipment area.

11.5.1.5 Ceiling and Roof

Ceiling: The entire facility will be exposed structural framing and roof panels. The ceiling slab at the ERs will be 2-hr fire-rated concrete over metal decking construction.

Roof: Insulated composite metal roof panels over steel beams and purlins. Roof construction classification will be Class B.

11.5.1.6 Windows

The PAB has no windows.

11.5.1.7 Doors

All rollup steel doors are power operated. Building doors are flush hollow metal 3-ft wide by 7-ft high. All exterior doors will be insulated.

11.5.1.8 Hardware

All hardware complies with Builders Hardware Manufacturers Association (BHMA) requirements.

11.5.1.9 Sound Control

The noise level inside the PAB will be limited to 85 dBA.

11.5.1.10 Stairs, Ladders, and Railings

Stairs, ladders, and railings comply with OSHA 29 CFR 1910 and AR 190-59 and DA Pam 385-64.

11.5.2 STRUCTURAL

11.5.2.1 Roof Framing

The building roof system consists of a complete load-carrying steel frame consisting of purlins, beams, girders and columns. The lateral wind and seismic loads of the building roof are carried to the vertical load-resisting system through rigid horizontal bracing system.

The exterior walls consist of steel composite panels supported by evenly spaced girts system.

11.5.2.2 Floor System

All building floors are constructed of reinforced concrete. The floor of the PAB building consists of cast-in-place 8-inch concrete slab on 6-inch granular capillary system with 10-mil polyethylene vapor barriers on compacted engineered fill.

11.5.2.3 Lateral Load resisting system

Lateral forces due to wind and seismic loads for the main structure are resisted by vertical steel concentric braced framed system.

11.5.2.4 Foundations

The allowable net static soil bearing capacities are assumed to vary from 2100 lb/ft^2 for continuous foundations to 2500 lb/ft^2 for the spread foundations. The differential settlements should be limited to 0.75 inch using the above soil-bearing values. The foundations are spread footings, grade beams, or mat foundations. The foundations extend a minimum of 3 ft-0 inch below finished grade for possible frost considerations.

The ground water table is assumed to vary from 10 to 15 feet from existing grade elevation.

11.5.3 HVAC

The process support areas are non-agent (Category D) type.

11.5.3.1 Bay Area

The bay area will be ventilated in summer by means of fresh air louvers and exhaust ventilators, and hot water unit heaters are provided for winter heating.

11.5.3.2 Chemical Storage Area

A dedicated air handling unit with filter and hot water heating coil will be provided for ventilation in summer and heating in winter. Exhaust air ventilators are provided which exhaust air from floor and ceiling level to prevent any build-up of gases.

11.5.3.3 Electrical Rooms

Packaged roof top DX units with filter, electric heating coil, DX coil, and air-cooled condensing unit will be provided for each electrical room.

11.5.4 PLUMBING

The plumbing system will include potable water for emergency equipment from the site main 5 ft outside the structure.

11.5.5 ELECTRICAL

11.5.5.1 Electrical Equipment Rooms

The process auxiliary building has two electrical equipment rooms which contain 4160-V main switchgear, 4160-V MCCs, 480-V switchgear, 480V MCCs, distribution panels, lighting panels and 125 VDC system with batteries. Train A electrical equipment is segregated from Train B equipment by 2-hr rated fire barriers.

The 4160V MCCs and 480V switchgear/MCCs provide power to electrical load located in the PAB. The UPS power for critical load in PAB and Biotreatment Area is provided from the UPS system in the MDB.

11.5.5.2 Functional and Operational Characteristics/Requirements

Lightning protection required: An integrally mounted system consisting of air terminals, down conductors, ground connections, and grounding are provided for the PAB in accordance with NFPA 780.

Emergency standby power: The emergency power system consists of redundant feeders from SDGs. The SDGs can supply 100% of the essential load and critical load in case of a commercial power outage.

Critical power: The power supply for all critical loads is provided by a parallel redundant UPS system located in the MDB.

Electronic shielding: Not applicable.

Security systems: Yes, in accordance with AR 190-59.

Other special systems: No special requirement.

11.5.5.3 Power

Four sets of 4160-V feeders are provided from the main 4160-V switchgear in the UB for the two 4160-V MCCs and two 480-V switchgear. The feeders are terminated in the respective equipment. 4160-V MCCs are provided to supply 4160-V power to large loads.

For utilization and distribution of power, 480V, 3-phase, 4-wire, 60-Hz switchgear (including dry power transformers) and MCCs are provided. The 480-V MCCs are located in electrical rooms.

For loads requiring 208Y/120V system, 208Y/120V, 3-phase, 4-wire, 60-Hz panelboards are provided and located in electrical rooms and in strategic locations in the PAB.

Utilization voltages: Voltage ratings for equipment are as follows:

(1)	Motors larger than 150 HP:	4000V, 3-phase
(2)	Motors ½ to 150 HP:	460V, 3-phase
(3)	Motors less than ½ HP:	208Y/120-V, single phase
(4)	Lighting:	277-VAC
(5)	Receptacles:	480-V and 208-Y-120-V
(6)	Controls:	120-VAC
(7)	Instrumentation:	120-VAC/24 Vdc

11.5.5.4 Lighting

High-pressure sodium vapor or metal halide lights and incandescent pendant mount fixtures are used in the process areas. Fluorescent lights are used in electrical rooms. Lighting intensity level is in accordance with Architectural and Engineering Instructions Design Criteria.

11.5.5.5 Communications

A telephone station and public address system are provided in the electrical room. Soundproof or sound-isolated telephone stations are provided in process areas.

11.5.5.6 Specialty Items

Grounding and lightning protection:

(1) A lightning protection system in accordance with NFPA 780 and grounding system in accordance with AR and DA PAM 385-64 is provided for the PAB. A separate grounding system is provided for instrumentation, connected to the overall grounding system at one point.

(2) Exterior overhead pipes that enter the building are grounded and, at a point external to the building, bonded to the building grounding system. Metal stacks, metal doors, panels, stairs, ladders, etc. are grounded.

(3) The ground loop counterpoise has test points to permit additional equipment to be grounded after the building is erected. The counterpoise loop encircles all facility buildings.

Special controls and lighting: No special requirement.

Intrusion detection systems (IDSs): Not applicable.

Power systems:

System overview: See the System Overview section of the MDB for definition of electrical load systems.

Instrumentation/Controls: A control system takes care of all unusual electrical conditions such as partial and complete power outage, loss of feeder and power transformer, etc. The control system is capable of remote and centralized control commanding closing/opening of breakers/contactors in switchgear/MCCs and transferring electrical loads in response to each unusual condition.

Electric heat tracing: Electric heat tracing is provided where utilities are exposed to freezing weather at connection to the PAB.

Other:

(1) Convenience and welding receptacles are provided as required.

(2) Equipment mounting bases (pads) for transformers, switchgears, MCCs, etc., are provided.

11.5.6 FIRE PROTECTION

The building will be provided with a pre-action fire suppression system. The activation of this system will be by means of thermal detectors as appropriate.

A Class 1 standpipe system will be provided to allow hose streams access to all parts of the building.

SECTION 12

SAFETY DESIGN REQUIREMENT

This Safety Design Requirements Manual in Appendix E has been developed to provide safety design criteria for incorporation into the Assembled Chemical Weapons Assessment Project Engineering Development Study, ACWA EDS design. The safety design requirements in this safety manual address the potential toxic and explosive hazards inherent in the demilitarization operations planned for ACWA EDS.

SECTION 13

FIRE PROTECTION DESIGN ANALYSIS

The objective of this Fire Protection Design Analysis Report in Appendix F is to document the review of the Assembled Chemical Weapons Assessment Project Engineering Development Study, ACWA EDS design, and to demonstrate compliance with the requirements of MIL-HDBK-1008C, the National Fire Protection Association (NFPA), and the Uniform Building Code 1997 for the design of the buildings and their fire suppression and detection systems.

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SECTION 14

DELIVERABLES

14.1 TECHNICAL DOCUMENTATION – DOCUMENTS

14.1.1 GENERAL

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I/O Count
Instrument Tag List

Time & Motion Diagram

14.1.2 HEAT AND MATERIAL BALANCES

4.2-inch Mortar Design/DPE Case
4.2-inch Mortar Design/Wood Case
4.2-inch Mortar Design/Wood/DPE Case
155-mm Design/DPE Case
105-mm Design/DPE Case
4.2-inch Mortar Steady State/DPE Case
155-mm Steady State/DPE Case
105-mm Steady State/DPE Case

14.1.3 EQUIPMENT DATA SHEETS

010-TANK-103 Water Jet Day Tank	DAS-AAC-00-F-201
020-TANK-101 Washout Water Storage Tank	DAS-AAC-00-F-202
020-TANK-102/104 Agent Settling Tanks	DAS-AAC-00-F-203
030-TANK-101 Agent Holding Tank	DAS-AAC-00-F-204
030-TANK-102 Agent Surge Tank	DAS-AAC-00-F-205
030-TANK-103/104 MPT/CST Condensate Holding Tank	DAS-AAC-00-F-206
030-TANK-105/106/107 Spent Decon Holding Tank	DAS-AAC-00-F-207
030-TANK-110 Agent Concentrate Holding Tank	DAS-AAC-00-F-208
040-RCTR-101/102/103/104/105/106 Agent Hydrolyser	DAS-AAC-00-F-209
040-TANK-107 Agent Hydrolysate Holding Tank	DAS-AAC-00-F-210
050-RCTR-101/102/103 Energetics Neutralization Reactor	DAS-AAC-00-F-211
050-TANK-104 Energetics Hydrolysate Holding Tank	DAS-AAC-00-F-212
060-SEPA-101/102/103/104 Bioreactor Offgas K.O. Pot	DAS-AAC-00-F-213

Return

060-TANK-101/102/103/104 ICB Feed Tank	DAS-AAC-00-F-214
060-TANK-105/106/107/108 ICB Effluent Pump Tank	DAS-AAC-00-F-215
070-TANK-101 MPT Condensate Surge Tank	DAS-AAC-00-F-216
070-TOWR-101 MPT Quench Tower	DAS-AAC-00-F-217
075-TANK-121 CST Condensate Surge Tank	DAS-AAC-00-F-218
075-TOWR-121 CST Quench Tower	DAS-AAC-00-F-219
090-TANK-101 Evaporator Feed Tank	DAS-AAC-00-F-220
110-TANK-101 Sodium Hydroxide (50% NaOH) Storage Tank	DAS-AAC-00-F-222
110-TANK-102 18% Sodium Hydroxide Storage Tank	DAS-AAC-00-F-223
110-TANK-103 Sodium Hypochlorite Tank	DAS-AAC-00-F-224
110-TANK-104 Inorganic Nutrient Tank	DAS-AAC-00-F-225
110-TANK-105 Decon Supply Tank	DAS-AAC-00-F-226
140-TANK-101 Hot Process Water Tank	DAS-AAC-00-F-227
170-TANK-101/102/103/104/105/106 Agent Hydrolyser Heat Transfer Fluid Expansion Tank	DAS-AAC-00-F-228
180-TANK-101/102 ENR Heat Transfer Fluid Expansion Tank	DAS-AAC-00-F-229
200-TANK-109A/B Process Water Tanks	DAS-AAC-00-F-221
075-CST-121 Continuous Steam Treater	DAS-AAC-00-F-300
076-MPT-101 Batch Metal Parts Treater	DAS-AAC-00-F-301
070-MPT-101 Rotary Metal Parts Treater	DAS-AAC-00-F-302
060-ICBR-101 TO 060-ICBR-116 Bioreactor	DAS-AAC-00-F-303
020-RW-101/102 Rotary Washout Machine	DAS-AAC-00-F-304
010-WASH-101/102 Burster Washout Machine	DAS-AAC-00-F-305
100-PKG-101 Brine Reduction Package	DAS-AAC-00-F-306

14.2 TECHNICAL DOCUMENTATION - DRAWINGS

14.2.1 ARCHITECTURAL

Architectural Drawing Index	AAC-00-A-001
Architectural Symbols	APU-00-A-001
Abbreviations & Acronyms	APU-00-A-002
MDB - Major Equipment Legend	AAC-01-A-001
MDB - Major Equipment Legend	AAC-01-A-002
MDB - Major Equipment Legend	AAC-01-A-003
MDB - Overall Floor Plan, General Arrangement	AAC-01-A-004
MDB - First Floor Plan Area 1 - General Arrangement	AAC-01-A-005
MDB - First Floor Plan Area 2 - General Arrangement	AAC-01-A-006
MDB - First Floor Plan Area 3 - General Arrangement	AAC-01-A-007
MDB - First Floor Plan Area 4 - General Arrangement	AAC-01-A-008
MDB - First Floor Plan Area 5 - General Arrangement	AAC-01-A-009
MDB - First Floor Plan Area 6 - General Arrangement	AAC-01-A-010
MDB - First Floor Plan Area 7 - General Arrangement	AAC-01-A-011
MDB - First Floor Plan Area 8 - General Arrangement	AAC-01-A-012
MDB - Platform Level Plan Area 1 - General Arrangement	AAC-01-A-013
MDB - Platform Level Plan Area 2 - General Arrangement	AAC-01-A-014

MDB - Platform Level Plan Area 3 - General Arrangement	AAC-01-A-015
MDB - Platform Level Plan Area 4 - General Arrangement	AAC-01-A-016
MDB - Building Section A - General Arrangement	AAC-01-A-017
MDB - Building Section B - General Arrangement	AAC-01-A-018
MDB - Building Section C - General Arrangement	AAC-01-A-019
MDB - Building Section D - General Arrangement	AAC-01-A-020
MDB - Building Section E - General Arrangement	AAC-01-A-021
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MDB - First Floor Plan Area 2	AAC-01-A-023
MDB - First Floor Plan Area 3	AAC-01-A-024
MDB - First Floor Plan Area 4	AAC-01-A-025
MDB - First Floor Plan Area 5	AAC-01-A-026
MDB - First Floor Plan Area 6	AAC-01-A-027
MDB - First Floor Plan Area 7	AAC-01-A-028
MDB - First Floor Plan Area 8	AAC-01-A-029
MDB - Platform Level Plan Area 1	AAC-01-A-030
MDB - Platform Level Plan Area 2	AAC-01-A-031
MDB - Platform Level Plan Area 3	AAC-01-A-032
MDB - Platform Level Plan Area 4	AAC-01-A-033
MDB - Building Section A	AAC-01-A-034
MDB - Building Section B	AAC-01-A-035
MDB - Building Section C	AAC-01-A-036
MDB - Building Section D	AAC-01-A-037
MDB - Building Section E	AAC-01-A-038

PAB - Major Equipment Legend	AAC-44-A-001
PAB - Overall Floor Plan, General Arrangement	AAC-44-A-003
PAB - First Floor Plan Area 1 - General Arrangement	AAC-44-A-004
PAB - First Floor Plan Area 2 - General Arrangement	AAC-44-A-005
PAB - First Floor Plan Area 3 - General Arrangement	AAC-44-A-006
PAB - First Floor Plan Area 4 - General Arrangement	AAC-44-A-007
PAB - Platform Level Plan Area 1 - General Arrangement	AAC-44-A-008
PAB - Platform Level Plan Area 2 - General Arrangement	AAC-44-A-009
PAB - Platform Level Plan Area 3 - General Arrangement	AAC-44-A-010
PAB - Platform Level Plan Area 4 - General Arrangement	AAC-44-A-011
PAB - Building Section A - General Arrangement	AAC-44-A-012
PAB - Building Section B - General Arrangement	AAC-44-A-013
PAB - First Floor Plan Area 1	AAC-44-A-014
PAB - First Floor Plan Area 2	AAC-44-A-015
PAB - First Floor Plan Area 3	AAC-44-A-016
PAB - First Floor Plan Area 4	AAC-44-A-017
PAB - Platform Level Plan Area 1	AAC-44-A-018
PAB - Platform Level Plan Area 2	AAC-44-A-019
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14.2.2 CIVIL

Site Work Symbols, Legend and Abbreviations	APU-16-C-001
Site Work Overall Site Plan	AAC-16-C-002
Site Work Area 1 Plot Plan	APU-16-C-003
Site Work Area 2 Plot Plan	AAC-16-C-004
Site Work Area 3 Plot Plan	AAC-16-C-005
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Site Work Area 1 Paving Plan	APU-16-C-012
Site Work Area 2 Paving Plan	AAC-16-C-013
Site Work Area 3 Paving Plan	AAC-16-C-014
Site Work Area 4 Paving Plan	AAC-16-C-058
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Site Work Paving Sections	AAC-16-C-015
Overall Utility Plan	AAC-16-C-017
Site Work Area 1 Potable/Firewater Plan	APU-16-C-020
Site Work Area 2 Potable/Firewater Plan	AAC-16-C-021
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Site Work Area 5 Potable/Firewater Plan	AAC-16-C-023
Site Work Area 1 Sanitary Sewer Plan	APU-16-C-027
Site Work Area 2 Sanitary Sewer Plan	AAC-16-C-028
Site Work Area 3 Sanitary Sewer Plan	AAC-16-C-029
Site Work Area 4 Sanitary Sewer Plan	AAC-16-C-062
Site Work Area 5 Sanitary Sewer Plan	AAC-16-C-030
Site Work Area 1 Storm Drain Plan	APU-16-C-033
Site Work Area 2 Storm Drain Plan	AAC-16-C-034
Site Work Area 3 Storm Drain Plan	AAC-16-C-035
Site Work Area 4	AAC-16-C-061
Site Work Area 5 Storm Drain Plan	AAC-16-C-036

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Munitions Demilitarization Building (MDB)	AAC-01-E-002
Munitions Demilitarization Building (MDB) (Chil)	AAC-01-E-003
Munitions Demilitarization Building (MDB)	AAC-01-E-004
Munitions Demilitarization Building (MDB) (Chil & Fil)	AAC-01-E-021
Munitions Demilitarization Building (MDB)	AAC-01-E-022
Utility Building (UB)	AAC-02-E-001
Utility Building (UB)	AAC-02-E-002
Utility Building (UB)	AAC-02-E-003
Utility Building (UB)	AAC-02-E-007
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Standby Diesel Generator	AAC-10-E-002
Standby Diesel Generator	AAC-10-E-003
Standby Diesel Generator	AAC-10-E-004
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Munitions Demil Bldg. Filters	AAC-23-E-001
Process Auxiliary Building (PAB)	AAC-44-E-002

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Shutdown Block Diag. - MDB - Rotary Metal Parts Treater	AAC-01-D-900 Sheet 2
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Shutdown Block Diag. - MDB - Metal Parts Treater Offgas	AAC-01-D-900 Sheet 4
Shutdown Block Diag. - MDB - Batch Metal Parts Treater	AAC-01-D-900 Sheet 5
Shutdown Block Diag. - MDB - Toxic Storage	AAC-01-D-900 Sheet 6
Shutdown Block Diag. - MDB - Agent Collection	AAC-01-D-900 Sheet 7
Shutdown Block Diag. - MDB - Rotary Washout Machine	AAC-01-D-900 Sheet 8
Shutdown Block Diag. - MDB - Rotary MPT Conveyors	AAC-01-D-900 Sheet 9
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Shutdown Block Diag. - Utility Building	AAC-02-D-900 Sheet 1
Shutdown Block Diag. - Liquid Nitrogen Vaporization	AAC-16-D-900 Sheet 1
Shutdown Block Diag. - Fuel Gas Supply – LPG	AAC-16-D-900 Sheet 2
Shutdown Block Diag. - Biotreatment - ICB Catox	AAC-40-D-900 Sheet 1
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Shutdown Block Diag. - MDB - Munitions Handling Conveyors	AAC-50-D-900 Sheet 1
Shutdown Block Diag. - MDB - Burster Washout Machine	AAC-50-D-900 Sheet 2
Shutdown Block Diag. - MDB - Energetics Neutralization	AAC-50-D-900 Sheet 3
Shutdown Block Diag. - MDB - Continuous Steam Treater Offgas	AAC-50-D-900 Sheet 4
Shutdown Block Diag. - MDB - Continuous Steam Treater	AAC-50-D-900 Sheet 5
Shutdown Block Diag. - MDB - Contaminated Materials Handling	AAC-50-D-900 Sheet 6
Shutdown Block Diag. - MDB - Energetics Rotary Deactivator	AAC-50-D-900 Sheet 7

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Projo Propellant Reconfiguration Plan	AAC-01-M-003
Projo Propellant Reconfiguration Elevations	AAC-01-M-004
ECR Arrangement - Plan	AAC-01-M-005
PMD Input Conveyor System	AAC-01-M-006
PMD System Plan	AAC-01-M-007
PMD System Sections	AAC-01-M-008
Burster Water Wash System Plan & Sect	AAC-01-M-009
ECR Arrangement - Elevations	AAC-01-M-010
MDB General Layout Sects	AAC-01-M-011
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ERD System Plan	AAC-01-M-013
ERD System Sections	AAC-01-M-014
ECR Arrangement Elevations & Details	AAC-01-M-015
CST Area Arrangement Plan	AAC-01-M-016
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CST Elevation Sheet 2	AAC-01-M-018
Tray Return Conveyor Arrangement Plan & Elevation	AAC-01-M-019
Misc. Parts Transfer Arrangement	AAC-01-M-020
Misc. Parts Transfer Elevations Sheet 1	AAC-01-M-021
Misc. Parts Transfer Elevations Sheet 2	AAC-01-M-022
MDM Room General Layout	AAC-01-M-023
MDM Room Elevations	AAC-01-M-024
Projectile Pull and Drain Station Arrangement	AAC-01-M-025
Projectile Pull and Drain Station Elevations	AAC-01-M-026
Projectile Pull and Drain Station Elevations	AAC-01-M-027
Projectile Wash Station Assembly	AAC-01-M-028
Projo MPT Treater System Arrangement	AAC-01-M-029
Projo/Batch MPT Treater System Elevations	AAC-01-M-030
Batch MPT Treater Assembly	AAC-01-M-031
Monitoring Station Assembly	AAC-01-M-032
PDE Arrangement	AAC-01-M-033
Munitions Casing Handling Arrangement	AAC-01-M-034
Empty Munitions Casing Handling Elevations	AAC-01-M-035

14.2.6 MECHANICAL PROCESS

14.2.6.1 Legend and Symbols

General Symbols and Legend (ANE and AAC Dwgs.)	ANE-00-D-901
General Symbols and Legend (ANE and AAC Dwgs.)	ANE-00-D-902
General Symbols and Legend (ANE and AAC Dwgs.)	ANE-00-D-903
General Symbols and Legend (APU Dwgs.)	APU-00-D-901

14.2.6.2 Projectile Disassembly / Burster Washout

Feed Conveyors to WPMD	APU-50-D-505
Projectile/Mortar Disassembly & Output (A)	APU-50-D-509 Sheet 1
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Burster Pick-and-Place Machine and ERDS Conveyor	APU-50-D-509 Sheet 3
Small Parts Container Loading	APU-50-D-509 Sheet 4
Energetics Rotary Deactivator	AAC-50-D-601
Burster Washout Machine (A)	AAC-50-D-101
Water Jet (Non-Abr.) High Press. Pump (A) & Spare	AAC-50-D-103
Energetics Shredder (A)	AAC-50-D-105
Energetics Slurry Tank (A)	AAC-50-D-107
010-WPMD-101	APU-50-D-556
010-WPMD-101 DETAILS	APU-50-D-557

14.2.6.3 Munitions Demilitarization – Agent Processing

Feed Conveyor to Agent Washout	APU-01-D-515
Burster Well Pull - WMDM	AAC-01-D-662 Sheet 1
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Rotary Washout Machine	AAC-01-D-663 Sheet 1
Rotary Washout Machine Details	AAC-01-D-663 Sheet 2
Conveyor to Rotary MPT	AAC-01-D-663 Sheet 3
Agent Settling Tank	AAC-01-D-202
Water Jet Pumps	AAC-01-D-203
Wash Water Recirculation Pumps	AAC-01-D-204
Particle Reducer - Drained Agent	AAC-01-D-205
Agent Water Jet High Pressure Pumps	AAC-01-D-206
Particle Reducer - Agent Concentrate	AAC-01-D-207

14.2.6.4 Toxic Storage and Spent Decon

Agent Holding/Surge Tanks And Pumps	APU-01-D-536
MPT/CST Condensate Holding Tanks	ANE-01-D-501
MPT/CST Condensate Feed Pumps	ANE-01-D-502
MDB Sample Lab Chemical Waste Storage	ANE-01-D-580
Spent Decon Sumps - Category A	AAC-01-D-301
Spent Decon Sumps - Category B	AAC-01-D-302
Spent Decon Sumps - Category C	AAC-01-D-303

Emergency Shower & Decon Head Tanks	ANE-01-D-570
Spent Decon Holding Tanks Trains 1&2	APU-01-D-534
Spent Decon Holding Tanks - Train 3	APU-01-D-535
Agent Concentrate Holding Tank and Pumps	AAC-01-D-537

14.2.6.5 Neutralization – Agent

Agent Hydrolyser- Unit 1	ANE-01-D-410
Agent Hydrolyser Pumps - Unit 1	ANE-01-D-411
Agent Hydrolyser Heat Exchanger - Unit 1	ANE-01-D-412
Agent Hydrolyser Feed Manifold - Unit 1	ANE-01-D-422
Agent Hydrolysate Holding Tank	ANE-01-D-430
Agent Hydrolysate Pumps	ANE-01-D-434
Agent Hydrolysate Vent Condenser	ANE-01-D-435
Agent Neutralization Room No. 1 Glove Box	ANE-01-D-460
ANR-1 Glove Box Receiver	ANE-01-D-461

14.2.6.6 Neutralization – Energetics

Energetics Neutralization Reactor - Unit 1	ANE-50-D-510
Energetics Antifoam Pump - Unit 1	AAC-50-D-510A
Energetics Neutralization Pumps - Unit 1	ANE-50-D-511
Energetics Hydrolysate Holding Tank	ANE-50-D-530
Energetics Hydrolysate Pumps	ANE-50-D-534
Energetics Hydrolysate Vent Condenser	ANE-50-D-535
ENR Sampling Glove Box & Receiver	ANE-50-D-560

14.2.6.7 Bioreactors

ICB Feed Tank and Pumps - Module 1	AAC-40-D-602
ICB Feed Heat Exchanger - Module 1	AAC-40-D-602A
ICB Air Blower - Module 1	AAC-40-D-603
Immobilized Cell Bioreactor System - Module 1	AAC-40-D-604
Immobilized Cell Bioreactor System - Module 1	AAC-40-D-605
Immobilized Cell Bioreactor System - Module 1	AAC-40-D-606
Immobilized Cell Bioreactor System - Module 1	AAC-40-D-607
Bioreactor Offgas - Module 1	AAC-40-D-608
ICB Reactor Effluent Tank - Module 1	AAC-40-D-609
ICB Effluent Pump & Spare - Module 1	AAC-40-D-610
Inorganic Nutrients Supply System	AAC-44-D-810
Clarifier	AAC-40-D-639

14.2.6.8 Water Recovery

Thickener	AAC-44-D-101
Clarifier Sludge Dewatering	AAC-44-D-102
Dewatering Filter Press	AAC-44-D-103
Evaporator Feed Tank & Pumps	AAC-44-D-901

14.2.6.9 Metal Parts Treater – Agent

Rotary MPT Feed System	AAC-01-D-701
Rotary Metal Parts Treater	AAC-01-D-702
Rotary MPT Steam Superheater	AAC-01-D-703
Rotary MPT Effluent Heater	AAC-01-D-704
MPT Quench Tower	AAC-01-D-705
MPT Effluent Condenser and Recirc. Cooler	AAC-01-D-706
MPT Condensate Tank and Pumps	AAC-01-D-707
Rotary MPT Discharge System	AAC-01-D-708

14.2.6.10 Residue Handling

Conveyors to Projectile Deformation Machine	AAC-01-D-721
Projectile Deformation Machine	AAC-01-D-722
Miscellaneous Parts to Waste Disposal	AAC-01-D-723

14.2.6.11 Continuous Steam Treater – Shreddable Solid Waste

Continuous Steam Treater	AAC-50-D-714
CST Steam Superheater	AAC-50-D-715
CST Effluent Heater And Quench Tower	AAC-50-D-716 Sheet 1
CST Anti-foam Pump	AAC-50-D-716 Sheet 2
CST Condenser and Quench Recirc. Cooler	AAC-50-D-717
CST Condensate Surge Tank and Quench Recirc. Pumps	AAC-50-D-718
CST Discharge 5X Residue Handling	AAC-50-D-719

14.2.6.12 Metal Parts Treater – Energetics

Batch MPT Basket Loading	AAC-01-D-751 Sheet 1
Batch MPT Basket Loading	AAC-01-D-751 Sheet 2
Batch Metal Parts Treater	AAC-01-D-752
BMPT Steam Superheater	AAC-01-D-753
BMPT Effluent Heater	AAC-01-D-754
BMPT Discharge System	AAC-01-D-758

14.2.6.13 Offgas Treatment (CST)

CST Offgas Reheater	AAC-50-D-801
CST Offgas CATOX® Treaters	AAC-50-D-802
CST Offgas Economizer & Blower	AAC-50-D-803

14.2.6.14 Offgas Treatment (MPT)

MPT Offgas Reheater	AAC-01-D-801
MPT Offgas CATOX® Treaters -	AAC-01-D-802
MPT Offgas Economizer & Blower	AAC-01-D-803

14.2.6.15 Offgas Treatment (BIO)

ICB Offgas Blower and Reheater - Module 1	AAC-43-D-801
ICB Offgas CATOX® Treaters - Module 1	AAC-43-D-802
ICB Offgas Economizer	AAC-43-D-803

14.2.6.16 Bulk Chemical Storage

50% NaOH Storage Tank	ANE-44-D-010
50% NaOH Pumps	ANE-44-D-011
18% NaOH Storage Tank	ANE-44-D-013
18% NaOH Pumps	ANE-44-D-014
Decon Supply Tank	ANE-44-D-015
Decon Supply Pumps	ANE-44-D-016
Sodium Hypochlorite Tank	ANE-44-D-017
Sodium Hypochlorite Pumps	ANE-44-D-018

14.2.6.17 Contaminated Waste Preparation

Plastic Material Feed Conveyor	AAC-50-D-201 Sheet 1
Wood Material Feed Conveyor	AAC-50-D-201 Sheet 2
Contaminated Material Feed Shredders	AAC-50-D-201 Sheet 3
Loss in Weight Feeders	AAC-50-D-202 Sheet 1
CST Aggregate Feed Conveyor	AAC-50-D-202 Sheet 2

14.2.6.18 Secondary Heat Transfer Fluid Circulation System

Agent Hydrolyser HTF Exp. Tank and Pumps Unit 1	AAC-44-D-005
Agent Hydrolyser HTF Heater/Cooler Unit 1	AAC-44-D-006
Agent Hydrolyser Jacket Heater and Pumps Unit 1	AAC-44-D-007
Water Chiller Exp. Tank and Pumps	AAC-44-D-021
Combinaire Cooling Tower	AAC-16-D-023
ENR HTF Expansion Tank and Pumps Unit 1	AAC-44-D-105
ENR HTF Heater/Cooler Unit 1	AAC-44-D-106

14.2.6.19 Utility Systems

Boiler No. 1 and Deaerator	APU-02-D-001
Boiler No. 2	APU-02-D-002
Chemical Feed Systems (CFS)	APU-02-D-003
Chemical Feed System Sump	APU-02-D-004
Process Water Tank	ANE-16-D-001 Sheet 1
Process Water Tank	ANE-16-D-001 Sheet 2
Hot Process Water Tank	ANE-44-D-002
Liquid Nitrogen Storage & Vaporization	AAC-16-D-005
Fuel Gas Supply - LPG Storage Tank	APU-16-D-004 Sheet 1
Fuel Gas Supply - LPG Vaporizer/Air Blender	APU-16-D-004 Sheet 2
Water Treatment System	AAC-16-D-007
MPT/CST Demineralized Cooling Water System	AAC-01-D-711

Demineralized Cooling Water System	AAC-44-D-701
Air Compressor (A)	ANE-02-D-201
Air Compressor (B)	ANE-02-D-202
Air Compressor (C)	ANE-02-D-203
Air Dryer	ANE-02-D-204
Instrument Air Receivers	ANE-02-D-205
LSS Air Receivers	ANE-02-D-206
HP Breathing Air Bottle Filling System	ANE-02-D-207
HP Breathing Air Bottle Filling System	ANE-02-D-208

14.2.6.20 Utility Distribution

BIO Utilities Distribution	AAC-40-D-640
MRF Area Utilities Distribution	AAC-50-D-001
MRF Area Utilities Distribution	AAC-50-D-002
MRF Area Utilities Distribution	AAC-50-D-003
MDB Utilities Distribution	AAC-01-D-001
MDB Utilities Distribution	AAC-01-D-002
MDB Utilities Distribution	AAC-01-D-003
PMB Utilities Distribution	AAC-14-D-001
PAB/UB Utilities Distribution	AAC-44-D-001
PAB/UB Utilities Distribution	AAC-44-D-002
PAB/UB Utilities Distribution	AAC-44-D-003

14.2.7 MECHANICAL UTILITIES

HVAC Cascade Ventilation System Air Flow Diagram	AAC-01-H-001
HVAC Cascade Ventilation System Air Flow Diagram	AAC-01-H-002
HVAC Cascade Ventilation System Air Flow Diagram	AAC-01-H-003
HVAC Control Room Area, Air Flow Diagram	AAC-01-H-004
HVAC MDB Lab and Electrical Rooms, Air Flow Diagram	AAC-01-H-005
HVAC Cascade Ventilation System, Control Diagram	AAC-01-H-006
HVAC Control Room AHUs & Supply Filter Unit, Control Diagram	AAC-01-H-007
HVAC Chilled Water System Schematic	AAC-01-H-008
HVAC Equipment Schedules	AAC-01-H-009
HVAC Equipment Schedules	AAC-01-H-010
Fire Hazard Analysis Plan, Overall First Floor Plan	AAC-01-K-001
Fire Hazard Analysis Plan, First Floor Plan Area 1	AAC-01-K-002
Fire Hazard Analysis Plan, First Floor Plan Area 2 & 3	AAC-01-K-003
Fire Hazard Analysis Plan, First Floor Plan Area 4	AAC-01-K-004
Fire Hazard Analysis Plan, First Floor Plan Area 5 & 7	AAC-01-K-005
Fire Hazard Analysis Plan, First Floor Plan Area 6 & 8	AAC-01-K-006
Fire Hazard Analysis Plan, Platform Level Overall Floor Plan	AAC-01-K-007
Fire Hazard Analysis Plan, Platform Level Plan Area 1 & 2	AAC-01-K-008
Fire Hazard Analysis Plan, Platform Level Plan Area 3	AAC-01-K-009
Fire Hazard Analysis Plan, Platform Level Plan Area 4	AAC-01-K-010
HVAC Hot Water System Schematic	AAC-02-H-002

HVAC Exhaust Air Filtration Unit, Equipment Schedule & Control Diagram	AAC-23-H-001
HVAC Filtration Unit, General Arrangement	AAC-23-H-002
HVAC Filtration Unit, General Arrangement	AAC-23-H-003
HVAC Ventilation System, Air Flow Diagram	AAC-44-H-001
HVAC Legend, Symbols and Abbreviations	APU-01-H-901
Plumbing and Fire Protection Legend, Symbols and Abbreviations	APU-01-H-902
HVAC Piping and Instrumentation Legend, Symbols and Abbreviations	APU-01-H-903

14.2.8 PROCESS

Legend And Symbols	AAC-00-F-001
Projectile Disassembly/Burster Washout	AAC-50-F-010
Projectile Demilitarization	AAC-01-F-020
Agent Collection/Toxic Storage/Spent Decon	AAC-01-F-030
Neutralization - Agent	AAC-01-F-040
Neutralization - Energetics	AAC-50-F-050
Bioreactors	AAC-40-F-060
Rotary Metal Parts Treatment	AAC-01-F-070
Continuous Steam Treater	AAC-50-F-075
Batch Metal Parts Treatment	AAC-50-F-076
Offgas Treatment - MPT	AAC-01-F-080
Offgas Treatment - CST	AAC-50-F-085
Offgas Treatment - Bioreactor	AAC-40-F-087
Water Recovery	AAC-44-F-090
Brine Reduction Package - Brine Concentrator	AAC-44-F-100 Sheet 1
Brine Reduction Package - Evaporator/Crystallizer	AAC-44-F-100 Sheet 2
Bulk Chemical Storage	AAC-02-F-110
Contaminated Waste Preparation	AAC-50-F-120
Residue Handling	AAC-01-F-130
Water Balance	AAC-00-F-140
Process Block Flow Diagram	AAC-00-F-150
Secondary Heat Transfer Fluid Circulation System - Agent	AAC-01-F-170
Secondary Heat Transfer Fluid Circulation System - Energetics	AAC-50-F-180

14.2.9 STRUCTURAL

General Notes	APU-00-S-901
Legend and Abbreviations	APU-00-S-902
MDB Building Foundation Plan Area 4 - 8	AAC-01-S-001
MDB Building Foundation Plan Area 1 - 3	AAC-01-S-002
MDB Building Foundation Plan Area 6	AAC-01-S-005
MDB Building Foundation Plan Area 2	AAC-01-S-006
MDB Building Foundation Plan Area 5 - 6	AAC-01-S-007
MDB Building Foundation Plan Area	AAC-01-S-008

HVAC Chiller & Filter Foundation Details	AAC-16-S-005
Miscellaneous Foundations	APU-16-S-006
Pipe Supports Plan	APU-16-S-007
Pipe Supports Plan	APU-16-S-008
Pipe Supports Plan	APU-16-S-009
Pipe Supports Elevations	APU-16-S-010
Pipe Supports Elevations	APU-16-S-011
Pipe Supports Elevations	APU-16-S-012
Pipe Supports Foundation Plan	APU-16-S-014
Pipe Supports Foundation Plan	APU-16-S-015
Pipe Supports Foundation Plan	APU-16-S-016
MDB Filter and Stack Foundation Plan	APU-23-S-001
MDB Filter and Stack Foundation Plan	APU-23-S-002
Bioreactor Foundation Plan	AAC-40-S-001
Bioreactor Foundation Plan	AAC-40-S-002
PAB Building Foundation Plan	AAC-44-S-001

APPENDIX A

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

AASHTO	American Association of State Highway and Transportation Officials
ACWA EDS	Assembled Chemical Weapons Assessment Engineering Design Study
ACAMS	automatic, continuous air-monitoring system
ANR	agent neutralization room
ANSI	American National Standard Institute
API	American Petroleum Institute
AR	U.S. Army regulation
ASCE	American Society of Chemical Engineers
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
BC	bulk chemical or brine concentrator
BCS	bulk chemical storage
BHP	brake horsepower
BHMA	Builders Hardware Manufacturers Association
BMPT	batch metal parts treater
BOD	biochemical oxygen demand
BPCS	basic process control system
BRA	brine reduction area
BTA	biotreatment area
Btu	British thermal units
BWM	burster washout machine
°C	degrees Celsius
CAA	Clean Air Act
CAAA	Clean Air Act amendments
CAMDS	U.S. Army Chemical Agent Munitions Disposal System Site
CATOX®	proprietary Allied Signal oxidation catalyst (catalytic catalyst)
CBR	chemical, biological, and radiological (filter)
CCTV	closed circuit television
CEHNC	Corps of Engineers (U.S. Army Engineer Division, Huntsville)
CFR	Code of Federal Regulations

Return

CH	chlorohydrine
CO_2	carbon dioxide
COD	chemical oxygen demand
COM	communications room
CON	control room
CRA	control room area
CSDP	Chemical Stockpile Disposal Program
CST	continuous steam treater
CSTR	continuously stirred reactor
CWA	chemical warfare agent or Clean Water Act
CWCT	Chemical Weapons Convention Treaty
DAAMS	depot area air-monitoring system
DBA	decibels
DCS	digital control system
DFS	deactivation furnace system
DoD	U. S. Department of Defense
DOE	U. S. Department of Energy
DPE	demilitarization protective ensemble (suit)
DPG	U.S. Army Dugway Proving Ground
DSA	DPE support area
DX	self contained air handling unit
E/C	evaporator and crystallizer
ECF	entry control facility
ECR	explosive containment room
ECV	ECR vestibule
EDS	Engineering Design Study
ENR	energetics neutralization room
EPA	U.S. Environmental Protection Agency
ERD	energetics rotary deactivator
ESD	emergency shutdown
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
F/F	flange to flange
FIL	HVAC filter system
FM	factory mutual
FRP	fiberglass reinforced plastic

FSPF	full-scale pilot facility
ft^2	square feet
ft^2/d	square feet per day
ft^3	cubic feet
GFE	Government-furnished equipment
gpd	gas plasma display or gallons per day
gpm	gallons per minute
H&M	heat and material balance
HCL	hydrochloric acid
HD	blister agent distilled mustard, Bis (2Chlorethyl) sulfide or 2,2 dichlorodiethyl sulfide ($C_2H_8Cl_2S$)
HDPE	high density polyethylene
HEPA	high-efficiency particulate air (filter)
HER	hydraulic equipment room
HP	horsepower
HRT	hydraulic retention time
HSWA	hazardous and solid waste amendments
HT	blister agent (blend of 60% blister agent HD and 40% agent T)
HTF	heat transfer fluids
HVAC	heating, ventilating, and air conditioning
LANL	Los Alamos National Laboratory
lb.	pound
lbs./hr	pounds per hour
ICB™	immobilized cell bioreactor
Icfm	inlet cubic feet per minute
ID	inside dimension
IDS	intrusion detection system
JACADS	Johnson Atoll Chemical Agent Disposal System
LAB	laboratory
LLNL	Lawrence Livermore National Laboratory
LPG	liquid petroleum gas
LSS	life support system
MACT	maximum achievable control technology
MCE	maximum considered earthquake
MCC	motor control center
MDB	munitions demilitarization building

MDM	multi-purpose demilitarization machine
MER	mechanical equipment room
mg/l	milligrams per liter
ml	milliliter
MMBtu/hr	million British thermal units per hour
MRF	munitions reconfiguration facility
MPB	munitions processing bay
MPT	metal parts treater
MPT-OTS	metal parts treater offgas treatment system
MSB	munitions storage building
MSDS	material safety data sheet
NAAQS	National Ambient Air Quality Standards
NACE	National Association of Corrosion Engineers
NaCl	sodium chloride
NaOH	sodium hydroxide
NEC	National Electrical Code
NECDF	Newport Chemical Demilitarization Facility
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NOx	nitrogen oxides
NPDES	national pollutant discharge elimination system
NSPC	National Standard Plumbing Code
NSPS	new source performance standards
OSHA	Occupational Safety and Health Act
OTS	offgas treatment system
PA	public address system
PAB	process auxiliary building
Parsons	Parsons Corporation
PAS	pollution abatement system
PDAR	process data acquisition and recording
PFD	process flow diagram
P&ID	process and instrumentation diagram
pH	A scale for indicating the acidity, neutrality, or alkalinity of a solution.
PLC	programmable logic controller
PMACWA	Program Manager, Assembled Chemical Weapons Assessment
PMB	personnel and maintenance building

PMD	projectile and mortar demilitarization
PPE	personnel protective equipment
PRR	propellant reconfiguration room
PSB	personnel support building
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gage
PTA	parts transfer area
PVC	polyvinylcholride
PUB	process utilities building
PUDA	Pueblo Depot Activity
RCRA	Resource Conservation and Recovery Act
RF	radio frequency
RHA	residue handling area
rpm	revolutions per minute
scfh	standard cubic feet per hour
scfm	standard cubic feet per minute
SHTF	secondary heat transfer fluid
SS	stainless steel
T	blister agent
TCLP	toxic characteristic leaching procedure
TDG	thiodylycol
T/FOF	tangent to face of flange
TMA	toxic maintenance area
TM	technical manual
TNT	tri-nitro-tetryl
TOC	total organic compound
TOCDF	Tooele Chemical Disposal Facility
TOX	toxic cubicle
TSDF	treatment, storage, and disposal facility
TSS	total suspended solids
T/T	tangent to tangent
TWA	time-weighted average
UB	utility building
UBC	Uniform Building Code
UK	United Kingdom

UL	Underwriters Laboratories, Inc.
UPA	unpack area
UPS	uninterruptible power supply
USEPA	United States Environmental Protection Agency
UTS	Universal Treatment Standards
V	volts
Vac	volts alternating current
Vdc	volts direct current
VOC	volatile organic compound
% wt.	percent weight
WC	water column
WHEAT	Water Hydrolysis of Energetic and Agent Technologies
WMDM	WHEAT munition demilitarization machine
WPMD	WHEAT projectile/mortar demil machine

APPENDIX B

MISCELLANEOUS DESIGN INFORMATION

B.1 SITE DESIGN DATA

The ACWA WHEAT Technology is not site specific. However, the following site-specific correlations have been assumed for the ACWA WHEAT HD munitions processing facility.

Arid Site:

Summer Dry Bulb = 97 ^{o}F

Summer Wet Bulb = 61 ^{o}F

Winter Dry Bulb = -7 ^{o}F

Table B.1-1—Climatic Parameters

Data / Month	Average Relative Humidity (%)		Normal Daily Maximum Temperature (^{o}F)	Normal Daily Minimum Temperature (^{o}F)
	Morning (M)	Afternoon (A)		
JAN	69	49	45.3	14.2
FEB	65	37	50.7	19.5
MAR	67	34	57.2	26.1
APR	68	32	67.9	35.7
MAY	70	33	76.5	45.6
JUN	71	29	87.7	54.2
JUL	74	33	93.0	61.2
AUG	76	36	89.7	59
SEP	73	32	81.3	50.2
OCT	69	33	70.5	36.6
NOV	74	47	56.8	24.3
DEC	69	51	46.7	15.5
ANNUAL	70	37	68.6	36.8

Notes:

1. Above data obtained from the National Climatic Data Center Website at http://www.ncdc.noaa.gov/.
2. Average Relative Humidity Data through 1999 over a 20-year period.
3. Normal Daily Maximum Temperature Data between the years 1961 - 1990 over a 30-year period.
4. Normal Daily Minimum Temperature Data between the years 1961 - 1990 over a 30-year period.

<u>Elevated Site:</u>

Elevation = 4474 – 4814 ft

Pressure = 12.41 psia

B.2 MUNITION DATA

B.2.1 AGENT DATA

Table B.2.1-1—Physical Properties of Mustard

Property	HD	HT
Chemical name	Bis (2-chloroethyl) sulfide or 2, 2'-dichlorodiethyl sulfide	Same as HD with 40 wt% agent T, Bis[2 (2-chlorethylthio) – ethyl] either
Chemical formula	$C_4H_8C1_2S$	$C_{5\ .15}H_{10..3}C1_{2.0}\ O_{0.29}$
Molecular weight	159.07816	189.14764
Vapor specific gravity (air = 1.00)	5.4	6.92
Liquid density at 68 °F	79.49	79.49
Freezing point (°F)	58	32 to 34.3
Boiling point (°F)	423	442
Vapor pressure at 68°F (mm Hg)	0.0729	0.104
Flash point (°F)	221	212
Viscosity (centistokes at 68°F)	3.95	6.05
Color	Amber-dark brown liquid	Amber-dark brown liquid
Odor	Garlic	Garlic
Special properties	Permeates ordinary rubber	Permeates ordinary rubber
Solubility properties	Water (distilled), 0.092 g/100 cc at 72°F, completely soluble in acetone, $CC1_4CH_3C1$, tetrachloroethane, ethyl benzoate, ether	Water (distilled), 0.092 g/100 cc at 72°F, completely soluble in acetone, $CC1_4CH_3C1$, tetrachloroethane, ethyl benzoate, ether
High heating value (Btu/lb at 60°F)	8,500	9,400
Physical state at 70°F	Viscous liquid	Viscous liquid

Reference

CSDP, "PUCDF Process Design Basis" 90% Final Design Submittal (Contract DACA 87-86-C-0084), September 1995, Section 2, Table 2-5.

Table B.2.1-2—Composition of HD Stored in Steel Munitions*

Chemical Structure	Area %
HD, $ClCH_2CH_2SCH_2CH_2Cl$	89.2
$ClCH_2CH_2SCH_2CH_2SCH_2CH_2Cl$	4.7
$ClCH_2CH_2Cl$	2.4
$S(CH_2CH_2)_2S$(1,4-dithiane)	1.2
$S(CH_2CH_2)_2O$(1,4-thioxane)	0.5
$ClCH_2CH_2SCH_2CH_2CH_2Cl$	0.4
*Viscosity data is not available to size agent piping and pumping for all operating conditions. This data was derived from theoretical calculations in the referenced handbook.	

Reference

U.S. Army CBDCOM, "ACWA RFP (Solicitation Number DAAM01-97-R-0031)", 7/28/97, Section J.2, Table J.2-5.

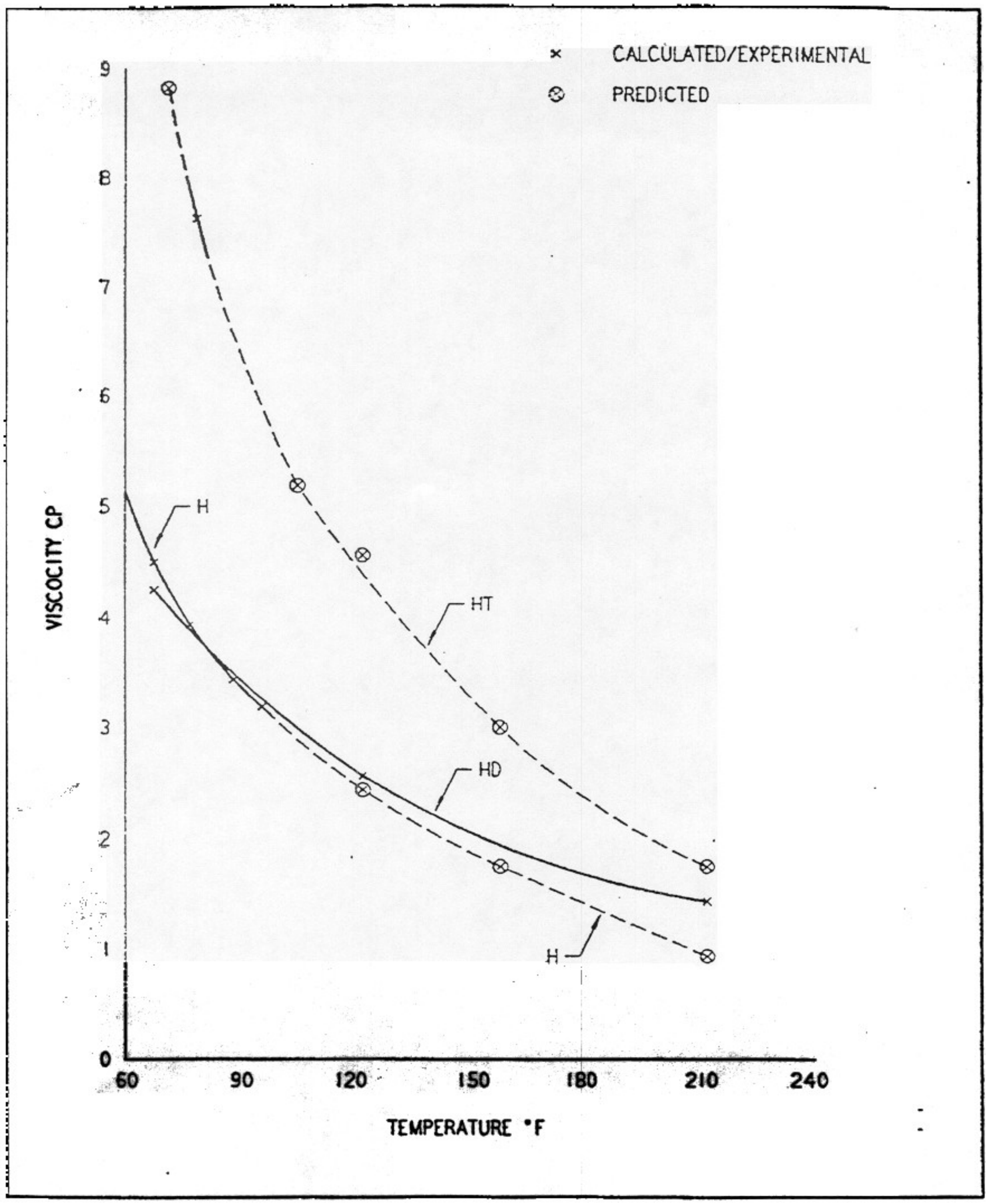
Table B.2.1-3—Composition of HT Stored in Steel Munitions*

Chemical Structure	Area %
HD, $ClCH_2CH_2SCH_2CH_2Cl$	67.0
T, $(ClCH_2CH_2SCH_2CH_2)_2O$	22.2
$ClCH_2CH_2SCH_2CH_2OCH_2CH_2Cl$	4.5
$ClCH_2CH_2SCH_2CH_2SCH_2CH_2Cl$	3.0
$S(CH_2CH_2)_2S$(1,4-dithiane)	1.8
$S(CH_2CH_2)_2O$(1,4-thioxane)	0.5
$ClCH_2CH_2SCH_2CH_2OH$	0.4
$ClCH_2CH_2Cl$	0.4
*Viscosity data is not available to size agent piping and pumping for all operating conditions. This data was derived from theoretical calculations in the referenced handbook.	

Reference

U.S. Army CBDCOM, "ACWA RFP (Solicitation Number DAAM01-97-R-0031)", 7/28/97, Section J.2, Table J.2-6.

Table B.2.1-4—Mustard Viscosity vs. Temperature



Reference:	Experimental	H	– CW vesicants, physical properties by MF Buckles July 1956
		HD	– Physical data mustard agents, US ARRADCOM
		HT	– to be identified
	Predicted		– Perrys Handbook 4th Edition, Figure 3-61, Page 3-228

B.2.2 ENERGETICS DATA

Table B.2.2-1—Composition and Heating Values of Munition Energetics

Component	Formula	Composition wt%	Molecular Weight	HHV at 77°F (Btu/lb)
Tetrytol				
2,4,6-trinitrophenyl-methylnitramine (tetryl)	$C_7H_5N_5O_8$	70.0	287.14625	5,265
2,4,6-trinitrotoluene (TNT)	$C_7H_5N_3O_6$	30.0	227.13405	6,517
Mixture (tetrytol)	$C_7H_5N_{4.29718}O_{7.29718}$	100.0	266.05736	5,641
Tetryl				
2,4,6-trinitrophenyl-methylnitramine	$C_7H_5N_5O_8$	-	287.14625	5,265
TNT				
2,4,6-trinitrotoluene	$C_7H_5N_3O_6$	-	227.13405	6,517
Propellant M67				
Nitrocellulose	$C_6H_{7.55}N_{2.45}0_{9.9}$	86.1	272.38725	4,308
Dinitrotoluene	$C_7H_6N_20_4$	9.9	182.13652	2,781
Dibutylphthalate	$C_{16}H_{22}0_4$	3.0	278.35054	13,321
Diphenyl amine	$C_{12}H_{11}N$	1.0	169.22757	16,297
Mixture (Propellant (67)	$C_{6.51038}H_{7.78732}N_{2.29648}0_{8.75626}$	100.0	258.30722	4,547
Propellant M6				
Nitrocellulose	$C_6H_{7.55}N_{2.45}0_{9.9}$	86.1	272.38725	4,308
Dinitrotoluene	$C_7H_6N_20_4$	9.9	182.13652	2,781
Dibutylphthalate	$C_{16}H_{22}0_4$	3.0	278.35054	13,321
Diphenylamine	$C_{12}H_{11}N$	1.0	169.22757	16,297
Mixture (Propellant M6)	$C_{6.51038}H_{7.78732}N_{2.29648}0_{8.75626}$	100.0	258.30722	4,547

Reference

CSDP, "PUCDF Process Design Basis" 90% Final Design Submittal (Contract DACA 87-86-C-0084), September 1995, Section 2, Table 2-7.

Table B.2.2-2—Mustard Munitions Energetics Data and Ignition Temperatures

Munition Type	Energetics Parts	Energetics Component	Chemical	Composition	Weight (%)	Total Weight (lb.)	Ignition Temp. (°F)
155-mm M110	Burster		Tetrytol	Tetryl	70	0.4143	190 - 194
				TNT	30		275 - 325
4.2-inch Mortar	Burster		Tetryl		100	0.1433	190 - 194
	Fuze						
		Detonator	AN # 6 priming mix	Potassium chlorate	33.4	0.0001	
				SB sulfide	33.3		
				PB azide	28.3		275 - 345
				Carborundum	5		
			PB azide		100	0.0003	275 - 345
			Tetryl		100	0.0002	190 - 194
		Cup	Tetryl		100	0.0003	190 - 194
105-mm M60	Burster		Tetrytol	Tetryl	70	0.2571	190 - 194
				TNT	30		275 - 325
	Fuze						
		M24 Detonator	AN # 6 priming mix	Potassium chlorate	33.4	0.00015	
				SB sulfide	33.3		
				PB azide	28.3		275 - 345
				Carborundum	5		
			PB azide		100	0.0004	275 - 345
		Black powder delay		Potassium nitrate	74	0.00005	
				Sulfur	10.4		
				Charcoal	15.6		
		M7 relay	PB azide		100	0.0002	275 - 345
	Booster cup	M17 detonator	PB azide		100	0.0006	275 - 345
			Tetryl		100	0.0002	190 - 194
		booster lead Charge	Tetryl		100	0.0005	190 - 194
		Booster pellet	Tetryl		100	0.0501	190 - 194

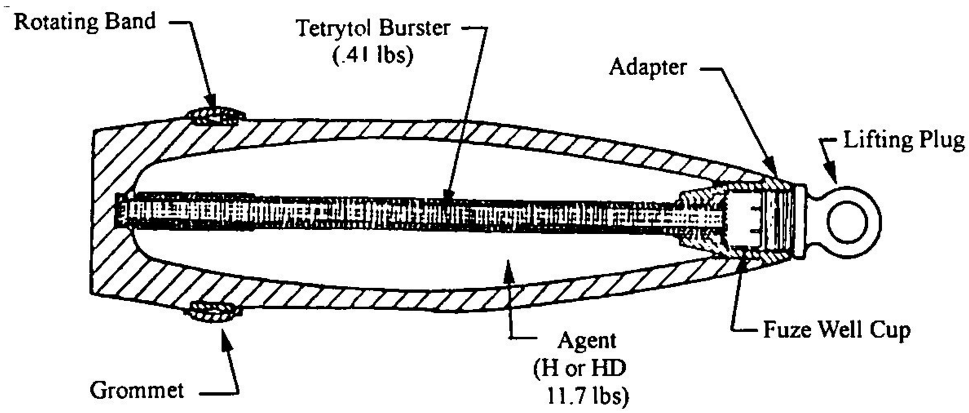
Reference

Munitions Data – Munition Items Disposition Action System (MIDAS) Team at the U.S. Army Defense Ammunition Center (DAC)

Ignition Temperatures – Department of the Army Technical Manual TM9-1300-214, “Military Explosives,” September 1984.

B.2.3 MUNITIONS METAL PARTS DATA

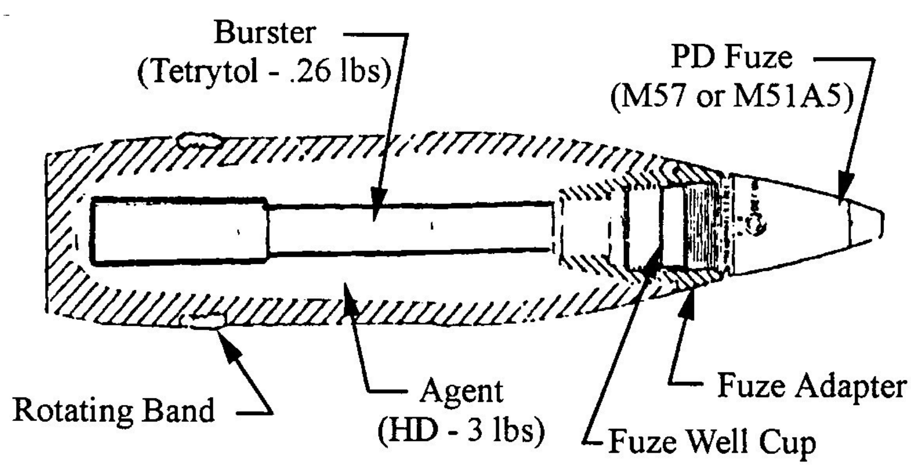
1320-D543 PROJECTILE 155mm M110 H, HD



1320-00-096-3067 HD Uncrated
1320-00-301-1824 H Uncrated
1320-00-529-7352 HD 8/Pallet
1320-00-529-7353 H 8/Pallet

Figure B.2.3-1—155-mm Shell M110 and M104 Projectiles

1315-C442 CARTRIDGE 105mm M60 HD



1315-00-028-4829 w/PD FZ M57
1315-00-322-6365 w/PD FZ M51A5

Figure B.2.3-2—105-mm Shell HD M60 Projectiles

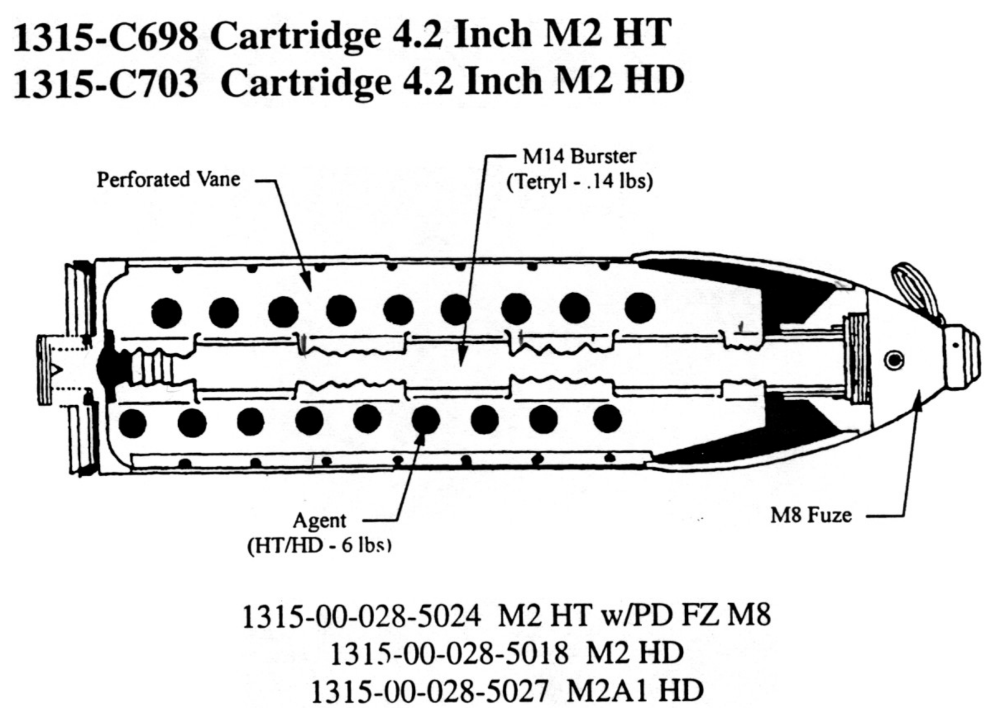


Figure B.2.3-3—4.2-inch M2/2A1 Mortars

Table B.2.3-1—Munitions Metal Parts Listing and Weights

Munition Type	Proj 155 mm HD M104		PROJ 155 mm HD M110	
NSN	1320005297350		1320000963067	
	Component Weight Lb.	Total Weight Lb.	Component Weight Lb.	Total Weight Lb.
Cup Fuze Well (Al Alloy)		0.0600		0.0600
Metal Parts Assembly		78.0600		77.7400
Adapter (Steel)	1.8400		1.8400	
Band rotating (gilding metal)	2.2200		1.2000	
Body shell (steel)	74.0000		74.7000	
Plug Lifting Type G (Steel)		1.7500		1.7500
Grommet		0.6900		0.4900
Housing (Steel)	0.5000		0.3300	
Liner (Chipboard)	0.1900		0.1600	
Burster Well		2.0300		2.0300
Casing (Steel)	1.4400		1.4400	
Tube Reinforcing (Steel)	0.3300		0.3300	
Sleeve (Steel)	0.2600		0.2600	
Burster Tube		0.4200		0.4200
Tube Burster (Steel Tubing)	0.4200		0.4200	
Total Metal Parts		83.0100		82.4900
HD + Tetrytol		12.1143		12.1143
Total Munition 155 mm Weight		95.1243		94.6043

Source: Munition Items Disposition Action System (MIDAS) Team at the U.S. Army Defense Ammunition Center (DAC).

Table B.2.3-2—Munitions Metal Parts Listing and Weights

Munition Type	Shell 105 mm HD M60	
NSN	1315HD1054829	
	Component Weight lb.	Total Weight lb.
Cup Fuze Well (Al Alloy)		0.0600
Metal Parts Assembly		26.5700
Adapter (Steel)	1.8600	
Band Rotating (Gliding Metal)	0.4700	
Body Shell (Steel)	24.2400	
Fuze		1.4047
Tube Flash (Steel)	0.0390	
Ogive (Al Alloy)	0.1121	
Body (Steel)	1.0786	
Interrupter (Brass)	0.0088	
Spring Interrupter (Steel Wire)	0.0003	
Disc Interrupter Closing (Brass)	0.0008	
Cushion Detonator (Cork)	0.0000	
Screw Detonator Retaining (Brass)	0.0010	
Head (Brass)	0.1603	
Support Firing Pin (Gliding Metal)	0.0009	
Disc Closing (Al Alloy)	0.0001	
Washer Closing Disc (Brass)	0.0004	
Pin Firing (Al Alloy)	0.0003	
Striker (Al Alloy)	0.0011	
Cup Detonator (Al Alloy)	0.0007	
Disc Detonator (Al Alloy)	0.0000	
Washer Retainer (Fuze Cloth)	0.0000	
Retainer (Al Alloy)	0.0002	
Burster Well		1.4800
Casing (Steel)	0.2600	
Tube Reinforcing (Steel)	0.3300	
Sleeve (Steel)	0.8900	
Burster Tube		0.2550
Tube Burster (Steel Tubing)	0.2550	
Total Metal Parts		29.7697
HD + Tetrytol + Detonator		3.4276
Total Munition 105 mm Weight		33.1973

Source: Munition Items Disposition Action System (MIDAS) team at the U.S. Army Defense Ammunition Center (Dac)

Table B.2.3-3—Munitions Metal Parts Listing and Weights

Munition Type	4.2-in. Mortars M2/2A1 HD	
NSN	1315HD4.25018	
	Component Weight Lb.	Total Weight Lb.
Metal Parts Assembly		15.3310
Adapter (Steel)	0.6400	
Disc Rotating (Brass)	0.4900	
Plate (Al Alloy)	0.3900	
Cntr Ctg (Steel)	0.5980	
Holder Prop (Steel wire)	0.0030	
Nut Pressure Plate (Al Tubing)	0.0400	
Body Shell (Steel)	12.1700	
Vane (Steel)	1.0000	
Fuze		0.7820
Plug (Brass)	0.0267	
Pin Lock (Brass)	0.0013	
Wire Shear (Cu Wire)	0.0002	
Body (Al Alloy)	0.4784	
Retainer (Brass)	0.1106	
Spring (Spring Steel)	0.0041	
Ball (Steel)	0.0094	
Screw Guide (brass)	0.0066	
Screw Set (Steel)	0.0031	
Spring Set-Back Pin (Spring Steel)	0.0004	
Plug Set-Back (Steel)	0.0009	
Striker (Steel)	0.0217	
Head Striker (Steel)	0.0166	
Socket Set-Back Pin (Brass)	0.0020	
Pin Set-Back (Steel)	0.0009	
Slider (Al Alloy)	0.0844	
Cup Detonator (Al Alloy)	0.0004	
Disc Detonator (Al Alloy)	0.0000	
Disc Detonator Closing (Al Alloy)	0.0000	
Cup (Brass)	0.0001	
Ring Safety Pin (Steel Wire)	0.0099	
Pin Cotter (Steel)	0.0043	
Burster Well		0.7700
Burster Tube		0.4735
Plug Burster Tube (Steel)	0.0071	
Tube Burster (Steel Tubing)	0.4664	
Total Metal Parts		17.3565
HD + Tetryl + Detonator		6.1442
Total Munition 4.2 inch Weight		23.5007

Source: Munition Items Disposition Action System (MIDAS) team at the U.S. Army Defense Ammunition Center (DAC).

B.3 BIOREACTION PROCESS BASICS

B.3.1 THE BIOLOGICAL PROCESS

The basis of biological wastewater treatment is the use of microbial populations to convert soluble organic compounds in industrial process and ground waters into insoluble organic material (more bacteria) which can then be physically removed from the wastewater stream. The result is the elimination of oxygen demanding organics from the wastewater and/or a reduction in the toxicity of the wastewater. The wastewater can then be discharged or reused depending upon site-specific conditions. The basic equation for the aerobic degradation of organics via this method is as follows:

Organics (TOC,COD,BOD)		Carbon Dioxide (CO_2)
Oxygen (0_2)	**Bacteria** →	Water (H_20)
Nitrogen (NH_3-N)		
Phosphorus (o-PO_4)		More Bacteria

B.3.1.1 The Bacteria - Biological Growth Theory

The primary types of bacteria involved in the biochemical oxidation of organic compounds are:

- Bacilli (singular bacillus): Rod shaped organisms approximately 2-5 microns (μ) in length and 1-2 μ in diameter.

- Cocci (singular coccus): Spherical shaped organisms approximately 1-2 μ in diameter.

- Spirochetes (singular spirochete): Spiral shaped organisms (10-100 μ).

For developing a simplified model of bacteria and how they function, we will use bacilli as an example. The bacillus cell is composed essentially of proteinaceous material. Its primary directive is to survive and reproduce. In biological wastewater treatment systems the reproduction or growth of bacterial populations results in the conversion of undesirable soluble organic materials present in wastewater to cellular materials and protein. In this way, undesirable soluble organics are transformed into innocuous insoluble biomass.

The growth of the bacteria involves a number of functions, but most critical is the oxidation of a carbon source (the organic chemical) through aerobic respiration (use of oxygen). This process generates energy, carbon dioxide (CO_2), and water (H_20). The energy is utilized for cell maintenance, metabolism, and reproduction of additional cells. Figure B.3-1 depicts a simple model of a bacterium and the conversion process involved in biological wastewater treatment.

B.3.1.2 Bacteria - The Central Element in Wastewater Treatment

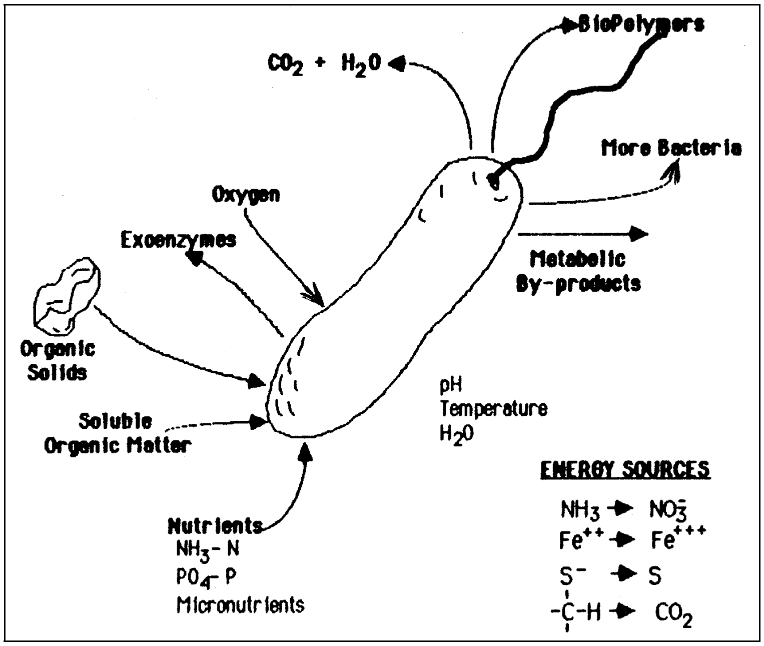


Figure B.3-1—Bacterial Conversion of Organics

The following are definitions of the terms used in this figure, and how they are involved in the biological process.

- **Soluble Organic Material:** The organic chemicals that are dissolved in the wastewater stream comprise the soluble organic material. This is the material that the organisms see as food or carbon and energy sources.

  Proteins known as enzymes catalyze all of the metabolic reactions that take place within microorganisms. Organisms are also able to effect changes to chemical compounds outside of the cell by releasing certain enzymes. Enzymes present within the cell are known as "intracellular." Enzymes excreted by the cell into its growth environment are called "extracellular" or "exoenzymes." Exoenzymes facilitate the conversion of insoluble organics such as fats, greases, oils, etc. into soluble materials. These enzymes may initiate the breakdown process by making a "large" molecule small enough to be transported across the cell win into the organism for additional metabolism. Intracellular enzymes can then facilitate the breaking and reforming of the chemical bonds necessary for energy production and new cell formation.

- **Nutrients:** In order for bacteria to perform their functions, certain essential elements are required. These elements are used to form new cell material and also play a key role in cellular metabolism. The most important of these nutrients include:

  - Nitrogen in the form of ammonia (NH_3-N)

- Phosphorus in the form of orthophosphate (PO_4-P)

- Micronutrients such as iron, zinc, cobalt. etc.

Inadequate amounts of these nutrients can severely inhibit the growth rates of bacteria and their ability to remove the hazardous organic compounds from the water.

- **Biopolymers:** These substances are composed of polysaccharides (sugars) which are secreted by the organisms and coat the outer cell wall. These biopolymers play a key role in biotreatment in that they allow agglomeration of numerous organisms into either floc particles or biofilms. Growth of the bacteria as a slime formation (biofilm) on surfaces is critical to the operation of biological systems such as biodiscs or submerged fixed-film reactors. Formation of a floc permits the use of gravity separation of the organisms from the waste stream as in activated sludge systems. Then biopolymers play a key role in the successful operation of biological systems.

- **Surfactants**: Bacteria also secrete compounds that act as surfactants to solubilize hydrophobic chemicals. Bacteria function best at interfaces, such as air-water boundaries. Hydrophobic chemicals, such as petroleum products, are readily biodegradable but have limited solubilities. The biosurfactants produced are used to solubilize these compounds and make them available as food to microorganisms.

- **Metabolic By-Products**: These are the compounds produced by the organisms during the metabolism of the carbon sources present. They are primarily composed of intermediate breakdown products, carbon dioxide, and water. Both uncontaminated (and in many cases contaminated) soils and liquids contain a wide variety of different strains of microbes. The food source for some of the organisms is the waste products of other organisms. Through the action of mixed microbial communities, complete degradation of the carbon sources is accomplished.

- **Additional Biomass:** This is the reproductive offspring of the original bacteria. In essence, it is a mass of protein (which is the main constituent of bacterial cells) that has been produced from the organic compounds present in the wastewater stream.

$$NH_3 + 0.05H_3PO_4 + C_6H_{12}O_6 + 3.6O_2 \rightarrow 3.6\ CO_2 + 3.6\ H_2O + 2.4\ C_4H_8ON(0.01P)$$

B.3.1.3 Biological Growth

Referring to Figure B.3-1, as the organisms assimilate and metabolize their food source (substrate) they grow and reproduce. Bacterial reproduction occurs by cell division, with every parent cell dividing into two cells. The time period for this to take place is 90 minutes under ideal conditions. It will be much slower in actuality depending upon environmental factors such as temperature, availability of nutrients, substrate (food), and adequate oxygen.

Under optimum growth conditions, the rate of accumulation of bacterial cells is very high. Figure B.3-2 shows this graphically.

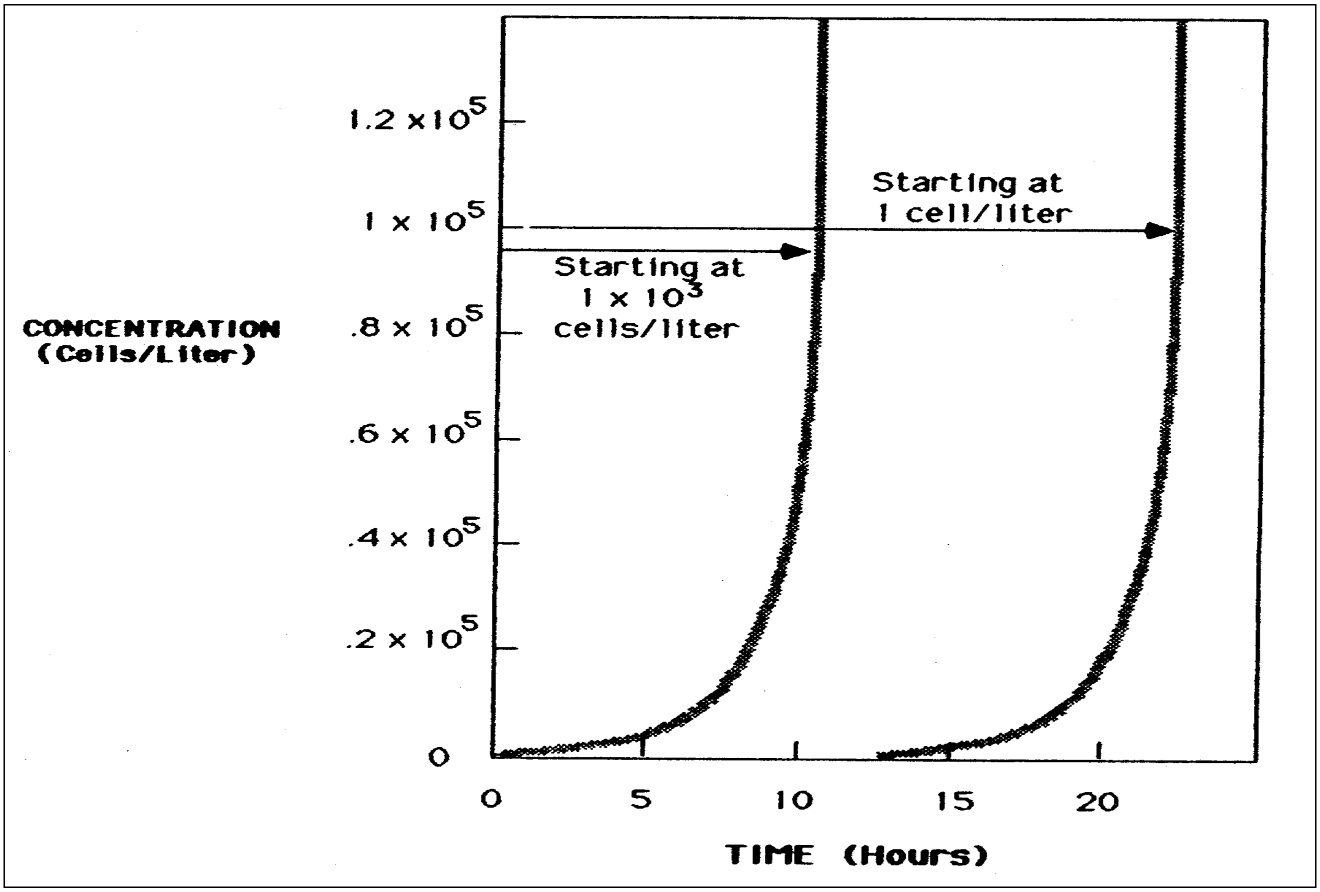


Figure B.3-2—Microbial Replication and Accumulation

The doubling time for each organism was assumed to be 20 minutes. with an initial cell concentration of one cell and 1,000 cells per liter. As the concentration of the available food for the organisms increases, the rate at which the organisms grow also increases until it reaches a maximum rate (noted as u_{max}). This phenomenon is shown in Figure B.3-3.

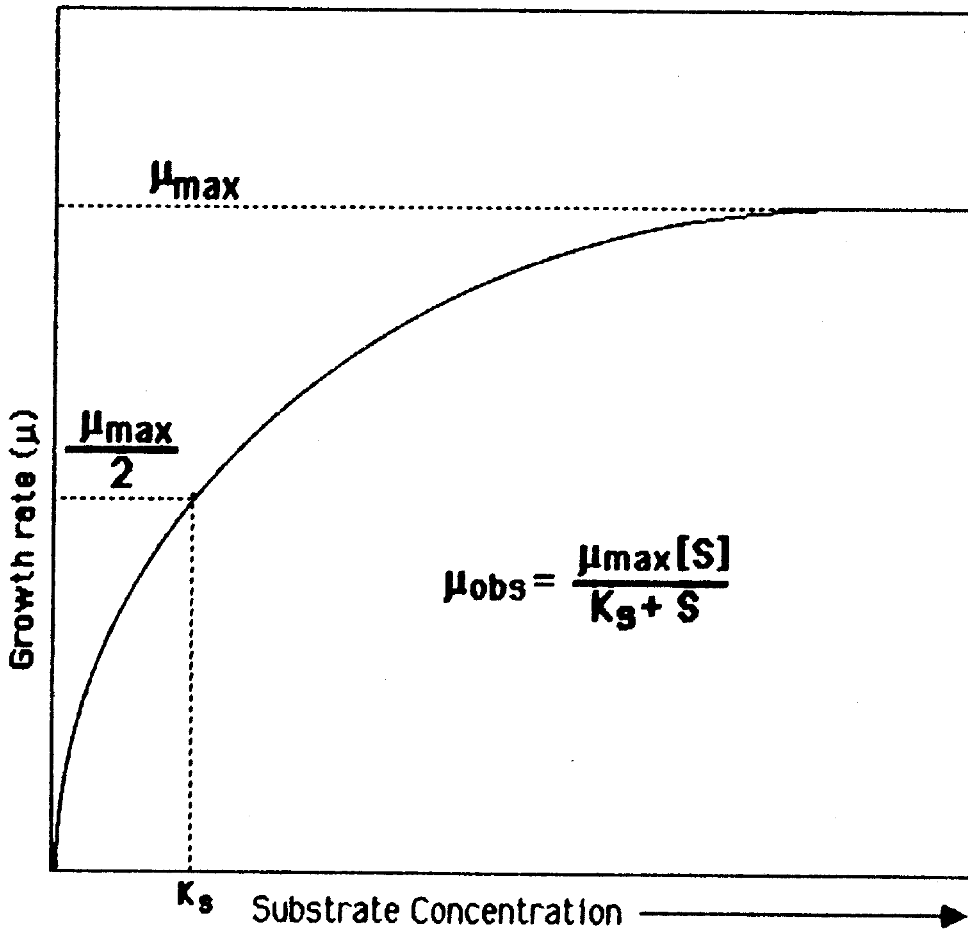


Figure B.3-3—Monod Kinetics for Non-Inhibitory Substrates

For nontoxic, readily biodegradable materials, the microbial growth rate increases with increasing substrate concentration. Conversely, the growth rate decreases as the substrate concentration decreases. This is the dynamic response characteristic. As the loading rate of the organic chemicals in the treatment plant increases (in pounds per day), the microbial growth rate increases up to some maximum value. The additional substrate is metabolized and more bacteria are produced. As the loading rate drops, the growth rate will slow down and fewer bacteria are produced. If the loading rate drops below the level required to maintain the existing number of bacteria, there will be a decline in the concentration of organisms in the biosystem. The organisms will starve and die off until their numbers are reduced to a level at which the food input to the system is sufficient to maintain them.

We can see from this simplified model of microbial growth that maintaining certain nutrient requirements is essential to both biological growth and the successful conversion of the soluble organics to the insoluble (bacterial) form. It is also important to remember that bacteria cannot survive without an appropriate working environment.

B.3.1.4 Environmental Factors

In addition to the food and nutrient conditions discussed, certain environmental conditions are required for biological growth:

- **pH:** Appropriate conditions for biological growth are generally between 6 to 9 pH units. The ability of certain organisms to survive and function on either side of this range is known, however. Excessive concentrations of either H^+ or OH^- in the growth environment can inhibit metabolic activity and can also cause the physical breakdown of the organism itself. The optimal pH for a biosystem is usually between 7.0 and 8.5 pH units.

- **Temperature:** Temperature will greatly affect the rate at which the organisms grow; bacteria can be simply thought of as bags of enzymes catalyzing desired chemical reactions. The rate at which bacteria can utilize organics in wastewater is directly related to the water temperature at which they function. For every 10 °C (or 18°F) increase in water temperature, the rate of metabolic activity will approximately double. For example, at 20°C (68°F) the overall metabolic rate will be much faster than at 10°C (50°F). However, at 40°C (104°F) or greater, many environmentally important microorganisms begin to lose their viability. At temperatures above 45 to 50°C (113 to 122°F), the enzymes that are required to facilitate breakdown of the organics will denature or break down due to thermal conditions, and the bacteria will die. Biological treatment systems typically operate in temperatures ranging from 10 to 32°C (50 to 90°F). Optimal treatment temperatures for biological treatment systems are generally between 20 to 30°C (69 to 86°F).

- **Water:** Water is a necessary medium for the survival of microorganisms. Water functions as a transport medium bringing necessary nutrients to the cells and taking metabolic end products away. It is also needed to facilitate the movement of microorganisms from one point to the next.

- **Toxicity:** An absence of inhibitory and/or toxic concentrations of inorganic or organic compounds is necessary to ensure proper growth of the microorganisms. The concentrations at which the compounds may be present will determine the extent of their toxicity on the biomes. In some instances, low concentrations of the toxic materials will slow down the biological growth rates and the corresponding rates of degradation, while at high concentrations biological activity may stop completely. This is illustrated in Figure B.3-4. With inhibitory and/or toxic compounds present, the bacterial growth rate will increase up to some maximum value and will then begin to decrease. This is in contrast to the growth rate seen with non-inhibitory compounds. It is also worth noting that property adapted organisms may be able to tolerate higher concentrations of toxic compounds than non-adapted organisms.

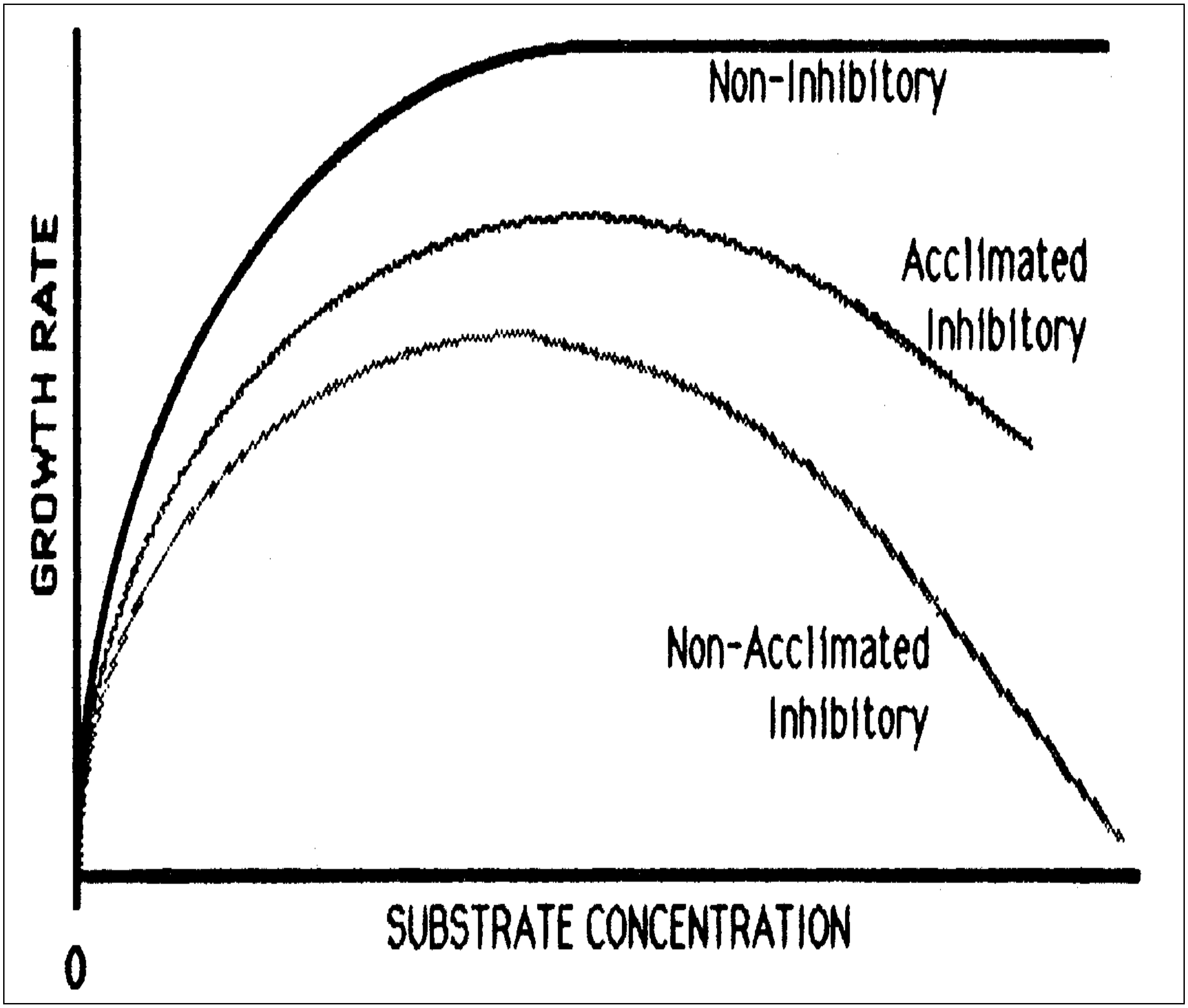


Figure B.3-4—Growth Rates With Inhibitory Substrates

B.3.2 SUBMERGED FIXED-FILM REACTORS

With a fundamental knowledge of the chemistry and microbiology involved in wastewater and groundwater treatment, we can now examine the specifics of submerged fixed-film treatment theory and operation.

B.3.2.1 Biological Flocculation and Slime Formation

Many bacteria have one unique characteristic that has enabled man to successfully utilize them in wastewater treatment. This characteristic is that many types of bacteria stick to each other and to other surfaces.

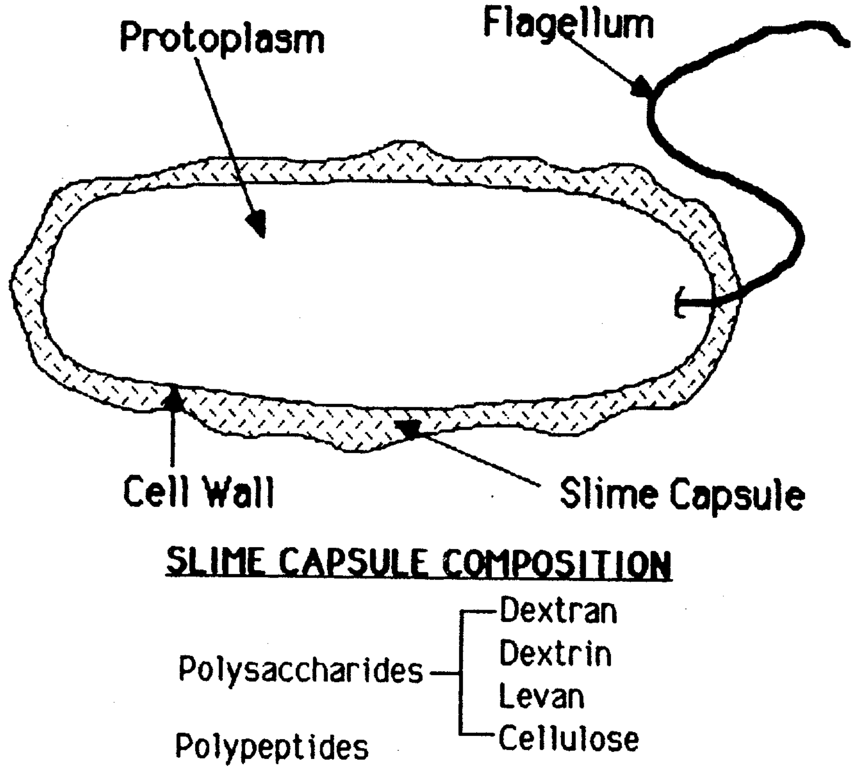


Figure B.3-5—Slime Formation around Bacterium

Bacteria frequently produce substances that coat the surface of the bacterial cell wall. These sticky materials are called biopolymers. and they form a slime capsule about the cell, as shown in Figure B.3-5. A very young cell typically does not have a slime capsule. Older cells tend to develop the capsule. but will lose it if they become starved for food. In some instances this slime capsule acts as a storage site for unmetabolized or partially metabolized food.

The presence of this slime capsule leads to the agglomeration of biological floc. Figure 6 depicts the agglomeration process and the formation of biological floc. Floc formation allows us to design a treatment process to finally separate the particulate organics (the biomass) from the clean water. Biological floc is heavier than water and will settle out under appropriate conditions. Individual bacterial cells. however, are not dense enough to settle out, and tend to remain in suspension. Process engineers found that they could mix bacteria with water, provide oxygen in the form of aeration, and then allow the bacterial flocs to settle from the treated water. The bacteria that settled out could then be used to treat additional wastewater if they were recovered and mixed with fresh wastewater. The process is known as a suspended growth process and is commonly known as activated sludge.

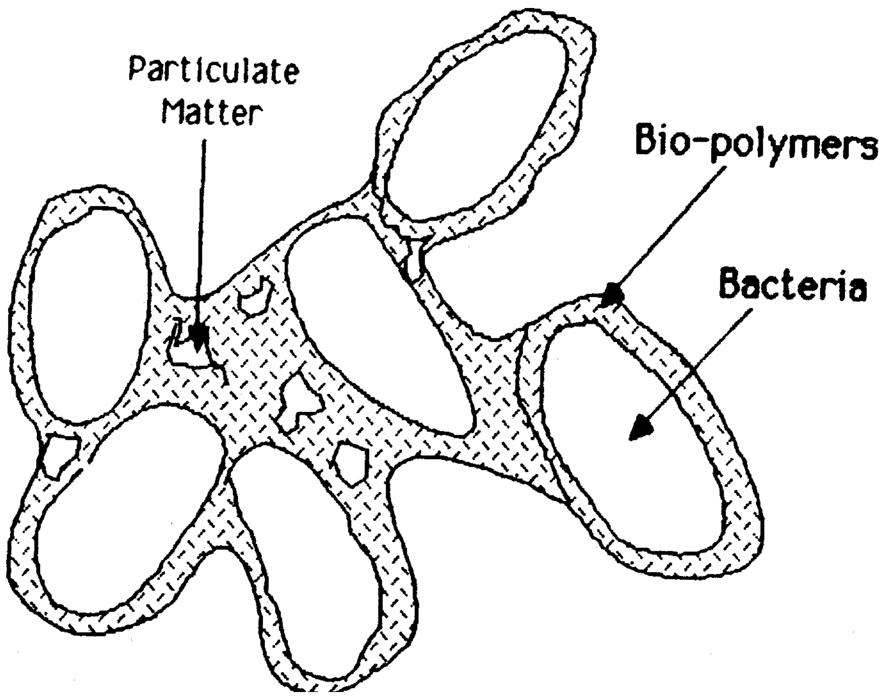


Figure B.3-6—Agglomeration of Bacterial Cells

It was also found that the formation of the slime capsule would enable the bacteria to attach themselves to solid surfaces as a biological film. This attached biofilm also does an excellent job of removing organics from water passing over the surface of the slime. The degree of organics removal from the water depends on a number of treatment factors, such as liquid-biofilm contact time, oxygen availability, and availability of nutrients.

The submerged fixed-film biological process was developed to exploit the ability of microorganisms to form biological films or slimes. Inert packing is installed in the reactor tank. The tank is then filled with contaminated water, and air is introduced below the media. Bacterial film accumulates on the packing, and the bacteria within the film removes the soluble organics from the wastewater as it passes through the tank. As the air rises through the media it provides mixing as well as oxygen transfer into the liquid. The movement of air and water also creates shear forces that regulate the amount of growth that is able to accumulate on the media surface.

B.3.2.2 Factors that Affect Flocculation and Slime Formation

The collective populations of bacteria in biological floc or films respond to the availability of food. If there is a great excess of food, the bacteria grow rapidly (assuming that the food is not toxic) and have a low average cell age. The bacteria do not have the opportunity to form a great deal of biopolymer on their cell walls, and as a result, grow as dispersed organisms. If there is a scarcity of food, on the other hand, the microorganisms do not have enough raw materials to make the biopolymers, and thus do not form a slime coating. In fact, if a healthy flocculating biological population is starved for any extended period of time, it will begin to consume the biopolymers as a food source and the floc or slime will break up.

Figure B.3-7 shows the classical growth curve for bacteria in a batch system. In this scheme, small microbial populations develop into massive populations, which then deplete a limited food supply. The organisms then begin to starve and die. Note that bioflocculation and slime formation are observed in the late log growth phase, stationary phase, and in the early death phase. Flocculation does not occur during log growth or late death phases. The impact of organic substrate availability on floc or slime formation is in important factor to keep in mind during the operation of biological treatment systems.

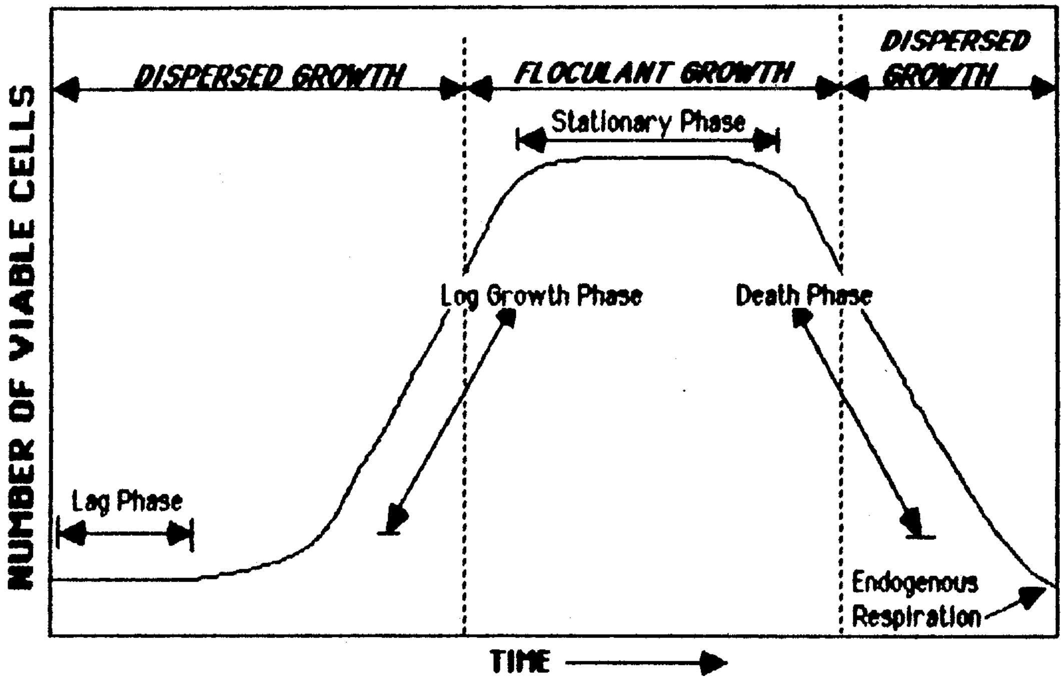


Figure B.3-7—Bacterial Growth Curve

B.3.2.3 Submerged Fixed-Film Reactors Process Theory

Biological wastewater treatment utilizing submerged filed-film relies on biological slime formation to grow bacteria attached to the surfaces of inert packing materials. The biofilm is then exposed to both the wastewater (containing the food source) and air (an oxygen source). The high surface-area-to-volume ratio of moot fixed-film units allows for the accumulation of a substantial mass of microorganisms in a relatively small reactor volume.

The basis of biological treatment is to allow a relatively high concentration of microorganisms to contact the wastewater while mixing and oxygen transfer occurs simultaneously. Since the ability of the biological solids to settle is not the controls factor for successful operation of this treatment system (as in the cage of the activated sludge process), a much more stable treatment design is possible. This design also allows for higher organic loads to be treated. By using a fixed-film configuration, a reduced quantity of biosolids will also be produced. This is due to the fact that the lower layers of the biofilm will be undergoing endogenous respiration, and will be consuming their own cellular components as a food source.

In submerged fixed-film bioreactor designs, the wastewater enters the tank and is rapidly mixed and contacted with the biological film (Figure B.3-8).

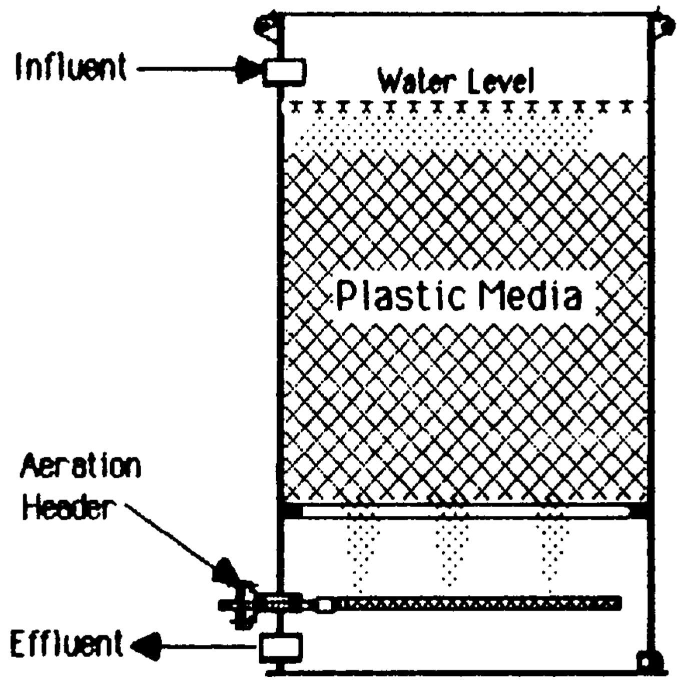


Figure B.3-8—Submerged Fixed-Film Bioreactor

The organics in the water, as well as dissolved oxygen and nutrients, rapidly diffuse from the bulk liquid into the biofilm where metabolism of the substrates occur (Figure B.3-9). These reactors are equilibrium reactors. and produce very low effluent discharge concentrations relative to influent organic concentrations.

B.3.2.4 Factors Affecting Diffusion Rates

- Concentration
- Temperature
- pH

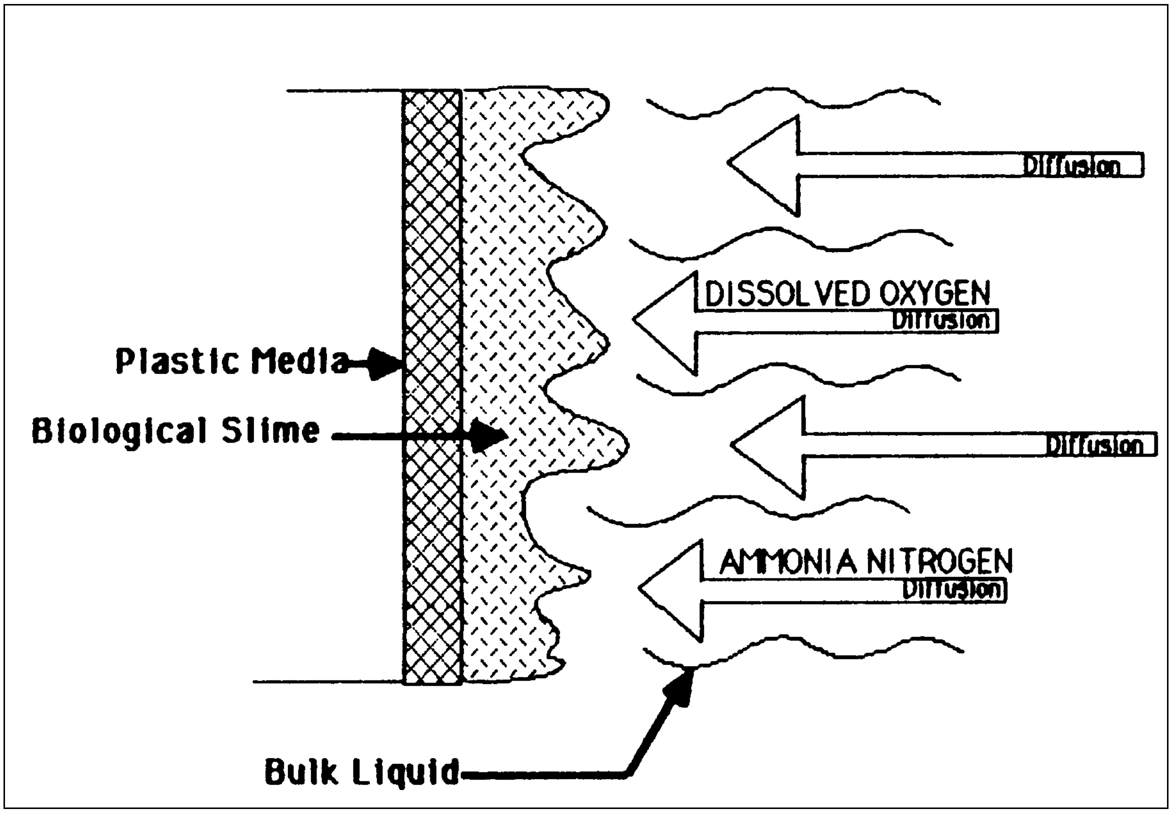


Figure B.3-9—The Diffusion Process

As growth of the biofilm occurs, it will continue to build in thickness (Figure B.3-10). At a critical film thickness, diffusion of oxygen and nutrients cannot reach the entire distance through the film to the support media surface. At some point, the film closest to the plastic media does not receive any food or nutrients (particularly oxygen). This inner layer of film becomes anaerobic, and the organisms present lose their ability to adhere to the media surface. The shear forces caused by water flowing past the attached biomass will ultimately become great enough to tear weakened portions of the film loose from its support. This process is called sloughing. The solids which slough from the support media will eventually be removed through clarification and filtration processes (if needed). The newly exposed portion of the media surface will repeat the process of biofilm growth and sloughing.

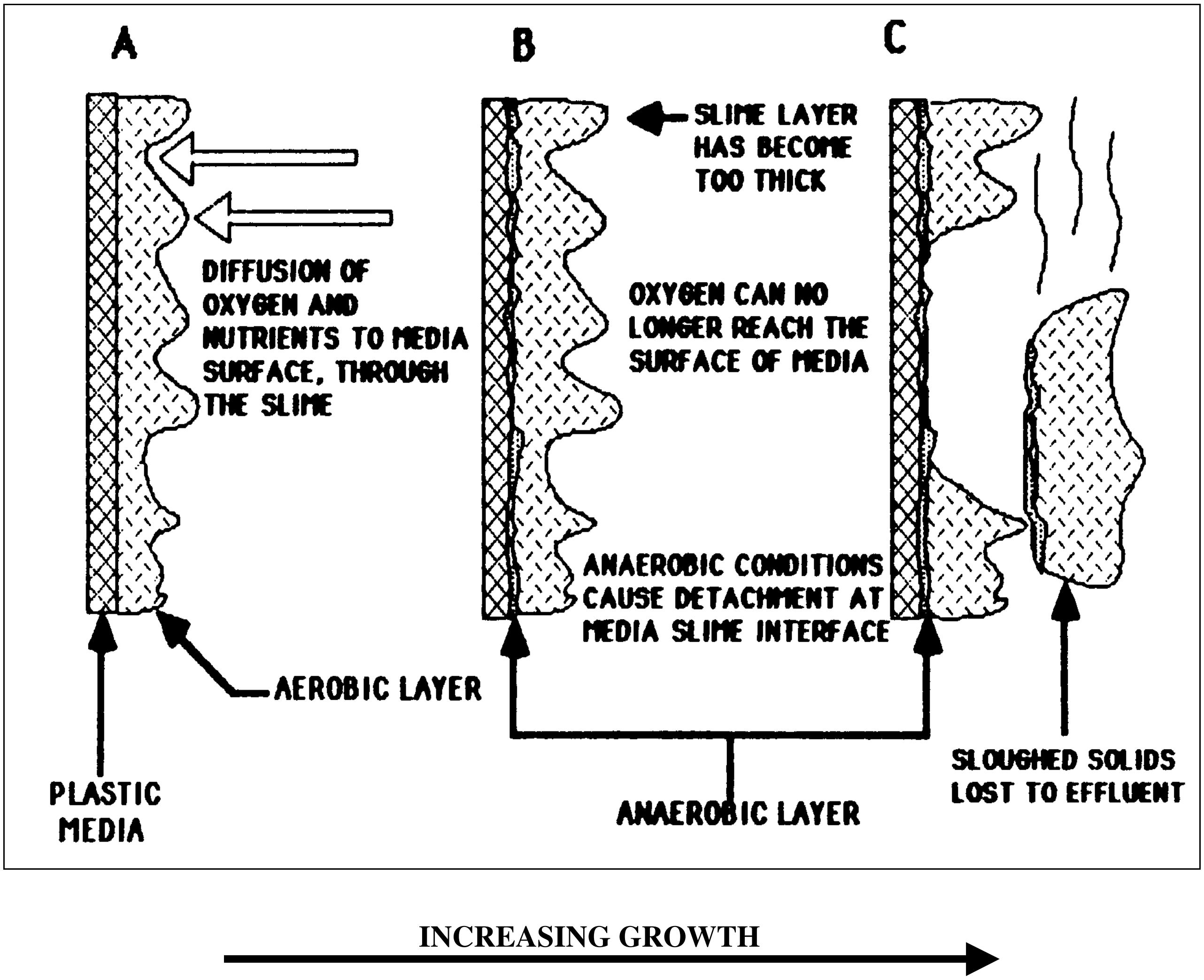


Figure B.3-10—Biofilm Growth and Sloughing

In actual operation, submerged fixed-film reactors are in a state of continuous growth and sloughing. At any given time, portions of the support media are at some point between forming a new film and sloughing. Different aerobic and anaerobic "microenvironments" are also present throughout the biofilm. Thus while the overall treatment process can be thought of as a “steady state" operation, many complex activities are actually taking place.

B.3.3 OPERATION AND CONTROL OF SUBMERGED FIXED-FILM BIOREACTORS

B.3.3.1 General Principles

With knowledge of the principles of biological growth and the submerged fixed-film process, considerations for the operation and control of these treatment systems can now be examined.

In order for the submerged fixed-film (or any other biological system) to perform properly, it is very important that the organic food source be the only factor limiting biological growth. Oxygen and all nutrients should be available in excess of that required for metabolism of the available substrate. Environmental growth factors (such as temperature, pH, absence of toxins, etc.) should be kept within favorable ranges to ensure successful operation and high treatment efficiency.

B.3.3.2 Controlling the Biological Growth Environment

The following parameters will define the optimum conditions for biological growth:

- **Biochemical Oxygen Demand (BOD):** BOD is a measurement of the amount of oxygen needed by microorganisms to metabolize the materials present in a given sample. The availability of organic chemical substrate (BOD) should be the only factor limiting microbial growth. All other required items (nutrients, oxygen, etc.) should be available in excess.

  For the optimum performance of any biological system, it is desirable that the quantity, concentration, and character of the organic chemicals (or BOD) entering the system be as consistent as possible. Equalization of the wastewater stream is the best method of ensuring the most uniform loading to the system. In actual operation this may not be practical, but large variations in the influent BOD should be avoided. BOD feed (in lbs/day) to the system should not vary by more than ± 20% over any 24-hour period. Variations in load greater than this can cause shock loading and upset conditions, which result in poor system performance. In extreme cases, these upsets can cause loss of biomass function due to toxicity of the wastewater.

  The organic loading of the biosystem can be adjusted by controlling the wastestream flow into the biosystem. For example, a sudden increase in the organic concentration of the inlet wastewater can be handled by reducing the flow rate to a level within ±20% of the total pounds of organics going through the system in the previous few days. Similarly, a sudden decrease in organic concentration can be corrected by increasing the hydraulic flow through the system so that the total pounds of organics entering the system are within the ± 20% daily variation.

- **Dissolved Oxygen (DO):** There should be some measurable residual of dissolved oxygen present throughout the system (>1.0 mg/L). Bioreactors are designed as aerobic systems use aerobic metabolic pathways for the primary and sequential breakdown of substrates present. The DO levels at the end of the system should always be in excess of 1.0 mg/L, or in most instances the effluent BOD will rise above the design effluent concentration for the system. Should the last stage of the treatment system show no residual DO, the system is organically overloaded and the overload should be mitigated by either (1) reducing the influent flow rate, (2) diluting the concentration of BOD in the influent, (3) increasing the aeration, or (4) redistributing the aeration to the system appropriately. Should the treatment system show high levels of DO (4 to 5 mg/L), additional BOD loading can be applied to the system until residual oxygen concentrations are in the range of 2-3 mg/L and all discharge criteria are still met.

- **Ammonia Nitrogen (NH_3-N):** The nitrogen present in ammonia is a required microbial nutrient. Stoichiometrically, for every 100 parts of organic carbon measured as BOD entering the system, between 5 to 10 parts of nitrogen are required for cellular metabolism. In the operation of a biosystem, a residual soluble ammonia concentration of 1 to 2 mg/L should be present in the effluent. In order to determine this concentration, the bioreactor effluent should be filtered through a 0.45-micron filter prior to analysis in order to determine soluble ammonia levels. By maintaining a residual NH_3-N concentration in the effluent, we ensure that the organisms have adequate nitrogen to perform their metabolic functions. It should be noted that as the BOD loading of the system varies, the amount of NH_3-N being fed to the system would need to be adjusted to maintain the 1 to 2 mg/L residual level.

- **Ortho-Phosphate Phosphorus (PO_4-P):** Soluble ortho-phosphate is also required for proper microbial metabolic functions. On a stoichiometric basis, for every 100 parts of carbon as BOD applied to the system, about 1 part of ortho-phosphate is required. As in the case of ammonia, about 1 to 2 mg/L of residual soluble orthophosphate should be measurable in a filtered bioreactor effluent sample.

- **pH:** The pH of the wastewater will typically decrease as it passes through the biosystem. The allowable pH range for normal biological activity is between 6 and 9 pH units. The optimum pH for treatment is generally 7.0 to 8.5 pH units. Changes in pH should not be greater than ± 0.5 to 1.0 pH units over a 24-hour period. Adjustment of pH can be accomplished by addition of the appropriate amount of acid or base to the influent wastewater. Dramatic and severe changes in pH can substantially inhibit or kill the biomass and should be avoided.

- **Temperature:** The temperature of the wastewater contacting the biofilms will affect the rate at which the microorganisms metabolize the substrate. The optimum treatment temperature range is between 15° and 35°C (59 to 95°F). Temperature less than 10°C will substantially retard the metabolic rates of the organisms and allow BOD to carry through to the effluent without being metabolized. Temperatures greater than 45°C (113°F) can cause the biofilm to break down. Temperatures greater than 45°C can also destroy both the enzymes and organisms present, resulting in observed high effluent BODs.

- **Heavy Metals:** High concentrations of compounds such as copper, lead, arsenic, chromium, etc., can have a severe toxic effect on microorganisms. At pH ranges between 7.0 to 8.5, the majority of these metals will precipitate and become insoluble in the wastewater. As such they will have no adverse effect on the microorganisms. Care should be taken that the concentration of any soluble heavy metal does not exceed 1.0 mg/L. Should metal toxicity become an operating problem, upstream pretreatment controls may be necessary.

- **Organic Toxicity:** The presence of certain organic compounds, such as perchloroethylene (PCE), quarternary amines, chlorinated aromatics, tertiary alcohols, etc. can severely inhibit the activity of biological systems. In some instances the compounds themselves can begin to break down the cell walls of the microbes, resulting in a loss of cell viability. In other cases, the organic compounds may inhibit enzyme activity and result in repressed biological activity.

Also, some compounds which do not cause inhibition or toxicity effects at low concentrations may become toxic at higher concentrations. During loading or upset conditions, the concentrations of organics in the microenvironment surrounding the microbes may increase and result in loss of biological activity. Compounds suspected of interfering with biological activity should be carefully screened prior to being introduced into the biological treatment system.

B.3.3.3 Operating Limits

In general, all biological systems should be run within the following limitations:

- **pH:** 6 to 9 units

<4.0	General loss of microbial activity
<5.0	Bacteria start to die
<6.0	Activity slows
<6.5	Nitrification stops
<10	Bacteria start to die; lost of microbial activity

- **Temperature:** 15° to 32°C (59 to 90°F)

<30°F	Bacteria are killed
<45°F	Little or no growth
<60°F	Activity slows
>99°F	Enzyme inactivation; bacteria start to die
>115°F	Bacteria are killed

- **Dissolved Oxygen:** 2 to 7 mg/L

< 0.5	mg/L Anoxic conditions
< 2.0	mg/L Oxygen limited
> 7.0	mg/L Slow growth and/or underloaded design
> 9.0	mg/L Bacteria dead and/or no food available

- **Ammonia Nitrogen (NH_3-N):** Soluble effluent > 1.0 mg/L

< 0.2	mg/L Rapid growth inhibited
< 1.0	mg/L Slow response to shock loads
> 300	mg/L NH_3 toxicity should be evaluated

- **Orthophosphate Phosphorus ($P0_4$-P):** Soluble effluent > 1.0 mg/L

< 0.2	mg/L Rapid growth inhibited
< 1.0	mg/L Slow response to shock loads

APPENDIX C

APPLICABLE CODES, REGULATIONS, AND GOVERNING AGENCIES

C.1 APPLICABLE CODES AND REGULATIONS

29 CFR	Code of Federal Regulations - Labor – Parts 1200, 1410, 1900 to 1910 (1901.1 to 1910.999)
40 CFR	Code of Federal Regulations – Protection Environment – Parts 50-99, 110, 122-149, 162, 240-257, 260-299, 300, 302, 350, 355, 370, 372, and 761
49 CFR	Code of Federal Regulations – Transportation– Parts 171-177
ACI 301	Specifications for Buildings
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 318	Building Code Requirements for Structural Concrete
ACI 530	Building Code Requirements for Masonry Structures
AEI	Architectural and Engineering Instructions Design Criteria
AISC	Seismic Provisions for Structural Steel Buildings
AISC ASD	Manual of Steel Construction, Allowable Stress Design
AISC LRFD	Manual of Steel Construction, Load and Resistance Factor Design
AISI	Specifications for the Design of Cold-Formed Steel Structural Members
AMC-AR 385-100	United States Army Material Command Safety Manual (Chapters 1, 2, 3, 4, and 13 only)
AMC-AR 385-61	United States Toxic Chemical Agent Safety Program
AMCPEO-CD-F-FR-87011	Design Criteria Handbook For Chemical Agents and Munitions Disposal Facilities
AMC-R 385-100	Safety Manual
AMC-R 385-131	Safety Regulations for Toxic Chemical Agents GB and VX
API RP 520 PTI	Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries, Part I – Sizing and Selection
API RP 520 PTII	Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries, Part II – Installation
API RP 521	Guide for Pressure-Relieving and Depressuring Systems
API RP 551	Process Measurement Instrumentation

Return

API RP 552	Transmission Systems
API STD 2000	Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated
API STD 526	Flanged Steel Safety-Relief Valves
API STD 527	Seat Tightness of Safety Relief Valves
API STD 598	Valve Inspection and Testing
API STD 602	Compact Steel Gate Valves – Flanged, Threaded, Welding and Extended Body Ends
API STD 620	Design and Construction of Large, Welded, Low-Pressure Storage Tanks
API STD 650	Welded Steel Tanks for Oil Storage
AR 190-59	United States Army Chemical Agent Security Program
AR 200-1	Environmental Quality – Environmental Protection and Enhancement
AR 200-2	Environmental Quality – Environmental Effects of Army Actions
AR 200-4	Solid and Hazardous Waste Management
AR 385-64	United States Army Explosives Safety Program
AR 415-5	Military Construction, Army (MCA) Program
AR-415-10	General Provision for Military Construction
AR 420-90	Fire and Emergency Service
ASCE 7	Minimum Design Loads for Buildings and Other Structures
ASME B1.20.1	Pipe Threads, General Purpose (Inch)
ASME B16.10	Face-to-Face and End-to-End Dimensions of Ferrous Valves
ASME B16.34	Valves – Flanged, Threaded, and Welding End
ASME B16.5	Pipe Flanges and Flanged Fittings NPS ½ through NPS 24
ASME B31.3	Process Piping
ASME B40.100	Pressure Gages and Gauge Attachments
ASME Boiler and Pressure Vessel Codes:	
ASME SEC I	Rules for Construction of Power Boilers
ASME SEC IV	Rules for Construction of Heating Boilers
ASME SEC VIII D1	Pressure Vessels Division 1
ASME SEC VIII D2	Pressure Vessels Alternative Rules Division 2
ASME MFC-3M	Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi
ASTM E-84	Fire Test for Interior Finish

ASTM E-119	Fire Endurance Test
AWS-D1.1-98	Structural Welding Code – Steel
CEGS 05055	Guide Specification for Welding, Structural
CEGS-13405	Process Control
CEGS-13801	Utility Monitoring Process Control
CEHND 1110-1-1	Design Manual for Architect-Engineers and USAEDH Personnel, U.S. Army Engineer Division, Huntsville, Alabama
DA-PAM 385-64	Ammunition and Explosive Safety Standards
DG 1110-3-122	Dept. of the Army Design Guide for Interior
DOD 6055.9-STD	Ammunition and Explosive Safety Standards
DOE/TIC- 11268	A Manual for the Prediction of Blast and Fragment Loadings on Structures, U.S. Department of Energy
ER 1110-345-100	Design Policy for Military Construction
ER 1110-345-122	Dept. of the Army – Engineering and Interior Design
ER 1110-345-700	Design Analysis
FCI 70-2	Control Valve Seat Leakage
FED-STD-595	Colors
FM	Approval Guide (Equipment, Materials, and Services for Conservation of Property), 2000 with Quarterly Supplements
FR-87011	Disposal Facilities
ICBO	Uniform Building Code
IEC 60751	Industrial Platinum Resistance Thermometer Sensors
IEC 61511-1	Functional safety: Safety Instrumented Systems for the process industry sector Part 1: General framework, definitions, system, software and hardware requirements
IEEE 518	Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources
ISA 88.01	Batch Control Part 1: Models and Terminology
ISA MC96.1	Temperature Measurement Thermocouples
ISA RP16.1, 2, 3	Terminology, Dimensions and Safety Practices for Indicating Variable Area Meters (Rotameters) RP16.1 Glass Tube, RP16.2 Metal Tube, RP16.3 Extension Type Glass Tube
ISA RP16.5	(1961) Installation, Operation, Maintenance Instructions for Glass Tube Variable Area Meters (Rotameters)

ISA RP42.1	Nomenclature for Instrument Tubing Fittings
ISA RP60.1	Control Center Facilities
ISA RP60.3	Human Engineering for Control Centers
ISA S18.1	Annunciator Sequences and Specification
ISA S20	Forms for Process Measurement and Control: Instruments, Primary Elements, and Control Valves
ISA S5.1	Instrumentation Symbols and Identification
ISA S5.2	Binary Logic Diagrams for Process Operations
ISA S5.3	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computed Systems
ISA S51.1	Process Instrumentation Terminology
ISA S7.0.01	Quality Standard for Instrument Air
ISA S75.01	Flow Equations for Sizing Control Valves
ISA S82.03	Safety Standard for Electrical and Electronic Test, Measuring, Controlling and Related Equipment ISA S84.01 Application of Safety Instrumented systems for the Process Industries
MBMA	Low-Rise Building Systems Manual
MD, AMCPEO-CD-F-FR-87011	Design Criteria Handbook for Chemical Agents and Munitions Disposal Facilities, US Army Office of the Program Executive Officer, Newport Chemical Depot.
MIL-HDBK-1008	Fire Protection for Facilities Engineering, Design and Construction
MIL-STD-12	Abbreviations for Use on Drawings, Specifications, Standards, and in Technical Documents
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MSS SP-72	Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	Bronze Gate, Globe, Angle and Check Valves
MTR 93W0000034	Assessment of Carbon Filter System Performance
NEHRP	Recommended Provisions for Seismic Regulations for New Buildings and Other Structures
NEMA ICS-1	Industrial Control and Systems General Requirements
NEMA ICS-6	Industrial Control and Systems Enclosures
NFPA	Fire Protection Hand Book
NFPA 101	Life Safety Code

NFPA 70	National Electrical Code
NFPA 80	Standard for Fire Doors and Windows
NFPA 80A	Recommended Practice for Buildings from Exterior Fire Exposures
SAMA PMC-22.1	Functional Diagramming of Instrument and Control Systems, Analog and Digital Systems
SDI-100	Standard Steel Doors and Frames
SJI	Recommended Code of Standard Practice for Steel Joist and Joist Girders
SWRI-6714	A manual to Predict Blast and Fragment Loadings from Accidental Explosions of Chemical Munitions Inside an Explosion Containment Structure, Volumes I and II, Prepared for U.S. Army Toxic and Hazardous Materials Agency and U. S. Army Corps of Engineers, Huntsville Division, Southwest Research Institute.
TB 700-4	Decontamination of Facilities and Equipment
TI 809-01	Load Assumptions for Buildings
TI 809-04	Seismic Design for Buildings
TI 809-29	Structural Considerations for Metal Roofing
TI 809-30	Metal Building Systems
TI 809-52	Commentary on Snow Loads
TI-809-02	Structural Design Criteria for Buildings
TM 5-785	Engineering Weather Data
TM 5-805-4	Noise and Vibration Control
TM 5-810-1	Mechanical Design for Heating, Ventilating, and Air-Conditioning
TM 5-815-3	Heating, Ventilating, and Air-Conditioning (HVAC) Control Systems
TM 5-822-14	Soil Stabilization for Pavements
TM 5-1300	Structures to Resist the Effects of Accidental Explosions.
TM 5-618	Paint and Protective Coatings
TM 5-803-1	Installation Master Planning Principle and Practice
TM 5-803-5	Installation Design
TM 5-805-4	Joint Sealing for Buildings
TM 5-805-6	Caulking and Sealing
TM 5-805-7	Welding Design, Procedures and Inspection
TM 5-809-12	Concrete Floor Slabs on Grade Subjected to Heavy Loads
TM 5-809-3	Masonry Structural Design for Buildings

TM 5-809-6	Structural Design of Structures Other than Buildings
TM 5-811-1	Electrical Power Design and Distribution
TM 5-811-2	Electrical Design, Interior Electrical Systems Protection
TM 5-811-3	Electrical Design, Lightning and Static Electricity Protection
TM 5-811-4	Electrical Design, Corrosion Control
TM 5-818	Soils and Geology, Procedures for Foundation Design of Buildings
TM 5-818-7	Foundations in Expansive Soils, September
TM 5-820-4	Drainage for Areas other than Airfields, October
TM 5-822-2	General Provisions and Geometric Design for Roads, Streets, Walks and Open Storage Areas
TM 5-822-5	Pavement Design for Roads, Streets, Walks and Open Storage Areas
TM 5-822-7	Standard Practice for Concrete Pavement

C.2 ADDITIONAL GOVERNING AGENCIES

(ADC) Air Diffusion Council
(AMCA) Air Moving and Conditioning Association
(ANSI) American National Standards Institute
(ARI) Air Conditioning and Refrigeration Institute
(ASHRAE) American Society of Heating, Refrigerating & Air Conditioning Engineers
(AWWA) American Water Works Association
Industrial Ventilation Manual of Recommended Practice
(OSHA) Occupational Safety and Health Administration
(SMACNA) Sheet Metal and Air Conditioning Contractor's National Association
(UL) Underwriters Laboratories, Inc.

APPENDIX D

SEISMIC CRITERIA

D.1 INTRODUCTION

The purpose of the seismic criteria is to define the requirements for consideration of the forces due to a projected seismic event in the design of the Assembled Chemical Weapons Assessment (ACWA) program using alternate chemical weapons demilitarization technology using the WHEAT process as developed by the Parsons-Allied Signal team. This document provides technical guidance to project personnel in defining seismic input and performing seismic analyses of structures for the ACWA-WHEAT project.

The seismic design will be in accordance with the requirements and methods of the U.S. Army Manual TI 809-04 [Ref. 1], "Technical Instructions – Seismic Design for Buildings," as modified herein. The design manual establishes an earthquake loading approach that is based on the National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Federal Emergency Management Agency (FEMA) 302 [Ref. 2a & 2b]. Also, NEHRP recommendations are adopted by the International Code Council (ICC), which has issued a new International Building Code (IBC) 2000 [Ref. 3]. IBC 2000 now a national code and has replaced various regional codes [Building Officials and Code Administrators (BOCA), Uniform Building Code (UBC), and Southern Building Code Congress International (SBCCI)] followed in the United States. The seismic criteria presented in this document provide for a more conservative design basis for critical structures whose failure in a seismic event could release toxic substances in quantities sufficient to be dangerous to the safety of the facility, its personnel, and the general public.

D.1.1 SEISMIC CLASSIFICATION

To perform any seismic analysis, the structures, systems, and components (SSCs) must be classified into the Seismic Use Group, Seismic Design Category, and structural Performance Level in accordance with TI 809-04 [Ref. 1]. Table D-1 presents the classification and design requirements of the various ACWA-WHEAT buildings. Table D-1 also summarizes the minimum procedures and design parameters to be used for analysis. The following paragraphs briefly describe the design philosophy of various components involved in the classifications abstracted from Ref. 1.

The seismic use group is established based on the occupancy or function of a building:

Group	Function
I	Standard occupancy
II	Special occupancy
III H	Hazardous facility
III E	Essential facilities

Table D-1—Classification of ACWA-WHEAT Buildings and Other Structural Seismic Design

Return

Table D-1—Classification of ACWA-WHEAT Buildings and Other Structural Seismic Design Criteria

Building or Area		Seismic Use Group[a]	Seismic Design Category[b]	Performance Level[c]	Performance Objective[d]	Ground Motion[e]	Min. Analysis Procedure[f,g]	Building Type[h]	R Factor[i]
*Munitions demilitarization bldg. Without toxic cubicle	MDB	III H	C	SE(2)	2B	3/4 MCE (B)	LE w/m	OSBF/OSMF/ SCSW	1[j]
*MDB toxic cubicle	TC	III E	C	IO(3)	3B	SSE	LE w/m	SCSW	1[j]
*Process auxiliary building	PAB	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4
*Munitions Storage Building	MSB	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4
*MDB and Laboratory Filter Area	FIL / LFA	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4
Utility building	UB	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4
Standby diesel generator building	SDG	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4
Laboratory building	LAB	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4
Personnel support building	PSB	I	B	LS(1)	!A	2/3MCE (A)	LW w/R	OWSW	6.5
Personnel and maintenance building	PMB	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OWSW	6.5
Entry control facility	ECF	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OCSW	4.5
*Site / Offsite Work Area	SITE/ WOS	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4
*Gas Cylinder Storage / Bio-treatment Area	GCS / BTA	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4
*Bio-reactor Equipment Buildings	BEB	I	B	LS(1)	1A	2/3 MCE (A)	LE w/R	OSBF/OSMF	4

[a]Table 4-1 of Ref. 1.
[b]Tables 4-2a and 4-2b of Ref. 1.
[c]IO = immediate occupancy, SE = safe egress, LS = life safety, Table 4-3 of Ref. 1.
[d]MCE = maximum considered earthquake, Ground Motion Type A or B, Table 4-4 of Ref. 1.
[e]SSE = site-specific earthquake, Risk Analysis Report, equal to peak ground acceleration (PGA) of 0.21 g.
[f]LE = linear elastic analysis with R and m factors.
[g]Tables 7-2 and 7-3 for OCSW m factors, Table 7-10 for OSBF m factors, and Table 7-12 or 7-13 for OSMF m factors, Ref. 1.
[h]OSBF = ordinary steel-braced frame, OSMF = ordinary steel moment frame, OCSW = ordinary concrete shear wall, SCSW = special concrete shear wall, OWSW =ordinary wood shear wall.
[i]Table 7-1 of Ref. 1.
[j]Section 5-2, c-2 of Reference 1
* These buildings are new for ACWA, others not marked are Base Line Design configuration.

Seismic design categories ranging from A to F are established based on the seismic use group and the projected severity of an earthquake at the site defined by short (S_S) and long (S_1) period spectral acceleration coefficients (site-related earthquake ground motion accelerations abstracted from seismic probabilistic maps). Category A is the least severe and Category F is the most severe. It is to be noted that Categories E and F are for high seismic areas where S_1 is equal to or greater than 0.75 g.

Performance objectives are defined by Performance Levels 1 to 3, depending on the desired performance of the building and the potential structural damage suffered after the designed earthquake event. The desired performance is defined in terms of a building's response range expressed as performance levels:

Level		Function
1	Minimum	Life safety (LS)
2	Intermediate	Safe egress (SE)
3	Maximum	Immediate occupancy (IO)

All building structures except the Munitions Demilitarization Building (MDB) of the ACWA-WHEAT is classified as Seismic Use Group I, Seismic Design Category B, and Performance Level 1 or LS, which are the minimum design criteria to be followed. The MDB is classified as Seismic Use Group III H, Seismic Design Category C, and Performance Level 2 or SE. The toxic cubicle (TC) inside the MDB contains the agent holding tank and the agent surge tank. The TC is classified as group III E, Seismic Design Category C, and Performance Level 3 or IO. These tanks contain a sufficient amount of chemical agent (CA) to pose a significant risk for offsite exposure as a result of a major seismic event. To reduce the risk, a seismic criterion having a peak ground acceleration (PGA) with a corresponding mean annual exceedance probability of 10^{-4} (return period of 10,000 years) is recommended for the ACWA-WHEAT TC, various tanks inside the TC, and the attached piping system. This recommendation is based on the Hazard and Risk Analysis study of the baseline design CSDP [Reference 4 a] and NECDF [Reference 4b], where the toxic area (housing the agent holding tank, surge tank, and attached piping) was designated as being required to sustain a greater seismic event than the remainder of munitions demilitarization building (MDB). This special seismic criterion for the TC is identified as the site-specific earthquake (SSE).

It must be noted that the ACWA-WHEAT classification of Seismic Category is in accordance with the requirements of TI 809-04 [Ref. 1]. Table D-1 summarizes seismic classification in accordance with Ref. 1.

D.2 SEISMIC INPUT DATA

D.2.1 DESIGN GROUND MOTIONS

Two levels of earthquake motion are defined for the seismic analysis of structures based on the seismic classification in Ref. 1. Both levels are defined in terms of spectral ordinates (acceleration in g's) with reference to the maximum considered earthquake (MCE). Contours of spectral ordinates at periods of 0.2 second (S_s) and 1.0 second (S_1) are delineated on the MCE maps that accompany FEMA 302 [Ref. 2]. These maps are based on the U.S. Geological Survey (USGS) probabilistic maps for ground motion with 2% probability of exceedance in 50 years (approximately a 2,500-year return period). The two levels of ground motion (Ground Motion A or B) to be used as a design criteria to achieve the desired performance objective are defined below.

D.2.1.1 MCE

Following spectral accelerations are assumed using USGS-prepared probabilistic spectral acceleration maps with a 5% damping for ground motion [Ref. 2b].

At 0.2-second period, $S_S = S_{0.2} = 0.20$ g from Map 1 [Ref. 2b]
At 1.0-second period, $S_1 = S_{1.0} = 0.06$ g from Map 2 [Ref. 2b]

D.2.1.2 Site Response Coefficients

The above MCE accelerations must be modified to account for the local site soil classification. The site classification system is categorized from Class A to Class F, depending on the characteristics of the soil layers. Class A soil is the stiffest (like hard rock) and Class F soil is very soft (like peat or organic clay). The various parameters defining the soil characteristics are defined by shear wave velocity (V_s), standard penetration resistance (N = value defined by the average number of blows per foot for the upper 100 feet of soil), undrained shear strength (S_U), plasticity index (PI), and water content. These parameters are provided by the geotechnical engineer after conducting a site geotechnical test, analyzing the test results, and making recommendations made after reviewing the results. For this facility design, Site D classification is assumed. Using the site classification D, short period response acceleration S_s, and 1-second period response acceleration S_1, the corresponding amplification factors F_a of 1.6 and F_v of 2.4 for short and long periods are obtained from Tables 3-2a and 3-2b of Ref. 1.

The adjusted MCE spectral accelerations for short period S_{ms} and 1-second period S_{m1} using site Class D are defined as:

$S_{ms} = F_a.S_s = 0.32$ g
$S_{m1} = F_v.S_1 = 0.15$ g

D.2.1.3 Ground Motion A

The traditional seismic risk level considered by most model building codes is 10% probability of exceedance in 50 years (return period of about 500 years). Thus, to match with the model building code return period, two-thirds of the MCE spectral ordinates obtained from the FEMA maps are used as a minimum basic design ground motion (identified as Ground Motion A) to be used for Performance Level 1 (LS) for all seismic use groups. Performance Level 2 (safe egress) is to be used for Seismic Use Group II. Thus, the spectral response design values S_{DS} and S_{D1} (for short and 1-second periods) are defined as:

$S_{DS} = 2/3\ S_{ms} = 0.22$ g
$S_{D1} = 2/3\ S_{m1} = 0.10$ g

The PGA at zero period = $0.4S_{DS} = 0.09$ g

D.2.1.4 Ground Motion B

To achieve the enhanced performance objective for Use Group III H and a Performance Level 2 (SE) and Level 3 (IO), a ground motion with a 5% probability of exceedance in 50 years (return period of about 1,000 years) is used as a design criterion. Thus, to obtain these ground motion parameters, three-fourths of the MCE spectral ordinates obtained from the FEMA maps are used as a design ground motion, and the spectral response design values S_{DS} and S_{D1} (for short and long periods) are defined as:

$S_{DS} = 3/4\ S_{MS} = 0.24$ g
$S_{D1} = 3/4\ S_{M1} = 0.12$ g

The PGA at zero period = $0.4S_{DS} = 0.10$ g

D.2.1.5 SSE

To satisfy the risk and hazard analysis criteria for a TC of the MDB, a return period of 10,000 years is assumed to obtain the design ground earthquake motion. A probabilistic seismic hazard analysis of the site is required to obtain the required site-specific design earthquake ground motion and the design spectra. At this time until further studies are performed, recommendation of the deterministic study of Reference 6 will be used for this design. However, deterministic geological- seismological investigation of earthquake hazards is required for the final design.

D.2.2 DESIGN RESPONSE SPECTRA

D.2.2.1 Ground Motions A and B

The design response spectrum curve for 5% damping using the above-defined design ground accelerations for the short-period S_{DS} and the 1-second period S_{D1} is developed using the Ref. 1 guidelines:

For period $T \leq T_0$, $S_a = 0.4\ S_{DS} + 0.6\ S_{DS}(T/T_0)$
For period $T > T_0$ and $\leq T_S$, $S_a = S_{DS}$
For period $T > T_S$ $S_a = S_{D1}/T$

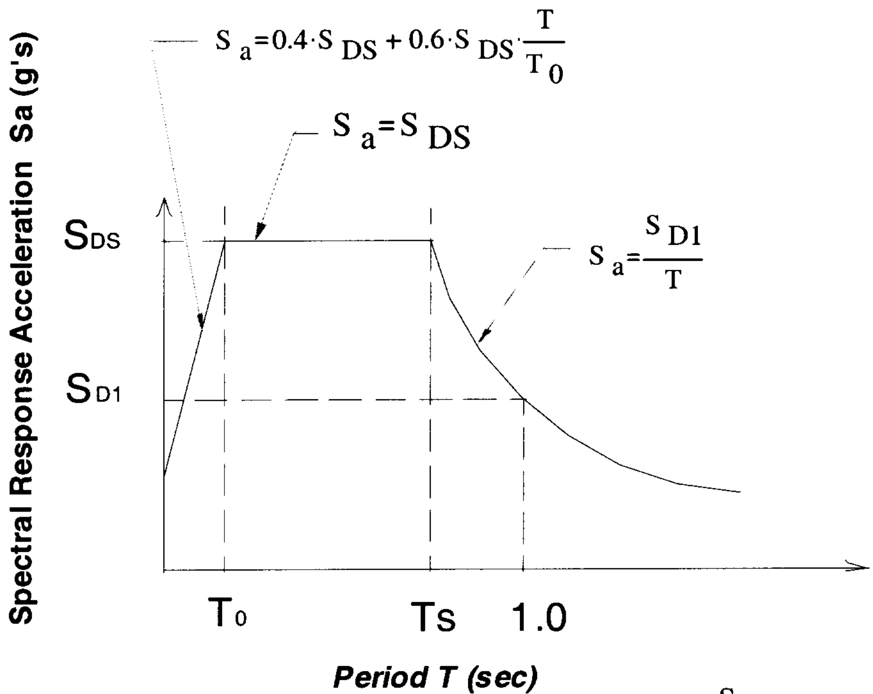
Where,

$T_0 = 0.2\ T_S$ and $T_S = S_{D1}/\ S_{DS}$

Using the design parameters S_{DS} and S_{D1} for Ground Motions A and B defined in Subsection D.2.1 and in the above equations, the design response spectral response acceleration S_a can be calculated for any period T. Figure D-1 presents the design response spectra plots for 5% damping using the above approach for the design Ground Motions A and B.

D.2.2.2 SSE

Figure D-2 presents the horizontal design response spectra for 5% and 7% damping values for the design PGA of 0.21 g. The requirements of Reference 1 having the site-specific spectra not less than 70% of the design spectra determined using United States Geological Survey (USGS) maps or data for the same return period have also been incorporated in the design spectra. This design spectra was developed based on the envelope of using 84-percentile curves with a return period of 10,000 years (or annual exceedance probability of 10^{-4}) seismic hazard analysis [Ref.6]



$T_0 = 0.20 \cdot T_S$

$T_S = \frac{S_{D1}}{S_{DS}}$

Ground Motion A

$S_{DS} = 0.22$ g

$S_{D1} = 0.10$ g

PGA = 0.40 $S_{DS} = 0.09$ g

$T_o = 0.09$ sec (f = 11.1 CPS)

$T_s = 0.46$ sec (f = 2.2 CPS)

* TI 809-04 (Reference 1)

Ground Motion B

$S_{DS} = 0.24$ g

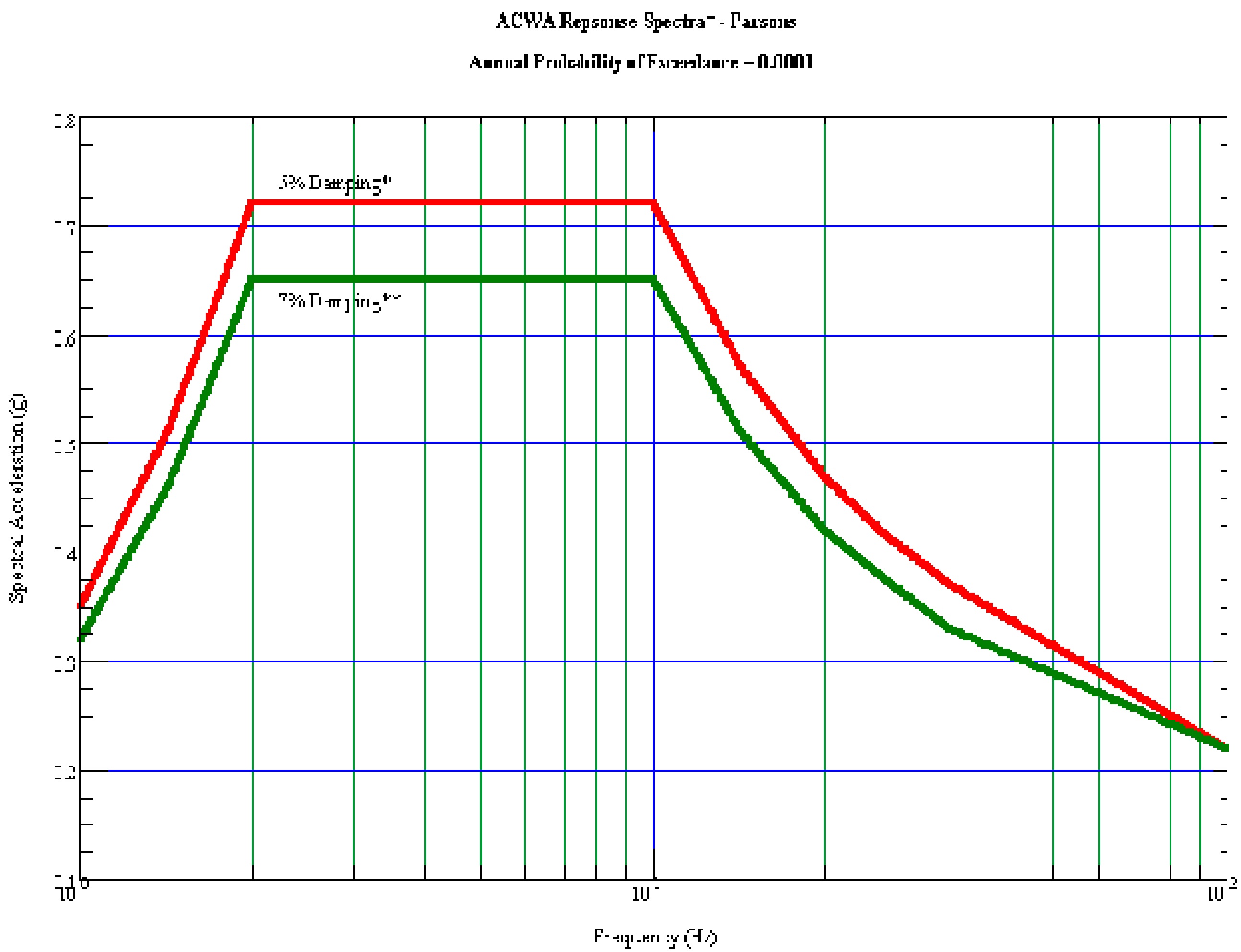
$S_{D1} = 0.12$ g

PGA = 0.40 $S_{DS} = 0.10$ g

$T_o = 0.10$ sec. (f = 10.0 CPS)

$T_s = 0.50$ sec (f = 2.0 CPS)

Figure D-1 – Design Response Spectrum, 5% Damping



*Based on Envelope of 70% of USGS 10,000 Years Return Period Spectra Ref. 9 and Site Specific Spectra Based on Ref. 6.

**7% Damping Spectra is Arrived by Multiplying a Factor of 0.9 to 5% Damping Spectra Values Based on Ref. 7.

Figure D-2 - SSE Design Response Spectra Based on Design Criteria PGA of 0.21g (returen period of 10,000 years)

and 70% of the design spectra determined by using USGS data for 10,000-year return period [Reference 9] as required by Reference 1. Reference 4 recommends that vertical design spectra be derived with amplitudes equal to two-thirds of the values shown for horizontal spectra.

D.2.3 CRITICAL DAMPING VALUES

D.2.3.1 Ground Motions A and B

When performing an elastic response spectrum dynamic analysis for structures, 5% damped design spectra for Ground Motions A and B will be used.

D.2.3.2 SSE Ground Motion

For SSE design spectra having a return period of 10,000 years, no design guidelines are given in Ref. 1 regarding the damping value to be used. For similar criteria used in the baseline design (CSDP) of the TC, 7% damping for reinforced concrete or steel structures [Ref. 7, Table 4-1] was used for a post-yield behavior normally assumed for such high return period design criteria. Hence for the ACWA, a 7% damping is recommended. The design response spectra for other damping values can be obtained by multiplying the factor for the 5% spectrum [Ref. 7, Table 3-7]. Multiplying by the factor of 0.9 is recommended to obtain the 7% design spectrum.

D.3 BUILDING SEISMIC ANALYSIS

D.3.1 SEISMIC ANALYSIS METHODS

A seismic analysis will be performed by the linear elastic static procedure or the linear elastic dynamic procedure, depending on the building height, building stiffness irregularity in a horizontal and/or vertical direction, and mass distribution irregularity in a horizontal and/or vertical direction, as recommended in TI 809-04 [Ref. 1].

D.3.1.1 Linear Elastic Static Procedure

The equivalent lateral force (ELF) procedure can be used for all regular buildings up to six stories in height. Ref. 1 (Section 5-2) will be used to determine the limitations of this procedure due to plan and vertical structural irregularities. Also, Ref. 2 (Tables 5.2.3.2 and 5.2.3.3) can be used for more detailed definition of structural irregularities, as appropriate.

In the ELF procedure, the total seismic base shear is given by the equation:

$$V = C_S W$$

where the lateral seismic response coefficient C_S is determined in accordance with the following equation:

$$C_S = S_{DS}/R$$

Where,

S_{DS} = Design Ground Motion A or B (as defined earlier)

R = response modification factor for the basic seismic force resisting system (Ref. 1, Table 7-1 or Ref. 2a, Table 14.2.1.1, as appropriate).

It is to be noted that for Ground Motion B, the factor R of 1.0 will be used for all structural framing systems. The value of C_S need not exceed the following:

$C_S = S_{D1}/(T.R)$ but will not be less than $C_S = 0.044\ S_{DS}$

Where,

T = the fundamental period of the structural framing system

For details of period T calculations, shear force distribution, and other pertinent data, Ref. 2 (Section 5.3) will be used.

D.3.1.2 Linear Elastic Dynamic Procedure (response spectrum method)

This procedure, also known as the modal analysis procedure, will be performed for all irregular structures (where the static procedure cannot be used) and for the TC in the MDB. The appropriate design response spectra (as defined earlier) will be used. Details of this procedure (described in Ref. 2, Subsection 5.4) will be followed.

The modeling procedure of Subsection 3.2 will be used to develop the mathematical dynamic models. A sufficient number of modes (significant modes) will be considered so that the inclusion of additional modes does not result in more than a 10% increase in response or a minimum of 90% participating modal mass.

The total mass inertia of the structure will be accounted for when developing the building seismic forces. The residual mass (or missing mass) not included in the modes considered in the dynamic analysis will be multiplied by the highest spectral acceleration beyond the analysis cutoff frequency and applied as a rigid body force system to the structure (rigid response mode). For modal combination purposes, this residual response will be considered as an additional mode having a frequency equal to the frequency cutoff or the PGA frequency, whichever is higher.

D.3.2 MATHEMATICAL MODELING PROCEDURES

The mathematical modeling procedures to be applied when dynamic analysis is used to determine seismic response of structures will be in accordance with TI 809-04, as supplemented herein.

D.3.2.1 Mass/Stiffness Considerations

When performing a dynamic analysis, a lumped-mass stick and/or finite element model with a sufficient number of masses and degrees of freedom will be used to capture the dynamic characteristics of the actual structure adequately. To represent the inertial mass of the structure, linear and rotational masses are lumped at nodal points of the model. In general, three translational and three rotational degrees of freedom will be considered at each nodal point. However, the degrees of freedom (e.g., rotational) that do not affect the response significantly need not be included in the dynamic model. The number of dynamic degrees of freedom will be selected so that all significant structural modes are preserved. As a minimum, the number of degrees of freedom will be equal to twice the number of modes required so that inclusion of additional modes does not result in more than a 10% increase in response.

The structural mass will be lumped so that the total mass, as well as the location of the center of gravity, is preserved, both for the total structure and for any of its major supported equipment. Miscellaneous supported equipment, piping, and an appropriate part of the live load must be considered in addition to the mass included above.

The mass/stiffness model will be discretized so that eccentricities between the centers of mass and the centers of rigidity (vertical and horizontal) are considered. Out-of-plane and in-plane flexibility of floor slabs will be considered for floor systems that cannot be justified as rigid for analysis purposes.

Best-estimate stiffness properties will be used in formulating the structural elements. Both shear and bending deformations will be considered when formulating the structural stiffness; however, transverse shear deformation may be neglected when it is determined to be insignificant.

D.3.2.2 Dynamic Coupling Criteria

When developing the analytical model, adequate consideration will be given to the coupling effects between the primary system and the supported subsystems. Primary systems are generally considered to be "major" building structures and their supporting media. Decoupling criteria are given in Ref. 8.

If the subsystem is rigid (when compared to the supporting primary system) and if it is also rigidly connected to the primary system, only the mass of the subsystem need be considered in the primary system model. In the case of a subsystem supported by very flexible connections (such as a pipe supported solely by hangers), the subsystem need not be included in the primary system model.

D.3.2.3 Soil-structure Interaction (SSI) Considerations

SSI will be considered in the dynamic analysis of structures. The effect of the embedment of structure, groundwater effects, layering effect of soil media, and radiation soil damping will be considered. Nonlinear behavior of soil will be considered and may be approximated by equivalent linear material properties.

For impedance function calculations, all mat foundations may be approximated by the equivalent rectangular or circular shapes. The equivalent rectangular or circular dimensions will be computed by equating the building footing contact area with soil for translational modes and by equating the contact area moment of inertia with respect to the reference axis of rotation for rotational modes. The equivalent embedment depth will be determined by equating the volume of soil displaced by the structure.

Values of shear modules and damping ratios used in the analysis are to be compatible with the strain levels expected in the free field consistent with the earthquake level. In no case will the material soil damping (as expressed by the hysteretic damping ratio D) exceed 15%.

D.3.3 COMBINING SPATIAL COMPONENTS

The simultaneous application of three components of earthquake motion will be considered for structures required in order to satisfy the SSE design criteria. The maximum structural responses due to each of the three components of earthquake motion will be combined by taking the square root sum of the squares (SRSS) of the maximum co directional responses caused by each of the three components of earthquake motion at a particular point of the structure.

D.3.4 SEISMIC INTERACTION BETWEEN STRUCTURES

The interface between structures must accommodate dynamic loads and/or displacements produced by each interfacing structure. Seismic interaction will be shown to be precluded or the effect of the interaction will be shown to be acceptable. If failure of a structure or component

(MDB) designed for a lower seismic design criteria (Ground Motion A or B) could impair the integrity of another structure (e.g., TC) designed for higher seismic design criteria (SSE design spectra), then the structure in the higher category (TC) will be analyzed for the impact of the collapsed component of the lower category structure, or the structural components of the lower category MDB superstructure should be designed to prevent their failure using the horizontal PGA corresponding to the SSE design criteria.

The TC will also be designed to resist the inertial forces (calculated using the SSE design spectra) transmitted from the attached structural component to the roof slab or walls of the TC. These forces can be reduced by the use of a frangible joint connection, which is designed to fail at a predetermined design force capacity.

D.4 SEISMIC ANALYSIS OF NONBUILDING STRUCTURAL SYSTEMS AND COMPONENTS

As a minimum, the seismic design of nonstructural components (architectural, mechanical, and electrical) will be in accordance with TI 809-04, Chapter 10 [Ref. 1] and FEMA 302, Chapter 6 [Ref. 2a]. Specification 13080 cites the detailed seismic requirements based on the seismic criteria established in Subsection D.4.1 for seismic protection of mechanical, process, and electrical equipment. However, the nonstructural components inside the TC (tanks and attached piping system) will be designed to satisfy the response accelerations developed from the dynamic analysis results using SSE design spectra.

Equipment in buildings will be considered to be within the scope of this paragraph if the maximum weight of the individual item of equipment does not exceed 10% of the total building weight, or 20% of the total weight of the floor at the equipment level. The response of equipment is dependent on the response of the building in which it is housed if the above weight limit of equipment is exceeded. If the weight of the equipment is appreciable (relative to the weight of the building), the interaction of the equipment with the building (i.e., the coupling effect) will change the building's response characteristics. It is assumed that equipment within the above limitations has a negligible effect on the response of the building. Equipment that is not within the above limitations will be included in the building model and equipment lateral seismic forces will be obtained from building analysis results using the guidelines of Subsection D.3.

In addition, if the equipment is supported above the base by another structure and the weight of the equipment is more than 25% of the combined weight of the equipment and supporting structure, then the equipment and supporting structural system will be analyzed using the guidelines of Subsection D.3.

D.4.1 NONSTRUCTURAL COMPONENTS OF BUILDING DESIGNED TO SATISFY GROUND MOTION A AND B DESIGN CRITERIA

Seismic design force F_P will be determined in accordance with:

$$F_P = (0.4\ a_p\ S_{DS}\ W_P)(1+ 2z/h)/(R_P/I_P)$$

F_P is not required to be taken as greater than:

$$F_P = 1.6 S_{DS} I_P W_P$$

Nor less than:

$$F_P = 0.3 S_{DS} I_P W_P$$

Where,

F_P = seismic design force centered at the component's center of gravity and distributed relative to component's mass distribution.

a_p = component amplification factor (which varies from 1.0 to 2.5) to be selected from Table D-2 or D-3 (Table 10-1 or 10-2 of Ref. 1).

S_{DS} = spectral acceleration, short period, as defined in Subsection 2.1 for Ground Motion A or B, as appropriate.

W_P = component operating weight.

R_P = component response modification factor (which varies from 1.0 to 5.0) to be selected from Table D-2 or D-3, as appropriate.

I_P = component importance factor, I_p of 1.0 for Performance Objective 1A and all other components for enhanced performance objectives, except as defined below.

I_P = 1.5 for life safety component required to function after an earthquake or component contains dangerous hazardous materials or components needed for continued operation of an essential facility (Seismic Use Group III E).

z = height in structure of highest point of attachment of component. For items at or below grade, the base, z, will be taken as 0.0.

h = average height of structure relative to grade elevation.

D.4.2 NONSTRUCTURAL COMPONENTS OF BUILDING DESIGNED TO SATISFY GROUND MOTION SSE DESIGN CRITERIA

Nonstructural components (tanks and attached piping system) inside the TC will be designed for acceleration responses or forces (as appropriate) obtained from the dynamic analysis results of the TC analyzed for SSE ground motion.

D.5 REFERENCES

[1] "Seismic Design for Buildings," Technical Instructions, TI 809-04, U.S. Army Corps of Engineers, December 1998.

[2a] "1997 Edition of NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures," FEMA 302, Federal Emergency Management Agency and Building Seismic Safety Council, Washington D.C., February 1998.

[2b] "Seismic Probabilistic Maps—Spectra Acceleration in g's 5% Damping," prepared by the USGS as a part of FEMA 302, February 1998.

[3] "International Building Code 2000," International Code Council, Alexandria, Virginia, March, 2000.

[4a] "Probabilistic Seismic Hazard Assessment for the U.S. Army Chemical Demilitarization Facility at Tooele, Utah", Jack Benjamin & Associates, June 1995.

[4b] "Probabilistic Seismic Hazard Analysis of the Newport Chemical Agent and Demilitarization Facility, Indiana", Weston Geophysical Corporation, Northboro, Massachusetts, June 1998.

[5a] "Final Foundation Analysis – Chemical Demilitarization Facility, Pueblo Depot Activity, Colorado"', Transmittal CP-573 dated July 25, 1991 from COEHND to Parsons.

[5b] "Dynamic Soil and Rock Parameters- Cryofracture Incineration Demonstration Plant, Pueblo, Colorado- October 1992", Transmittal CP-940 dated June 27, 1994 from COEHND to Parsons.

[6] "Geological-Seismological Investigation of Earthquake Hazards For a Chemical Stockpile Disposal Facility at the Pueblo Depot Activity, Colorado" Jacobs Engineering Group, Inc. and URS/John A. Blume & Associates, October 1987.

[7] "Technical Manual—Seismic Design Guidelines for Essential Buildings," Army TM 5-809-10-1, February 1986.

[8] "Decoupling of Secondary Systems for Seismic Analysis," Hadjian and Ellison, Proceedings ASME Pressure Vessel and Piping Conference, San Antonio, Texas, June 1984.

[9] "USGS Seismic Data for various annual exceedance levels or return periods "-E-mail dated April 6, 2000 from Mr. Steve Wright (CEHND-CS) to Mr. Dinesh Shah (Parsons) containing USGS seismic data for Pueblo site obtained from Mr. Art Frankel of USGS.

Table D-2—Architectural Component Coefficients
(based on Table 10-1 of TI 809-04 [Ref. 1])

Architectural Component or Element	A_p [a]	R_p [b]
Interior Nonstructural Walls and Partitions (See also Section 6.2.8 of FEMA 302)		
Plain (unreinforced) masonry walls	1.0	1.25
All other walls and partitions	1.0	2.5
Cantilever Elements (unbraced or braced to structural frame below its center of mass)		
Parapets and cantilever interior nonstructural walls	2.5	2.5
Chimneys and stacks where laterally supported by structures	2.5	2.5
Cantilever Elements (Braced to structural frame above its center of mass)		
Parapets	1.0	2.5
Chimneys and stacks	1.0	2.5
Exterior nonstructural walls	1.0 [c]	2.5
Exterior Nonstructural Wall Elements and Connections (see also Section 6.2.4 of FEMA 302)		
Wall element	1.0	2.5
Body of wall panel connections	1.0	2.5
Fasteners of the connecting system	1.25	1
Veneer		
High deformability elements and attachments	1.0	2.5
Low deformability elements and attachments	1.0	1.25
Penthouses (except when framed by an extension of the building frame)	2.5	3.5
Ceilings (see also Section 6.2.6 of FEMA 302)		
All	1.0	2.5
Cabinets		
Storage cabinets and laboratory equipment	1.0	2.5
Access floors (see also Section 6.2.7 of FEMA 302)		
Special access floors (designed in accordance with Section 6.2.7.2 of FEMA 302)	1.0	2.5
All other	1.0	1.25
Appendages and Ornamentation	2.5	2.5
Signs and Billboards	2.5	2.5
Other Rigid Components		
High deformability elements and attachments	1.0	3.5
Limited deformability elements and attachments	1.0	2.5
Low deformability elements and attachments	1.0	1.25
Other flexible components		
High deformability elements and attachments	2.5	3.5
Limited deformability elements and attachments	2.5	2.5
Low deformability elements and attachments	2.5	1.25

a A lower value for a_p may be justified by detailed dynamic analysis. The value for a_p shall not be less than 1.00. The value of a_p = 1 is for equipment generally regarded as rigid and rigidly attached. The value of a_p = 2.5 is for flexible components or flexibly attached components. See Chapter 2 of FEMA 302 for definitions of rigid components and flexible components, including attachments.

b R_p= 1.25 for anchorage design when component anchorage is provided by expansion anchor bolts, shallow chemical anchors, or shallow (nonductile) cast-in-place anchors, or when the component is constructed of nonductile materials. Powder-actuated fasteners (shot pins) shall not be used for component anchorage in tension applications in Seismic Design Categories D, E, or F. Shallow anchors are those with an embedment length-to-diameter ratio of less than 8.

c Where flexible diaphragms provide lateral support for walls and partitions, the design forces for anchorage to the diaphragm shall be as specified in Section 5.2.5.4.4 of FEMA 302.

Table D-3—Mechanical and Electrical Component Coefficients
(based on Table 10-2 of TI 809-04 [Ref. 1])

Mechanical and Electrical Component or Element[c]	a_p [a]	R_p [b]
General Mechanical		
Boilers and furnaces	1.0	2.5
Pressure vessels on skirts and free-standing	2.5	2.5
Stacks	2.5	2.5
Cantilevered chimneys	2.5	2.5
Other	1.0	2.5
Manufacturing and Process Machinery		
General	1.0	2.5
Conveyors (nonpersonnel)	2.5	2.5
Piping Systems		
High deformability elements and attachments	1.0	3.5
Limited deformability elements and attachments	1.0	2.5
Low deformability elements and attachments	1.0	1.25
HVAC System Equipment		
Vibration isolated	2.5	2.5
Non-vibration isolated	1.0	2.5
Mounted in-line with ductwork	1.0	2.5
Other	1.0	2.5
Elevator Components	1.0	2.5
Escalator Components	1.0	2.5
Trussed Towers (free-standing or guyed)	2.5	2.5
General Electrical		
Distributed systems (bus ducts, conduit, cable tray)	1.0	3.5
Equipment	1.0	2.5
Lighting Fixtures	1.0	1.25

a A lower value for a_p is permitted provided a detailed dynamic analysis is performed which justifies a lower limit. The value for a_p shall not be less than 1.00. The value of $a_p = 1$ is for equipment generally regarded as rigid or rigidly attached. The value of $a_p = 2.5$ is for flexible components or flexibly attached components. See Chapter 2 of FEMA 302 for definitions of rigid components and flexible components, including attachments.

b $R_p = 1.25$ for anchorage design when component anchorage is provided by expansion anchor bolts, shallow chemical anchors, or shallow low deformability cast-in-place anchors or when the component is constructed of nonductile materials. Powder-actuated fasteners (shot pins) shall not be used for component anchorage in Seismic Design Categories D, E, or F. Shallow anchors are those with an embedment length-to-diameter ratio of less than 8.

c Components mounted on vibration isolation systems shall have a bumper restraint or snubber in each horizontal direction. The design force shall be taken as $2F_P$.

REGULATORY REFERENCES

(1) Code of Federal Regulations (CFR)

(a) 29 CFR 1910.120, 1200, 1410

(b) 40 CFR 50-99

(c) 40 CFR 110

(d) 40 CFR 122 through 149

(e) 40 CFR 162

(f) 40 CFR 240 through 257

(g) 40 CFR 260 through 299

(h) 40 CFR 300, 302, 350, 355, 370, 372

(i) 40 CFR 761

(j) 49 CFR 171 through 177

(2) Army Regulations (AR)

(a) AR 200-1, Environmental Quality – Environmental Protection and Enhancement

(b) AR-200-2, Environmental Quality – Environmental Effects of Army Actions

(c) AR-200-4, Solid and Hazardous Waste Management