Assembled Chemical Weapons Assessment Program

Report to Congress

December 2002

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Table of Contents

Appendices

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Message from Mr. Michael A. Parker, Program Manager

The Assembled Chemical Weapons Assessment (ACWA) program has satisfied the requirements of Public Law 104-208. Four technologies have been demonstrated as viable alternatives to incineration for the disposal of assembled chemical weapons. These four technologies have been further defined as likely to apply at the Pueblo and/or Blue Grass chemical weapons storage sites in regards to cost and schedule. Based on a Defense Acquisition Board (DAB) recommendation, the Under Secretary of Defense for Acquisition, Technology and Logistics [USD (AT&L)] has selected the alternate technology of neutralization followed by biotreatment as the destruction technology for the Pueblo site. This selection was reflected in a Record of Decision (ROD) issued this past summer. For Blue Grass, the DAB recommended and the USD (AT&L) determined the agency preferred alternative of neutralization followed by supercritical water oxidation (SCWO) which will result in the release of the final Environmental Impact Statement (EIS) followed by the ROD in early calendar year 2003.

Since the very onset of the ACWA program, stakeholder involvement has been the priority. Continued involvement by the Citizens Advisory Technical Team (CATT), in addition to periodic updates to all affected stakeholders, has helped maintain transparency of day-to-day operations in addition to public trust. It is my commitment to continue to work diligently towards the swift and safe disposal of our nation's chemical weapons stockpile with this same open, public-involved approach. It is even more critical with the events of September 11, 2001 still fresh in our minds, to move forward assertively to dispose of and remove the threat posed by chemical weapons from our communities.

This final report completes the requirements assigned to the ACWA program through Public Law 104-208. While the evaluation and demonstration of alternative technologies is completed, implementation of these technologies pending the direction of the USD (AT&L), still remains. The ACWA program continues to work towards the eventual construction and operation of full-scale alternate technology facilities where so directed by the USD (AT&L) through the DAB decision process.

It remains my intention to actively involve affected stakeholders through the construction and piloting of the full-scale facilities, and also to establish the framework for the operations and closure of these facilities that embraces public involvement. The words I used in the 1997 Annual Report remain true, "It has been my belief, now validated by experience, that establishing and promoting a cooperative working relationship and understanding between a broad spectrum of stakeholders can and will yield positive results. Rather than giving up

authority, I have found that involving the public in the decision making process is a powerful tool for increasing the authority and legitimacy of the ultimate decisions."

In closing, I would like to express my gratitude to all those who have been involved with the ACWA program. Your contributions have made the program the success that it is. Community representatives, regulators, tribal representatives, technology providers and the government team all have represented a spectrum of interest that came together collaboratively to yield a result that exceeded expectations and provided the USD (AT&L) a viable alternative for consideration.

My heart felt thanks and admiration go out to all of you.

The views, opinions, and recommendations expressed in this message from the Dialogue on Assembled Chemical Weapons Assessment do not represent official government positions.

Message from the Dialogue on Assembled Chemical Weapons Assessment

The Assembled Chemical Weapons Assessment (ACWA) program was established in 1996 under Public Law 104-208 to facilitate and accelerate the ongoing destruction of chemical weapons stockpiles in the United States by demonstrating non-incineration, alternative technologies. The ACWA Dialogue was established in May 1997 by the ACWA Program Manager to ensure the upfront integration of concerns and ideas of the diversity of individuals likely to be impacted by or having an impact on chemical weapons demilitarization. The Dialogue, as noted by the signatories of this Message, includes individuals supporting and opposing incineration from the eight states with stockpiles of chemical weapons; federal, state, and tribal regulators and representatives; Department of Defense (DOD) staff from affected sites and headquarters; and representatives from national citizen groups such as the Chemical Weapons Working Group (CWWG), Global Green USA, and the Sierra Club, who regularly work on chemical weapons demilitarization issues. The Dialogue, through the ACWA program manager, formed a Citizens Advisory Technical Team (CATT), including an independent technical advisor, to assist the Dialogue in monitoring the demonstration and engineering studies conducted to evaluate various alternate technologies.

The Dialogue held its thirteenth and final meeting in June 2002 at which the members reviewed the status of the alternate technology studies, the progress toward technology decisions for destruction of the stockpiled assembled weapons at Pueblo, Colorado and Richmond, Kentucky, and the possibility of additional applications at other stockpile sites.

Based on our in-depth involvement in the ACWA program over the past five years, the Dialogue puts forth the following consensus recommendations and summary opinions.[1]

Dialogue Views and Recommendations

The Dialogue recommends that the four alternative technologies successfully demonstrated by ACWA be seriously considered by DOD, with input from relevant stakeholders, for use as a primary destruction method, a replacement of a current technology, or a supplement to current technologies at all stockpile sites that have assembled chemical weapons. Congress mandated that the ACWA program "shall identify and demonstrate not less than two alternatives to the baseline incineration process for the demilitarization of assembled chemical munitions." The ACWA program, in coordination with the Dialogue, identified and demonstrated six technologies. Four of these technologies were determined by ACWA and the Dialogue to be effective, safe, and publicly acceptable to destroy assembled chemical weapons. These four technologies include: 1) neutralization followed by bio-treatment; 2) neutralization followed by supercritical water oxidation (SCWO); 3) neutralization followed by SCWO and gas phase chemical reduction; and 4) electrochemical oxidation. Due to increased security concerns,

[1]The reader may refer to past ACWA Reports to Congress for greater detail on the history of the ACWA Program and Dialogue or to review prior recommendations from the ACWA Dialogue. These documents may be obtained by calling the ACWA information line at (888) 482-4312, or logging onto the ACWA website at http://www.pmacwa.org.

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DOD is evaluating methods to accelerate destruction of chemical weapons at all stockpile sites. The Dialogue recommends that the successfully demonstrated ACWA technologies be considered in this process.

The ACWA demonstrations show that three of the four technologies successfully demonstrated are specifically applicable to the stockpile in Kentucky, where a technology decision is now pending. The Dialogue recommends that these three technologies (neutralization and SCWO; neutralization, SCWO, and gas phase chemical reduction; and electrochemical oxidation) be seriously considered for destroying the Kentucky stockpile. A technology decision may be made for the Kentucky site by the end of the calendar year 2002.

The ACWA Dialogue recommends that DOD select the Agency preferred alternative of neutralization followed by bio-treatment, as the destruction technology for Colorado. It is anticipated that the Defense Acquisition Executive (DAE) will certify that this technology is as safe, cost-effective, and timely as incineration for destroying the Colorado stockpile.[2]

The ACWA Dialogue recommends that DOD implement public involvement mechanisms based on the ACWA model across the chemical demilitarization program at the site-specific and national levels. The ACWA Dialogue has been an excellent forum for ensuring effective public involvement throughout the life of the ACWA program. As the chemical demilitarization program moves further into site-specific phases involving environmental permitting, construction, testing, operations and closure, we recommend that local groups, similar to the ACWA Dialogue, be established to assist the program manager in safely and efficiently completing this important task. There is also a need for a National Dialogue on chemical weapons destruction to address national and multi-site issues such as transportation, programmatic prioritization, safety enhancement, and closure.

The ACWA Dialogue recommends that this dialogue process be considered by other federal agencies and the private sector as a potential model for consensus building and cooperative public policymaking. The Dialogue provides a method for assuring the marriage of the best science available while incorporating the concerns of the communities and the political realities of hotly debated topics.

Conclusion. The Dialogue wishes to thank Mike Parker, ACWA Program Manager, Bill Pehlivanian, Deputy Program Manager, and the entire ACWA staff for their extraordinary competence and flexibility in the execution of their goals, and for the opportunity to participate in this program. Throughout the process, Mr. Parker has ensured that the Dialogue was consulted on all-important decisions. The comments provided by Dialogue members have been received in a respectful manner and from all appearances those comments have been seriously considered in the decision-making process. We cannot ask for more than the opportunity to be heard and we are confident that this program has given us that opportunity.

[2] Facilitator Note: Since the Dialogue developed consensus upon this message, the DAE has selected neutralization followed by biotreatment as the agency preferred alternative and has directed ACWA and the Army to execute this alternative. However, the DAE has not yet certified that this technology is as safe, cost-effective, and timely as incineration.

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We would also like to specifically thank four of our Dialogue members, Douglas Hindman, Irene Kornelly, Bob Palzer, and Paul Walker who served as the CATT. It was through their eyes and ears that the Dialogue participated in behind-the-scenes deliberations and observed a multitude of demonstration tests. They dedicated literally thousands of hours of their time to this work and without their presence, objectivity and perseverance the coalition which comprises the Dialogue would not have held together. For this they have our most sincere gratitude.

The Dialogue members hope that our participation has been helpful and we believe that in the long run our effort will facilitate the safe and environmentally sound destruction of the chemical weapons at all of the stockpile sites. It is this common and historic goal of destroying the stockpile that brought us together, and the completion of which will be the measure of our success.

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Executive Summary

This report responds to the requirements contained in Title VIII, section 8065 of the Omnibus Consolidated Appropriations Act, 1997 (Public Law 104-208), and describes the final activities associated with the evaluation on the effectiveness of alternative technologies demonstrated under the Department of Defense (DOD) Assembled Chemical Weapons Assessment (ACWA) program. The submission of this report satisfies the requirements of Public Law 104-208. Significant activities included:

- **Completion of Engineering Design Studies (EDS) I for the two alternative technologies that were validated during Demonstration I testing to be effective in the destruction of assembled chemical weapons.**

  The two technologies are: neutralization followed by biotreatment, which was validated for processing mustard-containing munitions only; and neutralization followed by supercritical water oxidation, which was validated for processing all chemical weapons. The EDS I resulted in a preliminary full-scale design for the construction of a Pueblo Chemical Depot demilitarization facility with the associated cost, schedule, and preliminary hazard analysis.

- **Completion of EDS II for the two alternative technologies that were validated during Demonstration II testing to be effective in the destruction of assembled chemical weapons.**

  The two technologies are: electrochemical oxidation, which was validated for processing all chemical weapons; and neutralization followed by transpiring wall supercritical water oxidation and gas phase chemical reduction, which was validated for processing all chemical weapons. The EDS II resulted in a preliminary full-scale design for the construction of a Blue Grass Army Depot demilitarization facility with the associated cost, schedule, and preliminary hazard analysis. This information will be available for reference in the request for proposals if the Under Secretary of Defense for Acquisition, Technology and Logistics [USD (AT&L)] selects one of these alternative technologies for Blue Grass.

- **Conducting additional testing to supplement the Engineering Design Packages.**

  The ACWA program has identified areas where additional design and operating data are necessary. These areas include the disassembly of rockets (Rocket Dismantling Machine) and the washout of munitions (Projectile Washout System). The information from the testing will support a contract request for proposals and the Resource Conservation and Recovery Act permit application if the USD (AT&L) selects an alternative technology for Blue Grass.

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I. INTRODUCTION/BACKGROUND

This report is submitted to the United States (U.S.) Congress in compliance with the requirements contained in Title VIII, section 8065 of the Omnibus Consolidated Appropriations Act, 1997 (Public Law 104-208). This report presents the final activities associated with the evaluation on the effectiveness of alternative technologies demonstrated under the Department of Defense (DOD) Assembled Chemical Weapons Assessment (ACWA) Program.

Public Law 104-208 required the Under Secretary of Defense for Acquisition, Technology and Logistics [USD (AT&L)] to "demonstrate not less than two alternatives to the baseline incineration process for the demilitarization of assembled chemical munitions." Assembled chemical munitions for this purpose represent the chemical weapons stockpile configured with fuzes, explosives, propellant, chemical agents, shipping and firing tubes, and packaging materials.

The Program Manager for Assembled Chemical Weapons Assessment (PMACWA) completed demonstrations of six alternative technologies and determined that four of those technologies may be viable for pilot testing. The four technologies include: neutralization followed by biotreatment; neutralization followed by supercritical water oxidation; electrochemical oxidation; and neutralization followed by transpiring wall supercritical water oxidation (TW-SCWO) and gas phase chemical reduction.

PMACWA has completed Engineering Design Studies (EDS) of the four successfully demonstrated technologies to develop the information necessary to satisfy the requirements in the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (Public Law 105-261). This report presents the final activities associated with the EDS testing. The submission of this report satisfies the requirements of Public Law 104-208.

II. ENGINEERING DESIGN STUDIES

Public Law 105-261 mandated that if an alternative technology is chosen to be piloted, the USD (AT&L) must certify in writing to Congress that the technology to be implemented is as safe and cost effective for disposing of assembled chemical munitions as incineration; and, is capable of completing the destruction on or before the date by which the destruction of the munitions would be completed if incineration were used. The EDS were conducted in support of this certification.

A. Engineering Design Studies I (EDS I)

The EDS I were completed for the two alternative technologies that were validated during the Demonstration I program as having the potential to be effective in the destruction of chemical weapons. These two technologies use neutralization as the main destruction mechanism for the agent and energetics contained in the chemical weapons. The technology proposed by Parsons/Honeywell is neutralization followed by biotreatment, which was validated for processing of mustard-containing munitions only. The technology proposed by General Atomics is neutralization followed by supercritical water oxidation and was validated for processing all chemical weapons.

The EDS I has resulted in a preliminary full-scale design for the construction of a Pueblo Chemical Depot (PCD) demilitarization facility with the associated cost, schedule, and preliminary hazards analysis (PHA) for each of the two technologies validated during Demonstration I. This information is the basis for certification under Public Law 105-261. The design packages were available for reference in the request for proposal (RFP) for implementation of a technology at PCD.

1. Neutralization Followed by Supercritical Water Oxidation

The approach proposed by General Atomics for a total solution for the destruction of all assembled chemical weapons and associated propellant and packaging materials uses baseline shearing for rockets followed by water washout of residual agent. For the projectiles, baseline reverse assembly is used for fuze and burster removal, where they are then conveyed to the Energetics Rotary Hydrolyzer (ERH). Cryofracture is used for agent access in projectiles instead of the suction draining method used in the baseline process. Cryofracture is a process, developed and tested by General Atomics for the U.S. Army in the 1980's and 1990's, in which munitions are embrittled by cooling in liquid nitrogen and then fractured to access the agent after the energetics have been removed. General Atomics proposes to neutralize (hydrolyze with water and caustic) the agents and energetics separately. Agent hydrolysate and energetics hydrolysate combined with shredded dunnage will be destroyed using separate supercritical water oxidation (SCWO) units. SCWO mineralizes the hydrolysates at temperatures and pressures above the critical point of water, and produces solid and liquid effluents that can be held and tested before release. General Atomics proposes to recover process water for reuse and to dispose of dry salts and solid residues in a permitted waste landfill. Recovered metal parts will be thermally treated using resistance heating and released as scrap.

Previous testing of the General Atomics unit operations is discussed in the December 2000 and December 2001 Annual Reports to Congress and the June 2001 Supplemental Report to Congress. This testing included the ERH, Dunnage Shredding/Hydrolysis System (DSHS), and SCWO. The planned testing was expanded to include SCWO testing of VX hydrolysate simulant to support both the PMACWA and the Program Manager for Alternative Technologies and Approaches (PMATA) programs. This testing is described below.

a. Supercritical Water Oxidation of VX Hydrolysate Simulant

Testing was conducted using VX hydrolysate simulant in order to gain additional knowledge not available through the Engineering Scale Test that was conducted in support of the Newport Chemical Demilitarization Facility. Testing on this feed was conducted from September – November 2001 and supported both the PMACWA and PMATA programs. The objectives of the test included the following:

- Verify long-term, continuous operability of the SCWO system as proposed for the full-scale.
- Verify corrosion protection.
- Determine need for feed additives for salt transport.
- Determine maintenance schedule and frequency of flushes and shutdowns.

- Determine liner materials of construction.

In addition to over 500 hours of configuration and parameter testing conducted in support of the PMATA program, a continuous 500-hour test was conducted in support of the PMACWA program. The PMACWA testing demonstrated an 84% availability of the SCWO system, which was well within the needs established in the engineering design packages developed for the program.

2. Neutralization Followed by Biotreatment

The approach proposed by Parsons/Honeywell for a total solution for the destruction of mustard chemical weapons uses modified reverse assembly for chemical agent access. Modifications to reverse assembly include a high-pressure water washout of burster energetics and a different method is used for accessing agent than was used for baseline incineration. These modifications include cutting open mortars or crushing in the burster well of projectiles to gravity-drain the agent and washout residual agent or solids with high-pressure water. Parsons/Honeywell proposes to neutralize (hydrolyze with water and caustic) the agent and energetics and then destroy the hydrolysates using a biological treatment process operated at ambient temperature and pressure. Organic vapors and odors will be passed through a catalytic purifier (similar to an automotive catalytic converter) developed by Honeywell. Parsons/Honeywell proposes to recover process water for reuse and to dispose of dry salts and solid residues in a permitted waste landfill. Recovered metal parts will be thermally treated, in the presence of steam, and released as scrap.

The following Parsons/Honeywell unit operations were tested during the May – April 2001 timeframe as part of the EDS I program in order to provide the engineering basis for the designs being developed for the Water Hydrolysis of Explosives and Agent Technology. Four primary process systems were tested separately and concurrently by the Parsons/Honeywell team at locations including: Edgewood Chemical and Biological Center (ECBC) at Aberdeen Proving Ground (APG), Maryland; Illinois Institute of Technology Research Institute (IITRI) in Chicago, Illinois; and Chemical Agent Munitions Disposal System (CAMDS) in Tooele, Utah. These systems included: an Immobilized Cell Bioreactor (ICB^{TM}) to treat neutralized mustard and energetics, Continuous Steam Treater (CST) to treat metal parts and miscellaneous dunnage, a Catalytic Oxidation Unit (CatOx) to treat organics in the gaseous phase prior to carbon filtration, and a Projectile Washout System (PWS) to wash out mustard munitions that may contain heels.

Additional testing of the PWS is planned to gain additional knowledge specific to the properties of HT and H and their ability to be washed out and hydrolyzed. These tests are scheduled to take place from October 2002 to January 2003.

3. Engineering Design Package

The Engineering Design Packages (EDP) in support of the EDS I have been completed as reported in the June 2001 Supplemental Report to Congress.

B. Engineering Design Studies II

The EDS II were initiated in 2001 for the two alternative technologies that were validated during the Demonstration II program as having the potential to be effective in the destruction of chemical weapons. This report presents the EDS II activities that were conducted in 2002. The EDS II activities that were conducted in 2001 are presented in the December 2001 Report to Congress.

One technology, proposed by AEA Technology/CH2M Hill, uses electrochemical oxidation as the main destruction mechanism for the agent and energetics contained in the chemical weapons. The other technology, proposed by EcoLogic/Foster Wheeler/Kvaerner, uses neutralization as the main destruction mechanism for the agent and energetics contained in the chemical weapons. Neutralization is then followed by TW-SCWO and gas phase chemical reduction.

The EDS II resulted in a preliminary full-scale design for the construction of a full-scale chemical demilitarization facility at the Blue Grass Army Depot (BGAD) using these two alternative technologies. The associated capital cost, projected schedule, and PHA were also developed. This information is being used by PMACWA to develop the life cycle cost and schedule estimates. The life cycle cost and schedule estimates will be the basis for certification under Public Law 105-261. In addition, the design package will be made available as part of the RFP if the USD (AT&L) selects an alternative technology for Blue Grass.

1. Electrochemical Oxidation

The approach proposed by AEA Technology and CH2M Hill for a total solution for the destruction of all assembled chemical weapons uses modified baseline reverse assembly for chemical access, AEA Technology's patented SILVER II^{TM} process for destroying chemical agent and energetics, a Metal Parts Treater for the treatment of metal parts, and a Dunnage Treater for the treatment of dunnage.

Modifications to reverse assembly for accessing rockets include tube cutting, burster washout, propellant removal and grinding. Rockets are punched and drained to remove the chemical agent. The drained agent is treated in the SILVER II^{TM} process. Rockets are cut in a Rocket Dismantling Machine. The first cut removes a portion of the firing and shipping tube; the second cut separates the fuze. Fuzes are deactivated in the Metal Parts Treater. The burster is then washed out and the third cut removes the warhead section and exposes the motor. Once the propellant is exposed, it is removed and sent to a grinding machine for size reduction. The washed out burster energetics and milled propellant are treated in a separate SILVER II^{TM} process. Any metal fragments are processed in the Metal Parts Treater. Shredded dunnage is treated in a Dunnage Treater.

The SILVER II^{TM} process uses an electrochemical cell containing nitric acid and silver nitrate to generate silver (II) ions. Energetics and agents are oxidized either directly by the silver (II) ions or by other oxidizing compounds produced from reactions involving silver (II) ions. The process operates at 190°F and near atmospheric pressure (14.7 psia). All effluents from the SILVER II^{TM} process will be contained and tested to be agent-free before release, recycling or disposal.

The following unit operations were tested as part of the EDS program in 2001 in order to provide the engineering basis for the preliminary designs being developed for the AEA Technology/CH2M Hill total solution: energetics feed system, 12-kW SILVER II™ (Comp B/M28 Propellant and Agent Simulant), cell membrane life, fluoride removal system, hydrocyclone, high shear mixer, organic transfer, silver recovery, and evaporator. Information on this testing can be found in the December 2001 annual report.

The following unit operation was tested as part of the EDS II program in 2002 in order to confirm the engineering basis for the preliminary designs developed for the AEA Technology/CH2M Hill total solution: 12-kW Silver II™ (Tetrytol test run). The 12-kW and organic transfer testing was conducted at the Aberdeen Test Center (ATC) in APG, Maryland. All other lab scale testing was conducted at AEA facilities in the United Kingdom.

a. 12-kW SILVER II™ Plant - Tetrytol

The purpose of this test was to validate the ability of the SILVER II™ process to achieve and maintain a steady-state electrochemical efficiency and achieve a destruction and removal efficiency (DRE) of 99.999% for tetrytol. The specific objectives of this test included the following:

- Validate the ability of the SILVER II™ unit operation to achieve a DRE of 99.999 percent for Tetrytol (TNT and Tetryl).
- Further demonstrate continuous operability, reliability, and maintainability (i.e., operation of the full length of the test without unintended shutdown) of the SILVER II™ system as proposed for full-scale. For example:
  - Demonstrate that organic, silver, acid, and water in the catholyte circuit can be effectively managed over prolonged operational periods.
  - Demonstrate that process impurities that build-up in the anolyte circuit can be effectively managed over prolonged operational periods.
  - Determine the cell current efficiency to be used in the full-scale design.
- Determine impact of operations on materials of construction to be used in a full-scale system such as polymer-lined pipework.
- Demonstrate the operation and performance of the following key process components for future scale-up:
  - Instrumentation, valves, pumps, etc.
  - Electrochemical cell (electrodes and membranes).
  - Full height NO_x reformer.
  - Off-gas scrubber operating in conjunction with NO_x reformer.
- Characterize gas, liquid and solid process streams of the SILVER II™ process for selected chemical constituents and physical parameters and for the presence/absence of hazardous and toxic compounds.
- Demonstrate the ability/inability to recycle, reuse or dispose of nitric acid (i.e., within the plant).

Testing of tetrytol in the 12-kW SILVER II™ system was successfully completed in January 2002. All of AEA/CH2M Hill's EDS II test reports were completed by May 2002.

2. Neutralization Followed by Transpiring Wall Supercritical Water Oxidation and Gas Phase Chemical Reduction

The approach proposed by EcoLogic/Foster Wheeler/Kvaerner for a total solution for the destruction of all assembled chemical weapons uses: modified reverse assembly for chemical access to separate agent, energetics, and metal parts; chemical neutralization followed by supercritical water oxidation for treatment of the liquid; and gas phase chemical reduction for treatment of the gas effluent from agent/energetics neutralization and for the treatment of the metal parts and dunnage.

Modifications to reverse assembly include: extracting and grinding the propellant from rockets, using a high pressure wash to remove agent heels from projectiles and rockets, and using a Continuously Indexing Neutralization System (COINS™) to remove the energetics. The chemical agents and energetics are neutralized (hydrolyzed with water and caustic). The resulting product, known as hydrolysate, is processed in a transpiring wall supercritical water oxidation system TW-SCWO. The TW-SCWO oxidizes the Schedule 2 compounds and other organic compounds in the hydrolysate at conditions above the critical point of water. A continuous supply of clean water is introduced at the inside liner surface of the reactor to create a continuous film on the liner protecting it from corrosion and salt deposition. Liquid effluent from the TW-SCWO is processed in an evaporator. The resulting salts are sent to a landfill. The washed out metal parts, dunnage, solid process wastes, and gaseous emissions from the neutralization process are processed in the Thermal Reduction Batch Processor (TRBP)/Gas Phase Chemical Reduction™ (GPCR)™ system. By heating in a hydrogen-rich atmosphere, metal parts and dunnage are decontaminated to a 5X[3] level and volatile organic vapors are chemically reduced. The decontaminated solids can then be disposed. The gaseous effluent is scrubbed and potentially used as a fuel to generate steam in the boiler.

The following Eco Logic and Foster Wheeler unit operations were tested as part of the EDS program in 2001 in order to provide the engineering basis for the preliminary designs being developed for the EcoLogic/Foster Wheeler/Kvaerner Total Solution: M28 propellant grinding and gas phase chemical reduction. Information on this testing can be found in the December 2001 annual report.

The EDS II testing of the TW-SCWO was initiated in October 2001 and was successfully completed in April 2002. The evaporator/crystallizer tests were successfully completed in February 2002.

a. Transpiring Wall Supercritical Water Oxidation

The TW-SCWO system is used to treat the products of the agent and energetic neutralization process. This unit was tested at Dugway Proving Ground (DPG), Utah. The testing was comprised of two phases: Optimization Testing and Long Term Operability Testing.

[3] 5X refers to chemical agent decontamination achieved through treatment at 1000°F for 15 minutes.

Optimization Testing occurred in March and April 2001. The Long Term Operability testing was initiated in October 2001 and completed in April 2002. The specific objectives of the Long Term Operability Testing included the following:

- Verify long-term, continuous operability (i.e., operation for the full length of the test without unintended shutdown) of the SCWO system as proposed for full-scale with no plugging. Long-term, continuous operability includes, but is not limited to the following:
  - Operation with materials of construction proposed for the full-scale system.
  - Operation with all expected full-scale operating procedures (i.e., any SCWO system flushing sequences at expected intervals).
  - Operation with downstream solids separation units, new reactor, and oxygen.
  - Operation without plugging/fouling upstream and downstream of the reactor.
  - Operation without liner cracking/deformation.
  - Operation without feed port plugging.
  - Operation with minimal or no corrosion of the SCWO reactor.
  - Operation without plugging of the SCWO reactor.
  - Operation without erosion of the pressure control valve.
  - Destruction of Schedule 2 compounds.
- Characterize all operability issues to determine their causes and impact on the full-scale design.
- Confirm and supplement Demonstration II process effluent characterization.
- Improve the monitoring of effluent quality and develop an effective control strategy with respect to Schedule 2 compounds and organic carbon destruction.

The TW-SCWO Long Term Operability Testing was successfully conducted with feeds consisting of agent hydrolysates (or simulated agent hydrolysates) and energetics hydrolysates. Three different feeds were conducted: GB/energetics hydrolysate (conducted in 2001), VX/energetics hydrolysate, and HD/energetics hydrolysate. The energetics hydrolysate consisted of Comp B and propellant hydrolysates.

b. Evaporator/Crystallizer

The Evaporator/Crystallizer is used to concentrate the SCWO effluent, by evaporation, in the full-scale system. The Evaporator/Crystallizer testing occurred at the vendor's facility and with a pilot-scale unit that was located along with the TW-SCWO in DPG, Utah. The specific objectives of the testing include the following:

- Determine critical design parameters for the full-scale evaporator/crystallizer, including:
  - Maximum salt concentration in evaporator/crystallizer effluent.
  - Filterability of salt crystals and solids in the evaporator/crystallizer effluent.
  - Operating parameters for the filter press.
- Demonstrate the ability of the evaporator/crystallizer to operate as proposed for full-scale.

Lab testing was conducted on actual TW-SCWO effluent from the three test campaigns to determine the critical design parameters. In addition, the Evaporator/Crystallizer pilot-scale unit

was tested with actual VX/energetics hydrolysate effluent from the TW-SCWO at DPG, Utah and was successfully completed in February 2002.

3. Engineering Design Package

The EDS II testing conducted in 2001 supported the preparation of an EDP that was the basis for the cost, schedule, and safety criteria development. The EDPs included drawings and documentation sufficient to generate capital and operational and maintenance costs to within +/– 20%. The design package also included a capital cost estimate that was evaluated and is being used to develop a program life cycle cost estimate. A program schedule was also included in the package that is being used to develop the life cycle schedule. Finally, a PHA was included and will be used as a tool in the safety assessment and certification process. This information will be made available as part of the RFP if the USD (AT&L) selects an alternative technology for Blue Grass.

AEA Technology/CH2M Hill and EcoLogic/Foster Wheeler/Kvaerner generated an EDP for the chemical demilitarization facility at the BGAD. The Final EDPs were provided on December 14, 2001. Design presentations to the independent evaluators, including the National Research Council (NRC), Mitretek Systems, Army Materiel Systems Analysis Activity (AMSAA), the Operational Risk Assessment consultants, and the Cost Analysis Improvement Group (CAIG) were conducted in March 2002. PMACWA used the final design packages to conduct design and PHA assessments and develop life cycle cost and schedule estimates in June 2002. The independent evaluations were completed in October 2002.

III. NEXT STEPS

PMACWA has identified areas where additional design and operating data are necessary. These areas include the disassembly of rockets, the characterization of HT and H agent/heels, and the washout of HT and H munitions.

PMACWA is conducting additional testing to supplement the EDPs, which in turn will support a contract RFP and the Resource Conservation and Recovery Act (RCRA) permit application. This information will be made available as part of the RFP if the USD (AT&L) selects an alternative technology for Blue Grass.

A. Rocket Dismantling Machine

For the AEA/CH2M Hill and Eco Logic/Foster Wheeler/Kvaerner total solutions, a Rocket Dismantling Machine (RDM) is used to disassemble the rockets, which includes punching and draining the agent, burster removal, propellant removal, and separation of the fin assembly. The main purpose of this effort is to gather basic unit operations data, during testing, that will support a systems contractor's design, fabrication and testing of an RDM that is applicable to any alternative technology that is selected for the BGAD.

The data from testing basic unit operations, (i.e., cutting, gripping, extraction, and punch-drain and washout) to support the RDM design will be compiled in a final report by December 2002.

Testing occurred at the vendor's site in Salt Lake City, Utah and at the Naval Surface Warfare Center in Crane, Indiana from September through November 2002.

B. Projectile Washout System

Parsons/Honeywell developed a Projectile Washout System (PWS) to allow PMACWA to evaluate projectile agent access by use of a cutting wheel as well as agent cavity washout parameters. The washout parameters included washout water pressures, washout times, and water consumption at various pressures. This system is an alternative to cryofracture of munitions and supports the Parsons/Honeywell total solution design for PCD as well as the AEA/CH2M Hill and Eco Logic/Foster Wheeler/Kvaerner total solutions for BGAD.

The PWS was successfully tested using HD-filled mortars in July and August 2001, and yielded numerous design parameters that would satisfy the washout requirements for HD mortars. To verify that these washout parameters will also work for HT-filled mortars, PMACWA will conduct a washout test of these mortars in November 2002 at CAMDS.

A different method to access the agent cavity of projectiles will be employed on H-filled 155mm projectiles, and this will be done by crushing the burster well of projectiles to enlarge the agent cavity orifice. Similar washout parameters used on HD mortars will be employed on these 155mm projectiles. This test using 155mm projectiles will be conducted in January 2003, and a preliminary report of the effectiveness of the washout parameters will be available one month after the completion of testing.

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Appendices

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Appendix A

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Appendix B

Acronyms and Abbreviations

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Acronyms and Abbreviations

ACWA	Assembled Chemical Weapons Assessment
AMSAA	Army Materiel Systems Analysis Activity
APG	Aberdeen Proving Ground (Maryland)
ATC	Aberdeen Test Center
BGAD	Blue Grass Army Depot
CAMDS	Chemical Agent Munitions Disposal System (Utah)
CatOx	Catalytic Oxidation
CAC	Citizens' Advisory Commission
CAIG	Cost Analysis Improvement Group
CATT	Citizens Advisory Technical Team
COINS™	Continuously Indexing Neutralization System™
CST	Continuous Steam Treater
CWWG	Chemical Weapons Working Group
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DOD	Department of Defense
DPG	Dugway Proving Ground (Utah)
DRE	Destruction and Removal Efficiency
DSHS	Dunnage Shredding and Hydrolysis System
ECBC	Edgewood Chemical and Biological Center (Maryland)
EDS	Engineering Design Studies
EDP	Engineering Design Packages
EIS	Environmental Impact Statement
ERH	Energetics Rotary Hydrolyzer
GB	Designation for Nerve Agent Sarin
GPCR™	Gas Phase Chemical Reduction™
HD	Designation for Distilled Sulfur Mustard H
HT	Designation for Blistering Agent Mustard (H) with T
ICB™	Immobilized Cell Bioreactor™
IITRI	Illinois Institute of Technology Research Institute
kW	Kilowatt
NRC	National Research Council
PCD	Pueblo Chemical Depot
PHA	Preliminary Hazard Analysis
PMACWA	Program Manager Assembled Chemical Weapons Assessment
PMATA	Program Manager Alternative Technologies and Approaches
PWS	Projectile Washout System
RDM	Rocket Dismantling Machine
RFP	Request for Proposal
ROD	Record of Decision
SCWO	Supercritical Water Oxidation
TNT	Trinitrotoluene
TRBP	Thermal Reduction Batch Processor
TW	Transpiring Wall

U.S.	United States
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
VX	Designation for Nerve Agent Methylphosphonothioic Acid