Disposal of Legacy Nerve Agent GA and Lewisite Stocks at Deseret Chemical Depot Letter Report

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Committee on Disposal of Legacy Nerve Agent GA and Lewisite Stocks at Deseret Chemical Depot, National Research Council

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November 5, 2009

Mr. Conrad Whyne
Director
Chemical Materials Agency
5183 Blackhawk Road
Edgewood Area
Aberdeen Proving Ground, MD 21010-5424

RE: Disposal of Legacy Nerve Agent GA and Lewisite Stocks at Deseret Chemical Depot

Dear Mr. Whyne:

At your request, the National Research Council of the National Academies established a study committee to assess the disposal of stocks of legacy nerve agent GA and lewisite at Deseret Chemical Depot. (See Attachment A for the statement of task.) Specifically, the Committee on Disposal of Legacy Nerve Agent GA and Lewisite Stocks at Deseret Chemical Depot reviewed information provided to it on the 50 percent design of the Area Ten Liquid Incinerator (ATLIC) facility.

The findings and recommendations in this letter report are based on the information that the committee received in July and August 2009 from the Army and its contractors on the 50 percent design. The information came from presentations at the first meeting, which took place at Deseret Chemical Depot in Tooele, Utah, on July 21-22, 2009, a teleconference on July 29, 2009, and written design plans and other documents provided to the committee upon request. The committee was not asked to consider alternative methods of destroying the GA and lewisite.

The committee focused on differences between the process design being used for the ATLIC facility and those used at the Tooele Chemical Agent Disposal Facility (TOCDF), which has operated successfully for over a decade in campaigns to destroy nerve agents GB and VX and mustard agent. This letter report provides the technical information necessary to support the general and specific findings and recommendations of the committee.[1] Also, the committee took into consideration that the ATLIC facility would operate for only 3 months or so following approximately 4.5 months of systemization. Closure of the facility was not an issue within the scope of the design review conducted by the committee, nor were any specific details on this provided. Certain physical properties of GA and lewisite are provided in Attachment B. Process

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[1] The key findings (General Findings 1 to 8 and General Recommendations 1 and 2) are presented in this covering letter. Specific findings and recommendations are found in the remaining portion of this report, which is the detailed analysis of the 50 percent design for the ATLIC facility.

flow diagrams for GA and lewisite and a schematic diagram for the ATLIC facility pollution abatement system can be found in Attachment C. Abbreviations and acronyms are listed in Attachment D.

The committee notes that the GA stored at Deseret Chemical Depot contains no significant concentration of metal contaminants and is similar to GB. Because the lewisite contains a large amount (37 wt percent) of arsenic, this letter report is largely focused on destruction of the lewisite and management of the resulting waste streams.

What follows is the analysis of the committee based on the 50 percent design information provided for the ATLIC facility. This analysis is provided to satisfy the requirements in the committee's statement of task as summarized in the following extract from the statement:

- Examine the process design and procedural steps to be used for treating GA and lewisite at the Deseret Chemical Depot;
- Provide an assessment of the process design which includes a new incinerator and associated pollution abatement system to be tailored to the requirements for treating the GA and lewisite;
- Provide an assessment of the process design to determine the system's ability to reduce arsenic and mercury emissions to within the Maximum Achievable Control Technology (MACT) new source regulatory limits
- Produce a report covering the topics listed above.

The committee's general findings and recommendations are as follows:

General Finding 1. The committee believes that the Area Ten Liquid Incinerator and associated pollution abatement and process control systems being installed at Deseret Chemical Depot for processing GA and lewisite will safely and completely incinerate the GA and lewisite. However, the incinerator and the pollution abatement system constitute a first-of-a-kind system. Although this incinerator was available, it had never been used to destroy agent and is being modified with new burners and injectors and new integrated pollution abatement and integrated process control systems.

General Recommendation 1. The integrated Area Ten Liquid Incinerator and pollution abatement system should be assembled, tested, and debugged prior to installation in Area Ten and prior to systemization. The system should be tested with the same auxiliary fuel that will be used in the Area Ten Liquid Incinerator facility.

General Finding 2. The committee believes the principal challenges to be addressed for the Area Ten Liquid Incinerator facility arise largely from the arsenic content in the lewisite—that is, from capture of the arsenic species and management of the resulting arsenic waste streams. Since GA is chemically similar to GB and contains no extraordinary amounts of regulated metals, its incineration is expected to be straightforward and to present no issues that have not been successfully resolved during GB disposal operations at the Tooele Chemical Agent Disposal Facility.

General Finding 3. Based on its review of the Army's approach to ensure compliance with all required environmental regulations, the committee expects the necessary permits to construct and operate the Area Ten Liquid Incinerator facility for destruction of GA and lewisite to be forthcoming.

General Finding 4. The method proposed to access agent from the ton containers has been used extensively to obtain samples of other agents at Deseret Chemical Depot or to completely drain ton containers at other sites. The committee believes the Army can successfully remove the liquid GA or lewisite from the containers.

General Finding 5. In the information available to the committee, procedures for decontamination, rinsing, and sampling of ton containers to meet Chemical Weapons Convention treaty obligations as administered by the Organization for the Prohibition of Chemical Weapons and Resource Conservation and Recovery Act regulatory requirements for shipment off-site, were not provided in detail. However, the Army has prior experience with similar nonthermal decontamination procedures, such as those that were used at the Aberdeen, Maryland, site. The committee expects that procedures will be implemented for the Area Ten Liquid Incinerator facility pursuant to the conditions established in the state-approved Resource Conservation and Recovery Act permit.

General Finding 6. The committee expects that the pollution abatement system of the Area Ten Liquid Incinerator facility, as described in the 50 percent design, will effectively remove arsenic and mercury to below the EPA's Maximum Achievable Control Technology standards. This expectation is based on the use of redundant unit operations for arsenic and mercury removal in the pollution abatement system and in view of well-established principles for mercury removal. These factors counterbalance uncertainties that exist concerning the chemical forms of the arsenic and mercury that will be present, a lack of prior history on the effectiveness of removal for the high concentrations of arsenic that will be present in the gas stream, and uncertainties arising from the potential interferences caused by simultaneous arsenic and mercury removal.

General Finding 7. Until systemization and trial burns for the Area Ten Liquid Incinerator facility are completed, available data do not allow a determination of what form and in what waste streams the arsenic and mercury from agent destruction will be found.

General Recommendation 2. In the trial burns of lewisite, the Army must determine the removal efficiency of the arsenic and mercury and the distribution of these elements in the waste streams of the pollution abatement system of the Area Ten Liquid Incinerator facility. These analyses are critical to viable operation of the Area Ten Liquid Incinerator facility and waste management.

General Finding 8. The Army has been working with the Utah Division of Solid and Hazardous Waste to (1) identify all secondary waste streams generated at the Area Ten Liquid Incinerator facility; (2) adopt a comprehensive waste analysis plan that establishes appropriate sampling and analysis methods and waste control limits for each secondary waste to be treated in the Area Ten Liquid Incinerator facility or to be shipped off-site for treatment or disposal; and (3) ensure each secondary waste stream is properly managed in accordance with the facility-specific permit waste analysis plan and all applicable Resource Conservation and Recovery Act regulations and requirements.

Additional more specific findings and recommendations are provided in the detailed analysis of this letter report, which follows.

Sincerely,

Robert A. Beaudet, *Chair*
Committee on Disposal of Legacy
Nerve Agent GA and Lewisite
Stocks at Deseret Chemical Depot

Attachments

A Statement of Task
B Pertinent Properties of GA and Lewisite
C Process Flow Diagrams for GA and Lewisite Processing; Schematic Diagram of ATLIC Pollution Abatement System
D Abbreviations and Acronyms
E Committee on Disposal of Legacy Nerve Agent GA and Lewisite Stocks at Deseret Chemical Depot
F Acknowledgement of Reviewers

Detailed Analysis of 50 Percent Design for the ATLIC Facility

Approximately 44 percent of the more than 31,000 tons of the chemical agents in the original U.S. stockpile declared under the Chemical Weapons Convention (CWC) treaty were stored at Deseret Chemical Depot (DCD). Included in this material were some relatively small quantities of the nerve agent GA (also known as tabun) and the blister agent and lung irritant lewisite. Destruction of the large quantities of nerve agents GB and VX stored at DCD was begun in August 1996 at the Tooele Chemical Agent Disposal Facility (TOCDF) located at DCD and completed in 2006. Some mustard agent munitions and ton containers containing low levels of mercury have also been destroyed. The remaining mustard agent containing high levels of mercury will be destroyed following installation and systemization of the pollution abatement system carbon filter system at the TOCDF, which were under way when this report was being prepared.

This letter report examines the 50 percent process design provided by the Army and its contractor for the small destruction facility called the Area Ten Liquid Incinerator (ATLIC) facility, which will be used to destroy the GA and lewisite stored at DCD (see also the statement of task in Attachment A). The agents are being stored in bulk in sealed vessels commonly known as “ton containers” (TCs). The ATLIC facility is being designed to destroy 4 TCs of GA, 10 TCs of lewisite, and another 10 TCs that may contain lewisite residues. The ATLIC itself is an incinerator that had originally been constructed for another purpose but was available (albeit disassembled); its capacity is approximately one fourth that of the liquid incinerators at the TOCDF. This incinerator is being used to avoid interfering with the mustard agent destruction ongoing at the TOCDF or otherwise prolonging the latter’s overall schedule. Table 1 indicates the approximate composition and total mass of the GA and lewisite materials to be destroyed. One environmental challenge is the approximately 37 percent arsenic content in the lewisite that must be captured and sent to a hazardous waste treatment, storage, and disposal facility.[2]

At the time this report was prepared, DCD and the contractor considered the design of the ATLIC facility to be 50 percent complete. The Army’s Chemical Materials Agency (CMA) requested the National Research Council (NRC) to assemble a study committee to assess the design and associated issues relating to the ATLIC facility processes (see Attachment A).

PERMITTING AND REGULATORY CONTEXT

TOCDF currently operates under the conditions established by a Resource Conservation and Recovery Act (RCRA) permit issued by the state of Utah, Division of Solid and Hazardous Waste (UDSHW). Because the ATLIC facility is not included in the current TOCDF RCRA permit, its construction in the Area Ten storage area of the DCD will require a RCRA Class 3 permit modification to be filed with and approved by the UDSHW (Utah Rule R315). RCRA regulations concerning hazardous air emissions (Utah Rule R315-8-15) do not apply to hazardous waste incinerators that demonstrate

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[2] Kevin Morrissey, SAIC, “Characterization of lewisite and tabun stored at DCD: Application to DCD-LITANS,” November 4-5, 2008. Briefing paper provided to the committee on July 24, 2009.

TABLE 1 Composition of the Legacy Chemical Agents Stored at Deseret Chemical Depot

Item	Total Mass of Contents (tons)	Contents and Major Contaminants (wt-%)
4 TCs containing the agent GA	~ 2	GA (tabun): (32-63%) Chlorobenzene (4-15%) Diethyldimethlyphosphoramidate (0-11%) Tetramethylphosphorodiamide cyanide (3-5%) Diethyl 1,2-tetramethyldiamido-diphosphate (3-9%) Mercury (nondetect) Arsenic (36 ppm)
10 TCs containing lewisite	~13	Lewisite 1: $ClCH{=}CHAsCl_2$ (~73%) Lewisite 2: $[ClCH{=}CH]_2AsCl$ (~17%) Other arsenical compounds (3-5%) Mercury (56-536 ppm)
10 “transparency” TCs with lewisite residues[a]	~0	Now known to be empty except for traces of liquid

[a] The term “transparency” is associated with a designation from a CWC treaty perspective for the 10 TCs possibly containing lewisite residues. When declaring the total chemical stockpile, there was a question of whether these 10 TCs contained agent. In order to be transparent in the declaration, the 10 TCs were declared as part of the stockpile.

SOURCE: Kevin Morrissey, SAIC, “Characterization of lewisite and tabun stored at DCD: Application to DCD-LITANS,” Adapted from a November 4-5, 2008, briefing paper provided to the committee on July 24, 2009.

compliance with the Hazardous Waste Combustor Maximum Achievable Control Technology (MACT) requirements.

The Utah Division of Air Quality (UDAQ) has incorporated by reference the federal Environmental Protection Agency (EPA) National Emission Standards for Hazardous Air Pollutants (Utah Rule R307-214; 40 Code of Federal Regulations 63, Subpart EEE), effective as of July 1, 2007. This rule stipulates emission standards based on the performance of maximum achievable control technology. Section 112 of the Clean Air Act required the EPA to establish emissions standards for hazardous air pollutants. These National Emission Standards for Hazardous Pollutants are commonly referred to as MACT standards because the EPA used the MACT concept to determine the levels of emission control.[3] In essence, MACT standards ensure that all major sources of air toxic (i.e., hazardous air pollutant) emissions achieve the level of control already being

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[3] The MACT standards reflect the “maximum degree of reduction in emissions of . . . hazardous air pollutants” that the Administrator determines is achievable, taking into account the cost of achieving such emission reduction and any non-air-quality health and environmental impacts and energy requirements [Section 112(d)(2)].

achieved by the better-controlled and lower-emitting sources in each category. The EPA found that this approach assures citizens that each major source of toxic air pollution will be required to effectively control its emissions of air toxics.[4] For new hazardous waste incinerators, the MACT standards limit emissions of chlorinated dioxins and furans, carbon monoxide and hydrocarbons, toxic metals (including mercury and arsenic), hydrogen chloride and chlorine gas, and particulate matter.

Under the MACT rule, mercury emissions from new incinerators are currently limited to 8.1 μg/dscm corrected to 7 percent oxygen (40 CFR 63.1219(b)(2)); this would be applicable to mercury emissions from the proposed ATLIC. Also under the MACT rule, arsenic emissions are currently limited to 23 μg/dscm corrected to 7 percent oxygen (40 CFR 63.1219(b)(4)); this, too, would be applicable to arsenic emissions from the proposed ATLIC. As part of the MACT requirements, a comprehensive performance test must be conducted that includes a surrogate trial burn to satisfy both MACT and RCRA requirements. Therefore, a notice of intent to comply (NIC) will have to be filed with the UDSHW, including a proposed comprehensive performance test plan.

TOCDF operations are also conducted under the provisions of an existing depot-wide Clean Air Act Title V operating permit issued by the UDAQ. Although parts of the ATLIC facility already exist, the facility has not yet been permitted for the destruction of GA or lewisite. Therefore, the Army filed a notice of intent (NOI) with the UDAQ (Utah Rule R307-401-4) on September 3, 2009, to modify the existing Title V operating permit and approval order to include all ATLIC facility emissions and emission sources. Construction cannot begin until receipt of the approval order for installation of the ATLIC facility. An approval order will be issued if the UDAQ determines that the degree of pollution control for emissions, including fugitive emissions and fugitive dust, is at least the best available control technology and that the facility complies with all applicable requirements for other air quality conditions, including the National Emission Standards for Hazardous Air Pollutants. The Army expects to receive temporary authorization to begin some preparatory construction and installation of equipment prior to any operations.

In addition to compliance with any Clean Air Act approval order and permit requirements, the generation, storage, treatment, and disposal of secondary wastes (i.e., wastes generated during GA and lewisite treatment) must comply with all applicable RCRA characterization and management regulations, including compliance with any waste control limits (WCLs) for GA and lewisite, as established in the RCRA permit modification.

In addition, the ATLIC facility must also comply with the requirements of the Organization for the Prohibition of Chemical Weapons (OPCW) for declaring the ton containers to be empty of agent.[5]

Finding 1. As detailed in documentation provided to the committee, the Army appears to be complying with all required environmental regulations that pertain to the planned Area

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[4] 64 FR 53038, September 30, 1999, as amended at 65 FR 42297, July 10, 2000; 67 FR 6986, February 14, 2002; 70 FR 59540, October 12, 2005.

[5] The OPCW, headquartered in the Hague, Netherlands is the implementing organization for the CWC treaty, to which the United States is a signatory.

Ten Liquid Incinerator facility and should be expected to receive the necessary permits to construct and operate the facility.

DESIGN REVIEW OF THE ATLIC FACILITY

Brief Description of the Overall Process

As noted previously, the ATLIC facility will be located in Area Ten of the agent storage area at DCD, minimizing transport of GA and lewisite TCs from storage to the processing area. The ATLIC facility uses incineration to destroy the agents and other liquid secondary waste streams. It employs a two-stage incinerator that was originally built for use at another location but never used because it was no longer needed. In the overall process, TCs containing agent are transported from storage igloos to the ATLIC facility using the same type of equipment and methods that were used to sample mustard TCs stored in Area Ten for eventual disposal at TOCDF.[6] Figures 1 and 2 in Attachment C show steps in the processing of TCs containing GA and lewisite, respectively. Figure 3 is a schematic diagram of the pollution abatement system.

TCs arriving at the ATLIC site from storage are loaded onto TC carts and moved through a vestibule into one of two glove boxes. In the glove boxes, the TC vapor space and liquid are sampled, and, after their composition has been verified, the liquids are transferred to the incinerator or an incinerator feed tank in the toxic cubicle. After the drained TCs are treated with decontamination fluids, the fluids are drained to a collection tank for spent decontamination solution in the toxic cubicle. After decontamination, the TCs are rinsed with process water and sampled to verify that agent concentrations meet OPCW requirements for release from the declared stockpile. The rinse water is sent to the same collection tank. The liquid contents of the TCs as well as associated decontamination fluids and rinse water are fed to the ATLIC from the toxic cubicle. The agent contents drained from the TCs are sent to an injector in the primary chamber of the liquid incinerator, where the liquid is sprayed into the primary chamber burner flame. Except for the acetic acid solution, which will be sent to the primary chamber, and the nitric acid, which will be recovered by diffusion dialysis, spent decontamination liquids and rinse water will be injected into the burner flame in the secondary chamber.

Exhaust gas from the secondary chamber of the liquid incinerator is fed to a pollution abatement system (PAS). The PAS uses an aqueous quench to lower the temperature from 2000°F to approximately 185°F. The cooled gas flows first through a three-stage packed-bed scrubber and then a venturi to remove gaseous pollutants and entrained particulates from the cooled exhaust gas of the liquid incinerator. Caustic solution is used in both the scrubber and venturi. The gas is cooled to remove excess moisture, then reheated and fed to a baghouse along with powdered sulfur-impregnated activated carbon (SIC) to remove additional particulates, arsenic, and mercury. After the baghouse, the filtered exhaust gas flows through two SIC filter assemblies (mounted in

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[6] Jim Clark, URS, "GA/lewisite–Area Ten Liquid Incinerator (ATLIC) project overview," Presentation to the committee on July 21, 2009.

parallel flow) to remove any remaining mercury and arsenic and then through an induced draft fan, which discharges to a stack.[7]

All process areas are ventilated with conditioned air that is then discharged to the atmosphere through activated carbon filter banks to remove any agent or other toxic materials from the ventilation air. The carbon filters, which are identical to those used in ventilation systems at other chemical agent disposal incineration sites, including TOCDF, have an excellent record of performance.

Process exhaust gas streams and ventilation air streams are monitored for agent at intermediate points in the flow paths to verify that the various filters are operating effectively. Monitors will also be used between the beds of HVAC carbon filters to verify carbon filter effectiveness (URS, 2009).

Accessing GA and Lewisite from Ton Containers

Accessing operations for the TCs are designed to remove all drainable agent or other liquids in each TC and to decontaminate the TCs. All agent and decontamination fluids removed from the TCs are pumped to the appropriate ATLIC feed tank or directly to the incinerator. The standard approach for accessing all of the TCs—that is, the 4 GA TCs, the 10 lewisite TCs, and the 10 transparency TCs that might contain lewisite residues—includes the following key steps:

- All accessible liquid is transferred either to the primary chamber feed tank (lewisite and acetic acid rinse) or directly to the incinerator primary chamber (drainable GA liquid), followed by addition of the appropriate decontamination fluid to the TC. Decontamination fluids are agent-specific.
  - For GA, 100 gallons of 18 percent NaOH solution will be used and will be drained to the spent decontamination solution tank located in the toxic cubicle.
  - For lewisite, 100 gallons of 20 percent acetic acid will be used to dissolve and remove the remaining lewisite and then pumped to the acetic acid rinsate tank located in the toxic cubicle. From there, the acid will be pumped to the primary combustion chamber injector.
- After the acetic acid rinse, each lewisite TC will be treated with 100 gallons of 7.0 M nitric acid. The used nitric acid will be drained to the nitric acid rinsate tank in the toxic cubicle, where it will be analyzed and then sent to a diffusion dialysis unit for acid recovery.[8]
- Transparency TCs, if necessary, may be processed as lewisite TCs based on the results from solid samples taken with a borescope to ascertain the presence of agent. (This testing had not been completed by DCD and the contractor when this report was being prepared.)

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[7] Note that what are termed "carbon filters" in Army vernacular are more accurately described as carbon adsorption beds.

[8] Based on the NOI, either acetic or nitric acid may be used as the decontamination solution (URS, 2009). However, a presentation to the committee by Jim Clark, URS, "GA/lewisite–Area Ten Liquid Incinerator (ATLIC) facility design review," on July 21, 2009, indicated that both acetic acid and nitric acid would be used.

- For nitric acid rinses, the used acid solution will be sent to a diffusion dialysis unit to recover any remaining nitric acid.
- After each of the decontamination fluids has been used, the TCs will be rinsed three times, each time using 100 gallons of water and rotating the TCs for a prescribed cycle. The rinse water will be sampled to confirm that the agent concentration is below the WCL established in the state-approved RCRA permit. Rinsate will be sent to the spent decontamination solution tank in the toxic cubicle and then injected into the secondary chamber of the ATLIC. Alternatively, rinsate below the WCL could be disposed of off-site at a qualified TSDF (TOCDF, 2009).

Finding 2. The direct transfer of ton container liquid contents and decontamination fluid and rinse water to the Area Ten Liquid Incinerator primary chamber may not ensure that the flow and composition of the liquid to the primary chamber injector nozzle is uniform to thereby provide optimum incineration conditions. However, the Army is addressing this problem by providing a high fuel:feed ratio and by designing the injector to accommodate a range of fluid properties.

Finding 3. The procedures and chemicals used for decontaminating or removing residual agent from the ton containers appear to be adequate to ensure that the decontamination fluids and rinsates do not contain agent above the waste control limits. However, it is unclear whether occluded agent could be present on the internal surface of the ton container walls. Also, while no liquid had been found in the transparency ton containers at the time this report was prepared, a definitive determination of agent contents had not been completed.

Recommendation 1. The Army should establish a procedure for verifying that after decontamination the ton containers meet any requirements established in the approved waste analysis plan necessary to allow the containers to be cut and transported off-site in accordance with regulatory requirements.

Diffusion dialysis is a commercialized ion exchange membrane technology that is used in various electroplating processes—such as printed circuit board manufacture—to recover acids that have become contaminated with metals (Steffani, 1995). Diffusion dialysis separates acid from its metal contaminants by using an acid concentration gradient between two solution compartments, one filled with contaminated acid and the other with deionized water, separated by an anion exchange membrane. Acid diffuses across the membrane into the deionized water. Metal ions are blocked by their charge and the selectivity of the membrane. Diffusion dialysis does not employ an electrical potential or pressure gradient across the membrane. Rather, the transport of acid is driven by the difference in acid concentration in the two compartments separated by the membrane. Nitric acid recovered from the dialysis unit will be reused after adjusting the concentration of acid to 7.0 M by adding fresh concentrated nitric acid. Waste solution from the nitric acid diffusion dialysis unit, which will contain heavy metals, will be sent to the incinerator secondary chamber or disposed of as hazardous waste.

Finding 4. Diffusion dialysis is a commercial method of acid recovery and appears to be a valid method of recovering a portion of the nitric acid for reuse. But the application of this technology to nitric acid that contains both mercury and high concentrations of arsenic, as well as other contaminants from the lewisite ton containers, is untested. Alternatively, it might be possible to send the waste nitric acid that will be contaminated with arsenic, mercury, and other metals off-site for disposal to an appropriate treatment, storage, and disposal facility under conditions established in the state-approved Resource Conservation and Recovery Act permit, including any waste control limit for agent.

Recommendation 2. The Army should consider shipping waste nitric acid off-site for disposal without dialysis, provided it meets the agent waste control limit for off-site shipment established in the Resource Conservation and Recovery Act permit.

The ATLIC design uses the same common tanks to collect different liquids used for treating the TCs before feeding them to the primary or secondary incineration chamber. Thus, the flows of liquids from the TCs to these tanks must be carefully managed to avoid unexpected reactions—for example, reactions between acids and NaOH or between organic materials and 7.0 M nitric acid. These concerns have already been identified by the contractor and placed in the hazard tracking log, which is discussed in a later section of this report.[9]

Finding 5. Using the same tank to alternatively collect both acidic and basic (low- and high-pH) liquids or other solutions containing reactive chemicals during operations could pose a serious hazard.

Recommendation 3. If the Area Ten Liquid Incinerator facility design continues to call for the use of common tanks to collect different liquids from ton container treatment over the course of operations, each tank used in this manner should be flushed several times until the original liquid is no longer present in the tank before it is used to store a new liquid. Alternatively, different tanks could be installed for each of the different liquids collected from treating the ton containers.

Incinerator Design

The design of the existing small scale liquid incinerator is similar to that of the two liquid incinerators (LICs) that have been used at the TOCDF and other facilities to successfully destroy GB and VX and that are being used to destroy mustard agent contaminated with mercury at the TOCDF. The ATLIC has approximately one-fourth the capacity of the LICs at the TOCDF, based on the lewisite flow rate. It was started up during acceptance testing on fuel oil but never used to destroy agent. Design modifications that distinguish it from the TOCDF LICs resulted from the need to transport the small-scale incinerator to perform the task for which it was originally designed but never used. These modifications include horizontal instead of vertical primary and secondary combustion chambers and a water quench tower followed by three short interconnected scrubber towers with a common sump for scrubber liquid. Thus,

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[9] New hazard tracking log provided to the committee by CMA staff, July 20, 2009.

exhaust gas flows in series through the three scrubber towers while the scrubber liquid flows through these towers in parallel. This is in contrast to the single, tall scrubber tower used in the PAS units for the TOCDF LICs. Although this existing incinerator was available, it was never used to destroy agent and is being modified with new burners, new injectors, and new, integrated PAS and process control systems. Current plans call for testing to be performed off-site.

Finding 6. The Area Ten Liquid Incinerator and its pollution abatement system constitute a first-of-a-kind system that has not been integrated or tested in its final configuration. It is being modified with new burners and injectors. The incinerator unit has been stored in the open air at DCD for a number of years.

Recommendation 4. Prior to systemization, the integrated Area Ten Liquid Incinerator and pollution abatement system should be assembled, tested, and debugged off-site with the same auxiliary fuel to be used in Area Ten. Its design specifications must be verified. This preliminary testing prior to systemization will decrease the overall schedule and minimize unexpected problems.

The committee reviewed key materials of construction at the 50 percent design stage and deemed them adequate for the planned operating period of about 3 months of actual agent operation after approximately 4.5 months of systemization. The steel shells of the primary and secondary chambers are protected by the same refractory brick linings as used at TOCDF. The quench tower uses AL6XN alloy for the first 4 feet and Type 316 stainless steel for the remainder, protected by six nozzles spraying caustic on the vertical walls at the gas inlet.

Confidence in the performance of the ATLIC can be derived from the similarity of its operating conditions to those in the TOCDF LICs, including the following:

- Temperatures in the primary and secondary chambers of both the ATLIC and the TOCDF LICs are maintained at 2700°F and 2000°F, respectively.
- The design of both the ATLIC and the TOCDF LICs calls for 30 percent excess air, corresponding to an oxygen concentration of 5-6 percent at the exit of the secondary combustion chamber.

Differences between the incinerator components of the ATLIC and those of TOCDF LICs are these:

- The planned feed rate for GA is 200 lb/hr in the ATLIC versus a baseline feed rate for GB of 1,000 lb/hr in the TOCDF LICs. The primary burner rating for the ATLIC is 3 MMBtu/hr compared to 14 MMBtu/hr for each of the TOCDF LICs. The agent in the ATLIC provides a lower fraction of the total heat release in the ATLIC than does the agent in the TOCDF LICs. This provides for more robust operation but results in more natural gas or fuel oil consumption when the feed of agent or spent decontamination solution is cut off but the incinerator temperature must be maintained.

- There are minor differences in configuration. The primary and secondary combustion chambers in the ATLIC are horizontal, while those in the TOCDF LICs are vertical. The ATLIC primary combustion chamber is tied directly into the secondary chamber, which is also horizontal. This contrasts with the TOCDF LICs, where the vertical primary combustion chamber is connected to the vertical secondary chamber through a crossover duct. Agent (or spent decontamination solution) is injected through a separate gun angled at the combustion zone created by the incinerator fuel in the ATLIC rather than directly through the fuel burners as in the TOCDF LICs. The horizontal secondary combustion chamber may experience some drop-out and accumulation of noncombustibles on the bottom at the end of the chamber under the 22-inch induced-draft exhaust opening. Owing to the short operating period, this accumulation is not expected to cause operating problems; however, noncombustible material removal and disposal should be provided for.
- The sum of the residence times in the primary and secondary combustion chambers of the ATLIC is reported to be 5 seconds compared with 2 seconds in the TOCDF LICs.[10] The residence time for the TOCDF LICs does not, however, include the time in the cross-over duct, which is maintained at 1800°F.

Finding 7. Liquid incinerators used at chemical demilitarization facilities have provisions for removal of noncombustible material (slag). Noncombustible materials (e.g., slag) can be expected to accumulate at the bottom of the horizontal secondary chamber of the Area Ten Liquid Incinerator.

Recommendation 5. Although the operating time for the Area Ten Liquid Incinerator is of relatively short duration, the Army should consider the need for removal of noncombustible materials from the secondary chamber.

The increase in residence time for the ATLIC compared with that for the TOCDF LICs should lead to an even higher destruction efficiency for the agents to be processed in the former. The lower flow rates and smaller dimensions in the ATLIC will lead to lower Reynolds numbers and lower turbulence levels than in the TOCDF LICs, which might lead to reduced micromixing in the ATLIC. The change in the injection of agent will lead to differences in macromixing of the agent as well as the combustion patterns in the ATLIC relative to those in the TOCDF LICs. These changes will impact the details of the combustion patterns, but, given the reported increased total residence time, the Army expects that the destruction efficiencies will meet the RCRA requirements.[11] Trial burns with agent and spent decontamination solution liquid surrogates will be conducted to

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[10] Jim Clark, URS, “GA/lewisite–Area Ten Liquid Incinerator (ATLIC) project overview,” Presentation to the committee on July 21, 2009.

[11] A measure of the margin of safety in the ATLIC design is the requirement provided by the EPA Office of Enforcement and Compliance Assurance (OECA) for the destruction of PCBs, compounds considerably more refractory than GA and lewisite. One set of conditions specified by EPA is a residence time of 2 seconds, a temperature of 1200°C (2192°F), and an excess oxygen concentration of 3 percent, conditions exceeded by a safe margin in the ATLIC (OECA, 2004).

ensure that these changes do not impair the performance of the ATLIC. The ATLIC, with its longer residence time, will meet the destruction and removal efficiency (DRE) standards for the organic compounds in the GA and lewisite containers.

Finding 8. The committee believes that the temperatures and times in the primary and secondary combustion chambers of the Area Ten Liquid Incinerator will ensure destruction efficiencies that meet regulatory requirements for the organic content of the GA and lewisite ton containers.

The process for permitting a new incinerator under RCRA and MACT regulations requires trial burns to determine the range of operating conditions that will achieve the desired DRE. In place of the agent, the trial burn may involve injection of a surrogate compound that is as difficult or more difficult to destroy than the agent (NRC, 2007). The established measure of the relative destruction efficiency of hazardous chemicals is the incinerability index, which ranks compounds in order of their ease of destruction (Thurnau, 1989).[12] The ranked compounds are divided into seven classes, with Class 1 representing the most refractory compounds. Chlorobenzene, present at up to 15.3 percent in GA, is in Class 1. DCD estimates that GA and lewisite are in Class 5. GB also was ranked in Class 5 by the University of Dayton Research Institute (UDRI), the developers of the incinerability index (Taylor and Dellinger, 1990).

The substances selected for the ATLIC trial burns are (1) a mixture of 20 percent chlorobenzene and 80 percent of a Class 5 (or lower) organic with 100 ppm lead and sufficient arsenic to determine removal efficiency and (2) lewisite.[13] The committee believes these are judicious choices. Chlorobenzene is one of the more refractory compounds in Class 1 and is also found at up to 15.3 percent in the four GA TCs (Taylor and Dellinger, 1990). Inasmuch as the lewisite at DCD contains 37 percent arsenic, there are few arsenicals with such a high arsenic content that could be used as a surrogate, so that the use of lewisite for the second trial burn is a logical choice. The lewisite TCs also contain 56 to 536 ppm mercury, with a mean of 154 ppm, and an average of 34.6 ppm lead, so that no metal spiking is required.

The potential success of the ATLIC trial burns can be anticipated from the trial burns conducted on TOCDF LIC2 (NRC, 2007). These were successfully conducted with surrogates containing trichlorobenzene (Class 1)[14] and the agents GB (Class 5), VX (Class 5), and mustard agent H and HD (Class 4).

To facilitate the interpretation of trial burn results, it would be helpful to conduct equilibrium calculations for the agents to be destroyed under the expected incineration conditions. For the design of the PAS, it would have been prudent to know the amounts

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[12] The regulations are built around DRE = 100 × (Input mass – Output mass in exhaust gas)/Input mass. This allows for a combination of destruction such as by incineration (a measure of which is given by the incinerability index) and removal. For the primary and secondary combustion chambers, the only term of importance is the destruction efficiency. After the PAS, removal is included, so DRE is the proper measure. Thus, destruction efficiency is discussed for the primary and secondary combustors and DRE for the trial burns, which includes both the combustors and the PAS.

[13] Drew Papadakis, URS, “ATLIC environmental permitting,” Presentation to the committee, July 22, 2009.

[14] Chlorobenzene is ranked 19th and the 1,2,4- and 1,3,5- isomers of trichlorobenzene are ranked 22nd and 23rd of the 320 compounds in the incinerability index (Thurnau, 1989).

and form of the elemental and inorganic constituents in the combustion products that enter the PAS. In the absence of high chlorine concentrations, experiments show that As_2O_3 is the principal product of arsenic combustion (Hirsch et al., 2000; Wasson et al., 2005; and Hara and Maeda, 2007). However, in the presence of chlorine, $AsCl_3$ may be formed. Equilibrium calculations by Wu and Biswas (1993) indicate that in methane-air flames with a large excess of air, the hydrogen competes with the arsenic for the chlorine. For the proposed ATLIC incinerator operating conditions (100 percent excess air, 7×10^{-7} arsenic/methane molar ratio), $AsCl_3$ began to form in appreciable amounts only for Cl/As ratios exceeding 10 at 1521°F and 100 at 2240°F. These ratios are much higher than the ratios anticipated for the incineration of lewisite.

The Wu and Biswas (1993) calculations indicate that at a Cl/As ratio of 3, as occurs in lewisite, the arsenic will be emitted from the secondary combustion chamber primarily as As_2O_3. The conditions in the ATLIC, however, differ from those used by Wu and Biswas in one important respect: The ATLIC has an auxiliary fuel with a lower hydrogen content, a factor that may favor some $AsCl_3$ formation, meaning that some $AsCl_3$ formation in the ATLIC secondary combustion chamber cannot be ruled out.

Mercury leaving the primary combustion chamber at 2700°F will be present primarily in the elemental form. However, as the temperature drops to 2000°F in the secondary combustion chamber, the high Cl/Hg ratio in the gas stream from the combustion chambers during lewisite incineration means that the mercury will be present primarily as $HgCl_2$, according to equilibrium calculations and experiments (Fransden et al., 1994; Wu and Biswas, 1993; and Widmer et al., 1998).

Finding 9. Based on thermodynamic modeling calculations, the arsenic leaving the secondary combustion chamber for the case of lewisite incineration should be primarily in the form of As_2O_3.

Finding 10. Extrapolation of experimental measurements and thermodynamic analysis suggest that $HgCl_2$ is likely to be the dominant form of mercury at the exit of the secondary combustion chamber of the Area Ten Liquid Incinerator.

Pollution Abatement System

Based on the chemical composition of GA and lewisite, the anticipated products of combustion that will require treatment by postcombustion pollution abatement processes will be compounds containing arsenic (As), mercury (Hg), or phosphorus (P), and hydrogen chloride (HCl). Although oxides of nitrogen (NO_x) will also be present, as a pollutant, NO_x from GA and lewisite destruction will fall under the existing, sitewide RCRA permit. The PAS is intended to remove these combustion products from the gas stream. The exact chemical forms of the arsenic and mercury compounds, their relative proportions, and the transformations they may undergo throughout the PAS have not been well defined for this first-of-a-kind system.

To control emissions of arsenic, mercury, phosphorus, and hydrogen chloride, the PAS consists of the following components and processes (in order of gas flow):

- Rapid aqueous gas quench, with the gas temperature decreasing from ~2000°F to 185°F,
- Packed tower wet scrubber,
- Venturi scrubber,
- Entrainment separator (mist eliminator),
- Gas reheater, increasing the gas temperature from ~ 70°F to 180°F,
- Injection of powdered sulfur-impregnated activated carbon (SIC),
- Pulsed jet fabric filter (baghouse),
- Parallel filter assemblies each consisting of a prefilter, a HEPA filter, two granular (pelletized) SIC filter beds, and a second HEPA filter, and
- A variable-speed induced draft fan and stack.

The removal of compounds of arsenic and mercury can occur in one or more of the PAS components. The use of the PAS to control emissions of these compounds and also hydrogen chloride and phosphorus is discussed separately below.

Arsenic

The total residence times and temperatures that are maintained in the ATLIC are expected to yield combustion products whose composition reflects thermodynamic equilibrium. Although DCD has not conducted equilibrium calculations, those reported in the literature provide some guidance. Extrapolation of the equilibrium calculations by Fransden et al. (1994) determined that arsenic is present as AsO under standard oxidizing conditions at 2000°F. At lower temperatures, varying amounts of As_2O_3 and As_2O_5 will exist in equilibrium with the AsO. As discussed earlier (see “Incinerator Design”), similar equilibrium calculations for arsenic in the presence of chlorine indicate that the 3:1 chlorine:arsenic ratio of lewisite will cause the arsenic leaving the secondary chamber of the ATLIC to be primarily in the form of AsO (Wu and Biswas, 1993). Even if the chlorine:arsenic ratio were high enough to produce significant concentrations of $AsCl_3$ leaving the secondary chamber of the ATLIC, laboratory experiments suggest that subsequent hydrolysis in the PAS would convert $AsCl_3$ to As_2O_3 (Hara and Maeda, 2007). While As_2O_3 is not water soluble, laboratory experiments conducted on cacodylic acid suggest that as much as 60 percent of the As_2O_3 particulates could be captured in the wet scrubber (Hara and Maeda, 2007).

Finding 11. After quenching, the arsenic removed by the Area Ten Liquid Incinerator pollution abatement system is expected to be predominantly in the form of arsenic oxides. Any remaining $AsCl_3$ will be removed in the quench towers because it is water soluble.

DCD expects to capture arsenic through multiple pathways in the current PAS design: nucleation of As_2O_3 through (1) a rapid quench, (2) wet scrubbing of As_2O_3 in the packed tower wet scrubber, (3) induced growth of the particulate As_2O_3 in the wet scrubber, (4) subsequent removal of the larger size fraction of particles in the venturi, and (5) filtration of the smaller size fraction of the particles and adsorption of the remaining solid As_2O_3 by the fabric in the baghouse. The DCD estimates a 95 percent removal efficiency of arsenic across the venturi scrubber. Although DCD expects some arsenic removal to also occur in the packed tower wet scrubber and in the baghouse, no removal efficiency models or measurements were provided at the 50 percent design stage. There is little experience with the formation of As_2O_3 aerosols from the combustion of compounds with arsenic concentrations as high as those in lewisite. As the As_2O_3 nucleates and agglomerates, it will form an aerosol with a mean particle size that increases with the concentration of As_2O_3 in the gas phase and with the residence time of the combustion products from the point of condensation of the aerosols. The most relevant study is that of Hara and Maeda (2007), who observed As_2O_3 particles of about 0.5 microns produced from the combustion in an electrically heated laboratory furnace of a solution of 0.1 to 0.2 weight percent cacodylic acid $[(CH_3)_2AsO_2H]$, 54 percent arsenic by weight.

The committee believes that the multiple redundancies built into the ATLIC PAS to capture arsenic (as well as mercury) will be sufficient as designed to reduce concentrations of arsenic in the combustion gases to below MACT emission limits. At the same time, however, a number of uncertainties exist that are associated with specific PAS components and their role in removing arsenic. At the 50 percent design stage, some of these components had been specified in relatively sparse technical detail, limiting the degree to which their operating conditions and performance could be independently assessed by the committee.

Specifically, the committee has not been able to satisfactorily evaluate the proposed operation of the following PAS components:

- Venturi scrubber, specifically the pressure drop of the gas.
- Entrainment separator, specifically the suitability of the component design. and materials of construction for application to a potentially high loading of particulate arsenic.
- Reheater, specifically its effectiveness in drying fine, moisture-laden arsenic particles prior to the baghouse.
- Injection of powdered SIC, specifically the potential for interferences to occur during the simultaneous removal of arsenic compounds and mercury or mercury compounds onto the powdered SIC.

The committee believes that an important implication of these uncertainties is that DCD cannot yet state with reasonable certainty what the removal efficiency of arsenic will be in each PAS component. Nonetheless, the committee believes the bulk of the arsenic will be collected in the common sump for the quench tower, packed tower scrubber, and venturi scrubber.

Finding 12. At the 50 percent stage, the design status of the various components of the Area Ten Liquid Incinerator pollution abatement system ranges from design concepts to actual hardware that is ready for installation. While the design as a whole is 50 percent complete, the committee did not have access to detailed specifications for several of the more conceptual components and thus could not conduct an in-depth assessment of their operation.

Mercury

The mercury entering the PAS is primarily in the form of $HgCl_2$ and elemental mercury. DCD plans to capture mercury at three different locations in the PAS: $HgCl_2$ will be absorbed in the wet scrubbers, and elemental mercury and any remaining $HgCl_2$ will be adsorbed onto the powdered SIC injected into the gas stream upstream of the baghouse, or onto the granular SIC held in the filter beds. DCD has estimated mercury removal efficiencies for these steps to be 50 percent for the wet scrubber and 95 percent each for the injected SIC in the baghouse and the granular SIC in the filter beds.

DCD has stated that the amount of granular SIC in the final filter beds of the PAS has been estimated based on the total mercury load expected to be processed during the campaign, the reported mercury adsorption capacity of the SIC within a flow of simulated sulfur mustard combustion products, and a safety factor.[15] DCD asserts that the granular SIC filter bed will be capable of achieving the required overall mercury removal efficiency for the PAS even without contributions from the other PAS components. The committee believes that the sizing of the granular SIC filter beds will, under normal operating conditions, be sufficient to reduce concentrations of mercury in the combustion gases to below permitted levels.

While absorbing $HgCl_2$ in the packed tower wet scrubber and adsorbing elemental mercury on the SIC filter beds are both proven ways to control mercury emissions, the committee has concerns about the simultaneous capture of mercury and arsenic compounds on the powdered SIC in the baghouse. As noted above, excess moisture could be introduced into the dust cake on the fabric filters if fine, moisture-laden arsenic particles are not sufficiently dried during the gas reheating process. Such moisture could make it difficult to dislodge the dust cake during periodic bag cleaning. As noted earlier, for the high concentrations of As_2O_3 expected, only the larger particle size fraction will be removed by the venturi scrubber. The committee believes that simultaneous collection of both arsenic and mercury species may be difficult to achieve without interferences. The baghouse is an appropriate choice to use as a polishing particulate control device to preserve the operational life of the downstream HEPA filter; however, it is not clear that removal of arsenic and mercury compounds can be achieved independently and in parallel on the powdered SIC collected in the baghouse. Without the powdered SIC injection, the baghouse could remove the remaining As_2O_3 particulates while letting elemental mercury pass thorough to be adsorbed by the final granular activated carbon filters.

Finding 13. The committee believes the Area Ten Liquid Incinerator pollution abatement system, as designed, will meet EPA's Maximum Achievable Control Technology emissions limits for arsenic and mercury because it includes redundant operations for their removal.

Recommendation 6. As part of the systemization of the Area Ten Liquid Incinerator facility, the Army should determine what fraction of mercury is captured by the wet

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[15] Personal communication between Drew Papadakis, URS, and Herek Clack, committee member, July 22, 2009.

scrubbers and, based on the results, should make appropriate adjustments for how the baghouse is to be used.

Hydrogen Chloride and Phosphorus

The ATLIC facility design incorporates a packed tower wet scrubber into the PAS to remove HCl and H_3PO_4 formed from the phosphorus and chlorine in the GA and lewisite agents, respectively. The scrubber liquor will be maintained at a pH of 7. Based on the 50 percent design status, no issues have been identified surrounding the removal of the phosphorus and chlorine compounds.

MANAGEMENT OF SECONDARY WASTE STREAMS

Each secondary waste stream must be characterized and managed in accordance with its hazardous characteristics and applicable regulatory requirements. This practice is similar to that for secondary waste streams at the TOCDF (URS, 2009). The proper management, characterization, and ultimate disposal options for all secondary waste streams generated during the ATLIC operations will be established in the RCRA permit waste analysis plan (WAP), which must be approved prior to start-up of the ATLIC facility. The WAP was not available to the committee, but existing documentation indicates some secondary wastes (e.g., rinsates) will be treated by injection into the ATLIC, some (e.g., scrubber blowdown brine and decontaminated/rinsed TCs) will be shipped off-site to a properly permitted treatment, storage, and disposal facility, and some (e.g., lightly agent-contaminated personal protective equipment and solid wastes) may be treated in the Area Ten Autoclave System or the existing metal parts furnace in the TOCDF (TOCDF, 2009; URS, 2009). Since neither the WAP nor the trial burn data were available for review, the committee could not comment on the feasibility or efficacy of the management of all secondary waste streams. However, certain secondary wastes of concern unique to the ATLIC system are discussed below.

Secondary wastes from the ATLIC process comprise arsenic- and mercury-containing compounds captured in the various components of the PAS. It is noteworthy that the 37 percent arsenic content of the lewisite will lead to approximately 9,600 lb of arsenic waste (calculated as the element) from all 10 of the lewisite TCs. The unique waste streams of the ATLIC PAS containing arsenic are the following:

- Spent liquor from the common sump of the quench tower, packed-bed scrubbers, and the venturi scrubber;
- Particulate matter from the hopper that receives material dislodged from the baghouse filters;
- Spent SIC filters and HEPA filters used in the final stage of the PAS;
- Waste from the nitric acid diffusion dialysis process; and
- Rinsate from the TCs and spent decontamination solution.

There may also be some slag from the secondary chamber of the ATLIC. Each of the secondary wastes could be contaminated with mercury and/or arsenic. The chemical compositions must be determined before the wastes can be shipped off-site for further treatment and disposal at commercial facilities. Rinsate, which would be considered a secondary waste, will be fed to the secondary combustion chamber of the ATLIC as part of the water needed for scrubber operation or disposed of off-site.

The common sump will contain chloride and phosphate salts, dissolved $HgCl_2$, suspended As_2O_3 particulates, and dissolved arsenite salts. According to the 50 percent design, a small fraction of the scrubber liquor will be continuously drained as a waste stream (i.e., blowdown). This stream will generate approximately 355,000 gallons of brine, which will be characterized and shipped off-site as a hazardous liquid waste.

Powdered SIC containing mercury and arsenic compounds is removed from the baghouse hopper periodically and falls into a containment bin. The bin is removed periodically and the powdered SIC is characterized and sent off-site. The final SIC beds in the PAS will capture arsenic particulates, mercury, and trace organic vapors not captured earlier. The spent filters will be characterized and sent off-site for disposal.

Other secondary wastes common to chemical agent disposal facility operations generally include these:

- HVAC carbon filters, HEPA filters, and prefilters;
- Personnel protective equipment, including gloves, suits, aprons, booties, snd the like; and
- Decontaminated TCs.

After being drained, TCs will be decontaminated with the appropriate solution, rinsed, and returned to processing for cutting and inspection. The decontaminated TCs are then to be shipped off-site for disposal in a landfill (URS, 2009).

Finding 14. Available information on the management of secondary waste streams from the Area Ten Liquid Incinerator facility seems to indicate a reasonable approach is being taken, but a more complete review must await the development of further information such as the waste analysis plan required by RCRA regulations.

RISK ASSESSMENTS

The ATLIC facility project team has established a system safety engineering management plan (SSEMP) in accordance with the requirements of Mil-STD-882D and a hazard analysis and tracking process that complies with the TOCDF PRP-SA-057 hazard evaluation procedure. In the implementation of SSEMP, a hazard analysis that considers design, operation, and maintenance procedures is performed at various stages of design (conceptual through 100 percent). Hazards are identified and given a risk ranking using the Mil-STD- 882D. The risk ranking is based on the severity of possible consequences and the likelihood of occurrence for each hazard or identified potential failure. Using the risk rank code, hazards are tracked in a log and high-risk hazards are assigned to design and operations personnel for action to resolve high-risk hazards by eliminating them or reducing the likelihood or consequence of their occurrence.

The hazard tracking log is maintained throughout the development of the design, and all high-risk hazards must be satisfactorily resolved before design completion and start-up. Highlights from the hazard tracking log at 50 percent design were presented at the committee meeting in Tooele, Utah, on July 21-23, 2009. The log identified areas of concern, including both "open" and "closed" (resolved) findings. The open findings are being addressed as the design progresses.

After operations begin, a job hazard analysis procedure based on experience from TOCDF will be used. This procedure will be used for assessing all changes in design and operation so that a high level of safety is maintained throughout the life cycle for the GA and lewisite disposal project. No changes can be implemented without satisfactory resolution of the findings of the job hazard analysis.

All hazard analyses during design and, subsequently, operation are led by project safety engineers independent of the design and operations teams. In addition, the implementation of the hazard analysis and risk assessment is periodically reviewed by a team from the Centers for Disease Control under an agreement established with the Army.

The risk assessment and safety analysis approach being applied to the ATLIC facility project is identical in format to the approach applied by the Army's CMA for all facilities in the Chemical Stockpile Disposal Program (CSDP). That such an approach provides adequate assurance and transparency in the management of risk and safety is demonstrated by the outstanding safety record of operating CSDP facilities.

Finding 15. A review of the hazard tracking log provided to the committee for the 50 percent design of the Area Ten Liquid Incinerator facility indicates that the risk assessment and safety analysis techniques are being properly applied. Back-up assurance of the continuation of this practice is provided by the planned oversight by a Centers for Disease Control team throughout the design and testing of the Area Ten Liquid Incinerator facility.

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ATTACHMENT A

STATEMENT OF TASK

The program to destroy the United States stockpile of chemical weapons has been operational for nearly two decades. During that time, the Army's Chemical Materials Agency (CMA) (and predecessor PMCD) have constructed 7 disposal facilities. These facilities have destroyed all of the nerve agents GB and VX held at the storage sites adjacent to each disposal facility and are now in the process of, or continuing, the destruction of mustard agent stored in bulk containers or munitions. Deseret Chemical Depot (DCD), in Utah, originally had the largest repository of chemical agent stocks and munitions, approximately 44 percent of the entire U.S. inventory.

DCD also was the site where four ton containers (~ 2 U.S. tons) of legacy nerve agent GA from World War II came to be stored. Also stored at DCD from similar legacy circumstances were 10 ton containers (~ 13 U.S. tons) of the blister agent and lung irritant, lewisite, along with an additional 10 ton containers of possible lewisite residues. The Tooele Chemical Agent Disposal Facility (TOCDF) Systems Contractor (SC) has recently been tasked with disposal of these materials. These materials lie outside the destruction schedule set for the TOCDF at DCD, where the focus continues to be the destruction of the remaining much larger quantities of mustard agent as it was for the large quantities of nerve agents GB and VX that have already been destroyed.

Consequently, the TOCDF SC is developing an ancillary process to be co-located at DCD by which to destroy the GA and lewisite. As of December 2008, this process was at the 10 percent design stage. The National Research Council has been requested to examine and comment on the issues surrounding this initiative.

The NRC will establish a committee to:

- Examine the process design and procedural steps to be used for treating GA and lewisite at the Deseret Chemical Depot;
- Provide an assessment of the process design which includes a new incinerator and associated pollution abatement system to be tailored to the requirements for treating the GA and lewisite;
- Provide an assessment of the process design to determine the system's ability to reduce arsenic and mercury emissions to within the Maximum Achievable Controls Technology (MACT) new source regulatory limits;
- Produce a report covering the topics listed above.

ATTACHMENT B

PERTINENT PROPERTIES OF GA AND LEWISITE

GA (ethyl N,N-dimethylphosphoroamido cyanidate) is an anticholinesterase organophosphate nerve agent whose effects and potency are similar to those of GB (sarin). Its vapor pressure (0.057 torr at 25ºC) and volatility (497 mg/m^3 at 25ºC) are the lowest of the G nerve agents. It is soluble in water and organic solvents. Diethyl dimethylphosphoramidate is the principle impurity found in munitions-grade GA. Hydrolysis of GA is more rapid in acidic and basic solutions than in neutral pH, and the rate increases with temperature. Sodium hypochlorite is an effective decontaminant for GA.

Lewisite (2-chlorovinyl-dichloroarsine) is a blister-forming agent with irritative effects on the eyes and respiratory tract. Lewisite has the volatility of water with a vapor pressure of 34.6 torr at 25°C and a volatility of 386 mg/m^3 at 25ºC and is only slightly soluble in water. Hydrolysis of lewisite is rapid, forming water-soluble dihydroxy 2-chlorovinylarsine (2-chlorovinyl arsenous acid), which is nonvolatile.

SOURCE: U.S. Army, “Potential military chemical/biological agents and compounds,” Manual FM3-11.9, January 2005.

ATTACHMENT C

PROCESS FLOW DIAGRAMS FOR GA AND LEWISITE PROCESSING AND SCHEMATIC DIAGRAM FOR ATLIC POLLUTION ABATEMENT SYSTEM (PAS)

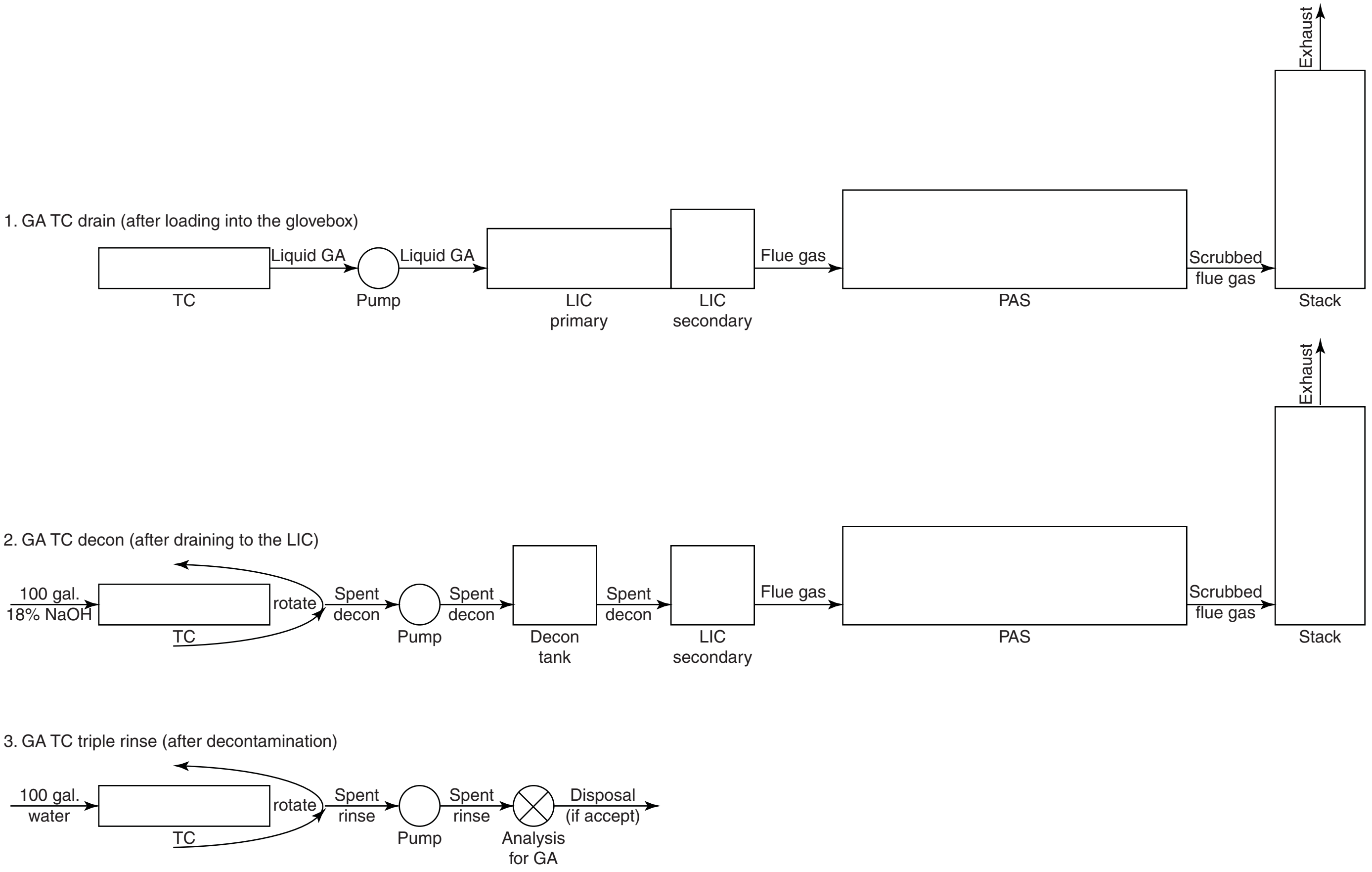

FIGURE C-1 ATLIC facility process flow diagram for GA. SOURCE: Jim Clark, Planning and Project Control Manager, URS, “GA/lewisite—Area Ten Liquid Incinerator (ATLIC) facility design review,” Presentation to the committee, July 21, 2009.

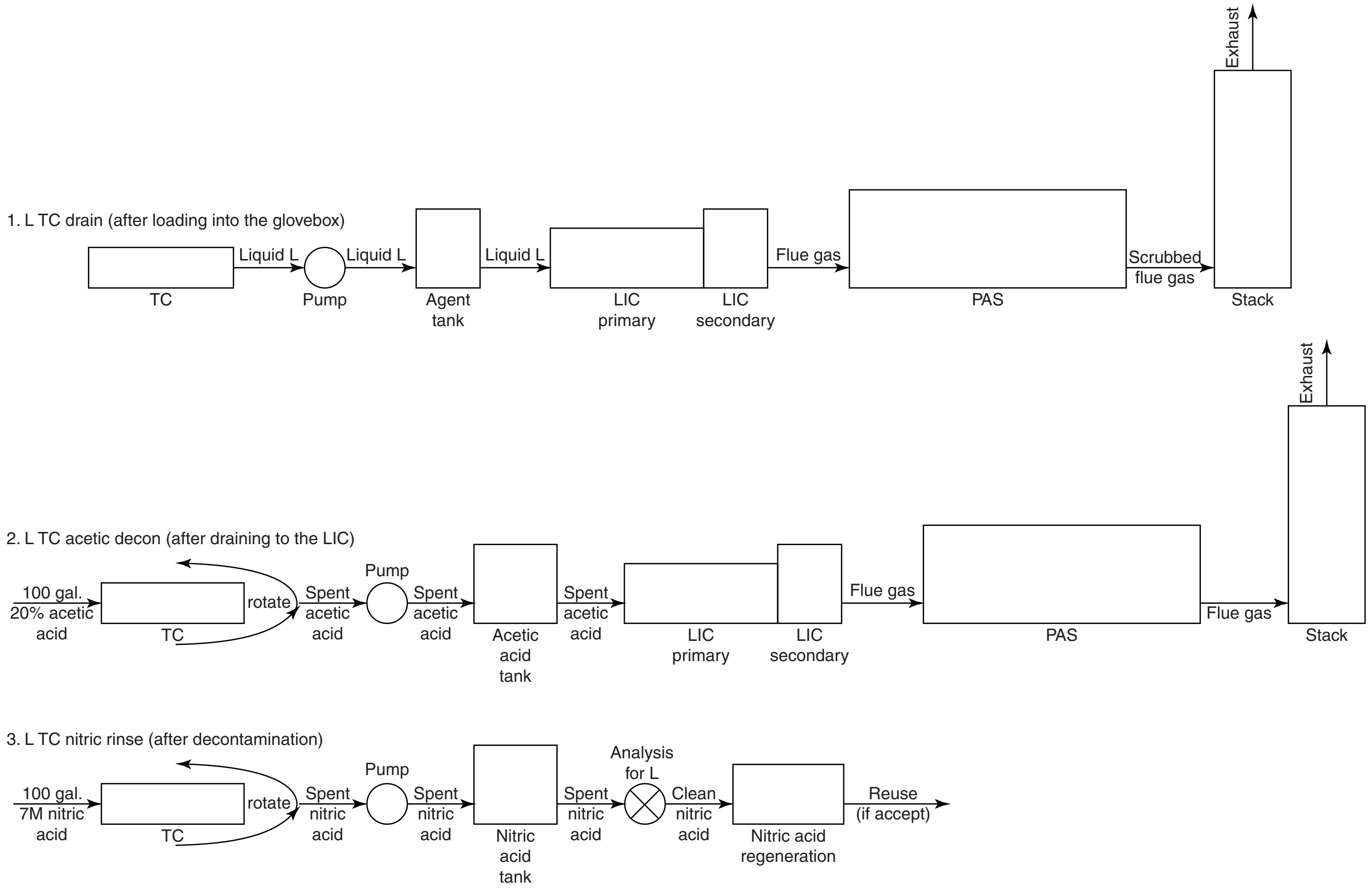

FIGURE C-2 ATLIC facility process flow diagram for lewisite. SOURCE: Jim Clark, Planning and Project Control Manager, URS, “GA/lewisite—Area Ten Liquid Incinerator (ATLIC) facility design review,” Presentation to the committee, July 21, 2009.

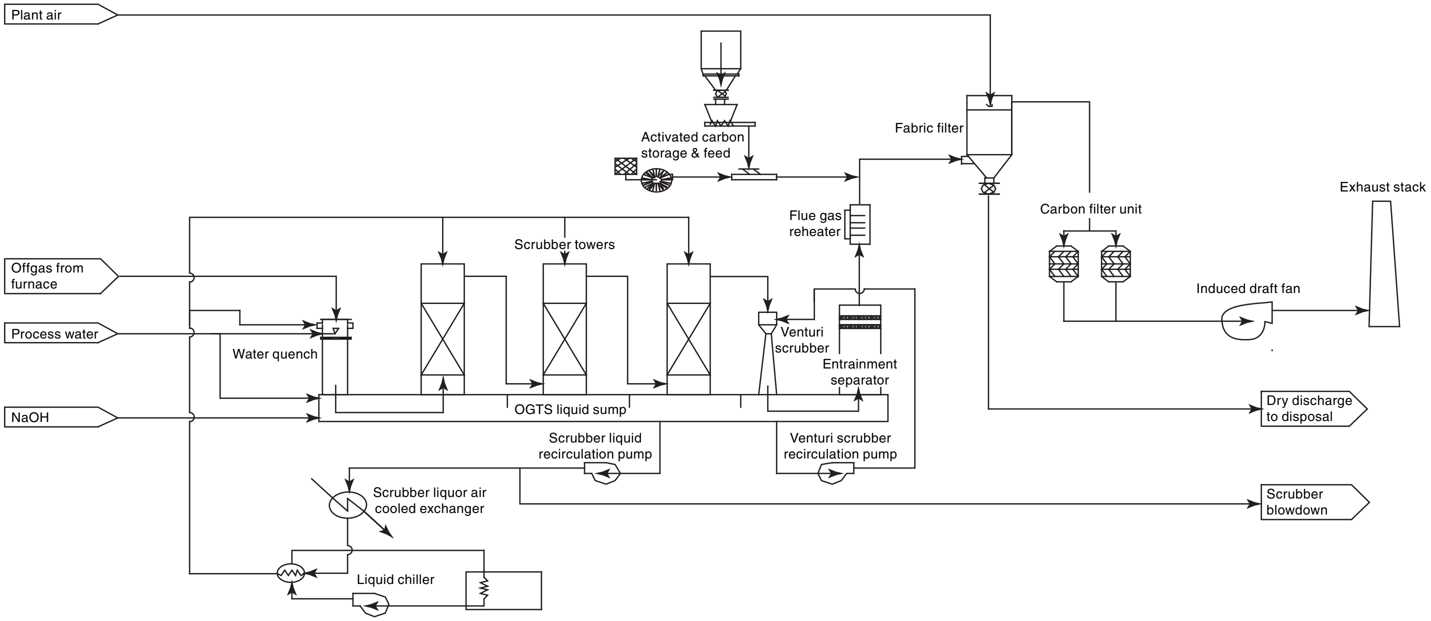

FIGURE C-3 PAS schematic flow diagram for the ATLIC facility. SOURCE: Jim Clark, Planning and Project Control Manager, URS, “GA/lewisite—Area Ten Liquid Incinerator (ATLIC) facility design review,” Presentation to the committee, July 21, 2009.

ATTACHMENT D

ABBREVIATIONS AND ACRONYMS

ATLIC	Area Ten Liquid Incinerator
CMA	Chemical Materials Agency
CSDP	Chemical Stockpile Disposal Program
CWC	Chemical Weapons Convention
DCD	Deseret Chemical Depot
DRE	destruction and removal efficiency
EPA	Environmental Protection Agency
GA	tabun, a nerve agent
GB	sarin, a nerve agent
HEPA	high efficiency particulate air (filter)
HVAC	heating, ventilation, and air conditioning (system)
L	lewisite
LIC	liquid incinerator
M	molar (concentration)
MACT	maximum achievable control technology
NIC	notice of intent to comply
NOI	notice of intent
NRC	National Research Council
OPCW	Organization for the Prohibition of Chemical Weapons
PAS	pollution abatement system
RCRA	Resource Conservation and Recovery Act
SSEMP	system safety engineering management plan
SIC	sulfur-impregnated carbon
TC	ton container
TOCDF	Tooele Chemical Agent Disposal Facility
VX	a nerve agent
UDAQ	Utah Division of Air Quality
UDSHW	Utah Division of Solid and Hazardous Waste
WAP	waste analysis plan
WCL	waste control limit

ATTACHMENT E

COMMITTEE ON DISPOSAL OF LEGACY NERVE AGENT GA AND LEWISITE STOCKS AT DESERET CHEMICAL DEPOT

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ATTACHMENT F

ACKNOWLEDGEMENT OF REVIEWERS

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Edward L. Cussler, NAE, University of Minnesota,
Russell S. Kemp, ENVIRON International Corporation,
Todd A. Kimmell, Argonne National Laboratory,
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John E. Morral, Ohio State University,
Robert L. Olson, Consultant,
Robert E. Nickell, NAE, Applied Science and Technology, Inc.,
George W. Parshall, NAS, E.I. Dupont de Nemours & Company (retired), and
William J. Walsh, Pepper Hamilton, LLP.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Hyla Napadensky. Appointed by the National Research Council, she was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.