# Assessment of the Continuing Operability of Chemical Agent Disposal Facilities and Equipment

Committee on Continuing Operability of Chemical
Agent Disposal Facilities and Equipment

Board on Army Science and Technology

Division on Engineering and Physical Sciences

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*Cover:* Shown clockwise from upper center are representative types of equipment used in disassembly of chemical munitions and containers: (1) a munitions demilitarization machine, (2) a bulk drain station, (3) a transfer conveyor and mine machine, and (4) a fuzewell assembly removal station on the mine machine. Photographs taken at the Chemical Demilitarization Training Facility in Edgewood, Maryland, and provided courtesy of Colin Drury.

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# Preface

As the timeline for destruction of chemical weapons lengthens, there is concern that destruction facilities may face growing operational problems from processing a deteriorating stockpile with aging equipment. The challenges of continuing operability and the threat of obsolescence cannot be ignored. We would like to thank the committee for its hard work in visiting, interviewing, and assessing pertinent issues at each of the incineration sites, and for developing findings and recommendations to address these concerns.

The committee in turn is grateful to the Chemical Materials Agency, its staff, field offices, and site contractors for the timely and useful information they provided. We also greatly appreciate the support and assistance of the National Research Council (NRC) staff who ably assisted the committee in its fact-finding activities and in the production of this report.

The study was conducted under the auspices of the National Research Council's Board on Army Science and Technology (BAST). The BAST was established in 1982 as a unit of the National Research Council at the request of the United States Army. The BAST brings to bear broad military, industrial, and academic scientific, engineering, and management expertise on Army technical challenges and other issues of importance to senior Army leaders. The board discusses potential studies of interest; develops and frames study tasks; ensures proper project planning; suggests potential committee members and reviewers for reports produced by fully independent ad hoc study committees; and convenes meetings to examine strategic issues. Board members with appropriate expertise are sometimes nominated to serve as formal members of study committees, or as report reviewers. The board members listed in this report were not asked to endorse the committee's conclusions or recommendations, nor did they review the final draft of this report before its release.

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Otis Shelton, *Vice Chair*
Committee on Continuing Operability of Chemical Agent Disposal Facilities and Equipment

# Acknowledgment 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 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:

Joan B. Berkowitz, Farkas Berkowitz & Company,
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Joseph E. Pecoraro, Parsons Infrastructure and Technology Corporation, and
Robert B. Puyear, Consultant, Chesterfield, Missouri.

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 Henry J. Hatch, Army Chief of Engineers (retired). Appointed by the National Research Council, he 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.

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# Abbreviations

| | |
|---|---|
| ABCDF | Aberdeen Chemical Agent Disposal Facility (Maryland) |
| ACAMS | automatic continuous air monitoring system |
| ACWA | Assembled Chemical Weapons Alternatives |
| ANCDF | Anniston Chemical Agent Disposal Facility (Alabama) |
| BAST | Board on Army Science and Technology |
| BDS | bulk drain station |
| BGCAPP | Blue Grass Chemical Agent Destruction Pilot Plant (Kentucky) |
| BHS | bulk handling system |
| CAMDS | Chemical Agent Munitions Disposal System |
| CDTF | Chemical Demilitarization Training Facility (Edgewood, Maryland) |
| CHB | container handling building |
| CMA | (U.S. Army) Chemical Materials Agency |
| CWC | Chemical Weapons Convention |
| DAAMS | depot area air monitoring system |
| DCD | Deseret Chemical Depot (Utah) |
| DCP | document change procedure |
| DFS | deactivation furnace system |
| DOD | Department of Defense |
| DOT | Department of Transportation |
| DPE | demilitarization protective ensemble |
| DPPBI | Director's Programmatic Performance-Based Incentive |
| ECP | engineering change proposal |
| ECR | explosion containment room |
| GA | tabun (a nerve agent) |
| GB | sarin (a nerve agent) |
| H | sulfur mustard |
| HAZWOPER | hazardous waste and emergency response (standard) |
| HD | sulfur mustard (distilled) |
| HEPA | high-efficiency particulate air |
| HMI | human-machine interface |
| HRO | high reliability organization |
| HT | sulfur mustard, T-mustard mixture |
| HVAC | heating, ventilation and air conditioning |
| I/O | input/output |
| JACADS | Johnston Atoll Chemical Agent Disposal System (South Pacific Ocean) |
| LAN | local area network |
| LIC | liquid agent incinerator |
| MACT | maximum achievable control technology |
| MDB | munitions demilitarization building |
| MDMs | multipurpose demilitarization machines |
| MHS | mine handling system |
| MiniCAMS | miniature chemical agent monitoring system |
| MM | mine machine (drain station) |
| MPB | munitions processing bay or building |
| MPF | metal parts furnace |
| NECDF | Newport Chemical Agent Disposal Facility (Indiana) |
| NRC | National Research Council |
| OEM | original equipment manufacturer |
| OEM-LP | obsolescent equipment management lifecycle program |
| OSHA | Occupational Safety and Health Administration |

| | |
|---|---|
| PAS | pollution abatement system |
| PBCDF | Pine Bluff Chemical Agent Disposal Facility (Arkansas) |
| PCAPP | Pueblo Chemical Agent-Destruction Pilot Plant (Colorado) |
| PDARS | process data acquisition and recording system |
| PFS | PAS carbon bed filter system |
| PHS | projectile handling system |
| PLCs | programmable logic controllers |
| PMCD | program manager for chemical demilitarization |
| PMCSD | project manager for chemical stockpile demilitarization |
| PMCSE | project manager for chemical stockpile elimination |
| PMD | projectile or mortar disassembly (machine) |
| RCRA | Resource Conservation and Recovery Act |
| RFID | radio frequency identification |
| RHS | rocket handling system |
| RIR | recordable injury rate |
| RSM | rocket shear machine |
| SCBA | self-contained breathing apparatus |
| TOCDF | Tooele Chemical Agent Disposal Facility (Utah) |
| UMCDF | Umatilla Chemical Agent Disposal Facility (Oregon) |
| UPA | unpack area |
| VX | a nerve agent |

# Summary

This report focuses on issues pertaining to the continuing operability of the four chemical agent stockpile incineration facilities that are currently operated by site contractors under contract with the U.S. Army's Chemical Materials Agency (CMA). These facilities use several incineration furnace systems for the demilitarization (destruction) of the U.S. stockpile of obsolete and aging chemical weapons stored at each site. The report addresses potential weaknesses in the operability of the furnace systems' infrastructure and equipment, given that the facilities are being operated well beyond their original design lifetimes; assesses the Army's current and evolving obsolescence management programs;[1] and provides advice on ways these programs may be improved and strengthened to support safe and expeditious completion of stockpile destruction operations and closure of facilities at sites where incineration technology is being used.

## BACKGROUND

The director of the CMA requested that the National Research Council (NRC) assess and evaluate current and proposed policies and approaches by the Army and its contractors to adequately anticipate and address equipment and facilities obsolescence issues at chemical agent stockpile incineration facilities. This assessment examines the extent to which these policies and approaches are consistent with generally accepted practices in the chemical process industry. In conducting this assessment in accordance with the statement of task, the NRC's Committee on Continuing Operability of Chemical Agent Disposal Facilities and Equipment evaluated current and proposed activities involving:

- anticipation of equipment needs and upgrading facilities in a manner that does not compromise plant safety or environmental compliance, or have severe adverse effects on schedule;
- extension of the operational life of equipment and facilities as necessary while not compromising worker health and safety or environmental compliance;
- strategies to overcome scarce availability of spare parts and/or services for aging systems;
- prioritization plans for addressing obsolescence issues; and
- ensuring plant reliability, availability, and maintainability while upgrading equipment and facilities.

The four incineration facilities that are the main focus of this report all share a common design basis, and specialized major equipment items were procured for all the facilities in the 1990s. The refractory-lined furnaces and afterburners cause some operating constraints because they are susceptible to damage from thermal transients and must be kept hot during short-term changes in processing operations. Most major maintenance is scheduled during agent campaign changeovers when the furnaces are slowly cooled to a shutdown condition.

Similarly, plant personnel are highly trained and experienced in the particular chemical demilitarization operations, which makes it impractical to mothball or decommission a facility until after its mission is completed satisfactorily. Even at that point, some of the facility equipment and well-trained personnel will still be needed for closure activities to clean and remove all contaminated parts of the facility. Delays in processing not only increase program costs but also prolong the risk to the public of exposure to the aging stockpile.

The Army has standard procedures for addressing the

[1]"Obsolescence" is defined in the Merriam-Webster Online Dictionary as "the process of becoming obsolete or the condition of being nearly obsolete." "Obsolete" is defined as "no longer in use or no longer useful." See www.m-w.com/dictionary. Accessed July 12, 2006.

obsolescence of conventional military equipment and munitions, but these do not apply to an operational chemical stockpile processing facility. Normal chemical industry practices for preventing obsolescence in chemical processing plants apply only partially to stockpile disposal processing plants because of the latter's unique design and finite length of operation. Most chemical and manufacturing plants use well-developed technologies and are designed to operate efficiently and indefinitely with relatively common equipment—not just until a finite task is accomplished.

The most rational approach to mitigating obsolescence for stockpile processing facilities would allow for some equipment obsolescence or degradation as the plants age, as long as programmatic objectives can be ensured. Replacing old but still functional equipment unnecessarily would interrupt plant operations and schedule. Furthermore, such changes often require permit modification at the state level, which may cause an additional extension in schedule.

## CONDUCT OF THE STUDY

To accomplish its tasks the committee received briefings from government and contractor personnel associated with the chemical agent stockpile disposal program administered by the CMA. Members of the committee visited all of the four operating incineration system facility sites to gather information on the vulnerability of these facilities to obsolescence and other issues related to continuing operability. The committee focused on program vulnerabilities in four broad issue areas: (1) aging of critical facilities and equipment; (2) diminishing sources for components and spare parts; (3) loss of experienced personnel; and (4) information management.

The committee paid particular attention to operational experience gained at the now fully cleaned and decommissioned Johnston Atoll Chemical Agent Disposal System (JACADS) over the full life cycle of that facility,[2] and at the Tooele Chemical Agent Disposal Facility (TOCDF) in Utah, which is the oldest plant currently operating and the incineration facility where obsolescence problems are most likely to be encountered first. The committee also visited disposal facilities at Anniston, Alabama (ANCDF); Umatilla, Oregon (UMCDF); and Pine Bluff, Arkansas (PBCDF). The committee learned that programs to anticipate and manage problems associated with obsolescence have been initiated at all of these sites.

In the course of this study, the committee identified potential problems and examined various aspects concerning basic processing operations. It also assessed site-related and programmatic factors and influences affecting the continuing operability of the disposal facilities.

## REVIEW OF PROCESSING EQUIPMENT AND OPERATIONS

As a practical matter, all facilities and equipment become obsolete at some point in time. Even so, obsolescence does not necessarily mean nonfunctionality, as long as safety, environmental performance, operability, and the overall schedule of operations for a facility are not adversely impacted. Thus, with regard to chemical weapons destruction, the Army's objective is to ensure the continuing capability to safely and expeditiously process the remaining items in the chemical stockpile. The incineration sites have fairly well defined operational duties, and there is long experience with the equipment such that reliability and failure modes are well known. A proactive obsolescence management program can allow older equipment to function satisfactorily through the finite lifetime of the sites and also identify areas where replacement of equipment is warranted.

The committee investigated current obsolescence-related vulnerabilities in the CMA program as well as reviewed its past experience and future plans. Areas examined included the expected life cycle of the facilities themselves, the availability of spare and replacement equipment parts, disassembly robotics, furnaces and afterburners, and control systems.

The four currently operating incineration plants that are the focus of this study were designed in the 1980s, and major equipment items were procured together in the 1990s. These plants are expected to be in operation for another five or more years to complete stockpile processing and for an additional two to three years to accomplish closure. Considerations for continuing operability must also include location-specific vulnerabilities that might impact operations (e.g., those associated with site security, communications, or the integrity of utilities and emergency systems).

As equipment ages or becomes obsolescent and spare parts are no longer manufactured, the requirement to maintain and share adequate stocks of replacement parts becomes ever more critical. To date there is no evidence that major items critical to the continuing operability of chemical agent stockpile incineration facilities have been unavailable, causing operations to be stopped for a significant time.

Although the robotics and furnaces employed in chemical demilitarization are unique, they are robustly designed and are expected to have adequate operating life if they are maintained and upgraded as needed. The designers and manufacturers of these components are continuing businesses that are available for support and spare and replacement parts production.

Where there are problems due to aging of robotic components, the staff at the uncontaminated chemical demilitarization training facility (CDTF) at the Edgewood Area of

[2]Johnston Atoll is located in the Pacific Ocean approximately 700 miles southwest of Hawaii.

Aberdeen Proving Ground (Maryland), and the associated skunk works operated by General Physics Corporation have facilitated troubleshooting of robotics problems when they are encountered at the sites.[3]

The incineration facilities use several furnaces to complete the disposal process. A liquid incinerator destroys agent. A deactivation furnace system destroys energetic materials. To decontaminate the metal munition bodies and certain other materials, a metal parts furnace is used. The furnaces are critical to both the operation and the closure of the disposal facilities. In past operations the deactivation furnace system (DFS) kiln shell has exhibited periodic damage from the destruction of residual explosives. A loss of a furnace during operations would delay disposal operations for a significant period because of long procurement times.

The original control system design common to all of the incineration sites is also based on 1980s technology. Some improvements have been made to support continuing operations.

## SITE-RELATED INFLUENCES ON CONTINUING OPERABILITY

Each of the chemical agent stockpile incineration facility sites operates within a structure of policies, procedures, and training programs. As the facilities and equipment age, changes will be needed to proactively manage obsolescence. Changes to equipment, systems, and procedures are addressed by a process for active management of change, which has direct implications for the personnel involved at all levels. It is not just equipment that becomes obsolescent and requires adaptation; personnel involved in operations, laboratories, and maintenance all have skills and knowledge that change over time. Thus far, interchangeability of spare parts and expertise among the four sites has been useful and could offer considerable future benefits for the continuing operability of these incineration facilities.

The consequences of error in chemical weapons demilitarization are potentially large, and any involved organization must maintain a consistently low error rate over extended time periods to ensure public safety and public confidence. The committee observed that some of the principles that apply to high-reliability organizations were evident at all sites visited.

The CMA has determined that standard Army stockpile obsolescence management programs are not suitable for the demilitarization processing facilities, and has asked each of the sites to begin implementing effective obsolescence management programs that include cooperation with other sites.

The plant configuration is updated as changes are made through a management of change process that is intended to ensure operational safety and regulatory compliance. Each site also has systems in place for managing safety and environmental compliance, as well as to train and retain a knowledgeable workforce.

Aging equipment can continue to be operated safely if a rigorous testing, maintenance, and replacement program is followed. This approach requires, however, that the capabilities of site personnel be continually updated and renewed, especially as employees leave and new ones are hired and as equipment and procedures are updated. Specialized knowledge and skills must also be retained throughout the lifetime of operations and facility closure.

Information management is important to the management of obsolescence at stockpile sites, because it tracks the history of changes in the facilities and personnel over the lifetime of operations. Data of this sort can aid in identifying areas of potential obsolescence, facilitate forward planning, provide a permanent record that documents operations, and allow tracking of abnormal incidents.

The committee conducted a thorough review of the information management systems at the sites. This is an area that has not been thoroughly reviewed as a whole in the past by an NRC committee and includes physical facilities (servers, desktop units, storage, and distribution), software (operating systems and applications), and system development processes. The committee's major concern relates to the inconsistent way that information management is being practiced within and between sites.

## PROGRAMMATIC INFLUENCES ON CONTINUING OPERABILITY

In addition to a concern for the continuing operability of facilities, the management of facility obsolescence is affected on a programwide level by organizational structure, contractual relationships and incentives, community and regulatory relationships, and planning for emergencies and closure.

In the past five years CMA program management has shifted from an earlier model whereby the former management administered through the office of the program manager for chemical demilitarization (PMCD) provided top-down direction to site contractors. The current model involves a much smaller CMA staff that manages site performance through contractual incentives intended to encourage meeting CMA goals. Site management responsibility has shifted largely to individual site managers, with the CMA providing general guidance and oversight.

A result of this is that the strategies for obsolescence management developed at individual sites have significant differences. The CMA is encouraging interchanges among the sites and hopes that each may improve its plans by understanding approaches at other sites.

Continuing operability is as much a function of personnel management challenges and issues as it is of equipment

[3] The term "skunk works" in this context refers to a group within an organization given a high degree of autonomy to creatively address engineering and technical problems with minimal bureaucratic obstacles.

and supporting hardware concerns. An essential practice in the chemical industry is the tracking of abnormal events, their analysis, and the implementation of changes to minimize their recurrence—so called lessons-learned programs. The CMA lessons-learned program has been reinvented. The original program, while remaining available, is used only rarely. The new system is well designed, and the site managers report both regular additions to the database and increased usage.

The Department of Defense and congressional officials have expressed concern regarding the escalating cost of the chemical stockpile disposal program. Chemical stockpile demilitarization is safety and schedule driven. Although cost cannot be ignored, it has been subordinated to higher-priority project goals, such as ensuring the safety of workers, the public, and the environment. Nevertheless, adequate funding to maintain demilitarization facility operations is necessary to ensure timely elimination of the risk of the chemical weapons stockpile, especially as the stockpile continues to deteriorate.

As noted previously, closure operations of the four incineration facilities start at least four to six years following the publication of this report and continue for an additional two to three years. Steps are needed to ensure that the operational life of certain key equipment extends through the decommissioning and closure of the facilities.

## FINDINGS AND RECOMMENDATIONS

The committee developed findings and recommendations and prioritized each recommendation as being in one of three tiers, with Tier 1 being the highest and most important. Although all the recommendations are important, the committee considers the Tier 1 recommendations to be critical to the life-cycle continuing operability of the chemical stockpile demilitarization program. Tier 2 recommendations are important components supporting the Tier 1 recommendations. Tier 3 recommendations address more detailed items suggested for implementation. Table S-1 shows the hierarchy according to tier level for related recommendations.

The following findings and recommendations are from Chapter 2.

**Finding 1.** The four operating incineration facilities, although aging, are capable of safe and effective destruction of remaining stockpile inventories and completion of closure activities at each site, if strong and comprehensive obsolescence management programs are implemented. However, each chemical agent disposal facility is susceptible to location-specific external factors that may change over time. A need exists for these factors to be determined and evaluated at each site on a periodic basis.

**Recommendation 1.** An operational security analysis program should be established for each chemical agent disposal facility to evaluate external factors (including the integrity of critical utilities) that could adversely impact continuing operability. **(Tier 3)**

**Finding 2.** The contract with Rockwell Automation for management of control system spares is an effective way to ensure long-term availability of control system spares. This contract is currently subject to annual renewal as part of an existing WGI-JACADS contract.[4] This holding-pattern approach to a long-term commitment is due in part to an indemnification issue pertaining to issuance of a new longer-term contract.

**Recommendation 2.** The Chemical Materials Agency should implement a firm long-term contract to handle control system spares management for each of the four incineration facilities and the Chemical Demilitarization Training Facility at the Edgewood Area of Aberdeen Proving Ground. This contract should be structured to provide support through all related closures. **(Tier 2)**

**Finding 3.** No systematic approach exists for managing spare parts inventories across the four different chemical agent stockpile incineration facility sites, although there is a clear need for one. The committee found effective systems at some sites, but they are not consistent in parts identification codes, do not integrate information about control system spares, do not have internal trending and tracking capabilities, and only react to loss of suppliers on discovery that a supplier is no longer able to provide needed parts, typically when parts are reordered.

**Recommendation 3.** The Chemical Materials Agency should implement a more formal inventory management system that models usage, usage variability, lead times, and costs to ensure a very low rate of out-of-stock items. The spare parts inventory should be modeled across the four chemical agent stockpile incineration facility sites to ensure the capability to translate across different identification numbers for the same spare part, and to facilitate the optimum distribution of inventory between site warehouses and the central parts storage warehouse. Such a coordinated spare parts inventory management system should be accessible to and updated regularly by all sites and should indicate the status of key vendors supporting spare parts availability. A proactive program should be instituted to check more regularly whether each inventory item is still available, for example, by telephone or Internet query. **(Tier 2)**

[4]This contract will exist until all the JACADS environmental permits are closed.

TABLE S-1 Tier-Level Hierarchy for Related Recommendations

| Recommendation Number and Topic Area by Tier Level | | |
|---|---|---|
| Tier 1 | Tier 2 | Tier 3 |
| 6 (CMA oversight of control system improvements)<br>9 (Safety programs) | | |
| | 21 (Lessons-learned program) | |
| | | 1 (Continuing operational security analyses) |
| 18 (CMA staffing)<br>19 (Programmatic guidance)<br>20 (Intersite obsolescence management) | | |
| | 3 (Integrated spares management) | |
| | | 2 (Control system spares contract)<br>5 (Spare DFS kiln) |
| | 8 (Development of consistent obsolescence management system) | |
| | | 4 (Maintain skunk works)<br>7 (Replace inapplicable DOD standards)<br>23 (Key equipment planning for closure) |
| | 10 (Knowledge management)<br>11 (Personnel retention)<br>12 (Information management) | |
| | | 13 (Servers)<br>14 (PCs)<br>15 (Operating systems)<br>16 (Data formats and archiving)<br>17 (Ongoing information management surveys and assessments) |
| 22 (Continuous, predictable funding) | | |

**Finding 4.** The Chemical Demilitarization Training Facility/skunk works remains an extremely valuable resource for continued support of the disassembly robotics operation.

**Recommendation 4.** The Chemical Demilitarization Training Facility/skunk works facility and its knowledgeable personnel should be maintained as a support resource until all chemical agent stocks have been safely removed from storage and processed by the disassembly robotics at all incineration sites. **(Tier 3)**

**Finding 5.** Upcoming chemical agent disposal campaigns at ANCDF, UMCDF, and PBCDF have some potential to severely degrade the DFS kiln shells. Procurement of new kiln sections requires a lead time of about a year.

**Recommendation 5.** The Chemical Materials Agency should implement its plan to order a spare DFS kiln in time for mine disposal operations at ANCDF and continue to evaluate whether additional kilns are needed to support the subsequent campaigns at UMCDF and PBCDF. **(Tier 3)**

**Finding 6.** The process control system design is old, but the systems can be satisfactorily maintained and are being upgraded as justified to enhance performance. There is some divergence in the choice of components at individual chemical agent disposal facility sites as upgrades are made, and this may limit future interchangeability of parts and operational knowledge.

**Recommendation 6.** The Chemical Materials Agency should continue to oversee control system improvements at individual chemical agent stockpile incineration facility sites to ensure that total performance standards are met and that sites coordinate those parts of the control system and its operation that can provide more robust continuing operations at a programmatic level. **(Tier 1)**

The following findings and recommendations are from Chapter 3.

**Finding 7.** The Department of Defense (DOD) standards on obsolescence are focused on criteria and considerations concerning obsolete weapons and other military equipment stockpiles. The DOD standards do not address the broader range of issues encountered in an operational processing facility. Another barrier to partial use of these standards is that they categorize the risk of obsolescence in a manner that is the inverse of the stockpile facilities' long-standing categorization of safety-related risks.

**Recommendation 7.** The Chemical Materials Agency should disengage from using the inapplicable DOD diminishing manufacturing sources and material shortages standards and develop a program for obsolescence management that is tailored to the needs of the chemical agent stockpile disposal program. **(Tier 3)**

**Finding 8.** The site contractors for the chemical agent stockpile incineration facility sites are developing and implementing plans for managing obsolescence at each site. The Army and its contractors recognize that a process to continuously identify and evaluate critical components and parts is necessary to offset increasing vulnerability to obsolescence. Evolving systems at the various sites differ in approach and how critical components and parts are identified. These differences can have adverse implications for future program obsolescence management.

**Recommendation 8.** The Chemical Materials Agency should implement an effective, consistent, and documented system to manage obsolescence, including the sharing of expertise and spare equipment and parts across the chemical agent stockpile incineration facility sites. **(Tier 2)**

**Finding 9.** The chemical agent stockpile incineration facility sites all have adequate safety programs, but there is considerable variability from site to site in definitions of critical safety systems; dissemination and response to site-specific and programmatic safety alerts (advisories); procedures for control of nonroutine hazardous work; details in policies for management of change systems; applicable attributes of high-reliability organizations; and organization and implementation of training programs, including the testing of their effectiveness. As facilities and their equipment continue to age, effective safety programs must be maintained until each facility is fully decommissioned (closed).

**Recommendation 9.** In the interest of continuing safe operability, facility staff at each chemical agent stockpile incineration facility site should continue to compare their operations and performance with those at other sites and with practices in the broader chemical industry for dealing with hazardous materials to ensure continual improvement in safety performance, consistency in major safety practices, and safety-related cooperation among the sites. **(Tier 1)**

**Finding 10.** Only limited evidence was observed regarding programs or measures to share or protect the knowledge base important to the safe and effective functioning of the various communities that together constitute the capabilities on which the operability of chemical agent stockpile incineration facility systems depends.

**Recommendation 10.** A formal knowledge management program should be implemented by site managers under the guidance of the Chemical Materials Agency to identify various communities of practice among the workforce at chemical agent stockpile incineration facility sites, define the skills these communities encompass, and ensure that the skills of each member in a particular community are made available to the community as a whole as necessary. This program should also monitor the skills inventory in each community with the aim of detecting potential vulnerabilities (e.g., situations where the personnel to deliver any particular mission-critical capability are limited), and implement measures to retain staff and increase capabilities among staff where such vulnerabilities (limitations) are encountered. **(Tier 2)**

**Finding 11.** Personnel turnover varies across chemical agent stockpile incineration facility sites, but is generally low. However, this situation may not continue as facilities approach the end of disposal operations. Retention incentives have not yet been applied in an effective manner to help ensure continuing safe operations.

**Recommendation 11.** The Chemical Materials Agency should ensure that site contractors promptly develop staffing plans capable of being tailored to site-specific needs while recognizing the challenges of maintaining a competent staff throughout operations and closure. **(Tier 2)**

The following findings and recommendations are from Chapter 4.

**Finding 12.** The committee found no central or unified approach to identifying information technology solutions and implementing information technology changes at chemical agent stockpile incineration facility sites. This lack can lead to an erosion of compatibility, increased costs, a reduced potential for interoperability, and other challenges to continued operation.

**Recommendation 12.** The Chemical Materials Agency should implement a mechanism to coordinate and formally demand consensus in areas of information management where joint operations between the chemical agent stockpile incineration facilities are appropriate. Such mechanisms should be developed, implemented, and reinforced for the remaining life span of the chemical agent stockpile disposal program. **(Tier 2)**

**Finding 13.** The server systems at chemical agent stockpile incineration facilities in their present physical state do not constitute a threat to the continuing operability of the facilities as long as budgets and management procedures enable the progressive updating and replacement of systems as needed.

**Recommendation 13.** Continued vigilant monitoring and maintenance of servers, based on adequate funding and management of core capabilities, is a mandatory element of the continued operability of chemical agent stockpile incineration facilities and should be ensured across sites under guidance from the Chemical Materials Agency. **(Tier 3)**

**Finding 14.** While personal computers (PCs) dedicated to typical office applications are generally kept relatively modern and up-to-date at chemical agent stockpile incineration facility sites, certain other PCs in use in laboratories, because of their linkages to dated analytical facilities, are out-of-date to the point that their continued use is problematic.

**Recommendation 14.** The Chemical Materials Agency (CMA) should devise and implement a life-cycle replacement program for all PCs. Consideration should be given to setting a maximum life span for PCs (e.g., three years) and replacing older machines with current hardware according to a predetermined service cycle. The CMA should specify that when a PC has been retained beyond a reasonable life-cycle expectation because it was required to support dated peripheral devices, software, or other features that are themselves substantially dated, alternatives to those peripheral items, should be identified and if possible acquired so that the overall system can be updated to current standards. **(Tier 3)**

**Finding 15.** A wide range of operating systems exist in the chemical agent stockpile incineration facilities, and this variability could pose problems for effective long-term continued operability. At the least, costs and maintenance are complicated by this diversity and apparent lack of integrated planning.

**Recommendation 15.** The Chemical Materials Agency should conduct an overall evaluation of security requirements, maintenance implications, and impending evolutionary changes in the basic computer operating systems (Windows and Linux) used at chemical agent disposal facilities. A migration path that drives toward a minimally heterogeneous and maximally robust environment should be identified and considered for implementation. **(Tier 3)**

**Finding 16.** A variety of data formats are used in different contexts in the chemical agent stockpile incineration facilities, and the prospect of long-term records retention and recovery is complicated by the resulting variability of native data formats.

**Recommendation 16.** The Chemical Materials Agency (CMA) should consider formally requiring that each copy of an electronic document requiring long-term availability be preserved in an agreed permanent or semipermanent form defined by the CMA (e.g., ASCII or portable document format). **(Tier 3)**

**Finding 17.** Service and support capabilities in the information management sector are continually improving.

**Recommendation 17.** Annually or biennially, the Chemical Materials Agency should survey current information management maintenance options, determine whether costs and benefits in the systems under consideration are consistent with current best practices, and require changes in practice programwide where improvements in reliability or reductions in cost are identified that can secure continued operability. **(Tier 3)**

The following findings and recommendations are from Chapter 5.

**Finding 18.** The program manager for chemical stockpile elimination (PMCSE, formerly PMCSD) has a small central staff, which limits the technical expertise that is available within the Chemical Materials Agency (CMA). The PMCSE is responsible to the CMA director for the functioning of the chemical agent stockpile incineration facility sites but has no contracting or other authority to ensure a desired result. The PMCSE must depend on personal persuasion and the responsibility of site contractors, operating under CMA-generated financial incentives, to keep the chemical agent stockpile disposal program functioning safely and effectively.

**Recommendation 18.** The Chemical Materials Agency (CMA) and Army management of the chemical stockpile elimination program should adjust PMCSE resources and authority, commensurate with CMA responsibility, to manage the program in the interest of the Army and the U.S. citizenry. Adjustments should ensure that an appropriate balance between assigned responsibility, resource adequacy, and granted authority is attained. **(Tier 1)**

**Finding 19.** Adoption of the site-focused management system, while promoting some improvements in the workforce culture and performance at chemical agent stockpile incineration facility sites, risks allowing a degree of independence in contractor decision making and action that could result in a loss of a critical capability for interchangeability crucial to continuing operability.

**Recommendation 19.** The Chemical Materials Agency should exercise sufficient centralized management control to ensure that there is appropriate programwide interchangeability of resources important to the continuing operability of chemical agent disposal incineration facilities. **(Tier 1)**

**Finding 20.** The Chemical Materials Agency has initiated an obsolescence management program that is based on using contractual means to incentivize chemical agent stockpile incineration facility site contractors to develop site-specific programs and then to share approaches and specific strategies across sites. Although the program is still evolving, the sites have begun to approach some obsolescence issues collectively.

**Recommendation 20.** The Chemical Materials Agency should strengthen its obsolescence management strategies programmatically and at each chemical agent stockpile incineration facility site to incorporate measures for intersite coordination and cooperation to facilitate continuing operability through to the completion of the chemical stockpile disposal program. **(Tier 1)**

**Finding 21.** The current lessons-learned system is much better organized and user-friendly than the original system, and is actively used to retain past and current programmatic knowledge of operational and hardware improvements.

**Recommendation 21.** The current lessons-learned program should be continually evaluated and improved as appropriate to ensure the safety and continuing operability of the chemical agent stockpile incineration facilities as obsolescence challenges increase. Wider topical aspects should be incorporated, including near-miss information and root cause accident analyses. Provision should also be made for incorporation of lessons learned into all training programs, as well as for incentives at the individual employee level when appropriate contributions to the lessons-learned program are made. **(Tier 2)**

**Finding 22.** Factors impacting the chemical stockpile disposal program include:

- scheduling pressure driven by compliance with the Chemical Weapons Convention;
- safety demands of dealing with highly toxic materials;
- requirements of detailed and demanding environmental permits;
- high public and political visibility; and
- a mandate to minimize risk to the public, to workers, and to the environment.

To ensure the continuity of operations in view of these circumstances, a stable workforce and a stable, continuous source of funds are required. Failure to provide for funding continuity will undoubtedly lead to program interruption and adversely affect the completion date for demilitarization operations as well as program costs. Adequate, stable, and dependable funding of the chemical stockpile disposal program is an essential element of program success.

**Recommendation 22.** The Department of the Army, Department of Defense, Office of Management and Budget, and Congress should recognize the critical need for adequate, continuous, and predictable funding of the Chemical Materials Agency as a basis for operational planning essential to accomplishing the mission of chemical agent stockpile disposal. **(Tier 1)**

**Finding 23.** Plans for mitigating the obsolescence of key equipment that will be required for closure of chemical agent stockpile incineration facilities, such as the LIC and MPF furnaces with their PAS/PFS systems, have not yet been developed.

**Recommendation 23.** Key equipment required for closure of chemical agent stockpile incineration facilities should be identified now, and steps to mitigate and manage obsolescence should be extended to include that equipment's operational life. **(Tier 3)**

# 1

# Introduction

This report presents the findings of the National Research Council (NRC) Committee on the Continuing Operability of Chemical Agent Disposal Facilities and Equipment. Although focused on equipment/facilities obsolescence at chemical agent stockpile incineration facilities, the report takes a broader view of the problem in the context of the ability of the facilities to satisfactorily complete their site and programmatic missions. [1] How these systems are managed, repaired, replaced, and maintained is important to "continuing operability."

## BRIEF HISTORY OF CHEMICAL STOCKPILE DISPOSAL PROGRAM

The United States has stockpiled chemical agents and weapons for more than 50 years. The agents include the nerve agents GA, GB, and VX and the mustard blister agents H, HD, and HT. Following their manufacture, these agents were loaded into millions of individual munitions or stored in bulk containers. Almost all the agent and containment systems are over 40 years old and are deteriorating. In 1985 the U.S. Congress directed the Army to begin destroying the M55 rockets in the stockpile. The Army was subsequently mandated by Congress in 1992 to destroy the entire stockpile (Public Law 102-484). In 1997 the United States became a signatory to the Chemical Weapons Convention (CWC) following its ratification by Congress. This in turn required that the stockpile be totally destroyed by April 29, 2007. The provisions of the CWC provide for a five-year extension to the ten-year period following ratification during which declared chemical warfare items are to be destroyed. Application for a five-year extension to 2012 was approved in late 2006.

Since 1984, the NRC has provided scientific and technical guidance to the Army on important aspects of the stockpile disposal plans and programs with an overarching goal of safe and expeditious implementation of stockpile destruction. This guidance has taken the form of over 40 reports produced to date.

Box 1-1 shows a timeline with some historic program milestones. At the start of the disposal program, the chemical weapons stockpile was located at eight U.S. sites and on Johnston Island in the mid-Pacific. Table 1-1 shows the locations and the present status of disposal at the individual sites. Because of its remote location, the Johnston Atoll Chemical Agent Disposal System (JACADS) was used to demonstrate the baseline incineration system destruction technology developed by the Army. The stockpile consists of bulk storage tanks as well as rockets, mines, bombs, cartridges, and projectiles. The stockpile munitions are configured with bursters and propellant charges, but were not designed for disassembly. Although the Army had some limited experience with the destruction of chemical weapons in the past, the size and complexity of the entire original stockpile of over 30,000 tons of chemical agents along with the associated munitions and containers created a major new challenge. The destruction process involves disassembly that includes robotic separation of agent from munitions and bulk containers within an explosive containment structure, followed by incineration of the separated streams in three special types of furnaces: (1) the liquid agent incinerator (LIC); (2) the deactivation furnace system (DFS), for energetics and smaller metal parts; and (3) the metal parts furnace (MPF), for bulk metal and waste items. Associated systems for monitoring, treatment of all effluents, process control, and utilities have been designed and operated to protect the safety of the process as well as that of the workers, the community, and the environment. Because of the unique nature of the

[1]Obsolescence is defined in the Merriam-Webster Online Dictionary as "the process of becoming obsolete or the condition of being nearly obsolete." Obsolete is defined as "no longer in use or no longer useful." See www.m-w.com/dictionary. Accessed July 12, 2006.

**BOX 1-1**
**Some Historic Milestones in the U.S. Chemical Weapons Program**

| | |
|---|---|
| 1942-1945 | Mustard H manufactured at Rocky Mountain Arsenal |
| 1945-1946 | Mustard HD made at Rocky Mountain Arsenal |
| 1953-1957 | GB made at Rocky Mountain Arsenal |
| 1961-1968 | VX made at Newport, Indiana, munitions loaded with agent and stockpiled |
| 1981 | CAMDS started for limited munitions processing (now in closure) |
| 1982 | Army recommends use of separation of munitions followed by incineration for chemical stockpile disposal |
| 1983-1984 | NRC Committee on Demilitarization of Chemical Munitions and Agents writes 1984 report. Stockpile destruction end date estimated by Army as 2001 |
| 1985 | PL 99-145 mandates M55 rockets destruction |
| 1985 | Life-cycle program cost estimate $2.1 billion |
| 1987 | NRC Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program formed (it issued more than 40 reports before it ended in 2005) |
| 1990 | JACADS commenced operations |
| 1992 | PL 102-484 mandates destruction of entire stockpile |
| 1994 | Army estimates stockpile destruction completed by 2003 (NRC, 1994) |
| 1995 | Life-cycle program cost estimate $12.7 billion |
| 1996 | TOCDF commenced operations |
| 1998 | Life-cycle program cost estimate $15.3 billion |
| 2002 | JACADS completed operations (now closed) |
| 2003 | ABCDF commenced operations (now in closure)<br>ANCDF commenced operations |
| 2004 | Life-cycle program cost estimate $24.7 billion<br>UMCDF commenced operations |
| 2005 | NRC standing Committee on Chemical Demilitarization formed in 2005, PBCDF started, ACWA site design contracts let |
| 2006 | Life-cycle program cost estimate $25.8 billion |

stockpile, the facility design involved the integration of components, some standard and some unique, into a new prototype design that was built at JACADS.

JACADS operations were started in 1990, and although that facility performed well, lessons learned during JACADS operations were incorporated into the design of the second-generation plant at the Deseret Chemical Depot (DCD) in Tooele, Utah. Since the Army planned to continue to employ the basic design of its incineration system at the various sites, when major specialized equipment was ordered for the Tooele Chemical Agent Disposal Facility (TOCDF) in the 1980s, duplicates of major items were also procured for incineration facilities to be constructed subsequently.[2] (At that time, the estimate for program completion was 2001.) This equipment included the large specialized furnaces, disassembly robotics, and the plant control systems. Such equipment was stored until the subsequent sites received approval for construction. Consequently, much of the major equipment in the present incineration facilities is of 1980s or earlier design and was delivered in the early 1990s. As TOCDF was built and operations begun in the mid-1990s, the Army learned that it had seriously underestimated the time required to obtain permits at sites in the continental United States and the program timeline started to extend considerably.

The Army has scheduled the demilitarization operations at each site on the basis of destroying the highest-risk stockpile components first. Therefore, items containing GB were processed first, VX second, and mustard agent last. In between each agent campaign the disposal facility equipment is cleaned, scheduled maintenance is performed, and the agent monitoring capability is modified for the next agent. In each agent campaign the M55 rockets are processed first because of concerns about their long-term stability and their potential for creating the highest risk to the public in the event of a storage accident. Their destruction is then followed by that of other munitions and finally by destruction of bulk items.

A previous NRC committee assessed the degradation of the stockpile condition over time and its effects on stockpile disposal operations (NRC, 2004). Some of the concerns addressed in that report included:

- degradation of agent leading to crystallization or gelling that impedes agent draining during processing;
- corrosion problems leading to leakage; and
- potential destabilization of M55 rocket propellant grains.

These and other aging problems are likely to continue and worsen over time, with potential impacts on both stockpile and processing safety. Thus, an incentive exists to dispose of the stockpile as soon as possible.

The schedule for the overall demilitarization of the nation's stockpile has continued to slip considerably from initial Army projections for a variety of reasons, including permitting delays, budget constraints, and some operational problems. Therefore, the aging of the equipment, the unavailability of spare parts, and the loss of specialized expertise are among current concerns since these factors may impede the safe and effective operability of the disposal

[2]Congress had mandated against the transport of any part of the chemical stockpile. Consequently, destruction facilities had to be built at each site where the U.S. chemical stockpile was stored.

TABLE 1-1 Stockpile Sites and Disposal Status as of January 2006

| Site | Percent of Original Stockpile | Stockpile Components | Disposal Status |
|---|---|---|---|
| JACADS/Johnston Island | 6.6 | All agents<br>Munitions and bulk | Prototype plant<br>Destruction completed<br>(in final environmental closure) |
| ABCDF/Aberdeen, MD | 5.0 | HD ton containers | Neutralization plant<br>Destruction completed<br>Into closure operations |
| TOCDF/Tooele, UT | 42.3 | All agents<br>Munitions and bulk | 2nd generation incineration plant<br>54.5% destroyed<br>(all GB and VX) |
| ANCDF/Anniston, AL | 7.1 | All agents<br>Munitions and bulk | 3rd generation incineration plant<br>18.7% destroyed<br>(all GB) |
| UMCDF/Umatilla, OR | 11.6 | All agents<br>Munitions and bulk | 3rd generation incineration plant<br>7.9% destroyed |
| PBCDF/Pine Bluff, AR | 12.0 | All agents<br>Munitions and bulk | 3rd generation incineration plant<br>4.7% destroyed |
| NECDF/Newport, IN | 3.9 | VX ton containers | Neutralization started<br>Hydrolysate being stored pending disposal decision |
| PCAPP/Pueblo, CO | 9.9 | HD<br>Munitions | In design and site preparation |
| BGCAPP/Blue Grass, KY | 1.6 | All agents<br>Munitions and bulk | In design and site preparation |

SOURCE: Adapted from Chemical Stockpile Disposal (CSD) Facilities and Equipment Obsolescence Assessment. Briefing by Joseph Pecoraro, project manager for chemical stockpile disposal, CMA, to the committee, January 25, 2006.

facilities during the remainder of destruction operations and facility closure at each site.

## FOCUS AND IMPLEMENTATION OF THIS CONTINUING OPERABILITY STUDY

Once a plant is operational, it is best to avoid unnecessary interruptions in operation, because operational transients stress the equipment. Prolonged outages also impact the performance of plant workers, so unnecessary shutdowns are counterproductive and probably increase both overall risk and costs. Although equipment that may show some signs of wear may still be able to operate satisfactorily, it is important that the capabilities and safety consciousness of facility workers and supervisors always remain at a high level. It is also essential that communications with regulatory and community groups continue to be effective so that any emerging issues or future changes in requirements can be identified and addressed in a timely manner.

In addressing issues that pertain to the safe continuing operability of a stockpile disposal facility, particular attention was paid to the operational experience at JACADS over the full life-cycle of that facility, and then at TOCDF, which is the oldest plant currently operating and where obsolescence problems are likely to be encountered first. Facilities at Anniston, Alabama (ANCDF); Umatilla, Oregon (UMCDF); and Pine Bluff, Arkansas (PBCDF) are all now operating and also have initiated programs to anticipate and manage problems associated with obsolescence.

In conducting this study the committee was aware that the Army's standard procedures for addressing obsolescence of conventional Army equipment and munitions do not apply to an operational chemical stockpile processing facility, notwithstanding that the Army is destroying obsolete munitions (U.S. Army, 1999). Some simple cost reduction options for slowing or interrupting operations that might apply to a simpler system are not feasible in a complex stockpile incineration facility. For example, the facility refractory-lined furnaces and afterburners must be kept hot during short-term changes in processing operations to avoid thermal damage from temperature transients, so there is no cost savings associated with slowing processing rates. Furthermore, plant personnel are highly trained and have acquired extensive experience in operations. A consequence of these conditions is that a facility cannot be realistically mothballed or decommissioned until after its mission is completed satisfactorily. Even at that point, some of the facility equipment and well-trained personnel will still be needed for closure activities to clean and remove all contaminated parts of the facility. Not only do delays in the program increase costs but they also prolong the risk to the public of exposure to the agents in the aging stockpile.

Normal chemical industry practices for preventing obsolescence in process plants likewise apply only in part to stockpile processing plants because of their unique design and finite length of operation. Most chemical and manufacturing plants use well-developed technologies and are designed to operate efficiently and indefinitely with relatively common equipment—not just until a finite task is accomplished.

Thus, the Army's objective for stockpile processing is to ensure the continuing capability to safely and expeditiously process the remaining stockpile items. The most rational approach for stockpile processing facilities would allow for some equipment obsolescence or degradation as the plants age, as long as this main programmatic objective is not compromised. Replacing equipment that is old but still functional usually involves a major interruption in plant operations, which in turn would increase overall program risk because of prolonged exposure to the stockpile. Such changes often require permit modification at the state level, which may cause further extensions in schedule.

Figure 1-1 shows the conceptual framework that the committee used for evaluating issues of continuing operability. At the bottom of the pyramid are the elements of facility operations that are required for processing the chemical stockpile. These are the elements where obsolescence or loss of capabilities may create vulnerabilities that impact successful continuing operability. At each site, systems from the middle level of the pyramid are in place to ensure the safety of workers, the public, and the environment, as well as to meet regulatory requirements. These are the systems that can be employed to detect and correct or manage the impact of potential vulnerabilities. At the top of the pyramid is the programmatic management that not only will ensure that programwide standards are achieved but also will enhance the robustness of the program facilities against obsolescence through the sharing of knowledge and spare parts across sites.

This report will focus on the four presently operational incineration facilities. The neutralization plants at Aberdeen, Maryland (ABCDF) and Newport, Indiana (NECDF) are not directly included in the study since one has already completed operations and the other is awaiting resolution of issues around neutralization product disposal. The two remaining sites at Blue Grass (Kentucky) and Pueblo (Colorado), which are under the Assembled Chemical Weapons Alternatives (ACWA) program, are still in the late stages of design. Although these plants were not specifically addressed in this study, some of the findings and recommendations may be helpful in addressing and avoiding some future obsolescence issues at the ACWA sites.

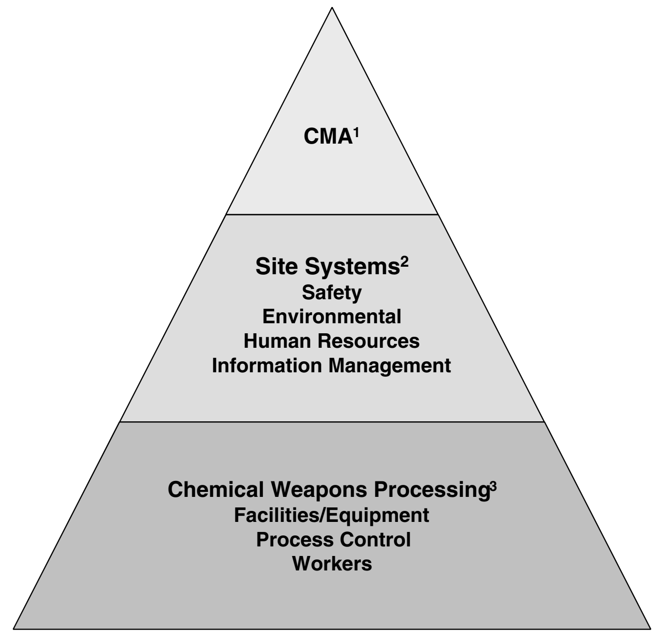


FIGURE 1-1 Conceptual framework for achieving continuing operability.

[1]Manage programmatically across sites to facilitate mission completion.

[2]Ensure that site systems are in place to manage vulnerabilities.

[3]Identify vulnerabilities that may impact continuing operations.

The report is based on a review of ongoing programs conducted by the Army and its site contractors to resolve potential problems related to facility obsolescence. Each site operates fairly independently under a site contractor with some Army oversight and with separate contractual obligations and incentives. The TOCDF site is managed by EG&G and the other incineration facility sites are managed by the Washington Demilitarization Corporation, a part of the Washington Group International, which is the contracting authority. The site contractors are encouraged to interact frequently and share information and spare parts. However, obsolescence issues and management vary by site.

At the committee's first meeting in January 2006 at the Chemical Materials Agency (CMA) Headquarters at the Edgewood Area of Aberdeen Proving Ground in Aberdeen, Maryland, programmatic responses were given to a list of committee queries, and the objectives on which the statement of task is based were further clarified. The Edgewood

Area also is the location of the Chemical Demilitarization Training Facility (CDTF), where operational replicas of the robotic disassembly systems, the vestibule areas for toxic entry, and the control room are used for training purposes. The committee observed how these systems and areas were operated, discussed how general troubleshooting activities can be done in an uncontaminated environment, and interviewed CDTF training personnel. The committee also held meetings at Tooele, Utah, and Anniston, Alabama, where members spoke with groups of experts and workers, examined documents, and toured parts of the facilities. Committee subgroups also visited the facilities at Umatilla, Oregon, and Pine Bluff, Arkansas. A briefing was received on the two ACWA sites to indicate where committee input might be helpful. See Appendix A for a listing of committee meetings and site visits.

As the data-gathering part of this study was coming to an end, a further change in program management within the CMA organization was announced. The project manager for chemical stockpile disposal retired on May 30, 2006, and his responsibilities were combined with those of the project manager for alternative technologies and approaches to form a new organization led by a project manager for chemical stockpile elimination.

## STATEMENT OF TASK

The statement of task that this report is intended to address is as follows:

> At the request of the director of the Army's Chemical Materials Agency, the NRC will establish an ad hoc committee to assess and evaluate current and proposed policies and approaches by the Army and its contractors to adequately anticipate and address equipment/facilities obsolescence at chemical demilitarization facilities. The assessment will examine the extent to which these policies and approaches are consistent with generally accepted practices in the chemical process industry. In conducting this assessment, the NRC will evaluate current and proposed activities involving:
>
> - anticipating equipment needs and upgrading facilities in a manner that does not compromise plant safety or environmental compliance, or have severe adverse effects on schedule
> - extending the operational life of equipment and facilities as necessary while not compromising worker health and safety or environmental compliance
> - strategies to overcome scarce availability of spare parts and/or services for aging systems
> - prioritization plans for addressing obsolescence issues
> - maintaining plant reliability, availability, and maintainability while upgrading equipment and facilities

## REPORT STRUCTURE

This report examines the various ways that obsolescence, resulting from significant schedule extensions beyond the originally planned facility life, may impact future stockpile disposal operations and how these potential problems are identified and managed by the Army and its site contractors. Chapter 2 examines the vulnerabilities relating to obsolescence at stockpile incineration disposal facilities. Chapter 3 addresses the site-related means being used to implement sound continuing operations management programs, and reviews several issues relating to specific sites. Chapter 4 specifically addresses continuing operability issues concerning the information management and technology systems used at chemical stockpile incineration facilities. Chapter 5 addresses higher-level program management systems that are employed by the CMA and the site contractor management teams to enhance continuing plant operability and safety through programwide cooperation.

The findings and recommendations that appear throughout the chapters of this report are numbered in accordance with the order of their appearance. They have been compiled in one location at the end of the Summary for this report. The committee ranked all of its recommendations into three tiers to indicate their prioritization, with Tier 1 being the highest. Although all the recommendations are important, the committee considers the Tier 1 recommendations to be critical to the life-cycle continuing operability of the chemical stockpile disposal program. A description of the three tier levels follows:

- Tier 1: Recommendations critical to the life-cycle operability of the chemical stockpile disposal program;
- Tier 2: Recommendations that are important initiatives supporting higher-level recommendations; and
- Tier 3: Recommendations that are other desirable action items.

Table 1-2 shows the hierarchy according to tier level for related recommendations. Numerous other observations and suggestions are discussed throughout the general text of the report. The report also includes a detailed assessment of information management systems, including physical facilities, software, and system development processes.

## REFERENCES

NRC (National Research Council). 1994. Recommendations for the Disposal of Chemical Agents and Munitions. Washington, D.C.: National Academy Press.

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TABLE I-2 Tier-Level Hierarchy for Related Recommendations

| Recommendation Number and Topic Area by Tier Level | | |
|---|---|---|
| Tier 1 | Tier 2 | Tier 3 |
| 6 (CMA oversight of control system improvements)<br>9 (Safety programs) | | |
| | 21 (Lessons-learned program) | |
| | | 1 (Continuing operational security analyses) |
| 18 (CMA staffing)<br>19 (Programmatic guidance)<br>20 (Intersite obsolescence management) | | |
| | 3 (Integrated spares management) | |
| | | 2 (Control system spares contract)<br>5 (Spare DFS kiln) |
| | 8 (Development of consistent obsolescence management system) | |
| | | 4 (Maintain skunk works)<br>7 (Replace inapplicable DOD standards)<br>23 (Key equipment planning for closure) |
| | 10 (Knowledge management)<br>11 (Personnel retention)<br>12 (Information management) | |
| | | 13 (Servers)<br>14 (PCs)<br>15 (Operating systems)<br>16 (Data formats and archiving)<br>17 (Ongoing information management surveys and assessments) |
| 22 (Continuous, predictable funding) | | |

# 2

# Potential Problems Relating to Obsolescence in Chemical Demilitarization Processing Operations

This chapter examines potential vulnerabilities to successful completion of the U.S. chemical stockpile disposal program that could become issues due to obsolescence. This chapter is focused on facilities, equipment, and the personnel required to operate, maintain, and eventually close the chemical agent stockpile incineration facilities at each operational incineration site.

As a practical matter, all facilities and equipment become obsolete at some point in time. Even so, "obsolescence" does not necessarily mean "nonfunctional," as long as safety, environmental performance, operability, and overall schedule are not adversely impacted. The facilities and much of the equipment and supporting systems covered in this report are unique to the chemical stockpile disposal program, which is an enterprise of finite duration. As such, they are not likely to be superseded by new technology over the course of the mission for which they were designed and cannot be considered to be or become obsolete on that basis.[1] Operational challenges are expected to increase because of continuing degradation of stockpile components.

While the obsolescence issues regarding facilities and equipment constitute a major focus of this report, also of critical importance is the avoidance of having the quality and capability of plant personnel degrade over time. The latter could increase the potential for a serious accident or a permit violation that may stop operations for a prolonged period and create additional challenges for the continuing operability of the disposal facilities. Since delays prolong exposure to stockpile risks, all these factors are related to overall program obsolescence.

Consequently, the key question considered by the committee was not necessarily one concerned strictly with obsolescence, but one that more broadly assessed continuing functionality and reliability through the systematic anticipation of problems and the implementation of sound obsolescence management programs. These considerations are central themes in this and subsequent chapters.

## INCINERATION FACILITIES FOR CHEMICAL STOCKPILE DISPOSAL

As the chemical weapons stockpile disposal program was evolving in the 1980s and 1990s, the Army initiated plans to build chemical agent disposal facilities at each of the stockpile storage sites since Congress had proscribed the transportation of stockpiled chemical warfare items. When the decision was made to develop the baseline incineration destruction system, incineration facilities were built at five of the nine locations where large quantities of varied stockpile items were located. Although these facilities had a common design, parallel processing lines tailored to the mission of destroying the specific stockpile items at each location were added.[2]

Even though agent destruction was initially intended to take place over a relatively short time frame, the robust structural requirements by which chemical agent stockpile incineration facilities were built should allow their potential operating life in all probability to exceed even the most pessimistic current schedule for completion of chemical weapons destruction.

While certain components and systems of the physical facilities may become damaged or deteriorate and require repair or replacement, it is unlikely that these situations would be sufficiently frequent or serious enough to adversely impact process safety, the environment, or the overall destruction schedule except for the highly remote occurrence of rare catastrophic events of either natural or process origin.

[1]Some computer-based systems can be partially upgraded, if necessary, through addition of supplemental hardware or by software changes.

[2]Three other sites have had only a single agent in their stockpile and a fourth site had a small stockpile with a variety of munitions and agents. Alternative technologies other than incineration were chosen for these sites.

The site contractors have done a very capable job of scheduling repairs, maintenance, and replacements to minimize schedule disruptions, having been encouraged by the Army's contractual incentives to maintain schedule as long as safety and environmental performance remain at a high level. Major maintenance activities are planned during shutdowns between the demilitarization campaigns. Obsolescence management programs are now under development to identify possible future vulnerabilities from unplanned failures due to the aging of equipment and operational systems and to take proactive preventive actions.

The four currently operating incineration plants that are the focus of this study are expected to be in operation for periods of another five or more years to complete stockpile processing and for an additional two to three years to accomplish closure.[3] The processing periods depend on the site-specific stockpiles and the continuing operability performance of the facilities. Chemical agent disposal facilities are by definition unique and are probably not readily adaptable to other uses, including chemical or conventional waste processing. Moreover, industrial waste treatment facilities would be able to process wastes more efficiently and economically than modified chemical demilitarization furnaces, and there is excess capacity in the hazardous waste treatment business at this time. Further complicating the possibility of adaptive reuse of disposal facilities is the long-term risk and liability associated with possible latent agent contamination in standing structures, especially in the facilities that processed nerve agents.

The closure periods for these facilities are dependent on the amount of accumulated secondary hazardous waste that requires disposal and the end state of clean-up established for each site. The latter is a matter for consultation and negotiation between the Army and the governors of each affected site. In recognition of the environmental contamination in these plants, the CMA currently plans to decontaminate and demolish the agent processing facilities to bare ground suitable for industrial reuse. Uncontaminated associated structures might be adapted for reuse. Transfer of ownership from the CMA would also require satisfactory closure of any permits and likely a willingness for the new owner to assume any future liability from the CMA.

The planning and execution of maintenance, repair, and replacement activities should anticipate the termination of destruction operations and facility closure. During the terminal phase of destruction operations, these activities should be strictly limited to those that are essential to ensure continuing safe and efficient operations and regulatory compliance. During visits to the facilities, the committee found them to be generally well maintained and of good appearance.

In the wake of the September 11, 2001, events, the chemical industry has undertaken steps to further enhance plant security systems by conducting periodic and comprehensive operational security analyses. The committee found good physical security programs at the sites and a high level of safety awareness, although more scrutiny has historically been given to the processing facilities than to the associated storage yards. While the CMA has conducted risk assessments for each facility in the past, these do not include acts of terrorism, nor do they identify external factors that might disrupt the continuing operability of the plants (e.g., those associated with site security or the integrity of utilities, communications, and other emergency systems). The effects of future changes in surrounding communities and the regulatory environment are not systematically tracked.

**Finding 1.** The four operating incineration facilities, although aging, are capable of safe and effective destruction of remaining stockpile inventories and completion of closure activities at each site, if strong and comprehensive obsolescence management programs are implemented. However, each chemical agent disposal facility is susceptible to location-specific external factors that may change over time. A need exists for these factors to be determined and evaluated at each site on a periodic basis.

**Recommendation 1.** An operational security analysis program should be established for each chemical agent disposal facility to evaluate external factors (including the integrity of critical utilities) that could adversely impact continuing operability. **(Tier 3)**

## INCINERATION SYSTEM PROCESS EQUIPMENT

### Overview

A detailed process diagram for a typical chemical agent incineration facility is presented in Figure 2-1. Some differences in configuration exist between the sites due to differences in the stockpiles to be processed. For example, the unpack area is reconfigured at PBCDF. There also are some differences in the number of parallel processing lines provided at individual plants. In the generic design, munitions and containment systems are moved from stockpile storage areas to the munitions demilitarization building (MDB) in sturdy on-site containers, which are received at a container handling building (CHB) and lifted to the second floor unpack area (UPA), where the munitions and bulk items are unpacked and put on input conveyors to the MDB. Four separate systems are employed to transfer munitions from the UPA to the explosion containment room (ECR) and the munitions processing building (MPB). These are the rocket handling system (RHS), the bulk handling system (BHS), the

[3]Chemical Stockpile Disposal (CSD) Facilities and Equipment Obsolescence Assessment, briefing by Joseph Pecoraro, project manager for chemical stockpile disposal, CMA, to the committee, January 25, 2006.

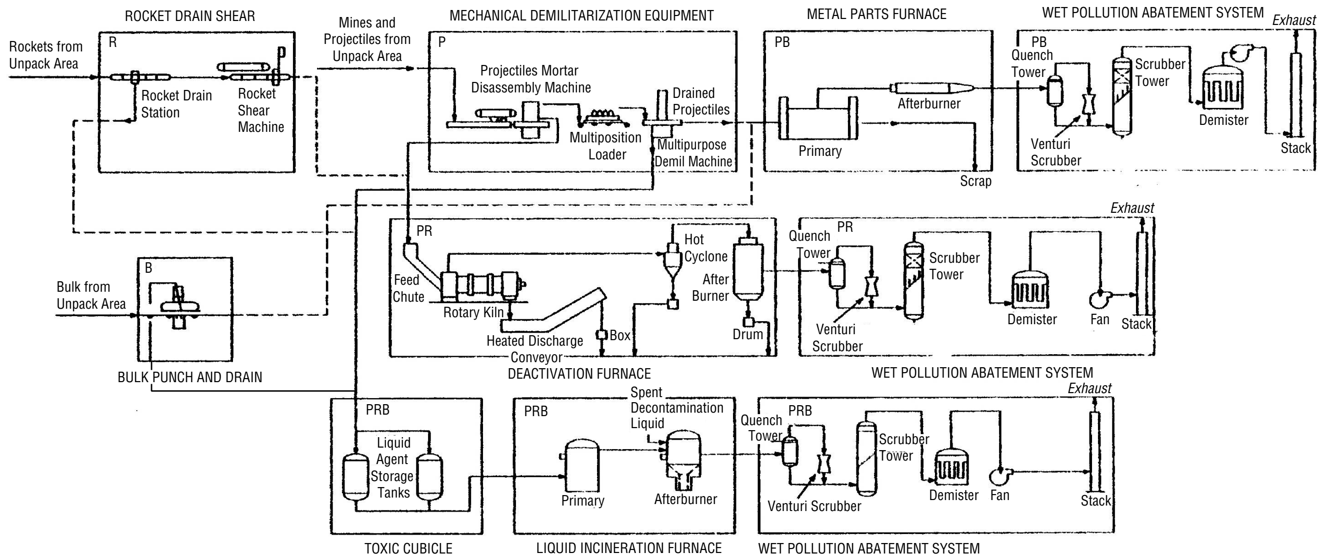


FIGURE 2-1 Schematic of the baseline incineration system. SOURCE: Adapted from NRC (1996).

projectile handling system (PHS), and the mine handling system (MHS). There are two ECRs within the MDB where energetics are removed by projectile/mortar disassembly (PMD) machines. After removal the energetics drop through feed chutes to the deactivation furnace system (DFS).

Multipurpose demilitarization machines (MDMs) remove the burster well, drain the agent, and then reinsert the burster well. The agent flows into agent holding tanks and is burned in a liquid agent incinerator (LIC). Drained munitions, which in some cases may contain a solidified heel of agent, are processed in a three-zone metal parts furnace (MPF).

Bulk ton containers are simply punched and drained, rinsed, and passed through the MPF for final decontamination.

Exhaust gases from each furnace and afterburner system go to a high-performance pollution abatement system (PAS) consisting of wet scrubbers and filters.

Subsequent sections examine the potential vulnerabilities to obsolescence for the major types of equipment.

### Spare and Replacement Parts Availability

Essential to the continuing operability of the processing equipment is the requirement to maintain adequate stocks of spare parts to allow maintenance as equipment performance deteriorates from age or other causes. This section provides a description of the spare or replacement parts program on a facility and programmatic basis. The committee examined how the systems for managing the spares inventory function currently and how these systems might need to be improved for continuing operations.

#### *Control System Spares*

At present, control system spares are supported by an external contractor; other spare parts are managed on a site-by-site basis, with provision for sites to get spares from other sites in the event of a local shortage in inventory.

At the time this report was being prepared, the control system included some equipment that could be considered obsolete, but was still functional. To ensure continuing support for control system spares, a control system spares management contract has been negotiated with Rockwell Automation, the present owner of the Allen Bradley operations that provided the original control system components.

The committee did a careful assessment of the maintenance and spares support program (i.e., the Rockwell Automation Asset Management Program) for the older control system components: programmable logic controllers-3s (PLC-3s), PLC-5s, Data Highway, and AB 1700 series input/output (I/O) modules. In the committee's view this program is well designed and will satisfy the required support throughout the operational and mission life of all the incineration facilities.

Under an annually renewed, systemwide contract with WGI, Rockwell Automation works with all of the incineration sites through surveys and visits to forecast requirements for control system spares (based on historical and forecast spares depletion rates), establish certified spares inventory levels for each site, repair or rebuild failed parts and components, and to special-build new parts and circuit cards as needed to keep maintenance inventories at a safe operational level. The Rockwell Automation support group, located in Cleveland, Ohio, also implemented a relatively simple software module upgrade so that the older PLC-3s could improve performance and interface with new additions to the control systems.

Rockwell Automation also maintains a stockpile of spares at its facility in Memphis, Tennessee, equivalent to about 20 percent to 25 percent of the installed base to permit 24-hour turnaround for spares requests. The inventory of control system spares consists of about 75 percent of the installed part types. This includes a recent discovery of a cache of I/O parts at UMCDF, which will allow the inventory to provide for most part types. Any shortages are filled from Rockwell Automation's general spares supply that it uses for all its customers. Currently, about 90 percent of the CMA/WGI control system spares inventory have been retested and recertified.

The local site inventories of control system spares are specified to be at least 10 percent of the installed base, with a minimum of two for each replaceable part. However, sites are maintaining their own supplies of additional noncertified control system spare parts and this is not well coordinated with the central spares control system at Rockwell Automation. The spares inventory control systems vary from site to site, and the committee noted that there is no comprehensive accounting of the inventory levels of spares, nor of the testing and certification status of spares, at some sites. This can result in program inefficiencies and cost penalties.

**Finding 2.** The contract with Rockwell Automation for management of control system spares is an effective way to ensure long-term availability of control system spares. This contract is currently subject to annual renewal as part of an existing WGI-JACADS contract.[4] This holding-pattern approach to a long-term commitment is due in part to an indemnification issue pertaining to issuance of a new longer-term contract.

**Recommendation 2.** The Chemical Materials Agency should implement a firm long-term contract to handle control system spares management for each of the four incineration facilities and the Chemical Demilitarization Training Facility at the Edgewood Area of Aberdeen Proving Ground. This contract should be structured to provide support through all related closures. **(Tier 2)**

### *Other Equipment Spares*

The basic spare parts inventory is located in warehouses at each site. Smaller local inventories are also situated in such areas as the mechanical maintenance shop, where frequently used parts can be stored conveniently inside the perimeter fence to prevent repeated security delays in bringing spares into the main facility. Some spares backup accessibility is also provided by (1) a central warehouse colocated with TOCDF (which is stocked with parts from JACADS and surplus from other related Army activities) and (2) a cooperative mutual support program with the local warehouses at other sites using overnight shipment of parts.

At each site the warehouse uses a reorder policy for maximum and minimum stock levels with a reorder threshold level established for each item stocked. The maximum, minimum, and reorder levels are based on the initial experience of spare parts management from JACADS with modifications based on ongoing continued operating experience at active facilities. One site had a goal of 98 percent parts availability, and that goal is currently being met.

The committee saw no evidence that a mathematical-model-based inventory policy as used in many manufacturing industries was being employed. The objective of such policies is to minimize inventory storage costs while ensuring a defined and very low probability of out-of-stock items. The central warehouse uses a MAXIMO database, but relies on human intervention to notice any unusual usage that would trigger a change in required inventory levels. At the sites, warehouses use the TRACS system, which is much more comprehensive than just parts tracking, as it also provides for control over scheduling, work orders, and personnel function.

An informal network of communications exists between warehouse personnel across the sites to locate specialized major demilitarization equipment items, such as a spare furnace section. Such items have long lead times, if they are currently available at all, but usage is so low that separate inventories at each site are neither required nor economical. Warehouse managers gave many examples of this network in use, stating that parts can be shipped between sites in "one or two days."[5] Warehouses keep track of loans and paybacks to other sites for correct charging.

One obstacle is that part numbers are not consistent across sites, nor with the original government-furnished equipment identifiers. Warehouse personnel often use the original drawings as the basis for positive identification of particular parts, where the shape, size, and material can be easily communicated between sites. Site warehouse personnel reported little use of the central warehouse (adjacent the TOCDF) with its stock of refurbished JACADS parts, although all knew of its existence; however, the management of the central warehouse reported use of its parts at different sites.

If parts are no longer available from their original equipment manufacturers (OEMs), a number of techniques are used. Occasionally, parts can be fabricated by the small but well-used machine shop at each site. This also allows the

[4]This contract will exist until all the JACADS environmental permits are closed.

[5]Personal communication between Ken Morse, TOCDF, and Colin Drury, committee member, March 2, 2006.

rapid production on nights and weekends of otherwise unavailable but needed parts. The second strategy is to use a replacement part from another manufacturer. This option is used for relatively common chemical and oil industry parts, such as pumps or valves, where a component with identical or improved performance can be substituted. This typically requires less modification of permits than changes involving more specialized demilitarization equipment. Such parts sometimes do not have identical couplings so that some machining of adaptors is required. The third strategy is to identify the impending loss of an OEM supplier and take steps to buy up its remaining inventory. For example, this strategy was used for self-contained breathing apparatus (SCBA) systems that are certified to use with protective suits for entry into agent-contaminated areas of the plant. In this case the manufacturer's entire stock was purchased after a calculation was made that it would be sufficient to complete the chemical stockpile disposal program.

At one facility electrical substation, parts that were no longer supplied by the vendor had to be replaced. Through the use of the engineering change proposal (ECP) system employed at the plant, equivalent replacement parts were obtained through a local vendor. This is another example of the types of proactive steps being taken by plant management to address potential obsolescence issues.

For any of the above strategies to be used there must be a trigger that alerts warehouse personnel to the situation. This typically occurs when personnel reorder a part only to find that it is no longer available. The reordering mechanism could also involve a Web site posting of a requirement, and then having no vendor provide a quote on the item required. Automatic reordering has been instituted at some sites, where reaching the established minimum stock level automatically triggers a reorder that is then processed by hand. These mechanisms constitute essentially a system that reacts to detected changes rather than a proactive system that would anticipate the changes, although some vendors do notify sites when parts are discontinued. The reorder level is based on the assumption that a replacement part will be available within the anticipated lead time when ordered from the current supplier. Should that not be the case, an unanticipated extended delay is incurred while an alternate supplier is found (if one exists) or a replacement is approved through the appropriate management of change process. It should be possible to have office personnel make regular checks on each item in the inventory so that the discovery that a part was unavailable would not depend on and be linked to the reorder level. In this way stock-out situations could be more easily avoided.

Many examples of inventory management software and systems exist with capabilities to translate across different part identification numbers and actively track inventories. The Army should not have to engage in basic design and development of software. Conversely, not all existing applications are appropriate or effective for this particular situation. On the contrary, in the absence of a judicious choice of platforms, costs can escalate and results can be problematic. Therefore, the implementation of an improved inventory management system should be done only after the requirements of the organization have been thoroughly defined and articulated, and a conscious effort then made to implement the minimum effective software solution to support that definition.

The committee acknowledges that to date no evidence was found that major items critical to continued operability had become unavailable and thus stopped operations using the current inventory management system. However, TOCDF did experience considerable and unnecessary damage to its DFS kiln when kiln speed sensors were not accurately measuring the speeds needed for safe operation during VX mine processing. These sensors were obsolescent and were no longer supported by the vendor.

**Finding 3.** No systematic approach exists for managing spare parts inventories across the four different chemical agent stockpile incineration facility sites, although there is a clear need for one. The committee found effective systems at some sites, but they are not consistent in parts identification codes, do not integrate information about control system spares, do not have internal trending and tracking capabilities, and only react to loss of suppliers on discovery that a supplier is no longer able to provide needed parts, typically when parts are reordered.

**Recommendation 3.** The Chemical Materials Agency should implement a more formal inventory management system that models usage, usage variability, lead times, and costs to ensure a very low rate of out-of-stock items. The spare parts inventory should be modeled across the four chemical agent stockpile incineration facility sites to ensure the capability to translate across different identification numbers for the same spare part, and to facilitate the optimum distribution of inventory between site warehouses and the central parts storage warehouse. Such a coordinated spare parts inventory management system should be accessible to and updated regularly by all sites and should indicate the status of key vendors supporting spare parts availability. A proactive program should be instituted to check more regularly whether each inventory item is still available, for example, by telephone or Internet query. **(Tier 2)**

### Disassembly Robotics

The rocket shear machine (RSM), bulk drain station (BDS), mine machine (MM) drain station, the projectile/mortar disassembly (PMD) machine, and the multipurpose demilitarization machines (MDMs) are collectively referred to as disassembly robotics. These machines are automated and remotely controlled equipment connected by a conveyor system. They are unique to the chemical stockpile disposal program and were initially designed with the assistance of Surface Combustion Corporation, under contract to Edgewood Arsenal with later design work by El Dorado Engineering Inc. (EDE) under contract to the program manager for chemical demilitarization (PMCD). The contractual terms provided for PMCD to obtain the detailed drawings for all the robotic units so that the drawings are available for replacement parts to be made as required. Both the PMDs and the MDMs were built by Wright Industries of Nashville, Tennessee. Surface Combustion Corporation, EDE, and Wright Industries are still in business and are available for equipment support as required.

General Physics Corporation continues to have personnel at the CDTF at the Edgewood Area of Aberdeen Proving Ground in Maryland, where the robotic and processing control systems designed for the incineration facilities are replicated and used for training. In addition to the CDTF's longtime training function, part of the operation at CDTF includes a skunk works[6] for the purpose of troubleshooting unforeseen problems that have occurred with the disassembly robotics. Since the CDTF/skunk works is not contaminated with agent, troubleshooting can be more readily accomplished than doing so at the four operating facilities.

Experienced General Physics personnel spent considerable time with the committee, demonstrating the robotics operation on agent-free rockets, ton containers, munitions, and mines. They also answered numerous committee member questions and described the skunk works operation.[7]

**Finding 4.** The Chemical Demilitarization Training Facility/skunk works remains an extremely valuable resource for continued support of the disassembly robotics operation.

**Recommendation 4.** The Chemical Demilitarization Training Facility/skunk works facility and its knowledgeable personnel should be maintained as a support resource until all chemical agent stocks have been safely removed from storage and processed by the disassembly robotics at all incineration sites. **(Tier 3)**

### Furnaces and Afterburners

The incineration facilities utilize three types of furnaces for the destruction of agent and decontamination of materials, the DFS, LIC, and MPF. Representations of the three furnaces are presented in Figure 2-2.

The DFS is a thick-shell alloy steel, counter-current-flow rotary kiln for destruction of energetic materials. It has internal spiral flights to advance and keep energetic pieces separated. Gases discharged from the kiln pass through an afterburner where they are subjected to a temperature of 2200°F. The DFS is followed by a heated discharge conveyor (1000°F) for further decontamination of solid materials discharged from the DFS.

The LIC is a high-temperature liquid incinerator built by T-Thermal Company, utilizing a T-Thermal burner for destruction of chemical agents. Agent is atomized and destroyed at very high-temperature (~2700°F), with exhaust gases sent to a secondary chamber operating at 2200°F. The LIC has a carbon steel shell lined with high-temperature refractory brick with dip joints of high-temperature mortar. Maintaining the LIC at operating temperature and minimizing the number of heating and cooling cycles is important to maximize refractory life.

The MPF is a three-zone roller hearth, refractory-lined steel shell furnace built by Wellman Furnaces Inc. to operate at 1450°F or higher in order that materials to be processed can be heated to at least 1000°F for at least 15 minutes. It is used for decontamination of metal munition bodies and other materials. The MPF has multiple North American Manufacturing burners, special water spray cooling nozzles for temperature control, and entrance and discharge "air lock" chambers. Gases discharged from the furnace pass through an afterburner where they are subjected to a temperature of 2200°F.

The furnace designs were initially formulated at Surface Combustion Corporation in the early 1970s under contract to Edgewood Arsenal.[8] Each furnace has an afterburner with a high-temperature refractory-lined steel shell and commercial natural-gas-fired burners. The afterburners were also originally designed by Surface Combustion Corporation. Drawings and materials specifications are available so that replacement parts including the specified refractory materials can be purchased as required.

Subsequently, PMCD took over the design program and contracted with Stearns Catalytic Corporation to provide the furnaces. The latter utilized Allis Chalmers (now part of Metso Corporation) for the DFSs, Wellman Furnaces Inc. for the MPFs, and T-Thermal Corporation for the LICs. These companies, or their successors, continue to operate and can provide replacement parts as required for the furnaces. Continental Research & Engineering (CR&E) is a more recently established company that has personnel who are specialists with over a decade of experience in the operation and maintenance of chemical demilitarization furnaces and who continue to support the four incineration facilities.

[6]The term "skunk works" in this context refers to a group within an organization given a high degree of autonomy to creatively address engineering and technical problems with minimal bureaucratic obstacles.

[7]Question-and-answer session with CDTF personnel and the committee, January 24, 2006.

[8]Personal communication between Frank Rinker, Global R & E, and David Hoecke, committee member, June 1, 2006.

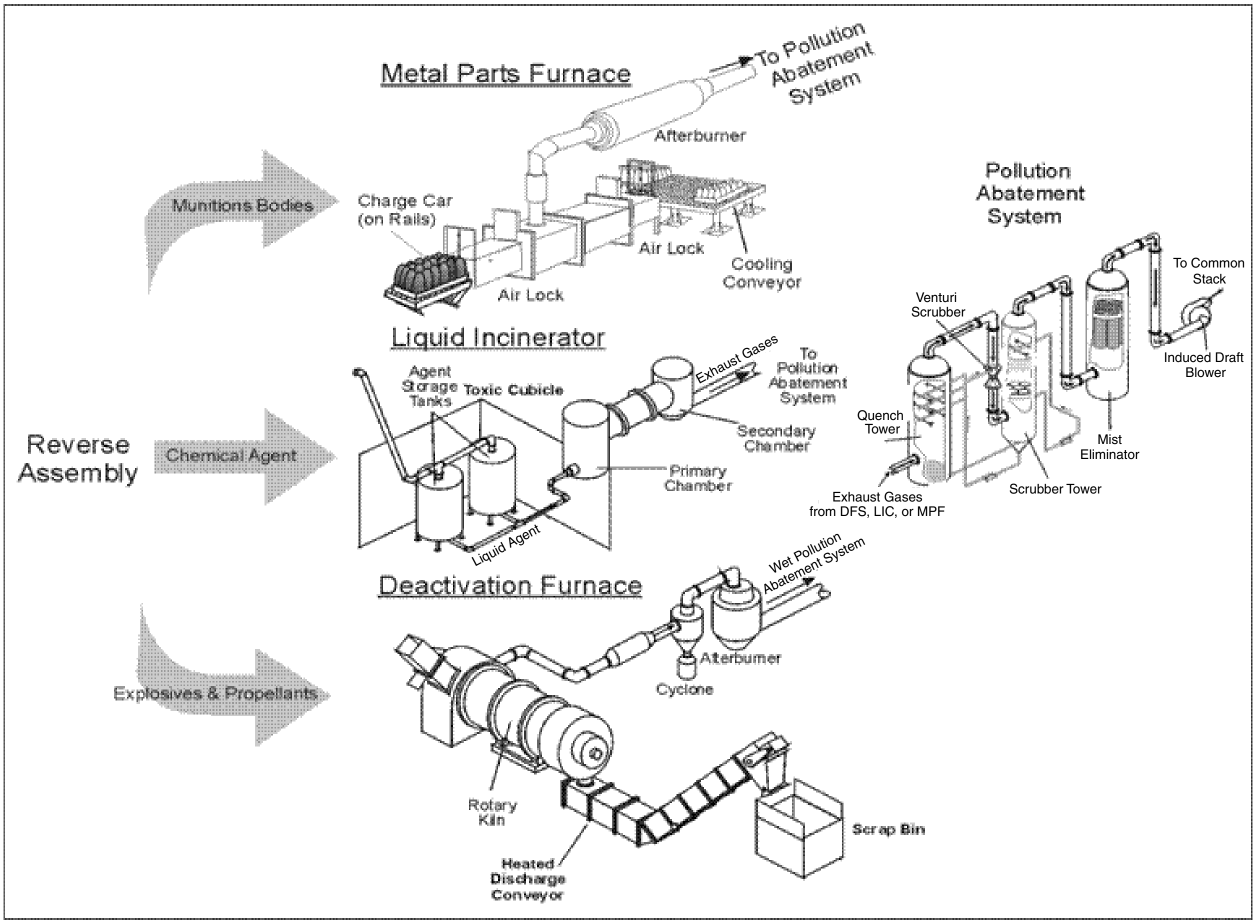


FIGURE 2-2 Schematic of chemical demilitarization incineration furnaces and a typical pollution abatement system without carbon filter. SOURCE: PMCSD Overview, briefing by Joseph Pecoraro, project manager for chemical stockpile disposal, CMA, to the committee, January 25, 2006.

The MPFs and the LICs are similar to equipment utilized in industry. The furnaces utilize commercially available components, such as burners, refractory, and thermocouples. With good maintenance, similar furnaces in industry can continue to be operated for three decades or longer.

The DFS is a more specialized design in that the shell sections at the munitions inlet end are 2 inches thick in order to withstand intermittent explosions of the energetic materials from rockets and mines and some projectiles. The helical flights are also subject to severe intermittent stresses. At TOCDF significant holes in the DFS shell were discovered during an inspection at the end of the VX destruction campaign. This was the result of the DFS having operated above the recommended 0.7 rpm during the VX mine disposal campaign and overfeeding energetics. As previously noted, the installed kiln speed sensors were not measuring the speeds accurately and the vendor was no longer supporting these sensors. An analysis of the damage to the DFS kiln resulted in a recommendation by ANCDF management, and with which the CMA concurred, to repair the damage by welding patches over the holes rather than replacing kiln shell sections.[9] Replacing one section of the kiln shell is difficult because of warping and lack of alignment with adjacent section(s). Munitions furnaces at other Army sites that process nonchemical munitions were repaired this way.

After the experiences at TOCDF, the ANCDF site project manager told the committee that there were concerns about the integrity of the DFS during the upcoming VX mines campaign at the Anniston facility. UMCDF and PBCDF also have upcoming campaigns involving mines, which were a significant processing problem at TOCDF.[10] Since procurement of new 2-inch-thick shell replacement sections for the DFS require a lead time from ordering to

[9]Personal communication between Timothy Garrett, ANCDF site project manager, CMA, and Dave Hoecke, committee member, April 6, 2006.

[10]Personal communication between Timothy Garrett, ANCDF site project manager, CMA, and Dave Hoecke, committee member, April 6, 2006.

delivery of almost a year, a failure that could not be safely patched would lead to an unacceptable delay in processing.

Recently the DFS helical flights at ANCDF were damaged during a 105-mm projectile campaign and had to be replaced. The DFS kiln is still safe to use, but the CMA has been requested to order a spare kiln to keep in stock for possible future site or programmatic needs. The CMA expects to authorize an order for a full kiln with a delivery date in the third quarter of Fiscal Year 2007. Present plans are to start processing VX mines at ANCDF in March 2008. After the start of the mine campaign at ANCDF, the CMA will take prompt action to place the order for a second spare kiln if that is determined to be necessary.[11]

The MPF was designed to handle some residual agent heels, but more degraded agent gels and sludges may require modifications in operating parameters to maintain furnace performance.

The LIC (which also burns decontamination fluids), the MPF, and possibly the DFS (if carbon micronization and combustion were to be utilized as at JACADS) are needed during closure, so they must be able to continue in operation beyond the completion of agent destruction.

Refractory materials used in the LIC and MPF and in the afterburners degrade gradually during processing operations and are replaced on a schedule coordinated with the end of processing campaigns. The relining of refractory must be done by experienced personnel who closely adhere to approved drawings, materials specifications, installation procedures, bake-out, and the initial heat-up schedule.

**Finding 5.** Upcoming chemical agent disposal campaigns at ANCDF, UMCDF, and PBCDF have some potential to severely degrade the DFS kiln shells. Procurement of new kiln sections requires a lead time of about a year.

**Recommendation 5.** The Chemical Materials Agency should implement its plan to order a spare DFS kiln in time for mine disposal operations at ANCDF and continue to evaluate whether additional kilns are needed to support the subsequent campaigns at UMCDF and PBCDF. **(Tier 3)**

### PAS/PFS Gas Cleaning Systems

Each furnace has a PAS gas cleaning system. ANCDF, UMCDF, and PBCDF also have a PAS carbon bed filter system (PFS) in series following the PAS. Figure 2-3 presents a schematic of the MPF PAS, including the PFS. The PAS for the other furnaces are similar at all sites. No PFS is presently installed at TOCDF. Plans call for a PFS to be added at TOCDF to meet the environmental requirements that must be satisfied for processing the mustard agent in storage at that site.

The PAS quench, venturi scrubber, scrubber tower, mist eliminator, and exhaust fan were originally designed by Esso Research & Engineering. Drawings and materials specifications are available for repairs and replacement parts. The mist eliminator elements ("candles") are available from Ceco Environmental and exhaust fan replacement components are available from Robinson, both of which are still in business.

The PFS is a more recent design than that of the PAS. It includes a gas reheater, particulate filter, multiple activated carbon beds, and a final HEPA filter. Ionex designed and provided the filter equipment and remains in business.

Two commercially available electric-motor-driven exhaust fans in series are utilized to provide for the high pressure drop through the PAS/PFS system. The facilities need to have both of the two exhaust fans operating to run at full capacity. If one fan fails, the facility can do a controlled shutdown using the remaining fan.

The committee does not know of any components of the PAS/PFS gas cleaning systems that are not available to the facilities to allow their continued operability.

### Process Control Systems

#### *General Configuration*

For purposes of this report, the process control system includes the closed-loop control of plant processes having control response times ranging from minutes to fractions of seconds. Higher-level information management and control is covered under "Information Management Systems" in Chapter 4.

The committee reviewed the process control systems at the TOCDF and ANCDF in detail to assess their capability and capacity to handle current and forecast workloads. In addition, maintenance procedures, spares supportability, reliability, and availability were evaluated. The control systems at these sites are typical of those at the other two incineration sites.

The current control system for incineration processes, HVAC, power, and alarms is relatively robust, with adequate performance margins for system response times, control capacity, and communications connectivity. The system architecture, along with the installed hardware and software, is of 1980 vintage. As such, the committee gave particular attention to the programming language, the human machine interface, built in diagnostics, processing capability, communication integrity, and supportability issues.

As indicated in the process data acquisition and recording system (PDARS) block diagram that is typical of the process control systems at all sites (see Figure 2-4), plant devices are connected to PLCs via Allen Bradley series 1700 I/O modules. PLC-3s handle digital inputs; PLC-5s handle analog inputs. The PLCs are interconnected by a Data High-

[11]Personal communication between Raj Malhotra, deputy, Technical Support Directorate, CMA, and Robert J. Love, NRC staff, June 14, 2006.

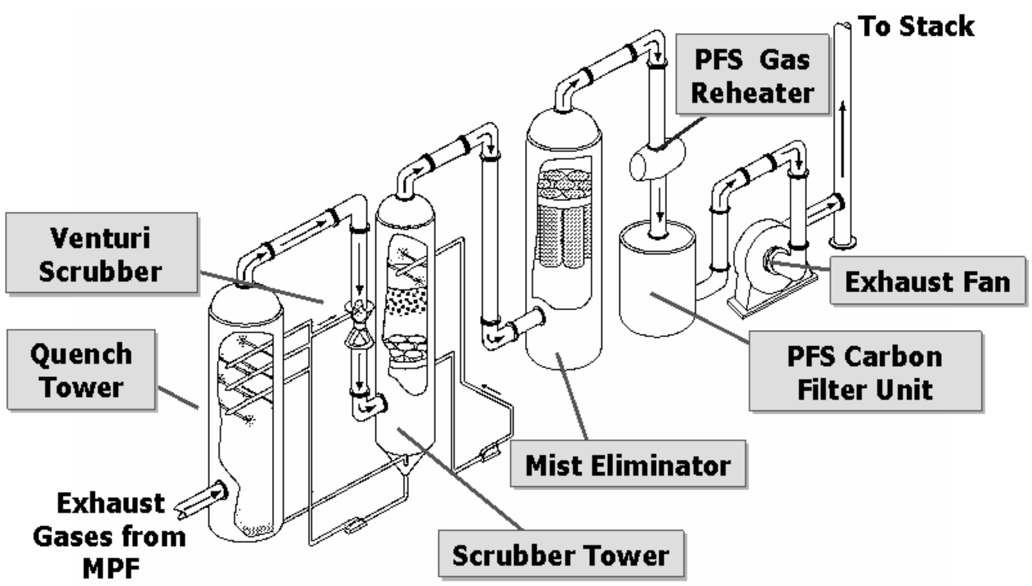


FIGURE 2-3 Schematic of the chemical demilitarization pollution abatement system for the metal parts furnace with carbon filter. SOURCE: PMCSD Overview, briefing by Joseph Pecoraro, project manager for chemical stockpile disposal, CMA, to the committee, January 25, 2006.

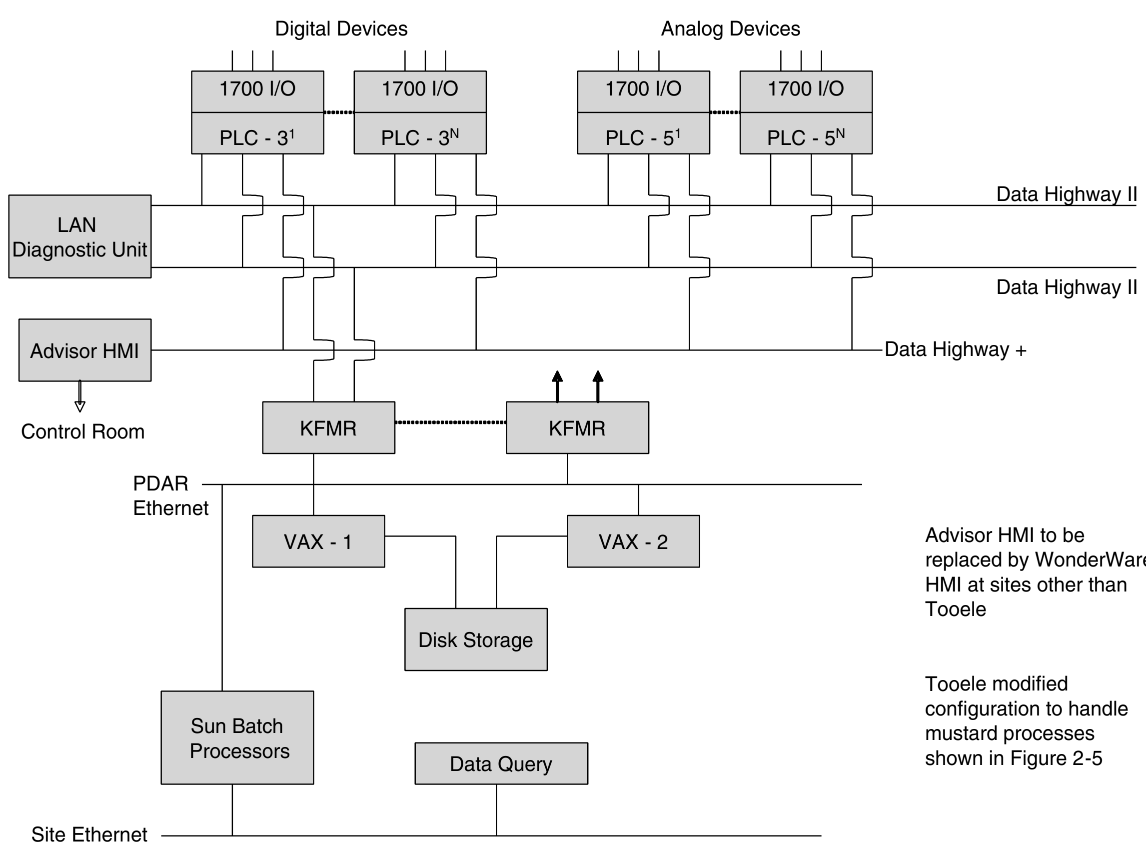


FIGURE 2-4 Schematic of the current TOCDF control system architecture. SOURCE: Provided by EG&G during committee meeting on March 3, 2006.

way II having redundant characteristics, and with a diagnostic unit checking the redundant paths for communication integrity. If there is a failure in one data highway, that path is disabled with the redundant path carrying traffic until the plant is shut down. Continued operation is not permitted when just one data highway is operational. In addition to being networked by Data Highway II, the PLCs are also connected via a Data Highway Plus to personal computers (PCs) that are used to provide the human-machine interface (HMI), and to accommodate control programming with ladder logic program language. The data highway network interconnects with VAX cell-level computers via Rockwell 1779 series KFMR communication interface units.

Batch process computers are networked with the VAX computers via a PDARS Ethernet network. Data query PCs are networked with Sun batch processors via the site Ethernet local area network (LAN). Data storage is managed by the cell-level VAXs in a redundant manner.

### *Modifications for Mustard Agent Processing at TOCDF*

The management of TOCDF has an outside system integration contractor developing a new, modern control subsystem (see Figure 2-5) that will be connected via a Rockwell 1779 series KP5R communications interface unit to the installed system and will support the planned processes for the mustard agent disposal campaign. The communication LAN will be a standard industrial Ethernet.

The committee noted that the new TOCDF control system Ethernet backbone does not have a parallel or redundant pathway. Although the single Ethernet backbone may have electronic reliability as good as the former redundant data highway, it could be vulnerable to failure from physical damage. TOCDF representatives stated that the installed cost of the single Ethernet was approximately $60,000. Provision of a redundant Ethernet path at TOCDF is worthy of reconsideration.

The batch process computers will be connected to the PDARS database via the PDARS Ethernet LAN, as in the initial system. A back-end database will also be connected via the Ethernet to the cell-level processing.

In the planned modifications to their PDARS configuration at TOCDF, plant devices are to be connected to PLCs via Allen Bradley 1700 series I/O modules, and PLC-3s and PLC-5s are networked by a redundant Data Highway II. This segment of the control system remains unchanged from the initial system.

In the new configuration, Data Highway II is also con-

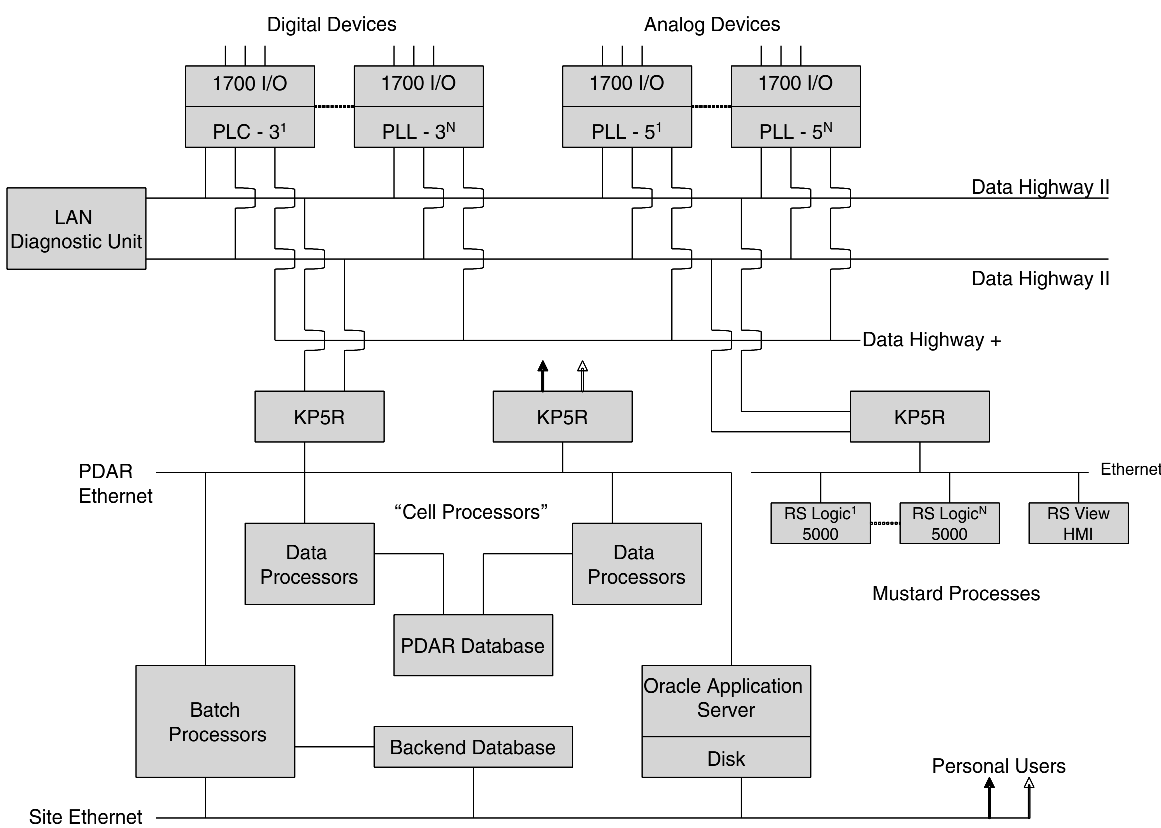


FIGURE 2-5 Schematic of the future TOCDF process control system architecture. SOURCE: Provided by EG&G during committee meeting on March 3, 2006.

nected via Rockwell 1779 series KP5R interfaces (10 times faster than the original series KFMRs) to RSLogic 500 systems, which will control the new processes for the mustard agent disposal campaign. RSLinx provides the interface to the PDARS VPN Ethernet LAN. New HMI PCs will have RSView software, and will have an RSLinx connection to the new Ethernet. TOCDF was the first site to recognize limitations in the Advisor HMI as planning was begun for the more complicated mustard agent processing campaigns. The RSView software was chosen without coordination with other sites at that time. As indicated above, a communication interface will permit the control center to have operational control and visibility for both the old and new subsystems.

The old Advisor system at ANCDF was also found in need of upgrading, and with the other WGI sites, a WonderWare system was selected as the replacement HMI. All WGI sites are scheduled to have the data highway diagnostic system upgraded with a new system developed by WGI that will be able to detect trouble at any LAN tap. This will enable fixes to be implemented without shutting down the whole system.

The logic behind the selection of two different HMI subsystems (RSView at TOCDF, WonderWare at the other sites) is based on the control systems architecture modifications necessary to accommodate mustard agent processing at TOCDF. The Tooele modification provides a simple, economic interface for the RSView subsystem, which in turn will provide for more efficient programming for the RSLogic PLCs dedicated to the mustard agent processes. It is the absence of such architecture modifications at the other three sites that allow for effective connection of the WonderWare subsystem.

The programming for mustard agent processing at TOCDF is unique, so software coordination problems should not arise. However, the display interfaces processed by the RSView HMI were modified so that display and related operator control processes would be consistent across all sites. Any future modifications of this type should similarly take consistency across sites into account.

**Finding 6.** The process control system design is old, but the systems can be satisfactorily maintained and are being upgraded as justified to enhance performance. There is some divergence in the choice of components at individual chemical agent disposal facility sites as upgrades are made, and this may limit future interchangeability of parts and operational knowledge.

**Recommendation 6.** The Chemical Materials Agency should continue to oversee control system improvements at individual chemical agent stockpile incineration facility sites to ensure that total performance standards are met and that sites coordinate those parts of the control system and its operation that can provide more robust continuing operations at a programmatic level. **(Tier 1)**

### Monitoring Systems

Chemical agent monitoring systems have been thoroughly reviewed by the NRC, most recently in 2005 (NRC, 2005). A key conclusion in that report was that the monitoring systems that are currently in place (ACAMS, DAAMS, and MiniCAMS) are adequate for their intended purposes and will remain so for the foreseeable future. Even though the supporting computer architecture could be considered to be obsolete, it is completely functional and should remain so for the life of the chemical stockpile disposal program.

Because of the risk reduction strategy incorporated into agent processing schedules (i.e., nerve agents first), near-real-time monitoring becomes less critical as destruction of nerve agents is completed. For example, there is no longer a need for ACAMS monitoring in much of the TOCDF facility because only mustard agent remains to be processed. The low volatility and lack of acute toxicity for mustard via the inhalation route of exposure obviate the need for extensive near-real-time monitoring. The same will be true for other facilities as nerve agent processing is completed.

The consequence of lessened ACAMS monitoring requirements is that ACAMS equipment should be available for sites that continue to process nerve agents. Some agent detection capability is needed in support of closure activities that include demolition and/or decontamination of facility structures and equipment. However, there should be enough remaining ACAMS to support these activities.

While there may be new detection technology available in the future, it may not be advisable to adopt such technology unless there are clear and compelling reasons for doing so. Prior to adopting new detection technology, there should be demonstrations that there are distinct advantages to safety, human health, or environmental protection and that the benefits clearly outweigh the cost (NRC, 2005).

## FACILITY PERSONNEL

Trained and knowledgeable personnel are crucial to successful safe continuing operations at the four operating chemical agent stockpile incineration facilities. Each site requires a highly competent workforce that must be maintained throughout the life of the project. In addition to the plant workers, teams of experts with specialized knowledge are also needed to address the processing upsets, incidents, and deterioration of equipment during extended operational campaigns. Operators and maintenance personnel need to be knowledgeable about the plant configuration at all times, including current operating and maintenance procedures. As the plant ages, personnel must also be alert to detecting equipment deterioration and to responding to abnormalities in processing that may require some corrective action.

Operating and maintenance procedures change in response to the aging of systems and must be updated accordingly. Workers will need training to stay current with such changes. The changes and the rationale for them need to be reviewed as part of the training, and workers need to demonstrate their understanding of the changes. Also important are the programs for maintaining a highly competent workforce, including site safety culture and communications of unusual process excursions or conditions. Site and programmatic aspects of these issues are further discussed in Chapters 3 and 5.

### Operating Procedures

Operating procedures provide technical guidance to personnel, as well as ensure consistency in the daily operation of the plants. The effective use of operating procedures in chemical agent stockpile incineration facilities is essential to their safe operation and continued operability. Operating procedures are reviewed by oversight groups focused on safety, environmental compliance, engineering, etc., and then approved prior to their use. These written procedures are available to operating personnel on the facility's database and are reviewed and updated periodically as needed. As facility equipment ages or is modified to maintain function, operating procedures are updated using the management of change processes described in Chapter 3. Operating personnel are involved in the review of operating procedures. The procedures address normal operation, emergency operation, temporary operation, and normal shutdown.

A particular challenge in chemical agent stockpile incineration facilities is the need for personnel to wear protective clothing in parts of the facility where agent is present or might be accidentally released. The highest level of protection is a demilitarization protective ensemble (DPE) suit that resembles a space suit with an air supply system and can allow workers to perform tasks in contaminated areas for periods of an hour or more. The suits are clumsy and hot, so work needs to be planned in advance to make sure that tasks can be performed without undue stress to the worker. The plants are designed to avoid routine worker operations in DPE suits, but nonroutine tasks and maintenance require human performance in DPE suits.

During the disposal of 1,120 overpacked leaking GB rockets at ANCDF, workers in DPE suits had to work inside the ECR to open the flanged overpack containers, remove the leaking rockets, and place them on the rocket disposal conveyors. A team of workers in DPE suits trained together to perform these operations and became quite adept at handling both routine and corroded overpacks. The committee was told that this team is going to UMCDF to work with a team there that will have to perform similar operations in the future.

In Chapter 3 the systems for managing the operating and maintenance procedures and maintaining a fully capable workforce are discussed in detail.

### Maintenance Procedures

As plants age there is a need for increased maintenance on the process equipment to ensure continued operability. To ensure safe and reliable operation, the maintenance practices used must follow suggested vendor recommendations or be defined internally to address technical and safety considerations. The continued operability of chemical agent stockpile incineration facilities is dependent in part on the effectiveness of the maintenance systems to proactively address obsolescence in their procedures and practices and to modify systems as required to process severely degraded stockpile items.

## REFERENCES

NRC (National Research Council). 1996. Review of Systemization of the Tooele Chemical Agent Disposal Facility. Washington, D.C.: National Academy Press.

NRC. 2005. Monitoring at Chemical Agent Disposal Facilities. Washington, D.C.: The National Academies Press.

# 3

# Site-Related Means for Effecting Continuing Operability

In this chapter the operational factors that affect and contribute to continuing operability at the chemical agent stockpile incineration facility sites are examined. These factors constitute the organizational framework by which the potential vulnerabilities described in Chapter 2 are managed. The first section focuses on the management of problems arising from obsolescence, the second on the means available to ensure that safety and environmental standards are met, and the third on personnel management. Information management is addressed separately in Chapter 4. The final section addresses some issues associated with specific sites.

## OBSOLESCENCE MANAGEMENT

### The Impacts of Obsolescence

The safest and most efficient operations occur when functional systems are stable. Unusual conditions (e.g., those arising from aging, unreliable, or substituted equipment; processing degraded agent and munitions; or something not covered by standard procedures) lead to less reliance on rule-based working and greater use of knowledge-based working (Rasmussen, 1983). Human participation is required in systems precisely because people can deal with unusual circumstances not covered by standard operating procedures through knowledge. This does not mean that human knowledge should be relied upon in place of stable operations. This section examines the actual and potential impacts that arise from changes of equipment, and how any negative impacts are and can be minimized. Some equipment changes may also require regulatory permit modifications that are discussed elsewhere in this report.

Equipment obsolescence and equipment changes can impact how operations and maintenance tasks are performed in the following ways:

1. Less reliable equipment can necessitate more nonroutine or off-nominal procedures, increasing reliance on knowledge-based reasoning.
2. Obsolescence can lead to a lack of trust in equipment, in turn leading to work-arounds and changed operating procedures for the purpose of reducing stress on the equipment and keeping it working longer.
3. Older equipment can require increased maintenance, potentially increasing DPE suit entries that are expensive and not without risk, and more time with the plant in maintenance (off-nominal) conditions.
4. Changing equipment from that originally installed may involve changes in the human interface and the operating characteristics. Both of these could lead to an increase in errors; these changes may also be a source of improved capabilities and hence improved performance if properly incorporated into procedures and training.

Changes to the equipment, system, or procedures must be addressed by a process for active management of change, which will have direct implications for the personnel involved at all levels. Moreover, it is not just equipment that becomes obsolescent and requires adaptation. The personnel involved in operations, laboratories, and maintenance all have skills and knowledge that change over time. In an employment field with a limited time horizon, such as chemical stockpile demilitarization, the public needs to be assured that there will be enough skill and knowledge retained in the workforce to safely complete the process across all sites.

### High Reliability Organizations

The consequences of error in chemical weapons demilitarization are potentially large so that any involved organization must maintain a consistently low error rate over extended time periods to ensure public safety and public confidence. Other organizations may have relevant experience that would also apply to chemical agent stockpile incineration facilities. For example, considerable research on high reliability organizations (HROs) has shown that they do in fact exist and have some common characteristics. These may be a useful model or benchmark for the chemical stockpile disposal program, in particular, in how HROs respond to change.

Roberts (1990) examined three organizations that had a very high level of safety performance while performing hazardous operations using complex technology and found several common characteristics. The organizations (an electrical supply company, the Federal Aviation Administration's air traffic control system, and a fighter squadron on a nuclear aircraft carrier) were all adept at "reacting to unexpected sequences of events" despite being in tightly coupled environments with highly time-dependent processes. Like the stockpile plants, these operations are too complex for reliance only on command-and-control procedure-driven processes. Workers also need to draw information from informal networks and from their own intuition when facing an unexpected situation. The characteristics Roberts (1990) reported that these organizations all use to achieve and maintain high reliability were:

1. constant training for normal and unusual conditions (e.g., one week in four);
2. redundancy in equipment and functions (e.g., a buddy system);
3. utilization of indirect as well as direct sources of information;
4. flexible layers of activities to reach goals; and
5. responsibility and accountability at all levels (e.g., any person can stop the activity).

All of these are present to some extent in chemical stockpile demilitarization, but can become increasingly important as the systems age and change, perhaps causing unexpected interactions, or what Roberts (1990, p. 107) calls "baffling interactions." In examining the chemical stockpile disposal program, the committee used the characteristics of HROs as one benchmark.

Examples of the use of HRO principles were evident at all sites, where people at all levels were seen to be willing to use their knowledge to intervene on the side of safety. For example:

- A "culture of inquisitiveness" was among the operating principles at several sites, and it was taught extensively in training and at team briefings where reasons were presented to improve the understanding of each procedure and its steps.[1]
- At ANCDF two incidents were reported where an operator had intervened through inquisitiveness. First, when the deactivation furnace system (DFS) appeared to be running hot, the problem was that a thermocouple had sagged, causing erroneous readings, and the operator took manual control. In a second reported incident, DFS pressure excursions too small to trigger the automatic action threshold were traced and corrected by the control room operator after an unpack operator had reported some unusual noises occurring after weapons had passed out of the unpack area into the adjacent processing area.
- Many examples were presented of operators stopping operations (e.g., during maintenance performed in DPE suits when the actual configuration of hardware did not match that shown in the procedure). At ANCDF and UMCDF at least, such actions are reported favorably in the daily newspaper and even are used as a basis for instant rewards of gift cards for local stores.

### Obsolescence Management Planning

The Chemical Materials Agency (CMA) stated at the committee's first meeting that it is committed to managing obsolescence problems and is also relying on its experienced site contractors who are those best equipped to understand potential issues.[2] As previously noted in Chapter 1, the Army does have standards and guidance on the management of obsolete weapons stockpiles and other military equipment (U.S. Army, 1999). But while the guidance does include some provisions for dealing with unavailability of parts, the guidance is largely not applicable to aging chemical agent disposal facilities. A further barrier involves differences in the nomenclature used. DOD uses Category 3 as its highest obsolescence risk, with Category 1 being routine. At stockpile disposal facilities, the safety ranking system has historically used Category 1 as the highest risk (that leads to a halt in processing) and Category 3 is routine. Introducing the inverse DOD categorization structure would be confusing from a human factors viewpoint.

**Finding 7.** The Department of Defense (DOD) standards on obsolescence are focused on criteria and considerations concerning obsolete weapons and other military equipment stockpiles. The DOD standards do not address the broader range of issues encountered in an operational processing facility. Another barrier to partial use of these standards is that they categorize the risk of obsolescence in a manner that is the inverse of the stockpile facilities' long-standing categorization of safety-related risks.

**Recommendation 7.** The Chemical Materials Agency should disengage from using the inapplicable DOD diminishing manufacturing sources and material shortages stan-

[1]Core Values of ANCDF Operations, presentation by Robert C. Love, project general manager, ANCDF, to the committee, April 6, 2006.

[2]Chemical Stockpile Disposal (CSD) Facilities and Equipment Obsolescence Assessment, presentation by Joseph Pecoraro, project manager for chemical stockpile disposal, CMA, to the committee, January 25, 2006.

dards and develop a program for obsolescence management that is tailored to the needs of the chemical agent stockpile disposal program. **(Tier 3)**

At the request of the CMA, site contractors have begun to develop plans for managing obsolescence. The TOCDF site started making plans independently; the Washington Group International (WGI) sites developed a three-site initiative for the other incineration sites.

Planning at TOCDF focused on high-risk systems—initially the critical utility systems: the emergency generators, the uninterruptible power supply, and the HVAC system.[3] Major upgrades on each of these systems have been made where vulnerabilities were found. A database system to track repair orders has been initiated, and plans are to incorporate this information into the TOCDF parts reorder program.

The program at WGI sites (ANCDF, UMCDF, and PBCDF) is focused on critical components and a systematic look for components with an unreliable supply.[4] A database on parts, spares, and frequency of repair or replacement, vendor(s), point of contact, etc., called the WGI Asset Management program, is being developed. TOCDF will eventually become part of the database since EG&G is also working on this program in close relationship with WGI.

The plan is to use the database information to develop an Obsolescent Equipment Management Lifecycle program (OEM-LP), which is an approach that was originally started at TOCDF. Aspects of this OEM-LP system were shown to the committee during a site visit to TOCDF in March 2006, and this work in progress seems to be progressing in a suitable manner.

While all of the incineration sites are participating in these activities, approaches and concerns differ to some extent from site to site. Progress on review and upgrading of the control systems was discussed in Chapter 2. A systematic review of other critical systems was started in 2004, beginning with a review of the metal parts furnace (MPF) at each of the sites and followed by a review of the conveyors for the container handling building (CHB) and the munitions demilitarization building (MDB), and the liquid agent incinerators (LICs). Reviews of the DFS and the pollution abatement system (PAS) have been scheduled. These reviews are intended to enhance the potential for identifying differences in configurations among the facility sites and the extent to which parts are interchangeable.

The incineration sites have collectively developed a list of experts for different systems and pieces of equipment. At present each expert has one or more backup people. As problems arise from the aging of equipment or changes in operations, these experts are shared by all the sites and can be dispatched for up to two weeks or longer to any site having a need for that particular expertise.

There is a daily teleconference among all the site managers where operations are discussed and where problems and responses to problems are shared.

**Finding 8.** The site contractors for the chemical agent stockpile incineration facility sites are developing and implementing plans for managing obsolescence at each site. The Army and its contractors recognize that a process to continuously identify and evaluate critical components and parts is necessary to offset increasing vulnerability to obsolescence. Evolving systems at the various sites differ in approach and how critical components and parts are identified. These differences can have adverse implications for future program obsolescence management.

**Recommendation 8.** The Chemical Materials Agency should implement an effective, consistent, and documented system to manage obsolescence, including the sharing of expertise and spare equipment and parts across the chemical agent stockpile incineration facility sites. **(Tier 2)**

## SITE SAFETY AND ENVIRONMENTAL MANAGEMENT

Each of the chemical agent stockpile incineration facility sites operates within a structure of policies, procedures, and training programs that are intended to ensure operational safety and regulatory compliance. As the facilities and equipment age, changes will be needed to proactively manage obsolescence. A key challenge is to continually update plant specifications, drawings, procedures, and other items related to plant configuration, so that the past and present status of the facilities are documented in an accessible manner and that all permits are up-to-date. In this section the committee presents a review of the configuration management processes in place at the sites, especially the management of change processes.

### Configuration Management

Equipment changes are not just a function of obsolescence; they also occur periodically as disposal campaigns change and as better methods of operation are devised. Examples are the upgrading of MDB chillers to meet increased heat load demand and better diagnosis of data highway bottlenecks using a new probe test system.

There are some changes necessary for continuing operability that have human performance implications. Certain worn equipment cannot be easily replaced as it ages or circumstances change. An example is the DFS at TOCDF,

[3]Obsolescence Issues of the Tooele Chemical Agent Disposal Facility, presentation by Terry Thomas, engineering manager, EG&G, to the committee, January 25, 2006.

[4]Obsolescence Issues of Other Incineration-Based Disposal Facilities, presentation by Anthony Medici, Washington Group International, to the committee, January 25, 2006.

which has required changes in operation, primarily reduced loading rates, to keep it running without causing it to be damaged during mine campaigns. Another example is the hydraulics system at TOCDF that had insufficient capacity and started to damage pumps by cavitation. This also led to loading restrictions. Similarly, the data highway at TOCDF has a bandwidth bottleneck so that currently unused screens (e.g., utility screens) in the control room have to be switched off to ensure reliable operations. A final example is from UMCDF, where manual valves located outside had to be "babied" as the handles and mechanisms were aging.

Equipment meant to replace obsolete equipment is not always identical to the installed equipment so machining work may be necessary to make connections fit (e.g., the lift cylinders for the bulk drain system at TOCDF). Sometimes a change in campaigns may lead to an unanticipated incompatibility of materials. An example of this is the sump lining material at TOCDF that was designed for compatibility with decontamination fluids for GB, but was eroded by the different decontamination fluids used for VX. The sumps had to be relined with a suitable new material.

### Management of Change

Effective configuration management in an environment where changes to equipment and procedures are occurring requires both an understanding of the change process and formal systems to ensure that the changes are indeed beneficial. As plants age there is an ongoing need for change to maintain process efficiency and safety and to reduce costs. These changes may reflect improvements in technology, lessons learned, equipment changes, or advisories (safety alerts), as well as new parts (other than replacements in kind) for existing processes because the original parts are no longer supplied by vendors. Engineering change proposals (ECPs) are the primary way the configuration of the plant is kept current as equipment is modified or procedures are changed as a result of obsolescence or lessons learned. Many ECPs are processed each year at chemical agent stockpile incineration facilities. For perspective, ANCDF has processed about 600 ECPs since starting operations and has a backlog of 40 awaiting action.[5] Each ECP must be reviewed and accepted by quality assurance, safety, maintenance, operations, engineering, and permit compliance departments before being implemented.

While ECPs are generated at all sites for major changes in plant configuration, the policies concerning review of more minor configuration changes vary from site to site, sometimes because of regulatory requirements. Since ECPs are generated independently as needed at each site, their implementation may lead to some divergence in configuration among the sites, unless intersite communications or implementation of a lesson learned lead to a common change. From a programmatic safety and operability viewpoint, a consistent policy for handling different sorts of configuration and procedural changes is desirable.

There are variations from site to site in the criteria for requiring an ECP for more minor changes. This often involves a judgment call that may overlook the need for a more comprehensive safety review. The committee reviewed about 75 lower-level changes that were made at TOCDF without requiring an ECP. These included the following items, all of which required a documentation change:

- work order No. 122836, Install a valve at ground level for 3/4 -V-56 Venturi;
- work order No. 125927, Install a new isolation valve V-9895 on Line 5244;
- work order No. 140939, Chilled water piping modification (not replacement in kind); and
- work order No. 142294, Change flame scanner cooling air from compressed air to instrument air source.

Changes such as these could have potential impact on overall system integrity. For example, at UMCDF under procedure UM-EN-003 minor changes do not require an engineering action classification and may be implemented with only a document change notice. The regulatory definition of management of change includes all modifications to equipment, procedures, raw materials, and processing conditions other than replacement in kind. The examples given above are not replacements in kind. As the equipment continues to age and have more modifications such as these, a careful review of the criteria for requiring and implementing ECPs consistently across the sites is prudent.

To ensure that changes do not adversely impact the safety and operability of chemical agent disposal facilities, a disciplined management of change process must be followed. When an ECP is adopted and leads to changes in processes or procedures, the changes are analyzed for any potential impacts on the process hazard analysis. This is the main documentation for determining that safety levels are acceptable. Changes that pass a proper process hazard analysis safety review will not have any significant impact on the overall results of the quantitative risk assessment for the facility.

If the ECP involves a physical change, an engineering work package is generated to implement the change. This triggers a configuration management process that includes updating plant drawings and relevant procedures. The Army field office at each site also has a configuration control board that approves and tracks these changes.

A means being used to make the change management process more effective at all sites the committee visited involves placing more reliance on team review, team training,

[5]ANCDF Site Overview, presentation by Timothy Garrett, site project manager, ANCDF, to the committee, Anniston, AL, April 6, 2006.

and mutual understanding, and less reliance on multiple sign-offs of ECPs. However, it is still not universal practice at some sites to have the engineers who write the ECPs verify them "on the ground" with actual users—an essential step in ensuring workable procedures and discouraging the need for subsequent revision.

Whenever an ECP results in a corresponding change in any of the written procedures or other configuration-related documents, a document change procedure (DCP) is initiated and subjected to review processes that are similar to an ECP. At UMCDF and ANCDF, the committee saw evidence of field walk-through reviews of revised procedures by teams including operators. These team reviews help to identify any errors or possible improvements to the procedures. The actual users of the procedures must sign that they have read them before work can start. Although such a process does not ensure that the procedures are well written, work documentation observed at all sites was typically well designed for operator use. For example, the work orders are self-contained and do not require the user to consult other documentation.

During this study, a DFS incident occurred at ANCDF (see Box 3-1) that highlights the importance and possible impacts of the management of change processes. Here the site used an ECP for the same operation from TOCDF and relied on an experienced contractor to provide safe implementation rather than perform an independent review that might have identified minor differences in configuration that turned out to be important. This incident notwithstanding, good configuration management and management of change procedures are in place at all sites, such that any differences between the DFS at ANCDF and the other sites can be reviewed individually. At the time this report was in development, a root cause analysis report of the ANCDF DFS bricking incident was being prepared. Recommendations are expected to result that should address contributing deficiencies in the management of change procedures.

**BOX 3-1**
**ANCDF Incident as Reported in the *Anniston Star***

**Fire Brick Spacing Error Blamed for Furnace Collapse**
***Ben Cunningham***

Army officials and contractors believe they now know why a furnace at the Anniston Chemical Agent Disposal Facility broke in two during a test run in May. They plan to have the facility running again by the end of July.

Workers were testing the deactivation furnace May 8, after destroying the last of the sarin nerve agent stored at the Anniston Army Depot in March. At about 10 p.m. that night, 72 carbon-steel bolts, which held the 7-foot-diameter, cylindrical steel furnace suspended above the ground, broke. The lower portion of the furnace fell away and became wedged 10 to 15 feet above the ground in a steel-beam frame around the furnace.

Officials from the Army and Westinghouse Anniston, which operates the chemical weapons incinerator for the government, said Thursday they believe the bolts broke because a lining of insulating bricks inside of the steel cylinder was replaced incorrectly after the last of the sarin was destroyed.

The bricks, which expand in the furnace's intense, 2,100-degree heat, were installed by contractors with gaps that were too small between sections of the brick, said Bob [Robert C.] Love, project manager for Westinghouse Anniston.

"The expansion without the proper gaps caused the bolts to shear," Love said.

Tim Garrett, the Army's project site manager for the incinerator, said the bricks were installed using an older design developed for the furnace's original construction. Engineers had decided to update the design, allowing more room for expansion of the bricks, but drawings provided to bricklayers did not contain updated instructions.

"They installed it by the instructions," Garrett said. "We're talking about portions of an inch here, but a half an inch or an inch makes a heck of a difference to us.

SOURCE: Reprinted, with permission, from the June 30, 2006, edition of the *Anniston Star,* Anniston, Alabama.

## Critical Safety and Emergency Systems

### *Critical Safety Systems*

Critical safety systems are usually considered to be those that are necessary for safe plant operation during processing and also those required for the safe shutdown of the plant in the event of an unanticipated malfunction. Within an incineration plant, examples of critical safety systems include agent monitoring systems, testing or inspection of pressure relief valves, ventilation flow and control systems, fire protection systems, emergency alarm and shutdown systems, process interlocks, and furnace temperature control systems.

As plant process equipment ages a continuing need exists to ensure the reliability and functionality of supporting systems that are critical to safe operations. Aging or leaking munitions may also cause safety systems to be activated with some increase in frequency. Factors that could adversely impact the effectiveness of the supporting critical safety systems thus require an established means for ongoing review and evaluation.

Within the incineration facilities, critical safety systems must be properly identified and maintained to ensure safe continuing operations. Since the incineration systems designs are similar at the four operating facilities, the critical safety systems should also be similar. The committee evaluated the consistency with which each of the plants identified critical safety systems, as well as evaluating the supporting maintenance and testing or inspection programs for validating the readiness of the systems.

Based on interviews with personnel at three of the incineration plants, the committee concluded that critical safety systems in general are clearly identified but that, as described previously, the definitions at TOCDF differ from those used for the WGI sites, although work is in process to integrate the best aspects of the two approaches into more consistent plans.

"Advisories" are safety alerts to address serious safety issues that need immediate attention. Advisories are communicated among the incineration plants and may be reviewed informally in the daily site manager teleconferences. However, no formal feedback mechanism to communicate and document that the safety alerts have been implemented was observed, although they often may become part of the lessons-learned database where follow-up is documented.

Supportive safety procedures are utilized to ensure that there are necessary controls in place for safe maintenance and repairs; that importantly includes nonroutine hazardous work. These procedures encompass rules governing lockout and tagout, confined space entry, elevated work, electrical work, etc. The committee found some minor problems in these supportive procedures and differences among the sites, especially when some of the work is done by subcontractors, who may have their own practices.

#### *Emergency Response*

The capability of a chemical agent disposal facility to have an effective emergency response is critical to its continuing operability. In evaluating the emergency planning capability at the incineration plants, the committee focused on the capabilities of the plants to address accidents, medical emergencies, significant operational safety events, process upsets, natural disasters, acts of terrorism or sabotage, and loss of utilities. Written emergency response procedures have been developed that address these identified emergency scenarios.

For those potential hazards that could affect the surrounding community, an active outreach program has been established to inform local emergency response agencies (fire department, police, civil defense, hospitals, etc.) as well as local civic organizations of emergency response actions to take in the event of an emergency. Civic organizations in the community are immediately notified in the event of an emergency. The outreach program includes training on shelter-in-place techniques and, at one facility, respirators have been provided to families in the potentially affected areas.

However, critical emergency safety systems may also be subject to potential obsolescence. For example, at one plant a potential obsolescence issue relating to maintenance of the fire water protection system had to be proactively addressed. Also, the committee was informed that the Mine Safety Appliances (MSA) Company, which has supplied parts for the self-contained breathing apparatus (SCBA) respirators, will no longer supply these respirators in the future. In response, the Army purchased the remaining supplies. At the current use rate these supplies are expected to last through the end of the chemical stockpile disposal program. Commercial suppliers of SCBA respirators are available. The committee believes a program to identify and evaluate other qualified suppliers of the respirators is prudent.

Obsolescence issues related to emergency systems are being proactively addressed at the incineration facilities. For instance, the ventilation system and emergency generators at TOCDF have been upgraded.

The committee was informed that operating and maintenance personnel from at least two plants are trained to Level 1 of the Occupational Safety and Health Administration's (OSHA) Hazardous Waste and Emergency Response Standard (HAZWOPER). Emergency responders also receive HAZWOPER training, which is required for cleanup operations at RCRA-permitted sites.

**Finding 9.** The chemical agent stockpile incineration facility sites all have adequate safety programs, but there is considerable variability from site to site in definitions of critical safety systems; dissemination and response to site-specific and programmatic safety alerts (advisories); procedures for control of nonroutine hazardous work; details in policies for management of change systems; applicable attributes of high-reliability organizations; and organization and implementation of training programs, including the testing of their effectiveness. As facilities and their equipment continue to age, effective safety programs must be maintained until each facility is fully decommissioned (closed).

**Recommendation 9.** In the interest of continuing safe operability, facility staff at each chemical agent stockpile incineration facility site should continue to compare their operations and performance with those at other sites and with practices in the broader chemical industry for dealing with hazardous materials to ensure continual improvement in safety performance, consistency in major safety practices, and safety-related cooperation among the sites. **(Tier 1)**

### Environmental Compliance and Waste Handling Systems

Each of the incineration sites operates under Resource Conservation and Recovery Act (RCRA) and other state and local permits that specify plant configuration and operating parameters approved for environmental compliance. Any significant changes to permitted conditions must be reported, and major modifications may require extended review and comment before a permit modification is issued. Obsolescence planning needs to anticipate any replacements or changes in operation that require permit changes so that timely application for permit modifications can minimize the impact of permitting delays on overall schedule.

Some of the incineration sites initially had permit constraints on the amounts and types of secondary waste (e.g., used DPE suits, packing materials, filter charcoal) that might be shipped off-site for commercial disposal. For example, TOCDF has a substantial backlog of secondary waste that will ultimately have to be treated during closure. TOCDF consequently will have an extended closure period. ANCDF has found ways to dispose of secondary waste to reduce backlogs during periods when the MPF is not being used for demilitarization operations. Other sites are allowed to do some off-site shipment of secondary waste to avoid accumulation. The WGI incineration facilities are incorporating programs for disposal of wastes into operational plans to avoid any significant accumulation for treatment during closure. Off-site shipment can significantly reduce the operating duty requirements imposed on the LIC and MPF by secondary waste disposal during plant operations and during closure.

## PERSONNEL MANAGEMENT

Maintaining the human capabilities of personnel within aging chemical agent stockpile incineration facilities is as important as dealing with the obsolescence of equipment. First of all, it is essential that a highly competent workforce exist at each site. A second critical issue is the retention and renewal of capable personnel and their expertise throughout the life of the facility operations.

As the facilities age it is crucial that operating and maintenance procedures are clear and current and that tasks are designed properly so that workers can be utilized most productively. As changes to obsolescent systems are incorporated, proper attention to human factors is likewise an opportunity for the continuing operability of the facilities to be enhanced.

### Knowledge Sharing

Safe operability depends not only on equipment but also on the skill and knowledge of workers and managers. Not all information essential to continued safe operation resides in specified procedures and system documentation, including past end-of-campaign reports from other sites; the committee noted that these reports were much consulted guides to current operations.

Programs to maintain the necessary personnel skill and knowledge within the demilitarization system are needed at all stages of operations, but they become particularly important as campaigns near their end, as problems with some badly degraded agent lots are identified, and during closure of a facility. Given the large investment made in personnel training for chemical demilitarization and the long time required to bring new hires up to safe operating standards, personnel retention is preferable to the alternative of recruiting new personnel.

Still, when people leave, even at the lower organizational levels, a system of knowledge retention can help to ensure that operational wisdom is not lost. Knowledge management includes processes for technically debriefing personnel who are departing in order to retain their knowledge and skills and transfer it to replacements. The committee observed little evidence of such knowledge management efforts at any site, with exit interviews being the typical limit in this regard. Knowledge management is important at all levels of relatively unique organizations such as those engaged in chemical demilitarization, from operators through maintenance personnel to engineers and managers. The previously noted list of experts that has been compiled across the sites is a useful way to begin a knowledge management program. All-site topical workshops scheduled among the sites and CMA several times each year also reinforce communities of practice at site and programmatic levels.

Even when staff members do not leave, important knowledge may not be available to address problems at one site if it is not known that a person with such useful knowledge exists somewhere else. To avoid this situation, the organization must be able to define the skills and knowledge necessary for each technical community, identify who has such skills or knowledge, and enable accessibility by each technical community to them when needed. Such an approach implies that communities of practice—plant operators or warehousing specialists, for example—be defined and supported in a formal knowledge management program. Although there has been some activity of this type already with respect to the chemical stockpile disposal program,[6] the overall state of practice regarding knowledge management is at this time ad hoc and incomplete.

A knowledge management program is clearly an important ingredient for continued successful operation of the disposal facilities, and will only become more critical as the number of operations decreases in the future and the current personnel are discharged. One of the challenges that will be particularly difficult in this situation is the limited number of individuals with experience in very specialized areas, making a traditional community of practice much more difficult to sustain. It is likely that more face-to-face contact between experts from the different facilities will be required to maintain necessary communications, and incentives to encourage

[6]An example is the periodic meeting of the 8+1 management group (the respective CMA and contractor site managers for each incineration facility and a manager representing the CMA headquarters).

that communication through monetary or other motivating devices will be needed for success. Careful thought should be given to implementing this system, and an inventory of critical knowledge should initially be completed to make sure that efforts are placed in the areas having the highest value for continuing operations.

**Finding 10.** Only limited evidence was observed regarding programs or measures to share or protect the knowledge base important to the safe and effective functioning of the various communities that together constitute the capabilities on which the operability of chemical agent stockpile incineration facility systems depends.

**Recommendation 10.** A formal knowledge management program should be implemented by site managers under the guidance of the Chemical Materials Agency to identify various communities of practice among the workforce at chemical agent stockpile incineration facility sites, define the skills these communities encompass, and ensure that the skills of each member in a particular community are made available to the community as a whole as necessary. This program should also monitor the skills inventory in each community with the aim of detecting potential vulnerabilities (e.g., situations where the personnel to deliver any particular mission-critical capability are limited), and implement measures to retain staff and increase capabilities among staff where such vulnerabilities (limitations) are encountered. **(Tier 2)**

### Personnel Retention

There is little potential for the creation of new jobs at the chemical agent stockpile incineration facilities since all of the contracts are already in place and operations are in progress. Workforce recruitment at these facilities has been based on a mixture of local personnel and experienced personnel from the Johnston Island facility or other continental U.S. facilities. The current workforce is relatively stable. The committee notes this is unlike the situation at Johnston Atoll Chemical Agent Disposal System (JACADS) where incentives were needed for retention. The turnover at current operating facilities is dependent on what other local opportunities are available and is lower (about 1 percent) at TOCDF but higher at ANCDF and UMCDF (about 10 percent) where more competing job alternatives exist. PBCDF still is not fully staffed because of a limited local skill pool and difficulties in getting nonlocal personnel to relocate. Opportunistic losses, such as when several maintenance staff at UMCDF left for jobs in an Alaska oilfield, also occur. As the operations at each site wind down, personnel may begin to leave for more permanent jobs before the stockpile demilitarization is completed. No evidence of this at present was reported to the committee, but that it happened at JACADS is a concern for the continuing operability at currently operating facilities.

Site contractors will probably employ various types of cash incentives, such as bonuses for continuing service or termination bonuses for staying to a predetermined end date based on programmatic needs. Retention incentives can go beyond cash rewards for continued employment. A variety of noncash incentives to help retain personnel were used at JACADS and continue to be used at the currently operating facilities in the continental United States. Related activities include support of community planning activities that might provide replacement jobs after facility closure. At JACADS the retention of personnel, and hence the skill and knowledge they possess, was accomplished with the introduction of retention bonuses, although these were started rather late in the operational life of that facility when many key personnel had already been lost. These included:

1. provision of educational and placement opportunities to make it easier for personnel to remain with the chemical stockpile disposal program to the end and still find employment after the closure of JACADS, as well as educational opportunities for the families of personnel employed;
2. extended medical benefits after closure; and
3. provision of portable 401k or similar retirement plans.

**Finding 11.** Personnel turnover varies across chemical agent stockpile incineration facility sites, but is generally low. However, this situation may not continue as facilities approach the end of disposal operations. Retention incentives have not yet been applied in an effective manner to help ensure continuing safe operations.

**Recommendation 11.** The Chemical Materials Agency should ensure that site contractors promptly develop staffing plans capable of being tailored to site-specific needs while recognizing the challenges of maintaining a competent staff throughout operations and closure. **(Tier 2)**

### Personnel Training and Procedures

Another aspect essential to the continuance of safe chemical stockpile demilitarization operations is the training of personnel. Since the equipment and operations at sites have undergone a gradual divergence, training is no longer centrally provided mainly by the CDTF at the Edgewood Area of Aberdeen Proving Ground (Maryland), but is now largely site specific. Training occurs in several ways: at initial hiring; as regular refresher training; and as needed (just in time) for new and changed operations. Although most recruits arrive with some chemical industry training and are knowledgeable about basic chemical process equipment, the specialized chemical demilitarization equipment and agent safety procedures will in many ways be novel.

The content of the training must be closely aligned with the current operating procedures. Evidence was presented to the committee that procedures and engineering changes were being revised and personnel trained more consistently at TOCDF than in the past.[7] Training is provided in a more performance-based manner, but still consists of either classroom or on-the-job (work experience) modes. Computer simulations are used in training control room operators to respond to upset or emergency conditions. In addition to computer-based training for knowledge transmission, more use of computer simulation models may also prove helpful in training teams to work through revised procedures before they are implemented in the plant.

Each plant's certification program for its operating personnel includes evaluation of their knowledge of the pertinent operating procedures and documentation of training and retraining. Because each site has developed its own training and testing programs, the committee noted some inconsistencies among sites. A sharing of best practices across sites could result in more effective programs at all sites.

## Incorporating Human Factors into Changes

### *Control Room Operating System*

One example of a well-thought-out change to address an issue of obsolescence is the replacement of the control room operating system (Assist) with a new one (RSView or WonderWare) when the former was no longer supported. There was a choice during this upgrading to change to an operator interface more cognizant of human factors than was possible with RSView. However, the decision was to change the operating system but to keep the interface similar to the original. This effectively decoupled the new operating system from the existing operating interface to allow each to be separately verified in operations. A second good feature of this change was to maintain the two systems in parallel on the two screens at each workplace until all operators and supervisors were comfortable with the change (Eason, 1989). This is an example of equipment redundancy essential to HROs.

At ANCDF this parallel running was preceded by using each system in turn to command changes while the other system was used to monitor the effects of these changes. However, one aspect of this change at ANCDF was not well engineered from a human factors perspective. The spatial mimic screen showing the ACAMS alarms and current readings was replaced by a tabular listing screen, to ensure good use of screen space. However, the list did not allow direct spatial perception of spreading changes in ACAMS readings, as could be experienced during upset conditions, thus increasing the time required for the operator to achieve the necessary situational awareness. Operators said, "We will soon learn it," but that approach is tantamount to using a training solution to address a hardware issue. The lesson is that any equipment interface changes must not adversely affect human performance.

At UMCDF the committee observed that there was consistency in format across procedures in that all sentences started with an action verb presented in bold type, and branches in procedures were well designed with an IF (condition), THEN (Action 1) ELSE (Action 2) format, although this was not seen in all cases. Further improvements could be the use of techniques such as the specialized language of Simplified English, and flowcharts at the start of each procedure to provide an overview to operators before they read the detailed steps.[8] Where changes are involved, the design and even the formatting of ECPs can help operating personnel to perform new or revised tasks with minimal or no increase in errors. Conversely, poor procedure design can lead directly to operating errors (Drury, 1999).

### *Maintenance*

The maintenance of facilities includes preventive maintenance programs that identify required preventive maintenance activities and recommended intervals based on safety, reliability, and economic considerations. Factors such as failure rate, replacement costs, impact on operations and safety, lessons learned, and analysis of incident causes are considered. Computerized programs provide for preventive maintenance schedules to be planned, implemented, and monitored.

Significantly, there also is a system at the WGI sites that encourages "condition reporting." Any employee can write a report that indicates a condition (e.g., corrosion, impaired operability, or a maintenance problem) that the employee thinks is worthy of further investigation. The condition report is entered into an online database and is directed to the employee's supervisor for assessment. If deemed valid, this triggers an investigation that ends with an action communicated to the initiator of the report.

The effectiveness of the maintenance program at two of the facilities reviewed was increased by using predictive maintenance. The predictive maintenance program monitors key equipment indicators predictive of impending problems by detecting problems in the early stages. Plans and schedules are then made for maintenance to be performed prior to predicted equipment failure.

Failure data generated during preventive maintenance and predictive maintenance present an opportunity to identify potential equipment obsolescence issues. For equipment

[7]Personal communication from Gary Weimer, EG&G, to committee members Elisabeth Drake, Colin Drury, and Charles McGinnis, March 3, 2006.

[8]Simplified technical English uses a limited vocabulary and simplified grammar to reduce ambiguity and improve understanding by people whose first language is not English (ASD, 2005).

whose parts are no longer supplied by vendors, ECPs are used. These include review and approval by quality assurance, safety, engineering, and operations personnel to ensure that technical and operational design considerations are evaluated.

In general, plant personnel use the recommended maintenance procedures provided by equipment vendors. These personnel have been trained and possess the skills needed for the type of maintenance work to be performed.

The maintenance system and its procedures have evolved over time and now include a 12-week planning horizon. This enables personnel to schedule procedures having similar requirements for access to areas and equipment at the same time. Another benefit is that teams are more stable and there is increased emphasis on knowledge-based operation that is cultivated within a culture of inquisitiveness. The longer-term scheduling also allows parts required for each job to be ordered well in advance. There is no formal "kitting" that gathers all parts and supplies needed for each job, but all of the more specialized equipment is stored together to make job preparation simpler and less error-prone.

## SITE-SPECIFIC ISSUES

This section discusses issues and concerns the committee identified at specific CMA sites. Specific and unique issues were identified at TOCDF, PBCDF, and the Newport Chemical Agent Disposal Facility (NECDF), which uses hydrolysis (neutralization) to destroy bulk VX nerve agent stored in ton containers instead of using incineration. Also included is a section on issues that may have applicability to, and should be considered in, the disposal operations planning for the two future Assembled Chemical Weapons Alternatives (ACWA) program facilities in Pueblo, Colorado, and Lexington (Blue Grass), Kentucky, which also employ neutralization as the primary destruction technology.

### At TOCDF

The stockpile at DCD represented over 42 percent of the total original U.S. chemical weapons stockpile, counting all agents and munition and container configurations. TOCDF began disposal operations in August 1996, first destroying GB agent and munitions and completing GB destruction in March 2002. After facility decontamination and changeover, destruction of VX agent and munitions began and was completed in June 2005. All GB- and VX-agent-filled munitions and containers have been successfully destroyed and represent 54.5 percent of the original DCD stockpile. As TOCDF prepares for starting mustard agent disposal operations, ways to deal with the mustard agent in ton containers that have been found to have some mercury contamination have been a subject of active planning. The consequence of this contamination is that processing times will need to be extended and significant system modifications may be required.

Preliminary testing has shown that an unknown number of the more than 6,400 ton containers of approximately 1,800 pounds of mustard agent each contain mercury contamination that could interfere with disposal operations and environmental permit compliance. Some of the containers also appear to have substantial heels of solid and gelled material. Sampling and characterization of the contents of each ton container is required. Under the joint sampling project, DCD workers will deliver bulk containers to specially outfitted and equipped igloos in the Area 10 munitions storage location, where EG&G workers will transfer them into sealed glove-box units, allowing operators to safely open them and remove samples for analysis and characterization by site laboratory personnel. Following sampling EG&G workers will close and return the containers to DCD personnel for segregation and storage according to their contents. Sampling operations will allow individual bulk containers to be categorized for later disposal. The sampling project is now underway and is expected to take two and one-half to three years to complete. Bulk container disposal operations were expected to begin in 2006, first targeting for destruction those sampled containers identified as having little or no mercury contamination and low solids content. Safety and operational risks are inherent due to the unique and largely manual operation for such a large quantity of containers.

### At PBCDF

The Pine Bluff stockpile contains approximately 12 percent of the original total U.S. stockpile and consists of GB agent in M55 rockets, VX agent in M55 rockets and M23 land mines, and HD and HT mustard agent in ton containers. PBCDF began disposal operations in March 2005. Like TOCDF, Pine Bluff has a unique feature in that the stockpile includes approximately 3,600 ton containers of mustard agent HT, which is a blend of approximately 60 percent HD (sulfur mustard) and 40 percent agent T.[9] Concern exists about the condition of the HT in the ton containers due to the unique mixture as well as the fact it was manufactured in the early 1940s. Limited sampling conducted in the 1970s indicated that there was a significant heel of sludge and solids in the containers. Because many of the ton containers at DCD came from the Pine Bluff site, it follows that the containers of HT at Pine Bluff should also be tested and the agent condition characterized regarding mercury as well as other contaminants and solids. Planning has been done and initial work begun to sample, analyze, and characterize the contents of

[9]Agent T is bis[2-(2chloroethylthio) ethyl] ether. HT is prepared by a chemical process that systhesizes the HT directly without further formulation in such a way that it contains both the HD and T constituents along with some impurities. The addition of T lowers the freezing point and expands the effective temperature range over which HT might be used in chemical warfare.

these HT containers. There currently is time to do this sampling and acquire any necessary equipment for processing these containers, while PBCDF continues destroying the remaining GB and VX M55 rockets and M23 landmine stocks. Mustard agent destruction operations are scheduled to begin in September 2008.

### At NECDF

The Newport stockpile represents approximately 4 percent of the original stockpile, consisting of bulk VX agent in ton containers. NECDF began neutralization of VX in May 2005 and had neutralized 19 percent of the stored VX as of mid-2006.

The hydrolysate resulting from the VX agent neutralization is being stored on-site pending a decision on the final disposition of the hydrolysate. Disposition or further treatment of the hydrolysate is necessary under Chemical Weapons Convention rules for agent destruction. NECDF continues to face issues regarding the disposition of the hydrolysate through shipment to an approved hazardous waste treatment facility. If off-site disposal is not permitted, an on-site treatment facility would have to be designed and built. This would have a major impact on schedule and costs and would also complicate site closure plans.

### Assembled Chemical Weapons Alternatives (ACWA) Facility Design and Operations Applications

For this report the committee did not evaluate the two ACWA program sites at Pueblo Chemical Depot (Colorado) and Blue Grass Army Depot (Kentucky). However, the committee suggests that ACWA government and contractor management personnel review this report in detail for information, issues, and recommendations that have potential applicability to the ACWA program procedures and processes. This is particularly important since the ACWA sites will likely be operating after the other stockpile sites complete destruction operations. There will essentially be no opportunity for hardware overlap at that point, and both of the ACWA plants are one-of-a-kind, first-generation pilot plant facilities. Additionally, a large number (over 700,000) of cartridges and projectiles are stored at the Pueblo site and processing them will require reliable operation of the munitions disassembly machines over a period of several years. Obsolescence of these machines and other equipment must be considered. Other areas include:

- obsolescence management programs at each site and at CMA, and lessons-learned programs;
- handling of the brine streams and secondary waste;
- detection and monitoring, process control systems, and spare parts;
- recruitment, training, and retention of critical skilled and experienced personnel;
- availability of water and other utilities; and
- facility closure.

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# 4

# Information Management Systems

## OVERVIEW

Information management is an important aspect of managing obsolescence at stockpile disposal sites because it facilitates tracking the history of changes in the facilities and personnel over the lifetime of operations. Data of this sort can aid in identifying areas of potential obsolescence, facilitate planning, provide a permanent record that documents operations, and track abnormal incidents and trends. Information management facilitates communications throughout the site, among the sites, and programmatically. However, since information management systems too may age, become outdated, or become no longer supportable or accessible, they are also subject to obsolescence.

Information is created during plant operations in a number of ways. Human resources systems, process control records, inventory and transaction management activities, and other sources of data collection are all based on computer software, or applications, that generate digital electronic information as a product. Specific sources include word processors, laboratory analytical software, spreadsheet software, electronic inventory archives, and related databases. The generated information must be maintained for periods of time dependent on the nature of the content and on regulatory requirements, program stipulations, or prudent management practices. For this to happen the information that is generated must be identified uniquely (so that it can be recognized at some point in the future), be collected at its point of origin, then be transported to data storage facilities and stored in an appropriate medium, and it must be accessible at some arbitrary or predetermined point in the future.

The nature of information management, and the volatile characteristics of the industry that supports the software, transmission facilities, computational systems, and storage media used in information management systems lead to challenges related to obsolescence when the operating programs that generate the information continues over a protracted period of time (see Appendix B).

The committee conducted a thorough review of the information management systems at the incineration facility sites. This is an area that has not been thoroughly reviewed as a whole in the past by an NRC committee and includes physical facilities (servers, desktop units, storage, and distribution), software (operating systems and applications), and system development processes. The committee's major concerns in the information management area relate to how it is being managed inconsistently within and between sites. These issues are discussed in the following section. Later sections address specific observations concerning the information management and technology systems currently in use.

## PLANNING AND DECISION MAKING

The process control systems at chemical agent stockpile incineration facilities employ information technologies that have of necessity been managed as part of the integrated processing system. However, a history of plant operations is stored in a process data acquisition and recording system (PDARS), which is part of the control system for the plant but also of the larger information management mission of each site. In the course of the committee's data gathering, some of the experts in the control system technology at the sites were consulted to provide general advice on the general elements of the information management systems.

There is a disparity in the way planning and decision making are approached at the various facilities. This is a consequence of the way information management processes are implemented. At ANCDF all aspects of information management governance are now coordinated centrally or are moving in that direction. At the other sites examined, information management governance is split into several areas, and coordinated in a loose collegial manner. At TOCDF, for example, the management of the new control subsystem for mustard agent processing will be assigned to the plant information systems department. The management of the existing control system will remain in the control engineering department.

At most sites personnel responsible for the office, laboratory, and technical functions, and in some cases human resources and other functions, make decisions on information technology and information management systems independently, although meetings are held to discuss needs and requirements on what is a locally determined basis. ANCDF is distinct from the other sites in the degree of central control exercised on information management decision making; the ANCDF site also has a level of autonomy on information technology and management decisions that involves little consultation with or guidance from the other sites or CMA.

This variability in governance is not in itself necessarily a threat to continuing operability, except to the extent that a lack of concerted purpose can lead to increased costs and decreased interoperability. However, it does raise questions. For example, ANCDF personnel made the decision to move toward a single-link fiber optic facility network backbone in place of the original double-loop wired system, based on their interpretation of needs and opportunities. The cited rationale for this was the greater reliability of fiber optics, which was interpreted to mean that a single fiber optic link was more reliable than a double-loop wired system. This is true from one perspective, but not necessarily so when considered from the perspective of a mechanical failure—as might be associated with an unplanned ordnance event. Whether that scenario is likely and whether the decision to change the network topology was correct is not argued here. What is noted as significant is that no perceived need or interest in consulting at a higher level on this decision was evident; the decision was entirely locally determined.

Another example of the variability in problem-solving approaches is the move to different software in the control room operating consoles. There are now two major systems in place among the sites in this regard rather than one, and there are local variations in how those systems are enabled. This is a questionable practice from a performance and reliability perspective. Again, it is not the end result that is being questioned here, it is the practice of devolving decision making on issues that affect uniformity and therefore inevitably reliability and interoperability. In the long term in the context of stressed resources and an extended operating period, such practices will tend to gravitate toward less effective programmatic results than when standards are regulated in some central way. This issue is dealt with in more detail in Chapter 5 of this report.

**Finding 12.** The committee found no central or unified approach to identifying information technology solutions and implementing information technology changes at chemical agent stockpile incineration facility sites. This lack can lead to an erosion of compatibility, increased costs, a reduced potential for interoperability, and other challenges to continued operation.

**Recommendation 12.** The Chemical Materials Agency should implement a mechanism to coordinate and formally demand consensus in areas of information management where joint operations between the chemical agent stockpile incineration facilities are appropriate. Such mechanisms should be developed, implemented, and reinforced for the remaining life span of the chemical agent stockpile disposal program. **(Tier 2)**

## DETAILED OBSOLESCENCE ASSESSMENT OF DISPOSAL SITE INFORMATION MANAGEMENT

This section provides more detailed information primarily relevant to specialists implementing information management programs at the disposal sites.

The scope of information management in this discussion is restricted to those elements that function in a supporting role to the actual processing operations. Other aspects of information handling, such as the instrumentation and computer control systems that are directly associated with plant operations, are not covered by this definition and are dealt with in Chapter 2. Also not included is information that may enter the plant from external sources, such as the Internet, e-mail, or physical storage media that could be transported onto the property, excepting updates to applications and other elements of information management discussed in this section. This latter group may have security significance or be relevant to operations in other ways, but are not fundamentally related to the issue of continuing operability. Similarly, the fate of information transported off the facility sites and out of facility control may be of significance, but is considered separate from the focus here on continuing operability.

Readers should note that many of the issue areas that are identified are presently managed at a local or site level in the facilities investigated, but would more properly be dealt with at a CMA level as discussed in an earlier section. The judgments made in this investigation are based on the premise that reliability is a governing requirement for the facilities being addressed. While it has not been possible to exhaustively review and eliminate all possible failure modes, this evaluation does recommend steps to eliminate substantial process, equipment, and software shortcomings that in the context of a continuing operation could or will threaten secure and reliable system performance.

### Physical Facilities

Overall, the facilities visited varied in form and detail, but all were effective in their ability to deliver services at this time.

#### *Servers*

At a minimum the observed server hardware was relatively modern, and interviews with personnel indicated that hardware at this level was being replaced as needed and was not constrained by budgets or other limitations. Uninterruptible power supplies and redundant storage were in place in all cases, and although Halon or other active nondamaging fire suppressant apparatus was not in place, the facilities themselves were secure and fire resistant.

**Finding 13.** The server systems at chemical agent stockpile incineration facilities in their present physical state do not constitute a threat to the continuing operability of the facilities as long as budgets and management procedures enable the progressive updating and replacement of systems as needed.

**Recommendation 13.** Continued vigilant monitoring and maintenance of servers, based on adequate funding and management of core capabilities, is a mandatory element of the continued operability of chemical agent stockpile incineration facilities and should be ensured across sites under guidance from the Chemical Materials Agency. **(Tier 3)**

### *Desktop Units*

User PCs varied widely in their degree of capability. Some units were current, but some were very old (in PC terms). The cause for this disparity seems to be related to intended functionality. As reported during interviews, hardware for completing common office tasks could be updated when needed. In contrast, hardware associated with technical activity was in some cases less easy to update because of its association with software or requirements that are static. The latter situation has resulted in older (in some cases much older) hardware still in service than is commonly encountered in professional operations today.

PC hardware that is not current does not constitute a direct threat to continuing operability as long as it is still functioning within operational tolerances since it can be readily modernized provided that external funding or procedural constraints to upgrades are eliminated. Nevertheless, the cost of maintenance will increase and support will become more difficult as older hardware ages even more. The problem is that if older hardware is being maintained because of the need to continue using an older version of an operating system, and that hardware then fails, it may be difficult to find a platform on which the legacy operating system will run. Rather than being approached as a balance between preferred PC replacement practices and other needs, PC maintenance is in some cases subordinated to peripheral requirements. In summary, the committee believes some inconsistency exists in how PCs are maintained.

**Finding 14.** While personal computers (PCs) dedicated to typical office applications are generally kept relatively modern and up-to-date at chemical agent stockpile incineration facility sites, certain other PCs in use in laboratories, because of their linkages to dated analytical facilities, are out-of-date to the point that their continued use is problematic.

**Recommendation 14.** The Chemical Materials Agency (CMA) should devise and implement a life-cycle replacement program for all PCs. Consideration should be given to setting a maximum life span for PCs (e.g., three years) and replacing older machines with current hardware according to a predetermined service cycle. The CMA should specify that when a PC has been retained beyond a reasonable life-cycle expectation because it was required to support dated peripheral devices, software, or other features that are themselves substantially dated, alternatives to those peripheral items should be identified and if possible acquired so that the overall system can be updated to current standards. **(Tier 3)**

### *Storage and Backup Facilities*

Details regarding storage and backup of data varied among facilities. However, there was general consistency in that (1) local storage was on digital media secured in a fireproof area outside or apart from the server room, (2) long-term storage was in a secure off-site location (electronically and physically), and (3) the transaction process was adequate in terms of methods and record keeping.

The digital format in which information is stored was not verified directly, but the committee was informed that data are stored in a format that is recoverable in the long term. The available space in those facilities was reported to be substantial in terms of foreseeable requirements. Therefore, the issues of continuing operability that may arise from the physical facilities are not expected to be affected by the protracted life span of the chemical stockpile disposal program unless at some future point the available space is exhausted or requirements change.

The physical storage facilities for electronic information media do not constitute an immediate threat to continuing operability. However, it would be prudent for CMA to conduct periodic review of and continued maintenance of storage facilities to ensure that they remain effective.

### *Communication Conduits*

The electronic links between buildings within the facilities examined were found to be varied, and have been changing over the life span of the facilities. For example, at ANCDF, the older twinned facilitywide communications backbone loop has been replaced by a single fiber optic cable, whereas at TOCDF, the original system remains in place.

Significant issues related to continuing operability are not presently apparent from this aspect of the physical systems, but the current situation could eventually indirectly reflect on the robustness of continuing operability.

## Commercially Available Software

Over 100 different commercially available applications were identified as being managed on computer systems in the facilities visited. It is convenient to consider these in several basic categories, namely,

- operating systems;
- office applications;
- technical software;
- electronic reference software;
- computer maintenance and management software; and
- program planning and management software.

Although there are differences in detail among the members of each category, the various individual applications have general commonalities in terms of maintenance and continuing operational requirements. The sections below discuss each of these categories in that light.

### *Operating Systems*

The operating system defines the backbone functional environment of each computer, and constitutes the envelope within which each user operates each software application on each piece of computer hardware. Examples of the operating systems used include Microsoft Windows (98, NT 4, 2000, 2000 Server, 2003 Server, and XP) and Linux (Red Hat and Slackware).

**Continuing Operability Issues.** The range of variability in operating systems is not ideal. Not all versions being used are current, and the heterogeneity found at the sites examined increases the complexity of support and maintenance. Operating systems inherently define system security, stability, and maintenance requirements, and in some cases, the suite of applications that users can run. They are seldom chosen or fully exploited by end users, but have profound consequences for the managers and users of information management systems alike. It is known that efforts are being made to eliminate older versions of operating systems, but the process of upgrading these systems will be an unending one as it is in any such operation. Of particular note are impending releases of Microsoft products in two dimensions. A substantial change in operating system was slated for release late in 2006, and a major initiative to simplify and facilitate system management is targeted for 2007. The continued development of Linux as an accepted and secure alternative for servers and desktop systems may also have implications for operating system management over the remaining life span of the facilities. A counter pressure to the continual updating of operating systems is the presence of special technical software that requires a specific version of an operating system (e.g., Windows 98) that would otherwise be retired.

**Finding 15.** A wide range of operating systems exist in the chemical agent stockpile incineration facilities, and this variability could pose problems for effective long-term continued operability. At the least, costs and maintenance are complicated by this diversity and apparent lack of integrated planning.

**Recommendation 15.** The Chemical Materials Agency should conduct an overall evaluation of security requirements, maintenance implications, and impending evolutionary changes in the basic computer operating systems (Windows and Linux) used at chemical agent disposal facilities. A migration path that drives toward a minimally heterogeneous and maximally robust environment should be identified and considered for implementation. **(Tier 3)**

### *Office Applications*

In general, office applications are used by workers at all levels, and have little special technical significance. They do provide workers with the basic capability to develop electronic documents and therefore communicate effectively. They are also the applications in which most document-level communication (memos, reports, and accompanying illustrations) are developed.

A wide range of office applications exist at the facilities. These include:

- Adobe (6.0 Pro, 6.0 Standard, 7.0 Pro, 7.0 Standard);
- Crystal Reports;
- Form Flow;
- Roxio Easy Media Creator 7;
- Adobe Illustrator;
- Corel Draw;
- Word Perfect Office (11, 12, 2002); and
- Microsoft Office (97, XP, 2003 Pro).

**Continuing Operability Issues.** In general, the heterogeneous deployment (both in vendor and version) of office applications has only moderate consequences from a continuing operability perspective. Vendors will typically limit support to legacy systems, and interoperability may suffer somewhat, but these can readily be surmounted by upgrading to new versions. Some software variability is caused by specific needs of the facilities (e.g., Word Perfect maintained because of a document limit inherent in Microsoft Word). Learning curves are minimal and commonly are collegially communicated if staff members do not already possess competency. It is considered unlikely that the variability of office software will cause more than nuisance issues over the life span of the chemical stockpile disposal program. However, vendor data formats are not always perfectly interchangeable, and in the long term, it may be that records stored in a proprietary vendor format will be unrecoverable.

There is also no consistent mechanism to evaluate the implications of changing software applications, or the impacts that might propagate through the system as a result of those changes. When any office application is retired, conducting a systematic review of content developed using that application by any site affected by this change is among steps that can be taken to ensure that such content is in a format that can be dependably recovered in the future.

**Finding 16.** A variety of data formats are used in different contexts in the chemical agent stockpile incineration facilities, and the prospect of long-term records retention and recovery is complicated by the resulting variability of native data formats.

**Recommendation 16.** The Chemical Materials Agency (CMA) should consider formally requiring that each copy of an electronic document requiring long-term availability be preserved in an agreed permanent or semipermanent form defined by the CMA (e.g., ASCII or portable document format). **(Tier 3)**

### *Technical Software*

Technical software is used by professional staff to conduct various job-related functions. In contrast with office applications, this software is typically specialized to the extent that only a subset of the staff will use it or know how to use it. Some examples of the wide range of technical software solutions used include:

- laboratory support software (Deltek GCS Premier, LabView, Honeywell Loveland DocuMint, Omega ME LIMS, ChemStation);
- computational software (MathCad 2000 and 2000i, SAS, Crystal Ball);
- Computer-aided design and drafting software (Alibre, AutoCad 2000 and LT 2000, Microstation, SmartSketch);
- programming software (Microsoft VB6, Visual Studio.NET 2003, 2005, Visual Source Safe);
- database environments (Oracle 8i and 10g, Microsoft SQL Server 2000 and 2005); and
- numerous other products covering topics such as human resources support, pipeline design, and thermochemical analysis.

**Continuing Operability Issues.** These applications inherently tend to be user preference driven, in part because of the learning curve associated with their effective application. As such, a drive to a uniform deployment model is complicated and possibly negated by user competencies. Hence, although there are benefits in principle with enterprise approaches to technical software, the status quo may already constitute an effective solution. Nevertheless, there are data interchange issues that emerge in the long term when multiple applications are used as solutions for the same technical purpose. Not all computer-aided design and drafting packages, for instance, are equally adept at importing competitor data formats. Also, users of one database environment may be uncomfortable or incapable when they encounter a competitive product. Therefore, measures that reduce the range of alternative products with common competencies are desirable.

A wide range of technical software that supports engineering, scientific, human resources, and other users exists in the facilities examined, and this could complicate operations in the long term if version control is not exercised. Lack of central control provides an environment conducive to this problem, and it appears to be emerging now.

The CMA might consider conducting a comprehensive inventory of technical software on a programwide basis, including the location and nature of each product. Thereafter, the CMA could require that before any facility elects to change the version of a product or introduce a new product, a programwide impact analysis be conducted to determine (1) whether an existing alternative can serve the purpose of the intended purchase, and in the case of a version change (2) whether all versions in the system should be upgraded to a common version.

### *Electronic Reference Software*

Electronic reference software applications provide source data used in technical operations. They are typically externally developed and accepted as authoritative by the purchasing firm. Where employed, they are important resources for specialized technical users. Software in this group included the 2000 International Building Code, Plumbing/Mechanical, Akton Psychrometric Chart for Windows, and AHFS First. The first two are self-explanatory; the third is a pharmaceutical database.

**Continuing Operability Issues.** Content can typically change over time, rendering old versions of vendor supplied data obsolete. Since users commonly apply content extracted without verifying that the source is up-to-date, these references must be maintained in current and up-to-date states in a formal and managed program. It is noted that the cited version of the International Building Code is out of date (2003 is current, and 2006 is pending).

Some reference databases exist within the facilities examined, and they may not all be current. This can increase costs and threaten collaborative interaction and quality control, all of which are problematic in the context of continued operability. A strategy to mitigate this involves implementing a mechanism that will determine acceptable practices in technical software management. Included in this are the following steps. First, an exhaustive inventory of all site technical reference databases is conducted. Second, opportunities for economies of scale are evaluated by considering acquisition systemwide. Third, maintenance and management requirements for each reference system are determined and appropriate programs implemented to avoid long-term erosion of capability.

### *Computer Maintenance and Management Software*

Computer maintenance and management software includes a wide range of facilitating products that have been developed to help information technology system managers maintain their facilities in a secure and stable state. Examples include applications such as BackupExec, DriveImage, LANDesk, Restorer 2000, Trend Office Scan, True Image, WebSense, and WhatsUp Gold.

**Continuing Operability Issues.** In general, the point of this group of applications is to maintain systems and ensure that they are up-to-date and stable. It is crucial that this kind of competency be maintained if the information technology and information management systems being evaluated are to achieve the goals set forth for continuing operability. That these kinds of applications were found and are being used speaks well for this element of the program. It may be that the evolving plans of Microsoft and others will affect the preferred suite of support applications, but until that happens the practice noted in this evaluation is effective.

A variety of applications are used to facilitate information system management. This is a positive factor, but one that is not uniformly pursued across all site systems. The variability implies costs and behaviors that are undesirable in a context of continuing operability. The continued use of the maintenance and support software encountered during this evaluation is encouraged.

**Finding 17.** Service and support capabilities in the information management sector are continually improving.

**Recommendation 17.** Annually or biennially, the Chemical Materials Agency should survey current information management maintenance options, determine whether costs and benefits in the systems under consideration are consistent with current best practices, and require changes in practice programwide where improvements in reliability or reductions in cost are identified that can secure continued operability. **(Tier 3)**

### *Program Planning and Management Software*

This group of applications is used in planning and managing enterprises or projects at various levels. Included in this group are project management software (Microsoft Project and Project Server, Primavera P3/EC, and Suretrak), document management software (Papervision), asset tracking software (Intellitrack, MAXIMO, TRACS), and facility maintenance software (ValveLink, PHA-Pro).

**Continuing Operability Issues.** For the most part the issues related to continuing operability in this set of tools are related more to whether they are used than to their inherent characteristics. Comments on these are therefore for the most part reserved for other elements of this report. It is noted, however, that the existence of these tools implies the competences to use them and that this is a positive indicator where continuing operability is concerned.

## Software Development

Software development is a key aspect of long-term operability, because it relates to some underpinnings of record keeping and process management. An example that is being effectively pursued but is nonetheless faced with substantial challenges can be found in the software used for parts warehousing at ANCDF. This problem is discussed earlier in Chapter 2 and is the basis for Finding and Recommendation 3.

A Microsoft Access product developed by local staff demonstrates an exemplary attempt to manage parts inventory to best effect. The product developed is substantial, and a cursory exploration of its structure suggests that it is technically well founded if not perfect. The product has an inventory of over 5,000 parts and has recorded over 7,000 transactions accumulated since 2001. Certainly, this type of product will help manage scarce resources to best effect, and will be a major asset going forward. However, there are some aspects of this that are not clearly defined. These include the following:

- No universal parts classification exists, which means that a method of reconciling parts identification schemes used at different facilities needs to be developed. A photo-image approach, an index mapping scheme, or other methods can resolve this, but such has yet to be defined.
- Data entry is manual, which means that errors can creep into record keeping. Bar codes, radio frequency identification (RFID), or other methods can address this, but these have yet to be evaluated and implemented.
- The software in question has no outside review, which means that it is likely effective for the immediate purposes of its developers, but may be missing opportunities to serve wider needs with efficiency.

In short, there has been an effective attempt to provide a solution that will assist in delivering a pivotal requirement for continued operability, namely, the effective location and management of parts inventories, but at present this is forced to work in a local and isolated way. This situation does not guarantee that applications developed in this way will have the staying power to support operations in the longer term. Although the foregoing text focuses on a specific case for illustrative purposes, other examples of this syndrome were detected. The significance of this is that it suggests there may be aspects to software maintenance and development that could benefit from a wider review of requirements and solutions.

There are useful efforts and capabilities to adapt or develop software at the various sites, and it is capably implemented at a local level, but there is no universal needs assessment or quality control mechanism in place for this function. This has the potential to engender results that are not effective in the long term.

A mechanism to provide some assurance that software development in the long term will not lead to operating difficulties as a result of uncoordinated standards and solutions could be beneficial. Options to approach this might be a more centralized management system, an agreed approach to standards setting, or other alternatives. Similarly, it could be beneficial if a formal as opposed to collegial approach to software development were implemented.

# 5

# Programwide Influences on Continuing Operability

Beyond concerns for the obsolescence of facilities, equipment, and personnel skills, knowledge, and abilities, managing for continuing operability is affected by organizational structure, contractual relationships and incentives, community and regulatory relationships, and planning for emergencies and closure. These concerns directly impact overall performance, and thus influence the organizational response to obsolescence and continuing operability challenges. This chapter will address these overarching issues that affect the overall chemical stockpile disposal program.

Programwide organization has a major influence on site interrelationships, the capability of subordinate management to perform according to expectations, and the job satisfaction of personnel. Managers need full authority commensurate with assigned responsibility, and they need the resources—financial as well as personnel—to accomplish assigned duties. The unique nature of the stockpile demilitarization processes—including the specialized types of equipment and knowledge, skills, and abilities required for plant operation—and the finite life expectancy of the disposal facilities, drive important program management decisions. Failure to recognize these facts and to consider them in program management organization and procedures will affect facility obsolescence and continuing operability in several ways. Loose configuration management will diminish intersite flexibility. An inappropriate balance between authority and responsibility will lead to frustration and loss of key personnel, inexorably risking the need for a program schedule extension and the possible erosion of desirable safety attitudes and actions. Organizational imbalance and complexity can result in confusion regarding accountability and difficulty in assuring management coverage of critical continuing operability issues. Contractor guidance through the use of contract incentive language risks a misunderstanding of incentive intents, and the possibility of incentive misstatement, all of which can have impacts on continuing operability performance and cost.

## PROGRAM MANAGEMENT

### Evolution of the Present Program Management Structure

Responsibility for achieving the multiple program objectives associated with the stockpile disposal program (e.g., protection of workers, the public, and the environment; CWC treaty obligations; cost control) rests with the U.S. Army. Initially the program manager for chemical demilitarization (PMCD) was delegated this responsibility by the Secretary of the Army, and authority and resources necessary to accomplish the mission were provided. Work was accomplished by private sector site contractor teams, under the close supervision of PMCD staff, many of whom were experienced in chemical demilitarization operations. Multiple contractors were employed to design, construct, operate, and maintain facilities, all under PMCD supervision. An Army field office located at each site provided additional oversight on costs and contractual issues.

After the first sites became operational and construction of the remaining incineration sites was well underway, subsequent resource limitations forced this centralized management structure to rely less on government employee staff and to depend more heavily on multiple contractors and subcontractors to accomplish its mission. Beginning in mid-2002 a shift began toward increased reliance on site contractors and decreased PMCD authority and staff. The PMCD office was disestablished, and in December 2003 the Chemical Materials Agency (CMA) was created to manage the chemical stockpile disposal program.[1] Thus, rather than depend on contractor performance under the close supervision of PMCD representatives, the great majority of responsibil-

[1]CMA Performance-based Contracting Approach, presentation by Brad Pierce, U.S. Army Field Support Command, CMA, to the committee, March 30, 2006.

ity moved to the contractor. The PMCD, and later the CMA, retained authority to make key decisions affecting contract cost.

The CMA also retained responsibility for oversight of the quality assurance program, authority and responsibility for governmental functions, and overall program responsibility to the Secretary of the Army, the Secretary of Defense, and the Congress. The CMA, acting through the newly created project manager for chemical stockpile disposal (PMCSD), since renamed the project manager for chemical stockpile elimination (PMCSE), continued to manage the overall schedule, budget, and risk and configuration management programs. With this change, the oversight of both stockpile storage and demilitarization operations came under the same organizational structure (i.e., the CMA). Figures 5-1 and 5-2 show previous and present organizational structures. The current structure (Figure 5-2) inserts contractual incentives between what was formerly (pre-2002) direct operational control of the sites, as shown in Figure 5-1.

Contract provisions thus became the major vehicle for guiding site performance and for encouraging cooperation among sites. Such cooperation constitutes an important element for managing coordinated responses to the problems of potential obsolescence associated with the similar processing equipment at the sites as well as issues concerning the aging of the stockpile itself. It is also noteworthy that site contractors already had been operating in location-specific regulatory and community environments, and had developed varying approaches that were tailored to local conditions.

Contracts were rewritten to reflect the intended changes (CMA, 1995). Contractors were protected and their financial risk reduced to a large degree by the cost reimbursable provisions of the contract. The stockpile demilitarization site contracts are all cost reimbursable, so the contractor is entitled to recover actual costs that are reasonable and allowable, including overhead, incurred in performance of the contract. Target reimbursable costs are established on a monthly basis and these serve as a basis for the contractor's fee pools. The contracts also include a fixed base fee of 3 percent of the target cost. This covers contractors' essential costs (such as cost of money), which the contractor gets re-

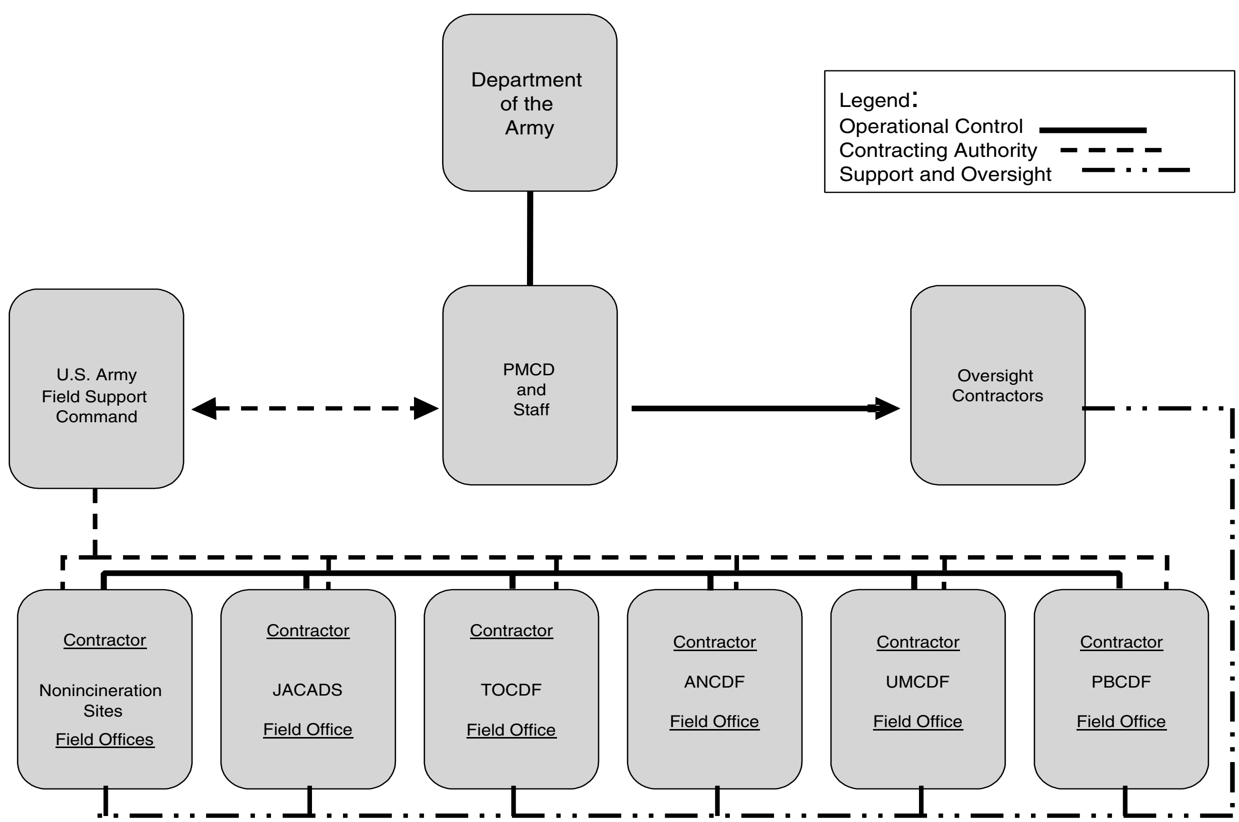


FIGURE 5-1 General organization structure for the chemical stockpile disposal program management pre-2002.

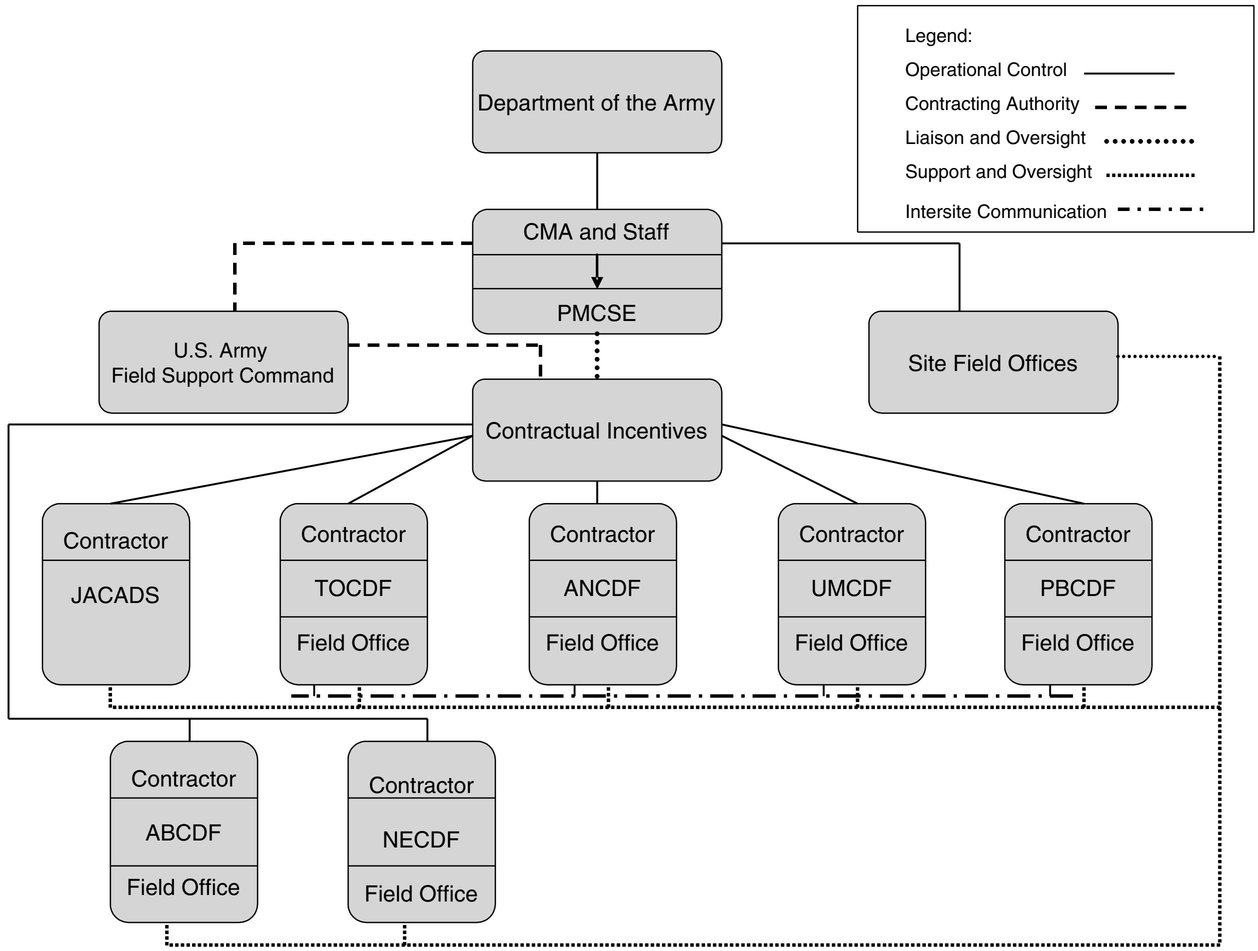


FIGURE 5-2 General organizational structure for the chemical stockpile disposal program management post-2003.

gardless of its performance. The base fee is paid out monthly over the estimated period of performance.

The award fee percentage ranges from 3 percent to 7 percent of target costs, based on the terms in the contract. Award fee is earned based on actual performance against the criteria established in the Award Fee Plan. Award fee evaluations are conducted semiannually (CMA, 2005).[2,3] Site personnel believe that the tone and substance of award and incentive fees motivate contractor cooperation with other site managers, excellence in operational performance, concern for safety, and general alignment with program purposes as intended by the CMA. They acknowledge, however, that CMA and contractor corporate purposes are not totally congruent. The CMA director's programmatic performance-based incentive (DPPBI) was implemented, at least in part, because of a "lack of Government and Systems Contractors' ability to readily and effectively translate successful solutions from one site to another" (CMA, 2006, p. 1). This translation is of key importance for developing systemwide obsolescence management programs, but it is not clear that the DPPBI has yet been successful in meeting this goal.

The effectiveness of the site-focused organizational model depends importantly on the confidence that the contracting parties have in the quality and fairness of the contractual incentives used to drive contractor performance. Contractor site personnel have indicated that the quality of a contractor's performance in those technical areas subject to objective measurement is easily agreed in conference between contractor site managers and CMA on-site representatives. Contractor performance measured subjectively, which also affects incentive awards, is more likely to be conten-

[2]Tooele Chemical Agent Disposal Facility personnel interview with Gary McCloskey, briefing to the committee, March 2, 2006.

[3]Personal communication between Raj Maholtra, deputy, Technical Support Directorate, CMA, and Robert J. Love, NRC staff, via e-mail, June 26, 2006.

tious (CMA, 2006). Directly involved government personnel report mixed opinions regarding the success of the new operating model. Some believe it is working reasonably well; others report that it is proceeding satisfactorily but that significant changes in the government's role have been challenging to accept and understand. Still others are overtly critical, feeling that responsibility and authority are not properly balanced, and that contractors are not well enough motivated to minimize program costs (CMA, 2006). For example, in the Award Fee Plan for Fiscal Year 2006 at TOCDF, cost performance is weighted only 10 percent in determining the contractor's qualifying score for incentive payment (CMA, 2005).

### Army CMA/Field Office/System Contractor Interactions

CMA representatives intend no significant differences in contractor responsibility at the four incineration sites. Implementation of this policy is challenging indeed in spite of the best efforts of senior leaders at CMA headquarters. The degree to which responsibility and authority have been delegated by contract to the private sector site operators makes oversight of site differences in program execution a major undertaking for the current level of CMA staffing. This is especially true since two different contractors are involved, EG&G at TOCDF and Washington Group International (WGI) at the other three sites. There also are site-specific differences in configuration and procedures, as well as in workforce culture among the WGI sites.[4] Contract relationships have led CMA oversight to depend mostly on coordination and influence rather than directive authority.[5]

The PMCSE functions from CMA headquarters with a total staff of 20. Increasingly, responsibility for technical issues is being transferred to the CMA technical support director, who reports to the CMA director, and not to the PMCSE.[6] Management of the stockpile disposal program in general is site-focused, thus diluting single-point responsibility and authority for program execution. The government field staff reports to the CMA director of operations rather than the PMCSE. The separation of technical and operational leadership conflicts with the need for close intersite cooperation and coordination that can be essential in promoting the sharing of critical system component spares and dependable communication of lessons learned. The PMCSD reported that absence of intersite cooperation is difficult to detect, and that cooperation has improved since all site contracts have been awarded and competition between contractors for additional work has subsided.[7] The PMCSD indicated a belief that in spite of this improvement, and in spite of increasingly attractive incentive programs, some differences in configuration and practices remain.[8,9]

The site contractor holds responsibility, directly or through subcontractors, for overall operations, including:

- production control;
- costs and schedules tracking;
- document and records control;
- protocol, property administration, maintenance, logistics, safety, security;
- quality assurance and quality control programs, environmental compliance, site engineering, laboratory training and operation;
- emergency medical support;
- planning for closure; and
- personnel surety program.

The site contractor responsibility also includes the administrative support of contractor staff, training, and such programs as lessons learned that involve interaction with other sites and with the CMA. The site contractor is responsible for constructive interaction with other sites in support of critical repair parts provision when required. Site security is generally handled by the host military unit responsible for the military installation upon which the chemical agent stockpile disposal facility is located. The site contractor holds responsibility for emergency response and notification, waste disposal, and supply procurement, stocking, and issuing. The concept, as described by the PMCSD, is for the site contractor to hold most of the responsibility, to have commensurate authority, and to be responsible to the CMA for safe, effective operations within limits prescribed by the contractual arrangement.

The PMCSE continues to be charged by the CMA with ensuring effective implementation of program directives; however, the committee does not believe that at present the PMCSE has commensurate authority to discharge this obligation effectively and with reasonable assurance of success.

[4]NRC Committee on Continuing Operability of Chemical Agent Disposal Facilities, presentation by Robert C. Love, ANCDF project general manager, CMA, to the committee, April 6, 2006.

[5]Chemical Stockpile Disposal (CSD) Facilities and Equipment Obsolescence Assessment, presentation by Joseph Pecoraro, project manager for chemical stockpile disposal, CMA, to the committee, January 25, 2006.

[6]Bruce Pringle, chief, Life Cycle Management Office, PMCSD-CMA, program management question-and-answer session with the committee, April 6, 2006.

[7]Chemical Stockpile Disposal (CSD) Facilities and Equipment Obsolescence Assessment, presentation by Joseph Pecoraro, project manager for chemical stockpile disposal, CMA, to the committee, January 25, 2006.

[8]Bruce Pringle, chief, Life Cycle Management Office, PMCSD-CMA, program management question-and-answer session with the committee, April 6, 2006.

[9]Chemical Stockpile Disposal (CSD) Facilities and Equipment Obsolescence Assessment, presentation by Joseph Pecoraro, project manager for chemical stockpile disposal, CMA, to the committee, January 25, 2006.

**Finding 18.** The program manager for chemical stockpile elimination (PMCSE, formerly PMCSD) has a small central staff, which limits the technical expertise that is available within the Chemical Materials Agency (CMA). The PMCSE is responsible to the CMA director for the functioning of the chemical agent stockpile incineration facility sites but has no contracting or other authority to ensure a desired result. The PMCSE must depend on personal persuasion and the responsibility of site contractors, operating under CMA-generated financial incentives, to keep the chemical agent stockpile disposal program functioning safely and effectively.

**Recommendation 18.** The Chemical Materials Agency (CMA) and Army management of the chemical stockpile elimination program should adjust PMCSE resources and authority, commensurate with CMA responsibility, to manage the program in the interest of the Army and the U.S. citizenry. Adjustments should ensure that an appropriate balance between assigned responsibility, resource adequacy, and granted authority is attained. **(Tier 1)**

The CMA administers the chemical stockpile demilitarization contract on behalf of the government and is responsible for quality assurance. It evaluates contractor performance as required to implement the basic and incentive provisions of the contract and accomplishes other governmental functions as may be required. The contractor's scope of work is provided through the contract with the CMA, with the CMA approving any changes to the scope, and providing resources to further the work. A CMA site representative leads a small team of government employees to accomplish these tasks, and is authorized to approve contract changes costing a maximum of $200,000 without reference to CMA headquarters. In a briefing to the committee at ANCDF, it was reported that this figure has not been changed over a period of several years while costs have escalated substantially, resulting in an increasing number of contract change requests that required CMA headquarters approval and associated delays while the requests are processed.

### Effects of Shifting Site Responsibility Largely to Contractor

While recognizing that site-focused management has some distinct advantages since both management and responsibility are focused locally, the committee noted some disadvantages that it believes should be balanced carefully with the advantages. Among these disadvantages is the necessity to comply with the rather rigid federal acquisition regulations with on-site contractors, which in turn limits decision flexibility.

Although efforts are being made to centralize some logistical support activities, as noted in Chapter 2, each site maintains its own stock of spares and to some degree its own channels of procurement. The likelihood of duplication of effort therefore clearly exists. With encouragement by the CMA through contract monetary incentives and the passage of time, there may be improvement in the communications, coordination, and cooperation among sites. This is happening, but it may not necessarily eliminate the negative effects of duplication of effort or divergence in configuration among sites.

At the very time that uniform standards would serve the program well, site-focused management utilizing two contractors has led to some divergence in hardware and software standards between sites. This problem is exacerbated by further separation of technical supervision at CMA headquarters from project management oversight. As equipment ages and some sites are decommissioned, the interoperability of sites and interchangeability of components will become increasingly important to continuing operations. The committee views the growth of intersite equipment and systems divergence as a weakness of incentive-driven, site-focused management.

**Finding 19.** Adoption of the site-focused management system, while promoting some improvements in the workforce culture and performance at chemical agent stockpile incineration facility sites, risks allowing a degree of independence in contractor decision making and action that could result in a loss of a critical capability for interchangeability crucial to continuing operability.

**Recommendation 19.** The Chemical Materials Agency should exercise sufficient centralized management control to ensure that there is appropriate programwide interchangeability of resources important to the continuing operability of chemical agent disposal incineration facilities. **(Tier 1)**

### Obsolescence Management

The interchangeability and exchanging of parts and knowledge among sites can facilitate continuing operability as time passes, equipment wears and ages, and employee expertise dissipates. While site-focused obsolescence management systems deal with issues at a tactical level, programmatic performance still requires centralized direction and oversight from the CMA using both contractual incentives and some command and control directives. However, in spite of a strong incentives program, management system complexity, process diversity, and site independence can impede optimum realization of the total program potential for success.

The Assembled Chemical Weapons Alternatives (ACWA) program sites (in Pueblo, Colorado, and Lexington [Blue Grass], Kentucky) are unlikely to benefit from interaction with incineration sites as far as spare parts interchangeability, although there is potential for interdependence on selected equipment items between the two sites. However, other experiential learning during the incineration programs may apply, for example, in training, maintaining a safety culture, safe practices in working in contaminated areas, configuration management, and documentation.

Effort by the CMA will be needed to detect and overcome some natural, negative tendencies inherent in the site-focused management approach. It may even be necessary to limit site manager independence in selecting replacement equipment and software to ensure maximum interoperability. It is important that ECPs be shared between sites so that problems that could well affect more than one site need be solved only once and in a coordinated manner. Evidence shows that this objective has been recognized and appropriate action taken to maximize sharing under the mandatory lessons learned program.[10]

As noted in previous chapters, the site-developed strategies for obsolescence management have significant differences among the sites. The CMA is encouraging interchanges in this regard among the sites, and hopes that plans may be improved by understanding approaches at the other sites. The CMA is in the process of building a programmatic strategy to deal with the management of obsolescence but this is still evolving.

**Finding 20.** The Chemical Materials Agency has initiated an obsolescence management program that is based on using contractual means to incentivize chemical agent stockpile incineration facility site contractors to develop site-specific programs and then to share approaches and specific strategies across sites. Although the program is still evolving, the sites have begun to approach some obsolescence issues collectively.

**Recommendation 20.** The Chemical Materials Agency should strengthen its obsolescence management strategies programmatically and at each chemical agent stockpile incineration facility site to incorporate measures for intersite coordination and cooperation to facilitate continuing operability through to the completion of the chemical stockpile disposal program. **(Tier 1)**

## ORGANIZATIONAL MANAGEMENT AND SPECIALIZED EXPERTISE RESOURCES

Continuing operability is as much a function of personnel management challenges and issues as it is of equipment and supporting hardware concerns. The committee noted that the chemical stockpile disposal program, having evolved over time from JACADS operations to the present circumstances, has seen the migration of experienced people from site to site, and from employer to employer. In many cases this has worked to the program's advantage, since the required training efforts were minimized for the experienced managers and craftsmen moving from JACADS to other sites. But this situation has also raised questions regarding the efficacy of the contractor-operated, site-focused management system as practiced. The chemical stockpile disposal program is small enough that many, if not most, of the senior people involved know and have worked with and/or for each other. It becomes especially important that the CMA monitor site activities with sensitivity to the possibility of there being too close a working relationship between the contractor and the government representative.

Further, much of the specialized knowledge and capability have moved from the old PMCD organization to the distributed site structure. Specialties and expertise are not equally duplicated at each site, so there is a need to share experts and knowledge across all the sites in response to operational or other problems.

### Performance Indicators, Incentives, and Their Effectiveness

Reported worker safety performance has continued to improve significantly under site-focused management. For example, in 2001 the OSHA recordable injury rate (RIR) was around 2.5 per 200,000 hours worked for TOCDF—the only facility operating at that time.[11] As of July 31, 2006, the programmatic RIR for all sites was 1.25, with TOCDF at 1.54. The ANCDF site safety record is commendable, with a present RIR of 0.73 while working over 9 million consecutive hours without a lost work day incident. The program is highly incentivized, with 75 percent of the money allocated to safety and surety going to safety. The total safety and surety component carries the highest weight of any incentive categories under award fee rules, 30 percent (CMA, 2005). It is not possible to know in an absolute sense how much improvement has been achieved in accident prevention because of the effect of incentives, but the committee believes that qualitatively substantial progress has been made.

Both EG&G and WGI managements have, at their own initiative, adopted a "flow down" process whereby corporate incentive fee earnings are shared with all employees on site. Annual employee payments under this plan at TOCDF were estimated to be approximately $500.[12] Awards were about $500 to $600 per year per employee at ANCDF.

[10]Raj Malholtra, CMA, presentation to the committee, April 7, 2006.

[11]Kevin Flamm, briefing, September 13, 2006. Note that the current RIR for the overall chemical manufacturing industry is 3.5 and the current programmatic RIR metric is 1.75 for the stockpile disposal facilities.

[12]Site briefings by Terry Thomas, engineering manager, EG&G, and Edward Banks, site contractor, lessons learned specialist, EG&G, and discussion with the committee, March 3, 2006.

### Command, Control, and Communications Channels

Site-focused management tends to complicate command, control, and communications problems. Although site contractors have a complex and large group of personnel, organizations, and agencies with which communication must be maintained, there is no real "communications central" serving to receive and relay messages. The TOCDF site contractor listed the following organizations and agencies with which communications are routinely exchanged, and other site operating contractors have similarly demanding situations:[13]

- EG&G corporate office;
- CMA representatives on site and at Edgewood Area of Aberdeen Proving Ground;
- federal and state regulators;
- OSHA;
- Deseret Chemical Depot representatives;
- community and political leaders;
- other sites and contractors; and
- numerous suppliers and subcontractors.

Under existing organizational circumstances, effective communications are highly dependent on voluntary cooperation that is usually forthcoming. The committee considers that in spite of its complexity and general lack of structure, the communication channels are working reasonably well at all the sites visited.

### Lessons Learned

The lessons-learned program has been reinvented. The original program, although it remains available, is used only rarely. No new entries to this program have been recorded since January 2002. For roughly two years from 2002 until 2004, there was no lessons learned program in regular use. The original program was useful in that it was common across sites, but not well used for a number of reasons. First, it was perceived as bureaucratic and not site-specific. Second, the program was expected to function largely as a standalone software system with very little human intervention. Third, the user interface was not particularly suited to the ultimate users (i.e., those who were looking for new ideas to implement). Finally, active implementation of lessons learned was not incentivized by management. All of these factors have been shown to be characteristics of low utilization (Voit and Drury, 2006). A new program that addresses most of these issues has been launched similar to the successful Department of Transportation (DOT) and Department of Energy (DOE) systems. The new system appears to be well designed, and the responsible site managers report both regular additions to the database and increased usage by staff. Frequent communication between sites and with the WGI central library of lessons learned have ensured prompt notice of new entries and quick availability of filed data. To date, the full process has not been formalized, and there has been no regular analysis of input data.[14] Continuing operability is not yet represented in the new system's limited database.

Lessons-learned programs are not the only way of capturing deviant conditions and potential solutions. Accident and incident reports are useful in themselves even though many form the basis for lessons learned. They alert people to potential safety issues so that the same adverse event is not repeated inadvertently. Near-miss reporting systems can be even more proactive as they allow personnel to avoid potential events as well as actual events.

**Finding 21.** The current lessons-learned system is much better organized and user-friendly than the original system, and is actively used to retain past and current programmatic knowledge of operational and hardware improvements.

**Recommendation 21.** The current lessons-learned program should be continually evaluated and improved as appropriate to ensure the safety and continuing operability of the chemical agent stockpile incineration facilities as obsolescence challenges increase. Wider topical aspects should be incorporated, including near-miss information and root cause accident analyses. Provision should also be made for incorporation of lessons learned into all training programs, as well as for incentives at the individual employee level when appropriate contributions to the lessons-learned program are made. **(Tier 2)**

### Configuration Management

Effective continuing operability planning requires careful attention to configuration management across sites if the benefits of interchangeability of parts and expertise are to be maintained. Although, as noted above, configuration management remains within the purview of the PMCSE, the committee observed that some divergence of hardware and software standards between sites has occurred.

## FUNDING

Department of Defense and congressional officials have expressed concern regarding the escalating cost of the chemi-

[13]Terry Thomas, engineering manager, EG&G, question-and-answer session with the committee, March 2, 2006.

[14]Site briefing by Edward Banks, site contractor, lessons-learned specialist, EG&G, and discussion with the committee, March 3, 2006.

cal stockpile disposal program. Chemical stockpile demilitarization is safety and schedule driven. While cost can never be ignored, it has been subordinated to higher-priority project purposes. Site contractor contracts and incentive plans are drafted consistent with this principle. The nature of the chemical stockpile disposal program suggests a level-of-effort approach to resource management, since plants are highly automated and individual disposal campaigns for specific munitions with a particular agent fill can proceed for several months. It is difficult and inefficient to accomplish these “higher purposes” in a climate of limited funding and funding uncertainty beyond the current budget year. With pay rates known and most other cost factors reasonably estimated based upon experience and known circumstances, a relatively steady cash flow projection is possible. The expenditure rate is insensitive to the rate of production.

For Fiscal Year 2006 the four incineration sites were required to lend $150 million to other DOD programs. Program officials doubt that this money will be returned. Even more onerous is a proposed $300 million cut in the Fiscal Year 2007 budget. Continued adequate funding for the operating facilities to ensure safe and environmentally compliant operations is essential. Suspending operations at any one of the operating facility sites would exacerbate obsolescence issues, unduly prolong the destruction schedule, and substantially increase program life-cycle costs.

Risk analyses, the results of which have been shared repeatedly with the public, show that continued storage of munitions and bulk agent entails more risk than do demilitarization operations (NRC, 1997). Suspension of operations at any chemical agent disposal facility could be expected to generate public and political concern.

**Finding 22.** Factors impacting the chemical stockpile disposal program include:

- scheduling pressure driven by compliance with the Chemical Weapons Convention;
- safety demands of dealing with highly toxic materials;
- requirements of detailed and demanding environmental permits;
- high public and political visibility; and
- a mandate to minimize risk to the public, to workers, and to the environment.

To ensure the continuity of operations in view of these circumstances, a stable workforce and a stable, continuous source of funds are required. Failure to provide for funding continuity will undoubtedly lead to program interruption and adversely affect the completion date for demilitarization operations as well as program costs. Adequate, stable, and dependable funding of the chemical stockpile disposal program is an essential element of program success.

**Recommendation 22.** The Department of the Army, Department of Defense, Office of Management and Budget, and Congress should recognize the critical need for adequate, continuous, and predictable funding of the Chemical Materials Agency as a basis for operational planning essential to accomplishing the mission of chemical agent stockpile disposal. **(Tier 1)**

## IMPACTS ON CLOSURE

Closure of the four incineration facilities will begin at least four to six years from the date of this report. Planning for closure is just getting underway at TOCDF and is still in preliminary stages at the other facilities.[15] The lessons learned at JACADS and provided in the NRC report on closure will serve as a basis for closure planning (NRC, 2002). If the closure operations are the same or similar to those carried out at JACADS, certain key pieces of equipment will have to be fully operational for a period of one to three years after completion of the agent disposal mission. The operational time required for each system will depend in part on how the secondary waste is managed during stockpile processing operations.

Closure will be expedited if obsolete, no longer needed equipment can be disposed of while disposal operations are still in progress. Industry practice is to retain only necessary equipment depending on the end use of a facility. In general, the practice in commercial industry is to close a facility to an industrial standard unless the intended end use dictates otherwise. Thus, early decisions on the end-use standard for each disposal facility to be closed would be helpful.

The equipment that may be required during closure of the incineration sites will include, but not be limited to, monitoring equipment, the metals parts furnace and its ancillary process equipment, the DFS and its ancillary process equipment, and the pollution abatement systems (PAS).

The two ACWA sites, Pueblo and Blue Grass, are still in the design phase. In those cases it is possible to consider closure during design, which will facilitate the closure process. Obsolescence at these sites, as well as at Newport, should not become a major consideration; however, continuing operability will remain a challenge.

**Finding 23.** Plans for mitigating the obsolescence of key equipment that will be required for closure of chemical agent stockpile incineration facilities, such as the LIC and MPF furnaces with their PAS/PFS systems, have not yet been developed.

**Recommendation 23.** Key equipment required for closure of chemical agent stockpile incineration facilities should be

[15] Communication between Bob Karlik, TOCDF, and Peter Lederman, committee member, March 2, 2006.

identified now and steps to mitigate and manage obsolescence should be extended to include that equipment's operational life. **(Tier 3)**

## COMMUNITY AND REGULATORY ISSUES

Good to excellent relations with the adjacent community and regulators were indicated at all of the incineration sites. Active public outreach programs are satisfactory for current operations. For example, at the ANCDF site, the site management considers the workers as the first and often best line of communication with the community. Site officials also visit regularly with community leaders, regulators, and state and local policy makers on an informal basis. The management at ANCDF believes that this multipronged program is most successful in gaining, if not support, certainly community acceptance.[16] It was not possible for the committee to verify this, but the committee believes this to be the current state of affairs.

All the sites are located in different states. While the regulators communicate with one another frequently, each state, and thus each site, operates in a somewhat different regulatory environment. The sites and the PMCSE manage these differences as appropriate.

Challenges could arise if obsolete equipment must be replaced with new, different equipment. If this is ruled a major change, it will require cooperation of both the regulators and the community. Depending on the particular situation, this could become a problem. This could occur if changes in the regulations that apply, such as the imposition of the maximum achievable control technology (MACT) regulations, make current equipment obsolete. This could also occur because of changes in operations, such as adoption of new procedures required to handle mercury contaminated material.

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[16]Communication between Timothy Garrett, site project manager, ANCDF, and Peter Lederman, committee member, May 30, 2006.

# Appendixes

# Appendix A

# Committee Meetings and Site Visits

## MEETINGS

### First Committee Meeting: January 24-25, 2006, Aberdeen Proving Ground, Maryland

*Objectives:* Receive briefings from the Army and facility contractors, discuss and arrive at initial approach to task, and discuss report development and future committee activities.

*Program Overview, Statement of Task and Sponsor's Expectations*, COL Joseph E. Pecoraro, Project Manager for Chemical Stockpile Disposal, Chemical Materials Agency

*Expectations from Systems Contractors*, Brad Pierce, U.S. Army Field Support Command

*Obsolescence Issues of the Tooele Chemical Agent Disposal Facility*, Terry Thomas, Engineering Manager, EG&G Division of the URS Corporation

*Obsolescence Issues of Other Incineration-Based Disposal Facilities*, Anthony Medici, Washington Group International

### Second Committee Meeting: March 2-4, 2006, Tooele, Utah

*Objectives:* Interview members of the staff of the Tooele Chemical Disposal Facility (TOCDF) on obsolescence issues. Survey specific portions of the plant facilities. Clarify the statement of task; discuss study organization and approach, committee activities, report development, and future activities.

No briefings. Informal discussions were held with members of the TOCDF staff on a variety of topics pertinent to the committee's task.

### Third Committee Meeting: April 6-8, 2006, Anniston, Alabama

*Objectives:* Interview staff and personnel at the Anniston Chemical Disposal Facility (ANCDF) on obsolescence. Tour the plant facilities and survey specific areas as needed. Plan final site visits and establish timeline for developing full message draft. Discuss study organization and approach, committee activities, report development, and future activities.

No briefings. Informal discussions were held with members of the ANCDF staff on a variety of topics pertinent to the committee's task.

### Fourth Committee Meeting: June 8-9, 2006, Woods Hole, Massachusetts

*Objectives:* Develop tentative recommendations; discuss and develop the first full message draft.

No briefings.

### Fifth Committee Meeting: July 17-18, 2006, Washington, D.C.

*Objectives:* Review preliminary concurrence draft; discuss and finalize report text, and achieve committee concurrence and discuss the NRC review process.

No briefings.

## DATA-GATHERING ACTIVITIES

### Edgewood, Maryland, May 30, 2006

*Objectives:* Receive briefings on ACWA Site Designs; discuss program management issues and closure planning and management; receive data-gathering activity updates.

*Presentations on ACWA Site Designs at Pueblo and Blue Grass*, Joe Novad, Program Manager, ACWA and Craig Myler, Bechtel National Corporation

*Program Management Issues*, Brad Pierce, Chemical Materials Agency

*Brief on Meeting with Washington Group International on Closure Planning and Management*, Peter Lederman, Committee Member

*Report on Site Visit to UMCDF*, Otis Shelton, Vice Chair and Colin Drury, Member

*NRC participants:* Lis Drake, Otis Shelton, Colin Drury, Chuck McGinnis, and Peter Lederman, committee members; Robert J. Love, study director; Alex Repace, project assistant; Nia Johnson, research associate.

## FACILITY SITE-VISIT ACTIVITIES

### Cleveland, Ohio, April 21, 2006

*Objectives: C*onduct a survey of the Rockwell Assessment Management Program as well as to assess that PLC-3, PLC-5, Data Highway, and 1700 series components will be available until full closure of all facilities which need them.

*NRC participant:* Dave Hoecke, committee member.

### Umatilla, Oregon, May 8-9, 2006

*Objectives:* Interview staff and personnel at the Umatilla Chemical Agent Disposal Facility (UMCDF) on obsolescence issues. Tour plant facilities and survey specific areas as needed.

*Individuals met with:* Tony Medici, Washington Group International, and Raj Malhotra, Chemical Materials Agency.

*NRC participants:* Otis Shelton and Colin Drury, committee members; Robert J. Love, study director.

### Pine Bluff, Arkansas, June 20-21, 2006

*Objectives:* Interview staff and personnel at the Pine Bluff Chemical Agent Disposal Facility (PBCDF) on obsolescence issues. Tour plant facilities and survey specific areas as needed.

*Individuals met with:* Tony Medici, Washington Group International; Clara Moraga, CMA Assistant Site Project Manager (Compliance) and Acting Site Project Manager; Jeff Rosiska, SAIC Operations SME, PBCDF Field Office; Guy Campbell, WDC Plant Manager and Acting Project General Manager; Richard Burleigh and Mike Henderson, WDC Engineering; and Jon Rosiska, WDC Operations Manager.

*NRC participants:* Jim Bacon and Colin Drury, committee members; Robert J. Love, study director.

# Appendix B

# Volatility Characteristics of Information Management and Technology Systems

The sequence of uniquely identifying information, collecting it at the point of origin, transporting it to data storage facilities, and accessing it at some arbitrary or predetermined time involves a number of transactions. Unless appropriate practices are followed, each of those transactions has the potential to introduce errors, corrupt files, or cause other negative consequences that frustrate the intent to maintain information in an accessible form. To avoid this, numerous safeguards and professional practices have been devised to address these potential erosions of information, and in modern practice this element of operations can be approached with a high level of confidence and an expectation that information can be safeguarded and retained in a highly robust and reliable manner.

Nonetheless, the points presented below identify some common examples of how the general developmental volatility characteristics over time of information management and technology systems can affect continued operability of facilities such as those that are the subject of this report. This outline should not be interpreted as a communication that any or all of the points on this list are threatening at any chemical demilitarization facility or have not been addressed at those facilities. Rather, it is intended to communicate many of the things that were considered during the committee's review of information management at the facilities.

**Application Changes.** Vendors may switch formats that are used by their applications, and at some point in the future, older datasets may not be readable by the descendants of the software with which it was developed. Even if formats are generally the same, changes in feature sets can lead to this problem.

**Application Elimination.** Vendors may go out of business or be assimilated by other vendors, and the products used to develop and interpret information may no longer be available.

**Application Incompatibility.** Records developed in one application may not be functionally compatible with another application even though both have the same operating role. For example, one vendor's CADD software may not be able to read another vendor's CADD software data (even though the reverse transaction may be possible). As a result, migrations in applications either over time or between facilities can be problematic in operating practice. This kind of compatibility erosion can challenge continued operations.

**Licensing Models.** Even if legacy applications are preserved to guard against the kinds of problems noted above, vendor practices may restrict the future use of current software.

**Operating System Changes.** The basic platform on which an application runs or on which a particular data format has meaning may change, or that platform may disappear, rendering stored records unreadable.

**Storage Media Failure.** Electronic records in a storage facility exist in the form of physical media that can be compromised. Fire, explosion, contamination, electronic impulses (in some cases), flooding (in some cases), or simple long-term signal degradation (more a problem in some cases than others) can render content unrecoverable.

**Storage Media Incompatibility.** Electronic records preserved on a particular form of media may in the long term be unrecoverable because the physical devices that read them may disappear from common use.

**Decryption Failure.** Records preserved in encrypted form may be unrecoverable for reasons that include loss of passwords and unavailability of suitable decryption software. Loss of passwords may be by human error (long-term lack of message passing) or loss of password vaults (software or systems in which passwords are securely stored).

**Device Failure.** Every physical system has a finite life span or can be physically compromised. Mechanical or other failures of high-speed disk drives, memory, tape units, processors or other system components can arise from long-term wear or physical assault (fire, accident, flood, contamination, and so on). The probability of these events increases with time. Some of them (e.g., fire) are not directly related to continued operability, but others (e.g., component wear) are.

**Device Obsolescence.** The record of computing system evolution over the last decade has been unequivocally one of continued rapid improvements in competency, including speed, density of storage, and so on. This pace of evolution will continue for the foreseeable future. This has several consequences. Some are not directly relevant to the mission of continued operability. An example of an irrelevant or secondary consequence is that the expectation of performance on the part of users consistently increases to match what is currently available. In the consumer marketplace and in many business contexts, this constitutes a real motivation for change. In the context of continuing operability, as long as a component functions, it is not. There may be human implications (dissatisfaction with the working environment engendered by slow computers or outdated user interfaces), but these are not necessarily direct challenges to continued operations. An example of an evolution that may be a factor is an evolution in processor technology. Changes in instruction sets can render old hardware useless for a particular application or an old application useless on new hardware, unless manufacturers accommodate legacy requirements (in either direction). Virtual system technologies can in some cases address this kind of problem, but the phenomenon nevertheless can pose challenges to continued operation.

**Human Skills Migration.** As new technologies emerge and users adapt to them, there is a migration away from old skill sets. This can lead to a point where a workforce able to run a device or cope with a technology cannot be found. Even if it can be found, user preferences and expectations can change to the point where (as noted above) outdated but serviceable equipment can be perceived as ineffective. These factors can be managed to some extent with education and incentives that will develop an effective continued workforce, but they do have the potential to pose a challenge to continued operability. This is particularly true in the information management world, where the pace of change is rapid in virtually every dimension.

**Evolving Electronic Threats.** Computer viruses, worms, spyware, and other malicious agents are a fact of life and continually change. Continued operation requires continued diligence against this kind of attack, and this requires that systems either be carefully isolated or maintained in an up-to-date state if they are to be preserved. This is a clear complication of continued operability, in that aged equipment and legacy software systems may pose challenges if the currently available virus protection does not support them. This is to some extent countered if those same legacy systems are not compatible with current viruses, but the existence of this threat and the need to manage it remains a consideration.

**Metadata Inadequacy.** Stored information can for the most part be readily retrieved if it has been recently archived and the sender is available to guide the recovery process, or if the basis for keywords or tags that identify the data are well enough documented that subsequent searchers can understand the terms used and request documents accordingly. However, it is common to find in the longer term that the scheme used to identify a dataset may be incomprehensible to later users of a system who might have a different contextual basis than the person(s) who archived the information. Particularly where a system was developed with a short-term usage horizon in mind but is tasked with a long-term use period, this kind of issue can lead to data recovery problems.

# Appendix C

# Biographical Sketches of Committee Members

**Elisabeth M. Drake**, *Chair,* a member of the National Academy of Engineering, is currently retired. Prior to her retirement, she served as the associate director of the M.I.T. Energy Laboratory. Dr. Drake graduated from Massachusetts Institute of Technology with a Sc.D. in chemical engineering. She has had considerable experience in risk management and communication; technology associated with the transport, processing, storage, and disposal of hazardous materials; and chemical engineering process design and control systems. Dr. Drake has a special interest in the interactions between technology and the environment and a comprehensive understanding of the chemical weapons demilitarization process. She has served on several NRC committees relating to chemical demilitarization.

**Otis A. Shelton,** *Vice Chair,* is associate director for the Safety & Environmental Services Compliance and Operational Assessments Program for Praxair Inc., a position he has held since 1992. In this position Mr. Shelton is responsible for managing Praxair's assessment program that focuses on environmental, operational safety, personnel safety, industrial hygiene, emergency planning, distribution, and medical gases programs. Previously Mr. Shelton managed Union Carbide Corporation's Regional Corporate Health, Safety, and Environmental Protection Audit program. This program reviewed UCC's health, safety, and environmental compliance in all UCC's operations worldwide. Mr. Shelton holds an M.S. in chemical engineering from the University of Houston, is serving as secretary of the American Institute of Chemical Engineers, and has served for 20 years as a member of the National Society of Black Engineers National Advisory Board.

**James L. Bacon**, P.E., is currently president and CEO of the Economic Development Alliance of Jefferson County, Arkansas. He most recently served in the Senior Executive Service of the U.S. Army as the program manager of the $25 billion program for the disposal of the U.S. stockpile of chemical weapons. Mr. Bacon received his master of science in engineering from the University of Arkansas in 1987. His career has consisted of 42 years of progressive project management and leadership of major engineering and environmental programs associated with chemical and biological weapons production, storage, and disposal. Mr. Bacon is a Life Member of the National Society of Professional Engineers, a fellow and life member of the American Society of Mechanical Engineers, and a member of the U.S. Army Chemical Corps Hall of Fame.

**Robert L. Cattoi** is a retired senior vice president of research, engineering, and manufacturing processes at Rockwell International Corporation. In November 1991 he was appointed chairman of the U.S. delegation to the International Steering Committee on Intelligent Manufacturing Systems (IMS), whose goal is to systematize, standardize, and develop manufacturing science and technology to provide the basis for agile and intelligent manufacturing systems in the 21st century. Subsequently, Mr. Cattoi became the international chairman for this activity. Mr. Cattoi earned a bachelor of science degree in electrical engineering with a physics minor from the University of Wisconsin. He is a past member of the Defense Science Board and is a member of the NRC Board on Army Science and Technology. He is a registered professional engineer in the state of Texas and is a member of the National Society of Professional Engineers.

**Colin G. Drury** is a University at Buffalo Distinguished Professor in Industrial and Systems Engineering, concentrating on the application of human factors techniques to manufacturing and maintenance processes. After receiving a Ph.D. from the University of Birmingham, U.K., he was manager of ergonomics at Pilkington Glass. He has extensive publications on topics in industrial process control, quality control, aviation maintenance and safety, and is the North American editor of Applied Ergonomics. He was the founding executive director of the Center for Industrial Effectiveness. He is a fellow of four professional societies in human factors and is a certified professional ergonomist. Dr. Drury has served on several previous NRC studies related to chemical demilitarization.

**J. Robert Gibson** is currently an independent consultant in the field of toxicology and occupational safety and health. Dr. Gibson graduated from Mississippi State University with a Ph.D. in physiology, and he holds a master's degree in zoology and a bachelor of science degree in general science from that same institution. After completing a postdoctoral research fellowship in pesticide metabolism at the University of Kentucky, he joined DuPont's Haskell Laboratory for Toxicology and Industrial Medicine as a research toxicologist. During his 30-year career with DuPont, Dr. Gibson held management positions in R&D, chemical manufacturing, and corporate administration (corporate director of safety and health). He was also assistant director of DuPont's Haskell Laboratory for Toxicology and Industrial Medicine. Dr. Gibson ended his DuPont career as a director in the Crop Protection Products Division in Wilmington, Delaware, in December 2001. He was board certified in toxicology by the American Board of Toxicology from 1980 through 2005. His numerous committee assignments include eight years of service on the NRC's Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program (Stockpile Committee), which provided oversight for the U.S. Army's chemical weapons disposal program. He was also a member of the NRC Committee on Evaluation of Chemical Events at Army Chemical Agent Disposal Facilities. Dr. Gibson is also the U.S. representative to the Scientific Advisory Board of the Organization for the Prohibition of Chemical Weapons and is a member of the NRC standing Committee on Chemical Demilitarization.

**David A. Hoecke** is currently president and CEO of Enercon Systems Inc. He graduated from the Cooper Union with a B.S.M.E. His expertise is in the fields of waste combustion, pyrolysis, heat transfer, and gas cleaning. In 1960 he began working for Midland-Ross Corporation as a project engineer, rising to be its chief engineer for incineration by 1972. At that time he founded his own company, and he has since been responsible for the design and construction of numerous combustion systems, including solid waste incinerators, thermal oxidizers, heat recovery systems, and gas-to-air heat exchangers. Mr. Hoecke has considerable expertise in incineration technologies employed by the Army in its demilitarization of chemical weapons.

**Peter B. Lederman** has a Ph.D. in chemical engineering from the University of Michigan, and retired as executive director, Hazardous Substance Management Research Center and Executive Director, Office of Intellectual Property, New Jersey Institute of Technology and Roy Weston Inc., where he served for 13 years as a vice president and one of the leaders of the Hazardous Materials Management practice. He continues to teach environmental management, policy and site remediation. He is active as a consultant in the area of hazardous materials management. Dr. Lederman has over 50 years of broad experience in all facets of environmental management, control, and policy development; considerable experience in hazardous substance treatment and management; process design and development in the petrochemical industry; and over 18 years of experience as an educator. He has industrial experience as a process designer and managed the development of new processes through full-scale plant demonstrations. He is well known for his work as a professor in chemical process design. He led his company's safety program in the early 1980s. Dr. Lederman is a registered professional engineer, registered professional planner, certified hazardous material manager, and a diplomate in environmental engineering. Dr. Lederman has also worked at the federal level (EPA) as a laboratory director and at state levels with particular emphasis on environmental policy. He is a national associate of the National Academies.

**Charles I. McGinnis** is currently an independent consultant in the realm of civil engineering. Previously he served in senior positions at the Construction Industry Institute in Austin, Texas. Retired from the U.S. Army as a major general, Mr. McGinnis has an M.E. in civil engineering from Texas A&M University and is a registered professional engineer in Texas and Missouri. He was a former director of civil works for the U.S. Army Corps of Engineers and also served as the director of engineering and construction for the Panama Canal Company and later as vice president of the company and lieutenant governor of the Panama Canal Zone. As director of civil works, he was responsible for a $3 billion-per-year planning, design, construction, operation, and maintenance program of water-resource-oriented public works on a nationwide basis. He has considerable experience with engineering and construction as well as unique understanding of facilities maintenance and chemical weapons demilitarization, and he has served on several NRC study committees looking at chemical demilitarization.

**A. Charles Rowney** is currently an independent consultant practicing in the areas of information management and organizational management as related to the technologies and practices that enable technical communities to operate effectively within an enterprise. Past activities have included a background in knowledge and information management, and he is currently active in projects that have him interacting with Chief Information Officers and their counterparts across the United States and Europe as they deal with issues related to collaboration and interoperability. Dr. Rowney holds B.Sc., B.A.Sc., M.A.Sc., and Ph.D. degrees from the University of Ottawa. He has over 25 years experience in the engineering industry, and in that capacity has worked with clients and colleagues throughout North America (Canada and the United States) and Europe (France, Germany, Denmark, Sweden, Scotland, Ireland, and England). Dr. Rowney has substantial experience in chemical agent remediation, as well as in water resources (he is a diplomate of the American Academy of Water Resources Engineers).