Chapter 1

Alternative Destruction Technologies—History and Summary

INTRODUCTION

The U.S. Army currently has custody of chemical weapons (CW) containing nerve and blister (vesicant) agents[1] located at eight sites in the continental United States and at Johnston Island, a small island in the Pacific Ocean. The Army's current disposal program calls for munition disassembly followed by incineration, on-site, at all of the present locations of the CW stockpiles. This approach has met with opposition by some communities and States that have CW stockpiles and by several national and international environmental groups. At the State level, this opposition may succeed in preventing or seriously delaying construction of the Army's planned CW disposal facilities at certain locations. The Army itself has expressed concern about potential regulatory obstacles to completing its CW disposal program. Additional program delays have also been experienced because the Army's Johnston Island demonstration program, required by Congress prior to construction of CW disposal facilities in the continental United States, has not yet been successfully completed.

Because of the legal, social, and technical obstacles faced by the Army, the Office of Technology Assessment (OTA) was asked to examine alternatives to on-site incineration for the destruction of these weapons. This report does not attempt to assess in any detail the technical aspects of the Army's current CW destruction program.[2] It reviews the status and availability of alternative technologies and discusses the factors that could lead to the consideration of such alternatives.

The need for an effective U.S. CW stockpile destruction program has been driven by several factors. The Army has had its own requirements for a disposal method for surplus and obsolete chemical weapons for as long as these materials have been part of its arsenal. In 1982, Under Secretary of the Army J.R. Ambrose stated in a letter to the chairman of the National Research Council (NRC) Board on Army Science and Technology that:

> [T]he United States faces a formidable problem in disposing of its current obsolete chemical munitions and agent stockpile. About 90 percent of the inventory of chemical agent and nearly as much of the munitions inventory has little or no military value and will require disposal regardless of future decisions regarding the binary weapons program (l).

A related and ongoing concern expressed both by the Army and the NRC is the potentially increasing risk from the existing U.S. CW stockpile as it deteriorates with age.

Congress has directed the Army to develop and implement a CW destruction program (see box l-A). The Department of Defense Appropriation Act of 1986 (Public Law 99-145) directed the Secretary of Defense to destroy the current U.S. CW stockpile in a safe and effective manner. This directive was originally tied to the Army's acquisition of newer binary chemical weapons, although the development of such weapons is no longer planned and few were actually ever built (2, 3). A plan provided by the Secretary of the Army to Congress in 1986 became the basis of a Programmatic Environmental Impact Statement (PEIS). As the Army's program development encountered unanticipated technical and political hurdles, Congress flexibly responded by amending completion timetables. Initially, the Army was required to destroy its CW stockpile by 1994. In 1988, Congress extended the completion date to 1997. Also in 1988 the Army compared alternatives of relocation of weapons to one or more central disposal sites to that of on-site disposal at each of the eight locations. The Army chose on-site disposal because it believed that any accident on an existing Army base would be easier to mitigate than an accident at some unknown point along a transportation route. Recently, the Army has submitted a revised completion date of 2000 to Congress that maintains the plan to build on-site disposal systems at each of eight sites (see table l-l) (4, 5, 6).

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[1] See box 2-A for a more complete description of chemical weapons agents and their effects.

[2] It also does not discuss cryofracture, an experimental munitions disassembly technique that freezes and crushes CWS. Cryofracture is part of the current development program and is considered by the Armytobeonlya"front end' process that must be coupled to incineration, and does not therefore constitute an incineration alternative.

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Box I-A—Federal Laws Addressing Chemical Weapons Disposal

A number of laws have been passed over the years that specifically address chemical weapons disposal.

The Department of Defense Authorization Act of 1986 (Pubic Law 99-145) mandated the destruction of the U.S. stockpile of lethal chemical agents and munitions. It directed the Department of Defense (DOD) to develop a comprehensive plan for destruction of the stockpile, which would be carried out by an Army management organization. The law established a destruction deadline of September 30, 1994, and provided a separate DOD account to fund all activities. The law further required that the Army plan should provide for maximum protection for the environment and human health and that the facilities constructed would only be used for destruction of chemical weapons and munitions. Public Law 99-145 clearly stated that once the stockpile elimination was complete, all facilities would be dismantled and removed.

Amendments and revisions have since been made to the law governing the stockpile destruction requirements and the Chemical Weapons Demilitarization Program. In the ***National Defense Authorization Act for Fiscal Year*** *1988 and 1989* (Public Law 100-180), Congress directed the Secretary of Defense to issue the final Programmatic Environmental Impact Statement on the chemical stockpile destruction program by January 1,1988. The law further required that funds designated for the program could not be obligated until the Secretary of Defense provides Congress, in writing, proof that the overall concept plan for the Chemical Demilitarization Program includes:

1. An evaluation of alternate technologies for disposal of the existing stockpile, and
2. Full-scale operational verification tests of the selected chemical weapons disposal technology or technologies.

In addition, Public Law 100-180 required the Secretary of Defense to submit an alternative concept plan for the chemical stockpile demilitarization program to both Committees on Armed Services of the Congress. This alternative concept plan was to be completed by March 15, 1988. The law also required the Secretary of Defense to establish an ongoing program for surveillance and maintenance of the stockpile and assess its overall condition.

The National Defense Authorization Act for Fiscal Year 1988 and 1989, (Public Law 100-456) made additional changes that affected the Army's program to destroy the chemical weapons stockpile. This law extended the stockpile elimination deadline to April 30, 1997. It also required the Army to complete Operational Verification Testing (OVT) of its demonstration facility at Johnston Atoll Chemical Agent Disposal System (JACADS) before proceeding with construction of similar full-scale facilities for the destruction of the chemical weapons stockpile located in the continental United States. However, this provision did not prohibit construction activities at the Chemical Agent Munition Disposal System in Tooele, Utah.

The National Defense Authorization Act for Fiscal Year 1991 (Public Law 101-510) also addressed the Chemical Weapons Demilitarization Program. This Iaw pays particular attention to issues involving the safety status and the integrity of the stockpile. In the law, Congress requires the Secretary of Defense to develop a Chemical Weapons Stockpile Safety Contingency Plan. This plan would detail the steps that DOD would follow if the chemical weapons stockpile began an accelerated rate of deterioration or any other question of its integrity arose before full-scale disposal capability was developed. This plan, which is to set forth a planning schedule, funding requirements, equipment needs, and time frame for emergency plan implementation, was to be submitted to Congress 180 days after the law was passed.

Currently, legislation involving the **Chemical Weapons Demilitarization Program addresses the delays in the program** and proposed deadlines. Both the House and Senate bills for ***National Defense Authorization for Fiscal Year 1992 and*** *1993 (S. 1507* and H.R. 2100) propose extending the stockpile elimination deadline to July 1999.

Other laws that helped shape the Chemical Weapons Demilitarization Program include Public Laws 91-672 and 92-532.

The Foreign Military Sales Act Amendment (Public Law 91-672), passed in 1971, prohibited the transportation of chemical weapons from the Island of Okinawa to the United States. It further directed the U.S. Department of Defense to destroy these chemical weapons outside the United States. (In 1971, the U.S. Army moved chemical weapons from Okinawa to storage facilities at Johnston Island.)

The Marine Protection, Research, and Sanctuaries ACt of 1972 (Public Law 92-532) prohibited ocean dumping of chemical weapons.

Table 1-1—Revised Programmatic Chemical Disposal Schedule

Location	Start facility construction	Start prove-out	Start operations	End operations
Johnston Island	November 1985	August 1988	July 1990	October 1995
Training Facility	June 1989	N/A	October 1991	December 1999
Tooele Army Depot	September 1989	August 1993	February 1995	April 2000
Anniston Depot	June 1993	April 1996	October 1997	November 2000
Umatilla Depot	January 1994	November 1996	May 1998	December 2000
Pine Bluff Arsenal	January 1994	September 1996	March 1998	November 2000
Lexington-Blue Grass	May 1994	March 1997	September 1998	February 2000
Pueblo Depot	May 1994	March 1997	September 1998	May 2000
Newport Ammo Plant	January 1995	June 1997	June 1998	April 1999
Aberdeen Proving Ground	January 1995	June 1997	June 1998	June 1999

NOTE: This schedule does not take into account delays from major system failures or litigation and is dependent on funding support.

SOURCE: S. Livingstone, Assistant Secretary of the Army (Installations, Logistics and Environment), testimony before the House Committee on Appropriations, Subcommittee on Defense, Apr. 1, 1992, Second Session, 102d Congress.

Bilateral treaties that were negotiated with the former Soviet Union (now the Commonwealth of Independent States, C. I. S.) contained deadlines for CW destruction by each signatory. One of these agreements that had been under final negotiation between the United States and the Soviet Union mandated staged destruction over time of the CW stockpile of both countries to 5,000 metric tons of agent by 2002. Even though this agreement has not been put into force, many believe it is in the best interest of the United States to honor its intent if not its timetables. However, both the United States and the C.I.S. are having difficulties in achieving these timetables for several reasons. The C.I.S. currently has no active CW disposal program, and past efforts to develop a disposal facility in the Soviet Union were derailed by local citizen opposition (7). At present, Russia has no project ready for the destruction of an estimated 40,000 tons of chemical weapons agents stored there (8). The agreements that have been negotiated appear to allow flexibility in accommodating technical and other problems that affect CW destruction program timetables. It is becoming clear that the flexibility is needed even given the significant pressures to move ahead expeditiously.

SUMMARY AND FINDINGS

Although the Army has done a credible job developing the technical aspects of its current program, major political and social obstacles remain. Analyses other than OTA's of the Army's current program indicate that there are also some remaining technical and cost obstacles (9, 10, 11, 12, 13, 14). At present, the Army has no backup plan should its current program be unsuccessful.

Opposition to the Army's Program

Local and national opposition may be able to prevent or seriously delay construction of the Army's planned CW disposal facilities. For example, the State of Kentucky has passed legislation establishing more stringent measures for the Army to obtain the permits required under the Resource Conservation and Recovery Act (RCRA) (see box 1-B). Other States could follow this lead. Also, the Army has not completed a congressionally mandated demonstration of its technology at Johnston Island. It is not clear that this demonstration as presently planned will adequately address concerns raised by groups who oppose the Army's CW program.

The Army itself has been concerned about the difficulties affecting the completion of its current CW disposal program (4). In 1984, after reviewing the Army's experience with CW neutralization and incineration, the National Research Council (NRC) endorsed the Army's decision to use incineration (1).

However, possibly in reaction to political opposition to its program, the Army recently requested the

Box l-B—State Authority Over the Siting, Construction, and Operation of Incinerators for Chemical Weapons Destruction

The Commonwealth of Kentucky has been delegated authority under the Resource Conservation and Recovery Act (RCRA) and the Clean Air Act to issue within the state construction and operation permits for hazardous waste management facilities such as a CW incinerator. State authority affects all phases of the construction and operation of an incineration facility. Statutes passed under this authority by the Kentucky State legislature have placed additional specific requirements for hazardous waste incinerators intended for use with chemical weapons (the Kentucky Revised Statutes Chapter 224, 224.865) (l). These revisions have not only included CW agents as chemicals to be regulated, but also required that an equivalent treatment/destruction technology be fully demonstrated prior to permitting the proposed CW incinerators.

These revised statutes require submission of:

> monitoring data from a comparable facility [that] reflects the absence of emissions from stack or fugitive sources including but not limited to the products of combustion and incomplete combustion which alone or in combination present any risk of acute or chronic human health effect or adverse environmental effect [Kentucky Revised Statute 224.865].

One interpretation of this requirement according to Kentucky State officials as suggested by the Center for Disease Control (CDC) is that it would require a 30-year epidemiological study on a similar site, along with complete monitoring data (l). In addition to State control over new incinerators, local county courts in Kentucky may also have authority to veto the siting of a CW destruction facility.

During the 1992 Session of the Kentucky General Assembly, House Bill 465 was passed and signed by the Governor on April 1, 1992. This legislation, effective July 15, 1992, specifically requires that before a permit can be issued to construct a CW destruction facility information must be provided showing that:

> no alternative method of treatment or disposal, including, but not limited to, neutralization and transportation to a less populated disposal site, exists. . .or is likely to exist or could be developed. . that creates less risk of release **or harm** to the public or the environment. . .

The legislation also sites State authority under Section 6929 of Title 42 of U.S. Code to:

> impose reasonable restrictions directly relating to public health and safety with respect to the management of hazardous wastes beyond the minimum standards established under federal law. [Moreover] [T]here exist

NRC Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program to reevaluate the status of incineration. An additional NRC committee has also been formed, the Committee on Alternative Chemical Demilitarization Technologies (Alternatives Committee), to examine alternatives for CW disposal. The first meeting of the Alternatives Committee was held in March 1992. Many believe that this new NRC committee effort is important not only because of technical benefits but because it could reflect the Army's willingness to integrate community and environmental concerns in its decisions.

Approaches to Developing Technologies

The nature of the political problems faced by the Army's CW destruction program suggests that completing its present program or developing a successful alternative one involves more than technology development. Any successful program will need to address the relevant social and political issues involved as well. This is likely to require the active participation of all interested parties, including the Army, regulators, contractors, community organizations, and environmental groups.

Such a collaborative effort could begin by developing criteria for an acceptable program that address the key technical and social obstacles. Features that are important to some groups include:

- Use of a destruction technology that does not have smokestacks, which are associated with uncontrolled environmental emissions;
- Selection of a technology with features specifically appropriate for the CW stockpile and that could not become the basis of continued operation for hazardous waste disposal at the facilities sites;
- Development of portable CW destruction systems that could be used directly in a munition

substantial gaps in information concerning the acute and chronic health effects and environmental consequences of exposure to [chemical weapons agents] and [their] degradation products.. .[which] justify the imposition of standards correlative to the uncertainties and severity of risks potentially posed by the treatment or disposal of the compounds.

The legislation specifies **that** before anyone may construct or operate a facility for treatment, storage, or disposal of CW agents, he or she must demonstrate that:

The proposed treatment or destruction technology has been fully proven in an operational facility of scale, configuration and throughput comparable to the proposed facility [to ensure] destruction [efficiency] of 99.9999 percent. . .as achievable during the design life of the facility under all operating conditions including during the occurrence of malfunctions, upsets, or unplanned shutdowns.

The legislation also requires monitoring data from an operation facility showing the "absence of emissions" that "present any **risk** of **acute or chronic** human health effects... ." Plans are also required for a State and local emergency response.

Representatives from other States legislatures that have CW depots within their States have made inquiries of the Kentucky state authorities about the nature of this strategy. According to a General Accounting Office (GAO) study, other States where the Army **has** proposed constructing CW destruction facilities, such as Indiana have shown an interest in how the Kentucky State legislature has dealt with the Army's program (2). The State of Utah has enacted legislation affecting the permitting of CW destruction facilities (2). Utah has required that the disposal facility built at Tooele, Utah will operate at 50 percent capacity for 6 months for each and every individual chemical agent to be destroyed (2). State environmental officials will then evaluate test data for the individual agents (2). According to the GAO report, in 1988, the Army's estimates for construction State dates assumed that State-issued environmental permits for each of the proposed sites could be obtained in 15 months. On the basis of its experience with Utah, the Army now anticipates that it will take 24 months, and it is not clear how realistic even this revised estimate will be (2).

References

1. Hudson, V., Deputy Commissioner for Special Projects, Kentucky Department for Environmental Protection, Frankfort Office Park Frankfort, KY. Telephone Conversation December 12, 1991.
2. U.S. Congress, General Accounting Office, ***Stockpile Destruction Cost Growth and Schedule Slippages are Likely to Continue, GAO/NSIAD-92-18*** (Washington, DC: November 1991).

storage facility to avoid risks associated with transporting and handling CWs away from their present storage locations;
. Development of individual programs with features specific to individual sites; and
. Development of safe and effective community emergency response programs.

Timing Questions

It is difficult to predict the time that may be required to develop an alternative program given the available information about alternative technologies. It is clear that the alternatives identified by OTA are all in early stages of development—perhaps several years behind the Army program's current development stage. It is also evident, however, that political or legal delays could prevent implementation of current technology at some or several of the weapons storage sites for a number of years.

While there are pressures to destroy the CW stockpile quickly, there is no technical basis to set absolute deadlines for completion of the CW destruction program. The condition of the existing CW stockpile is probably the most serious consideration but few data and no rigorous, comprehensive analysis of the risks posed by deterioration of the weapons exist. The Army's monitoring program has yet to identify trends of increasing deterioration. There are also domestic and international political pressures to expedite the weapons destruction program. However, many believe that congressional mandates and the status of bilateral treaties and agreements are sufficiently flexible to consider the development of alternative programs.

As stated above, the least flexible deadline maybe the increasing risk associated with deterioration of the CW stockpile. With the exception of the M55 rockets located at five of the eight continental U.S. sites, the best available information about the condition of the CW stockpile, including that from ongoing surveys, suggests there are few problems with agent leakage from bombs, artillery projectiles, mines, or bulk storage tanks (1, 15, 16). In 1984 the NRC indicated that although there were insufficient data to project the near-or long-term storage life of CW agent containers, available information suggested that the overall leak frequency had not substantially increased during the lifetime of the CW stockpile (l). However, the report also concluded that the M55 rocket is the primary basis for a maximum credible accident at each of the depots due to the possible harm that could be inflicted on both workers and civilian populations. In a 1985 study by the Army on the condition of the M55 rockets, the occurrence of a catastrophic event from a deteriorating stockpile in the near future was considered highly unlikely (17). Nevertheless, the continued storage of M55 rockets and other types of munitions at Army depots represents a continued, finite risk to communities located near these depots. To better quantify this risk, existing monitoring programs on the status of the U.S. CW stockpile could be expanded to provide additional information about the rate of deterioration of the M55's. In addition, further analyses of the risks from continued storage as well as possible risk reduction measures could be very useful in decisions about time available to pursue alternative programs (see box l-C).

The timing issue is critical in alternative technology development planning. One approach to an alternative program could be to try and find midterm corrections for the Army's current system, e.g., replacing one or more of the incinerators themselves with some other method of destruction but keeping the rest of the system. Another would be to start over with an entirely new system. The impact on the Army's current program clearly will be quite different with these two approaches. A sense of time constraints will also dictate where a new program can begin. For examples, if lots of time is available, then a new program could afford to begin in the laboratory; if less time is available, then a new program would probably be forced to consider only existing bench-scale technologies or technologies already tested in related areas.

How much time may be available to develop alternatives is not known nor is there an accurate estimate of time required for various approaches. Technical and regulatory hurdles faced by the current program may delay it well beyond its planned completion date. In any case, a clear analysis of time constraints is critical and it should include costs of delay, the risks of delaying, the degree of uncertainty and other factors.

Risks of Developing Alternatives

Even though it may be desirable to sponsor an alternative technology development program, it is important to understand the risks of such an effort. The prospects for success of an alternative program are not assured. There could always be a number of technical or political problems and delays associated with any development program. Failure of a technology or approach in a full-scale test is always possible. After even the best efforts to develop new technologies, it is possible that the results could be no better or even worse than those from the current system.

Therefore, if an alternative development program was supported it would not necessarily follow that the current program should be stopped. It may be possible to combine the best features of both programs in the future, or it may be that current technologies will be superior to any alternatives in the end.

Alternative Technologies

To be applicable to the current CW stockpile, a technology must be able to effectively destroy or decontaminate the chemical agents, the drained and empty munitions and containers, the associated explosives and propellants, and the munition packaging material (dunnage). The Army's current system incorporates all of these waste streams. Some alternatives that have been proposed, however, may be expected to be useful in destroying only the chemical agent itself. Others could possibly be applicable to other waste streams (e.g., explosives and propellants). In any case, any complete system would need to integrate the capability to handle all waste streams as well as to handle, disassemble, and drain the various types of containers or weapons involved.

OTA reviewed available data on alternative technologies. Of those that have been proposed by others for CW destruction, OTA selected four that are briefly discussed in this report (chemical neutralization, super critical water oxidation, steam gasification, and plasma arc pyrolysis). These four were selected only for the purpose of illustrating the

Box 1-Condition of the M55 Rockets

The M55 rockets (see figure l-l) are considered the most dangerous items in the current stockpile for a variety of reasons (1, 2). Since the M55 rocket is a fully assembled munition containing either agent VX or GB, along with fuses, burster charges, and propellants-in a configuration that cannot be separated easily-it is the most potentially hazardous item in the CW stockpile (3, 4). The M55 rockets are also the source of the greatest number of leaking munitions. Not surprisingly, M55s are the primary basis for a maximum credible accident at each of the depots where they are located due to the possible harm that could be inflicted on workers and civilian populations (1). Approximately 478,000 M55 rackets are located at five of the eight continental U.S. sites and at Johnston Atoll (3, 4). In part because of these problems, the 1984 National Research Council report recommended that disposal of the M55 rockets be expedited.

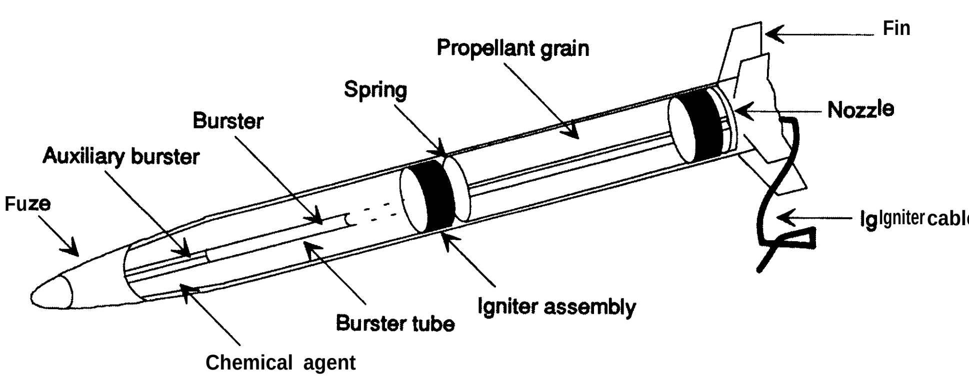
Historical records of the M55 rockets are largely lost, destroyed, misfiled, or nonexistent (3, 4). The rockets were developed in the 1950s. The GB-filled rockets were manufactured at Rocky Mountain Arsenal, Colorado, between 1%1 and 1965, and the VX rockets were manufactured at Newport Army Ammunition Plant, Indiana, in 1964 and 1%5. The M55 was shown to be erratic and undependable, and the Army declared it obsolete in 1981 (3, 4).

In the risk analysis for different transportation options at the eight U.S. CW storage sites (which assumed that incineration would be the destruction method; described more fully in appendix B), a large portion of the risk often was due to the presence of specific munitions(5). For example, the M55 rockets are stored at the Anniston (Alabama), Lexington-Blue Grass (Kentucky), Pine Bluff (Arkansas), Tooele (Utah), and Umatilla (Oregon) Army depots (6). At Anniston, with the option of continued CW storage and with the adoption of appropriate safety procedures, more than 40 percent of the remaining risk was associated with the M55 rockets (5). (The balance of the remaining risk is distributed among the other types of munitions.)

For on-site disposal with adoption of appropriate safety procedures at the Lexington-Blue Grass Army Depot, rockets are responsible for essentially all of the risk At Pine Bluff, for on-site destruction with adoption of appropriate safety procedures, more than 95 percent of the risk is due to the M55 rockets. At the Tooele site, most of the risk is associated with bulk containers of agent GB in warehouses, although handling projectiles, rockets, and mines with VX is also a contributing factor. At the Pueblo facility, which lacks M55 rockets, the on-site destruction alternative with adoption of appropriate safety procedures has most of the risk associated with the projectile munitions.

The M55 rocket contains a chemical agent (either VX or GB), in an aluminum warhead a rocket motor with a solid propellant; a burster loaded with an explosive to explode the warhead on impact and disseminate the agent; an igniter to ignite the rocket motor; and a fuse designed to arm after rocket launch and to detonate the burster on striking the ground (3, 4). Leaks or other degradation of any of these systems over time could lead to an increased risk of accident. In 1985 the U.S. Army Material Systems Analysis Activity (AMSAA) conducted a study on the condition of the M55 stockpile in which 393 rockets were selected randomly from the total stockpile of 478,000 (3, 4). These rockets were disassembled and the individual components assessed to estimate the amount of

Figure 1-1—M55 Rocket, Filled With Agent GB or VX



SOURCE: U.S. Department of the Army, "Independent Evaluation/Assessment of Rocket, 115mm: Chemical Agent (GB or VX), M55," U.S. Army Material Systems Analysis Activity, Aberdeen Proving Ground, MD, October 1985.

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Box 1-C-Condition of the M55 Rockets-Continued

degradation they had undergone after 20 to 25 years of storage. These estimates were presented as a means to estimate the continued storability of the rockets and were not considered accurate predictions.

Both external and internal leaks of chemical agents in the M55 rockets were found. The rocket propellant contains a stabilizer that was present at 1.6 to 2.2 percent by weight. If the stabilizer content, which is depleted during normal conditions, falls below 0.2 percent then auto ignition of the propellant could occur. The stabilizer has probably been diminishing ever since the weapons were manufactured, but because the 1985 assessment was the first evaluation since production, it was impossible to quantify stabilizer degradation over time. A worst-case estimate of remaining storage life, obtained by projecting stabilizer loss for the lot showing the greatest decrease since production (stored at Johnston Island), indicated that this lot would reach the "first decision point (increased surveillance)" after 25 years, in 2010. Overall, the propellant was estimated to show a minimal loss of stabilizer, which indicates an extensive remaining safe storage life. Other potential hazards identified in this project included interaction between internally leaking GB agent and the burster agent to produce a highly sensitive organometallic compound, although, "unless the reactions are highly efficient, sufficient amounts of the metal organic compounds [to cause an explosion] are not expected." Metal springs that keep the fuse in an unarmedposition may be corroded by internally leaking GB, causing the fuse to become armed and able to function during a handling accident. However, the study concluded that, overall, the occurrence of a catastrophic event with the M55 rocket in the near future is highly unlikely (3, 4).

Overall, the rocket stockpile was estimated to be in good condition by the Army's 1985 study. The Army has established a continued monitoring program to monitor degradation and rapidly identify new leakers (6). Although M55 rockets containing agent GB were first found to be leaking in 1966 (3, 4), there has been no trend toward an increased rate of leakers detected (7). At the Kentucky Blue Grass facility, as is routine at all U.S. CW storage facilities, air in igloos containing M55 rockets and other CW munitions is monitored for chemical agent prior to entry. The M55 rockets are stacked on wooden pallets with 15 rockets per pallet. A positive igloo detection of CW agent requires that the individual leaking rocket be located. Individual rockets, sealed in their fiberglass firing tubes, are also routinely tested for leaks. Leaking rockets are transferred to steel tubes that are bolted together and sealed at the middle with a flange and rubber "O" ring. However, only 897 individual rockets are monitored per quarter, out of a total of 69,500 at the Kentucky base (1.3 percent per quarter). Very few munitions other than the rackets have leaked at this facility (7). Although it is difficult to support conclusions made from data taken from the limited sample sizes used in these studies, the Army has found no trends in the frequency of leak detection in M55 rockets over time.

References

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7. Briefing to Office of Technology Assessment staff at the Lexington-Blue Grass Army Depot. Lexington. KY, Dec. 10, 1991.

state-of-the-art of alternatives we were able to examine and of showing the level of information that exists about alternatives. If a program to develop alternatives was pursued, these four may or may not be among those selected for further tests.

Present work with alternative technologies is focused on treatment of hazardous wastes other than chemical weapons. None of these techniques is available at present as a working alternative to the Army's current disassembly-incineration program. Moreover, it is not possible, on the basis of information currently available, to predict which alternative technique, if any, would be the best candidate for development into an acceptable and successful CW disposal technology. If the Army's present program does not succeed, there could well be advantages in supporting the development of more than a single CW destruction technology both to encourage competition and to ensure that at least one of them will be successful. There may also be advantages to certain technologies that are unique to specific sites.

Market forces alone cannot be expected to lead the development of alternative CW destruction technologies. The U.S. stockpile of chemical weapons is small compared to industrial chemical waste. If an alternative is to be developed, government will have to be depended on for at least some of the support. There are existing programs at the Federal and State level and in private industry and universities that are designed to promote alternative technologies for hazardous waste disposal. These might serve as models for development of alternative technologies for chemical weapons disposal, although none has been given this mission (see box l-D).

In developing alternative programs, a clearly defined process and definition for judging them will be required. Even though difficult, failure to establish applicable criteria for assessing alternative programs will make it impossible to gauge their success or to make necessary corrections.

For example, the limited scope of the Army's current technology demonstration project at Johnston Island was criticized in a 1991 NRC Letter

Box l-D—Programs for the Promotion of Alternative Technologies for Hazardous Waste Destruction

Existing programs designed to promote alternative technologies for hazardous waste disposal may serve as models for the development and promotion of alternative technologies for chemical weapons disposal. State and Federal Government, private industry, and universities have developed programs that attempt to address the technical, legal, and social obstacles involved with the development and introduction of new technologies for the disposal of hazardous waste. For example, a workshop at the annual meeting sponsored by the National Solid Wastes Management Association is titled, "Dealing With an Angry Public: Siting Strategies To Gain Public Acceptance." Topics include how to define realistic, measurable public acceptance goals; analysis of key audiences; identification and mobilization of grass-roots support; and implementation of cost-effective strategies and monitoring their success while building public acceptance (l).

The Technology Innovation Office (TIO) in the U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response has the mission of identifying and publicizing more efficient, cost-effective solutions from developers and technology users that address hazardous waste disposal problems faced by the Federal Government and private sector. The TIO mission includes promoting the use of innovative treatment technologies by government and industry on contaminated waste sites, soils, and groundwater by providing technology and market information to targeted audiences of Federal agencies, States, consulting engineering firms, technology developers, and the investment community (2). TIO also attempts to facilitate the cooperative development, evaluation, and implementation of innovative treatment alternatives at Federal facility sites (3). They have compiled a list of resources for alternative technology development including regional ERA offices that deal with permitting and performance standards; Federal and State assistance programs; Federal, State, nonprofit, and private test and evaluation facilities; and university affiliated hazardous waste research centers (4). EPA's Office of Research and Development (ORD) also plays a role in alternative technology development by helping vendors develop and test, at both pilot and full scale, technologies that may be applicable to U.S. waste site remediation, through such programs as the Superfund Innovative Technology Evaluation (SITE) program (5). The SITE includes a demonstration program that funds developers through a cost-sharing process in which developers pay for the

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Box l-D—Programs for the Promotion of Alternative Technologies for Hazardous Waste Destruction-Continued

mobilization and operation of technology demonstrations and EPA pays for the planning, sampling, analysis, quality assurance, and report preparation. SITE's Emerging Technologies Program, with currently more than 30 participants, funds up to $300,000 over 2 years for bench or pilot technology development.

The National Environmental Technology Applications Corporation (NETAC), has a similar mission of accelerating, on a national basis, the commercialization of environmental technologies under development by the public and private sectors (6, 7). This not-for-profit corporation was established through a cooperative agreement between EPA and the University of Pittsburgh Trust, specifically for the purpose of developing innovative commercial environmental technologies. This program reaches across all of the EPA programs described above, in addition to the private sector. NETAC offers a variety of services to the environmental technology developer, supplier, end user, and government official. Services include business planning, market and financial analysis, entry strategy, technology evaluation, laboratory services, and regulatory analysis.

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Review. The NRC pointed out that the Army was missing the opportunity to provide crucial assessments of the technology and program that would support the construction of future sites by generating higher levels of public confidence. The NRC also stated that the success of any demonstration project should be gauged by the degree to which it facilitates public understanding and acceptance by providing well-documented answers to reasonable, and probably inevitable, questions from concerned citizens as well as regulators. For example, a failure of the current demonstration is that it does not require measurement of products of incomplete combustion (PICs), especially dioxins and dibenzofurans (13). The Clean Air Act does not apply to the Johnston Atoll Chemical Agent Disposal System (JACADS) facility and therefore the Army is not collecting data to demonstrate compliance with this act, but the continental sites are covered by the Clean Air Act and the relevant States will need this type of information.

International Implications

A successful U.S. CW disposal program will have broad international implications. The United States and the C.I.S. are setting the stage for worldwide CW disposal. A United Nations special commission is currently investigating possible methods for the destruction of the Iraqi CW stockpile. As many as 18 countries in addition to the United States and the C.I.S. may now possess chemical weapons. With increasing international pressure to eliminate chemical weapons, the need for an appropriate and acceptable CW program also increases. This pressure also makes it difficult to discuss delays of any type. If any alternative technology development program is supported, it will be necessary to bring all of these considerations into the decision. This OTA background paper provides only some of the information about the potential benefits and risks that alternative technologies could offer. It is not clear at this point whether benefits exceed the risks, but directed development work on alternatives could help answer some of the key technical questions.

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