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Report to the Chairman, Committee on Governmental Affairs, U.S. Senate

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CHEMICAL WEAPONS

Stockpile Destruction Cost Growth and Schedule Slippages Are Likely to Continue

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National Security and
International Affairs Division

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The Honorable John Glenn
Chairman, Committee on Governmental
Affairs
United States Senate

Dear Mr. Chairman:

This report responds to your request that we review the Department of the Army's Chemical Stockpile Disposal Program. The report discusses whether the Army will be able to meet its 1988 estimates of program costs and schedules. It also discusses what actions the Army could take to (1) minimize further cost increases and schedule slippages and (2) better inform the Congress on the progress of the disposal program.

Unless you publicly announce its contents earlier, we plan no further distribution of this report for 30 days. At that time, we will send copies to the Chairmen of the House and Senate Committees on Armed Services and on Appropriations, the Secretaries of Defense and the Army, the Director of the Office of Management and Budget, and other interested parties.

Please contact me at (202) 275-4141 if you or your staff have any questions. Other major contributors are listed in appendix III.

Sincerely yours,

Richard Davis

Richard Davis
Director, Army Issues

Executive Summary

Purpose

In 1985 the Congress enacted Public Law 99-145, requiring the Department of Defense to destroy the U.S. stockpile of chemical munitions by September 30, 1994. At that time, the Army estimated it would cost about $1.7 billion to destroy the stockpile at the nine storage sites. In 1988 the Congress extended the completion date for the chemical weapons disposal to April 30, 1997. The Army estimated that the life-cycle cost had increased to $3.1 billion.

Because of the Chemical Stockpile Disposal Program's history of significant cost increases and schedule slippages, the Chairman of the Senate Committee on Governmental Affairs asked that GAO determine whether the Army would be able to meet its 1988 estimates of program costs and schedules. If not, the Chairman asked GAO to determine what actions the Army could take to (1) minimize further cost increases and schedule slippages and (2) better inform the Congress on the progress of the disposal program.

Background

To comply with Public Law 99-145, the Army, as program manager for the demilitarization (the process of destroying the offensive or defensive characteristics of equipment and materials) of chemical agents and munitions, in 1986 submitted a plan to the Congress that considered the costs and problems associated with three options for disposing of the stockpile: (1) transferring the entire stockpile to one site for disposal, (2) transferring the stockpile to two regional disposal sites, or (3) operating separate disposal facilities at the nine storage locations. In February 1988, the Army formally announced that on-site disposal at the nine storage locations was the preferred option because of concerns about safety during transportation between locations. The Army also chose to use a reverse assembly, high-temperature incineration process to destroy the stockpile.

The Army selected Johnston Atoll to build and test the first disposal facility because of the deteriorating condition of the munitions stored there and the atoll's remote location. Public Law 100-180, the National Defense Authorization Act for Fiscal Years 1988 and 1989, requires the Army to conduct full-scale verification tests of the disposal technology to prove that the process can safely destroy chemical weapons. Public Law 100-456, enacted in September 1988, specifies that testing of the stateside disposal facilities cannot start until operational data from the Johnston facility have been fully analyzed. The Army estimated that this analysis cannot be completed before March 1992. This date, however, will need to be revised to reflect a recent, unanticipated delay of

several months in performing operational testing at the Johnston facility.

Results in Brief

Continued problems in the Army's disposal program indicate that increased costs and additional time to destroy the stockpile should be expected. Since the Army issued its 1988 estimates to the Congress, the Army has experienced additional program requirements; material costs and wages have risen; and technical and programmatic problems have caused delays.

These changes caused the Army to report to the Congress in April 1991 that the disposal program would cost $6.5 billion and would not be completed until July 1999. However, the Army's July 1999 completion date is based on an overly optimistic projection of the number of chemical weapons and agents to be destroyed per hour—this projection almost doubles what the Army has been able to achieve during its initial test phase at the Johnston facility. The Army has been unable to achieve its goal because of technical and mechanical problems with the disposal process. While the Army has taken actions to correct the problems, operational testing has not been completed to ensure that the problems will not recur.

In addition, the July 1999 completion date does not reflect the recent 6-month shutdown of the Johnston facility while concerns about possible construction defects were investigated. Nor does the overall destruction schedule provide for time that may be needed to resolve additional unanticipated problems.

Since the Army made its decision to conduct on-site incineration of the chemical munitions at each storage location, it has gained more information about another disposal technology. Other potential technologies have also been further developed. With this information, the Army should be able to determine whether possibly faster and less costly alternatives exist for disposing of the chemical stockpile.

While complying with the legislative requirement for an annual report, the Department of the Army's annual report to the Congress does not contain detailed analyses of the program's estimated costs, destruction schedules, and factors that could affect the reliability of the estimates. Without such information, the Congress cannot fully assess the progress of the Army's efforts to destroy the stockpile.

Principal Findings

Cost Increases and Schedule Slippages Are Recurring

GAO believes that the disposal program's cost growth and schedule slippages will continue. In April 1991, the Army reported to the Congress that the estimated program life-cycle cost had increased from $3.1 billion to $6.5 billion and program completion had slipped from April 1997 to July 1999 because of additional program requirements, rising material costs and wages, and technical and programmatic problems.

The Army's estimated cost and completion date are based in part on destruction rates almost twice what it has been able to reach. The Army's highest average monthly destruction rate on Johnston Atoll from July 1990 through February 1991 was 13 rockets per hour, compared with the Army's monthly goal of 24 rockets per hour. The low destruction rate resulted primarily from technical and mechanical problems with conveyor belts, flange bolts, a pollution abatement system, and sliding gates. While the Army has taken various actions, such as design changes, to correct these problems, operational testing has not been completed to ensure that the problems have been fixed.

Recent concerns over defective welds in critical piping systems have further delayed the completion of Johnston Atoll's operational test phase by several months. This unanticipated delay will have a corresponding impact on completion of the overall destruction program, since, by law, follow-on facilities cannot be tested until the Johnston tests have been completed and analyzed. In determining its overall schedule, the Army did not take such problems into consideration.

Alternative Disposal Technologies Have Not Been Reexamined

Notwithstanding the increasing program costs and slippages, the Army has not reexamined other possibly faster and less costly alternatives to its current disposal program. Some factors have changed since the Army made its decision in 1988 to use high-temperature incineration disposal plants at each of the storage locations. For instance, the Congress, concerned about the current disposal program, directed the Army in 1990 to develop a cryofracture program as another possible disposal process.[1] Completion of the research, development, and testing of the process is

[1]The cryofracture process involves freezing the chemical agents and explosive munitions in liquid nitrogen baths and fracturing them in a hydraulic press before introducing the fractured pieces into an incineration furnace.

scheduled for March 1992. In addition, numerous other technologies exist that have been further developed since 1988.

Annual Report to the Congress Could Be More Informative

Although the Army has complied with the requirement of Public Law 99-145 to send an annual report on the disposal program to the Congress, the reports could be more informative. While the reports contained a summary of program activities, they did not provide a definitive assessment of the program's life-cycle cost, long-term milestones, or factors that could affect the reliability of the Army's estimates. Including such information would help the Congress assess the progress of the Army's efforts to destroy the chemical stockpile. The absence of this type of information has caused the Congress to request it on at least two occasions. In 1988 and 1991, at the request of the Congress, the Army provided it with estimates of the program's life-cycle costs and milestones.

Recommendations

GAO recommends that the Secretary of the Army determine whether faster and less costly technologies exist for destroying the stockpile. Particular attention should be given to the Army's earlier decision to use the reverse assembly, high-temperature incineration disposal process.

GAO also recommends that, to better inform the Congress on the progress of the Chemical Stockpile Disposal Program, the Secretary of the Army include the following information in future annual reports:

- estimated life-cycle costs of the disposal program that are based on both actual and projected destruction rates,
- causes of any growth in projected life-cycle costs,
- major events or problems that could materially affect program costs and goals, and
- estimated completion dates for the disposal projects that are based on both actual and projected destruction rates.

Agency Comments

As requested, GAO did not obtain official agency comments on this report. However, it discussed information obtained during the review with agency officials and included their views where appropriate.

Contents

Figures

Abbreviations

GAO	General Accounting Office
JACADS	Johnston Atoll Chemical Agent Disposal System

Introduction

In 1985, the Congress enacted Public Law 99-145, requiring the Department of Defense to destroy the U.S. stockpile of chemical weapons by September 30, 1994. The law directed the Secretary of Defense to establish a management organization within the Department of the Army to be responsible for the disposal program. The law also specified that the program should provide for the maximum protection of the environment, the general public, and personnel involved with the actual destruction of chemical munitions. On the basis of the Army's estimated construction and operational schedule in 1988, the Congress extended the completion date for the disposal program to April 30, 1997. At that time, the Army also estimated that the life-cycle costs to destroy the stockpile could be $3.1 billion—an increase of $1.4 billion over what it initially estimated.

Army's Disposal Program

During the 1970s, as U.S. chemical munitions became obsolete, the Army destroyed them primarily by high-temperature incineration or by chemical neutralization (the process of breaking down the agents chemically to negate their lethal qualities). In 1984, the National Academy of Sciences decided that high-temperature incineration was the more desirable disposal approach. The Academy concluded that the neutralization process was more costly and produced larger quantities of waste than anticipated. In 1986, the Department of the Army submitted to the Congress a plan to dispose of the chemical munitions. Its plan considered the costs and problems associated with three options: (1) transferring the entire stockpile to one site for disposal, (2) transferring the stockpile to two regional disposal sites, or (3) operating separate disposal plants at each of the storage locations. In 1988, the Army formally announced that reverse assembly, high-temperature incineration at the depots was the preferred option because of concerns about the safety of transporting chemical munitions.

The chemical agents and munitions to be destroyed are stored at eight Army depots in the continental U.S. and one overseas location at Johnston Atoll—a U.S. possession in the Pacific Ocean. The chemical munitions contain three types of lethal agents: GB, VX, and mustard. The "nonpersistent" nerve agent GB and the "persistent" nerve agent VX disrupt the nervous system and lead to the loss of muscular control and usually death.[1] Mustard agents (the H series that includes H, HD, and HT agents) blister the skin and can be lethal in large amounts. These

[1] Nonpersistent agents vaporize and dissipate readily, while persistent agents remain in liquid form for several days.

three types of chemical agents are contained in the munitions shown in table 1.1.

Table 1.1: Profile of U.S. Chemical Weapons in Storage

	Chemical munitions and container					
Storage location	**Ton container**	**Rocket**	**Mine**	**Spray tank**	**Bombs**	**Projectiles/ cartridges**
Aberdeen, Maryland	M					
Anniston, Alabama	M/N	N	N			M/N
Johnston Atoll	M/N	N	N		N	M/N
Lexington, Kentucky	N	N				M/N
Newport, Indiana	N					
Pine Bluff, Arkansas	M/N	N	N			
Pueblo, Colorado	M					M
Tooele, Utah	M/N	N	N	N	N	M/N
Umatilla, Oregon	M/N	N	N	N	N	N

M = Mustard Agent

N = Nerve Agent

In June 1990, the United States and the Union of Soviet Socialist Republics signed a bilateral agreement to reduce their chemical weapons. The agreement stipulates that the governments should start destroying their chemical weapons by December 31, 1992; destroy 50 percent of the stockpiles by December 31, 1999; and destroy all but 5,000 tons by 2002. In May 1991, the administration announced that it would destroy all of the U.S. chemical weapons. Table 1.2 summarizes the Army's schedule for constructing, testing, and operating the disposal facilities.

Table 1.2: Construction and Operation Schedules (as of March 1991)

Storage location	*Construction period*	*Test period*	*Disposal operations*
Aberdeen, Maryland	06/94–06/96	06/96–09/97	09/97–09/98
Anniston, Alabama	08/92–11/94	11/94–05/96	05/96–06/99
Johnston Atoll	Completed	07/90–04/92	04/92–03/95
Lexington, Kentucky	01/94–04/96	04/96–10/97	10/97–03/99
Newport, Indiana	06/94–06/96	06/96–09/97	09/97–07/98
Pine Bluff, Arkansas	01/93–04/95	04/95–10/96	10/96–06/99
Pueblo, Colorado	01/94–04/96	04/96–10/97	10/97–06/99
Tooele, Utah	09/89–08/92	08/92–02/94	02/94–04/99
Umatilla, Oregon	01/93–04/95	04/95–10/96	10/96–05/99

Management Structure of the Disposal Program

Public Law 99-145 directed the Secretary of Defense to establish a management organization within the Department of the Army to be responsible for the disposal program. The Army's management organization is headed by the Program Manager for Chemical Demilitarization, who is located at Aberdeen Proving Ground, Maryland, and who reports to the Office of the Assistant Secretary of the Army for Installations, Logistics, and the Environment. The Program Manager is responsible for providing technical and engineering oversight and direct management control. The law requires the Department of Defense to provide an annual report to the Congress regarding the program's activities.

Johnston Atoll Chemical Agent Disposal System

The Army selected Johnston Atoll to build and test the first U.S. chemical weapons disposal facility because of the deteriorating condition of the munitions stored there and the atoll's remote location. By operating the Johnston Atoll Chemical Agent Disposal System (JACADS), the Army hoped to gain experience in destroying the existing combinations of munitions and agents in the nation's stockpile. A more detailed discussion of the disposal process is included in appendix I. The second and only other plant under construction is at Tooele, Utah.

JACADS is a government-owned, contractor-operated facility. The U.S. Army Support Command-Hawaii provides the contracting officer for the JACADS operations and maintenance contract. The Army Corps of Engineers has awarded separate contracts for the design, construction, equipment installation, and operation and maintenance of JACADS.

Eleven months before construction on the JACADS plant was completed, the Congress passed Public Law 100-180 (the National Defense Authorization Act for Fiscal Years 1988 and 1989). This law requires the Secretary of Defense to certify that the program plan includes operational verification tests to demonstrate that the selected disposal technology can safely destroy the different agents and munitions while meeting all environmental requirements. In Public Law 100-456, enacted in September 1988, the Congress mandated that these tests be successfully completed before testing facilities in the continental United States begins. The first weapons destroyed as part of the operational test were the GB-filled, M-55 rockets.

GAO's Prior Concerns With the Army's Disposal Program

In prior reports, we have expressed concern about the Army's lack of progress in and the rising costs of the disposal program. In a May 1990 report, we concluded that the costs of the program would likely continue to escalate and that the Army would probably not meet the congressionally mandated completion date of April 30, 1997.[2] In a July 1990 report, we again concluded that the Army would experience further delays at JACADS and that costs would continue to increase.[3]

Objectives, Scope, and Methodology

Because of the Chemical Stockpile Disposal Program's history of significant cost increases and schedule slippages, the Chairman of the Senate Committee on Governmental Affairs asked that we determine whether the Army would be able to meet its 1988 estimates of program costs and schedules. If not, the Chairman asked us to determine what actions the Army could take to (1) minimize further cost increases and schedule slippages and (2) better inform the Congress on the progress of the disposal program.

To identify overall program schedule and cost estimates, we collected and analyzed schedule and cost documents and discussed the causes of schedule slippages and cost increases with Army and contractor officials. To ascertain contract performance specifications, we reviewed contracts, contract modifications, and subcontracts for the construction, equipment installation, and operation and maintenance of JACADS.

We used production reports, cost and budget reports, planning schedules, staffing reports, and other related documents to determine JACADS' progress. Our analyses also included assessing the impact JACADS has had on plans to construct and procure equipment for the other eight follow-on facilities. Also, we identified and analyzed the (1) current program schedule and cost estimates, (2) schedule slippages and their associated cost increases, (3) the Army's oversight activities for JACADS' operations and maintenance contractor, and (4) effects of JACADS' schedule and other factors on the Army's overall chemical disposal program. To evaluate certain aspects of the design and construction of JACADS, we analyzed (1) information on the operational efficiency of the facility's air filtration system, (2) test results for the filter system, and (3) the Army's process in awarding the contract for the system.

[2]Chemical Weapons: Obstacles to the Army's Plan to Destroy Obsolete U.S. Stockpile (GAO/NSIAD-90-155, May 24, 1990).

[3]Chemical Weapons: Stockpile Destruction Delayed at the Army's Prototype Disposal Facility (GAO/NSIAD-90-222, July 30, 1990).

We also interviewed officials and analyzed data given to us by officials representing the Army's Office of the Program Manager for Chemical Demilitarization in Aberdeen, Maryland; the offices of the operations and maintenance contractor on Johnston Atoll, at Fort Shafter in Honolulu, Hawaii, and in Denver, Colorado; the Army Corps of Engineers, Huntsville and Pacific Ocean divisions; and the Army Support Command-Hawaii.

We conducted our review from September 1990 to September 1991 in accordance with generally accepted government auditing standards. As requested, we did not obtain official agency comments on this report. However, we discussed information we obtained during our review with agency officials and included their views where appropriate.

Cost Increases and Schedule Slippages Are Likely to Continue

In this review and in our previous reports, we have identified problems in the Army's Chemical Stockpile Disposal Program that indicate that cost growth and schedule slippages are likely to continue. Since 1988, the Army has experienced additional program requirements; material costs and wages have risen; and technical and programmatic problems have caused delays. As a result, in April 1991, the Army increased its projected life-cycle costs from its 1988 estimate of $3.1 billion to $6.5 billion. In addition, the Army now anticipates that the program will be completed in July 1999, instead of April 1997.

However, the Army's July 1999 completion date assumes destruction rates that are almost double what the Army has been able to achieve during operational verification testing at JACADS. An important purpose of the test is to assess the mechanical reliability of the various component systems. JACADS did not perform as well as the Army expected during the initial testing due to technical and mechanical problems. While the Army has taken action to correct these problems, testing had not been completed to ensure the problems were fixed. In addition, the Army's July 1999 completion date does not reflect the impact of a delay of several months caused by concern about possibly defective welds in critical systems or future delays caused by other unanticipated problems.

Causes for Past Cost Increases and Schedule Slippages

In March 1988, the Army provided to the Congress an estimate of life-cycle cost and a schedule for the disposal program. At that time, the projected life-cycle cost was estimated at $3.1 billion, and the completion date for the program was estimated at April 1997.[1] In April 1991, the Army reported to the Congress that the estimated life-cycle cost totaled almost $6.5 billion and that the completion date for the program had slipped to July 1999. The Army attributed the increased cost and schedule slippage to unanticipated program requirements, higher costs for materials and wages, and technical and programmatic delays.[2] The projected increases in costs are shown in table 2.1.

[1]The Army's 1988 estimate of $3,136 million did not include $271 million appropriated in fiscal years 1986 and 1987 for construction and equipment. Inclusion of these funds increases the 1988 estimate to over $3.4 billion.

[2]Some of the programmatic delays were caused by the lack of personnel and training.

Table 2.1: Comparison of the Army's 1988 and 1991 Life-Cycle Cost Estimates to Complete the Program

Dollars in millions

Cost element	1988 estimate	Estimated increase	1991 estimate	Percent increase
Equipment acquisition	$645	$248	$893	38.4
Operations	502	617	1,119	122.9
JACADS	298	287	585	96.3
Construction	294	447	741	152.0
Program management	287	175	462	61.0
Equipment installation	179	339	518	189.4
Depot support	176	371	547	210.8
Systemization	114	307	421	269.3
Emergency preparedness	114	223	337	195.6
Training	96	46	142	47.9
Chemical Agent Munitions Disposal System	91	82	173	90.1
Engineering	66	67	133	101.5
Incapacitating agent disposal	51	21	72	41.2
Project control at the disposal sites	49	148	197	302.0
Plant closures	35	19	54	54.3
Germany stockpile retrograde	13	40	53	307.7
Cryofracture research	126	(95)	31	(75.4)
Total	**$3,136**	**$3,342**	**$6,478**	**106.6**

Army officials attribute the low cost estimate in 1988 to the immaturity of the program. In 1988, the prototype facility on Johnston Atoll had just been constructed, and equipment installation was in process. Systemization (the process of demonstrating that the operating equipment and control systems function properly) and operational verification testing had not yet started. As Army officials gained experience with the program's operations, further refinements were made to the estimate.

Unanticipated Program Requirements

New program requirements, which the Army did not anticipate in 1988, added to the increase in the projected life-cycle costs. They include

- new environmental and safety requirements,
- additional procedures for the emergency response program, and
- additional staff-years for systemization.

Since the Army prepared its 1988 estimate, the states have developed new environmental and safety requirements for the disposal program. For example, Army officials told us that, as part of Utah's permit process for the Tooele plant, the Army will be required to operate the disposal plant at 50 percent of capacity for 6 months every time a new chemical agent is introduced into the system. During the 6-month period, state environmental officials will evaluate test data on the changeover of agents. Army officials expect that this new requirement, as well as other undetermined requirements, could be part of the permit application process in the other states.

According to the Army, the requirements for the emergency response program have also grown significantly since 1988. As a result, the Army has increased the estimated costs of the emergency program from $114 million to $337 million. This increase reflects additional requirements for communication, protection, and warning equipment. Further, federal agencies and states plan biennial emergency response exercises for all disposal sites.

On the basis of lessons learned, the Army believes that systemization will cost more and require more staff-years than it had anticipated. In 1988, the Army estimated that systemization of all the disposal facilities would cost $114 million, compared with its 1991 estimate of $421 million. Army officials had estimated that 76 staff-years would be required to carry out systemization. On the basis of experience gained at JACADS, as well as increased testing and training requirements for the staffing certifications, the Army currently estimates that 539 staff-years will be needed to complete the systemization process.

Higher Costs for Materials and Wages

The Army has paid higher prices for services, materials, and equipment for the program and higher costs for salaries and wages than it anticipated in 1988. On the basis of lessons learned at JACADS and Tooele, the Army increased its cost estimates to reflect more realistic prices.

The Army's 1991 estimate of $893 million for equipment acquisition is $248 million higher than its 1988 estimate, and its 1991 estimate of $518 million for equipment installation is $339 million higher than its 1988 estimate. In addition, the Army's 1991 estimate of $741 million for construction is $447 million higher than its 1988 estimate. According to the Army, a portion of the increases is due to increased prices of materials, process equipment, furnaces, and pollution abatement equipment.

Further, the Army increased its estimated requirements for spare parts, safety and environmental equipment, and construction materials.

Since the 1988 estimate, the estimated number of personnel needed for equipment installation, systemization, operational verification testing, operations, and depot support has increased. For example, the staff requirement for JACADS has increased from 217 to 456. In addition, wages have increased since 1988 as a result of contract negotiations.

Technical and Programmatic Delays

The Army has experienced technical and programmatic delays in meeting the congressionally mandated completion date of April 1997. Army officials estimate that the completion of the disposal program will slip to July 1999 because of the additional time and costs needed to

- complete systemization and operational testing of the disposal plants,
- obtain state environmental permits, and
- procure and install plant equipment.

Delays in systemization represent a large portion of the schedule slippage. The hiring and training of the operators and the preoperational checks by government officials (part of the systemization process) have taken more time than the Army anticipated. In 1988, the Army's estimate of how long systemization would take was 12 months. On the basis of its experience with JACADS, the Army extended this estimate to 15 months for bulk storage facilities and 18 months for mixed-munitions facilities.

Delays in the start of JACADS' operational verification test and problems with the various equipment have contributed to the Army's extension of the estimated completion date for the program. Public Law 100-456 requires the Army to complete the operational testing of JACADS before testing in the continental United States. In 1988, the operational verification test was scheduled to start in August 1989. However, because of technical and personnel problems, the Army did not start the test until July 1990. In addition, the Army expanded the test period from 16 months to 21 months because of problems with the deactivation furnace system. This expansion meant that the scheduled completion date for the test slipped from December 1990 to March 1992.

The additional time needed to obtain environmental permits has also increased the slippage. The Army's construction start dates depend on

the states' issuing mandatory environmental permits for each of the proposed sites in 15 months, which was the Army's estimate in 1988 of how long it would take. However, on the basis of its experience with Utah, the Army now anticipates that it will take 24 months for the preparation and approval of the permits for future disposal plants. This increase in time has affected the program's schedule, and according to Army officials, changes in states' permit processes could further affect the schedule.

On the basis of its experience at JACADS and Tooele, the Army modified its 1988 schedule to more accurately reflect the time required to complete the procurement and installation of the disposal equipment. According to Army documents, more time is needed for the contractors to prepare their proposals for the follow-on contracts because they will be fixed-priced contracts, compared with JACADS' cost-plus-award-fee contract. On the basis of lessons learned, the Army plans to conduct longer technical discussions and negotiations with the contractors to help ensure a better understanding between the government and the contractors. In addition, installation of the equipment has been more complicated and staff-intensive than the Army estimated in 1988.

Program Costs Will Increase, and Completion Date Will Slip Further If Low Destruction Rates Continue

The Army's estimated costs and completion date, based on the achievement of projected destruction rates, are in further jeopardy if (1) JACADS' rate of destroying chemical weapons is not substantially increased at the other disposal sites or (2) unanticipated problems are encountered.

Low Destruction Rates

While JACADS' testing demonstrated that chemical weapons can be destroyed using high-temperature incineration technology, JACADS has not performed as well as the Army initially predicted. Even with the extension of the initial testing period from 16 weeks to 32 weeks, only 7,490 rockets were destroyed, compared with the Army's initial goal of 9,984 rockets. Before the completion of this test period on February 27, 1991, the best monthly destruction rate for the GB-filled, M-55 rockets was approximately 13 rockets per hour, compared with the Army's goal

of 24 per hour during a month. Table 2.2 compares selected JACADS performance goals with actual destruction rates during the initial test phase.

Table 2.2: Comparison of Selected JACADS Performance Goals With Actual Destruction Rates During the Initial Test Phase

Indicator	Goal	Actual	Percentage of goal met
Average destruction rate in rockets per hour	24	7	29.2
Best average monthly destruction rate in rockets per hour	24	13	54.2
Best daily shift destruction rate in rockets per hour	32	27	84.4

Due to technical and mechanical problems during the initial testing, the expected monthly destruction rate of 24 rockets per hour was not achieved, and JACADS was shut down a total of 900 unscheduled hours. Problems surfaced when the heated discharge conveyor jammed, the deactivation furnace flange bolts failed, the pollution abatement system plugged, and gates jammed. JACADS also had other day-to-day operational problems, but these were less significant. The Army has made several mechanical modifications to the processing equipment, but at the time of our review, it had not tested all of them to see whether they would work as planned. (See app. II for a description of the problems the Army and contractors encountered while installing JACADS' air filtration system.)

According to Army officials, some of the technical problems did not occur (1) at the Chemical Agent Munitions Disposal System (which is a developmental facility at the Tooele Army Depot in Utah) because the destruction rates were too small or (2) at JACADS during systemization because live agents were not used.[3] Army and industry officials believe that attempts to achieve higher destruction rates, combined with the use of live agents at JACADS, increased the technical and mechanical problems.

[3]The purpose of the Chemical Agent Munitions Disposal System at Tooele is to test the equipment and processes for use at future disposal facilities and to determine their ability to meet safety and environmental standards.

Heated Discharge Conveyor System Jammed

The heated discharge conveyor belt, part of the deactivation furnace system, was the largest contributor to JACADS' shutdown during the initial testing.[4] The belt is a continuous mesh belt used to move liquid and solid residue from the deactivation furnace out through JACADS' discharge gates to a waste collection bin for disposal. During the initial testing, JACADS was shut down for 248 hours because the heated discharge conveyor belt was jamming. The primary cause is the discharge of molten aluminum from the furnace onto the mesh weave belt. On the belt, the aluminum partially solidifies with fiberglass residue, causing the conveyor to jam. Since the initial test phase, the Army and the contractor have redesigned the conveyor belt.

Deactivation Furnace Bolts Failed

Failed bolts contributed to 120 hours of lost destruction time during the initial testing. The deactivation furnace system's kiln is constructed in five sections that are bolted together. The sections and the bolts are subjected to different temperatures that cause them to expand at different rates. The differences in expansion, combined with the fact that the kiln is rotated, caused the bolts to stretch or break on three different occasions. Recently, the Army installed bigger and stronger replacement bolts and developed improved installation procedures.

Pollution Abatement System Plugged

Problems with the deactivation furnace's pollution abatement system resulted in 96 hours of lost production. The purpose of the pollution abatement system is to cool and clean the exhaust gases produced in the deactivation furnace. The major problem with the system was that sodium salts and rust plugged two components of the system. The plugging reduced the opening for the exhaust gases from 24 inches to 6 inches, which required additional maintenance. A clean-out plate has since been added to the ducting.

Feed Chute and Gates Jammed

Jamming of the feed chute and slide gates was a problem for the Army in trying to maintain reliable processing operations. The feed chute moves munitions pieces between sections in JACADS, and the gates are designed to contain any explosion. The Army encountered operational problems with the slide gates, primarily when the hydraulic rod disconnected from the gates and when small pieces of munitions stuck in the tipping valve prevented the gates from closing. These problems resulted in 61 hours of downtime during the initial test period. Subsequently, the

[4]The deactivation furnace system is designed to process munitions containing residual chemical agents and explosive components. During the process, the system thermally (1) deactivates the fuses and charges, (2) detoxifies the metal parts, and (3) incinerates solid fuel material.

Army changed the slide gates to flapper gates, which tend to operate better.

Other Unanticipated Problems Encountered

Recent concerns over possibly defective welds in several critical piping systems will further delay completion of the JACADS' test phase. Program officials recently told us, after completion of our fieldwork, that testing at the Johnston facility was delayed 6 months, after an allegation was received that piping systems might be adversely affected by defective welds. The officials further advised us that the investigation had identified a limited number of welds that did not meet specifications and that corrective action had been taken.

This unanticipated delay in completing the testing at the Johnston facility will have a corresponding impact on the completion of the overall disposal program. By law, testing of the follow-on disposal facilities under this program cannot begin until the Johnston test program has been completed. Our review of the program schedule did not disclose any provision for this type of delay, either at the Johnston facility or any follow-on facility.

However, if the production goals are not achieved or if other unanticipated mechanical or technical problems cause extended shutdowns, the Army will have to make additional modifications to the cost and schedule estimates. While the life-cycle cost estimates for fiscal years 1992 and 1993 are the most accurate portion of the overall estimate, according to Army officials all estimates are vulnerable to change because of fluctuating inflation rates, design changes, and changing environmental laws and regulations. Estimates for fiscal years 1994 through 1997 could increase because they depend on production rates that have not been demonstrated, environmental permit limits that have not been determined, international agreements with requirements that have not been defined, and contingency drills that have not been exercised. Further, cost estimates for fiscal year 1998 and beyond are the most vulnerable to significant cost and schedule revisions because all earlier problems will affect costs during this time.

Alternatives to the Current Disposal Program Should Be Reexamined, and Information Reported to the Congress Can Be Improved

Notwithstanding the continued cost growth and schedule slippage of the disposal program, the Army has not reexamined alternatives to the current program. Concerned about the program, the Congress directed the Army to develop a cryofracture program as a possible disposal process. According to the Army, completion of the research, development, and testing of the process is scheduled for March 1992. Other technologies exist that could also be further explored.

While complying with the legislative requirement for an annual report, the Army's report to the Congress does not contain detailed analyses of the program's estimated costs, destruction schedules, and factors that could affect the reliability of the estimates. We believe that without such information the Congress cannot fully assess the progress of the Army's efforts to destroy the chemical stockpile.

Alternative Technologies for Destroying the Chemical Stockpile Have Not Been Reexamined

The likelihood of further costs increases and schedule slippages suggests that the Army needs to determine whether there are faster and less costly alternatives to its current disposal plan. The Army selected the reverse assembly, high-temperature incineration process to be performed at each storage site as the preferred alternative because it was perceived to be the least costly technology at that time and posed the least risk to public health and the environment. However, factors have changed since the Army's 1988 decision. For instance, the estimated life-cycle cost of using the incineration process at each storage site has doubled since 1988—from $3.1 billion to $6.5 billion. Further, more information now exists about other disposal technologies, such as cryofracture.

The cost of the current disposal program has been a concern of the Congress. In the 1990 Department of Defense Appropriations Act (Public Law 101-165), the Congress provided the Army funds of not less than $6.1 million to develop a cryofracture program as a possible disposal technology and required that not less than $16.3 million from a prior appropriation be obligated for the program not later than January 15, 1990. The cryofracture process involves freezing the chemical agents and explosive munitions in liquid nitrogen baths and fracturing the munitions in a hydraulic press before introducing the fractured pieces into an incineration furnace. Completion of the research, development, and testing of the cryofracture process is scheduled for March 1992. At this time, more information should be available about whether the cryofracture technology offers a less expensive disposal method.

Information on other potential disposal technologies could also be updated. For example, since the National Academy of Sciences concluded in 1984 that the chemical neutralization disposal process was more costly and created more waste than high-temperature incineration, the Soviet Union has gained some experience with the neutralization technology.[1] The Soviet Union is also considering several other disposal technologies that could be used to destroy its chemical weapons as required by the 1990 bilateral agreement with the United States. In 1991, Greenpeace International cataloged seven broad categories of alternative disposal technologies. Greenpeace asserted that these technologies have undergone tremendous growth in research and development since the Army decided to use the incineration technology.

Army's Annual Report to the Congress Could Be More Informative

Public Law 99-145 requires the Secretary of Defense to provide a report to the Congress each year by December 15 on the chemical stockpile disposal activities for the preceding year ending September 30. The report is required to contain (1) a description of the construction, equipment, operation, and dismantling of the disposal facilities during the fiscal year; (2) a description of any accidents or unplanned occurrences associated with the disposal program; and (3) an accounting of all program funds expended during the fiscal year. In addition, Public Law 101-510 added an additional requirement to this report—an assessment of the safety status and condition of the stockpile. We found that the Army had complied with these annual reporting requirements.

However, the annual report could be improved by including information that would provide the Congress with a definitive view of the program's costs and future milestones. For example, the report does not include life-cycle cost estimates and long-term milestones, which would allow the Congress and others in the Department of Defense to be better informed about the need to increase funding levels and grant program extensions. In addition, the report does not identify causes of the growth in the program's life-cycle cost estimates. Such an analysis would enable the Congress and the Army to identify actions needed to resolve problems and prevent similar ones in the future. We believe that the report could also identify events or problems that could materially affect the program's estimated costs and goals. The information would be useful to the Congress and the Army in planning and funding the

[1]Chemical neutralization was one of the processes used by the U.S. Army to dispose of chemical munitions during the 1970s.

disposal program and in assessing the need for alternatives that are less costly and quicker.

Our suggestion for making the annual report more informative is consistent with a prior suggestion by the Army. In September 1990, the Assistant Secretary of the Army for Financial Management recommended that the Army develop a more structured process for reporting the program's progress to the Congress. For example, the Assistant Secretary suggested that the Army's report include initial and baseline cost and milestone estimates for measuring the progress of the program. The Assistant Secretary also suggested that the causes of cost variances should be identified and explained to the Congress.

The absence of this type of information has caused the Congress to request it on at least two occasions from the Army. For example, the Congress requested that the Army provide it with the program's life-cycle cost estimates, along with other data, in 1988 and 1991.[2] Although the Army's 1991 response did not contain detailed analyses of the estimated costs and planned production rates for the various weapons, it did identify a small number of factors that could affect the reliability of the program's life-cycle cost estimates. The response, however, did not identify the potential effect of these factors on program costs and schedule.

Conclusions

The Army has experienced new safety and environmental requirements; costs and wages have risen; and technical and programmatic problems have caused schedule delays. As a result, in 1991 the Army increased its projected life-cycle cost to $6.5 billion and the scheduled completion date to 1999. However, we found that the Army's estimates are doubtful, because they are based on destruction rates almost double what the Army has been able to achieve at Johnston Atoll and because they do not reflect recent delays in completing JACADS' test phase. We believe that the completion of JACADS' operational verification test, currently scheduled to occur in 1992, will provide needed evidence of whether or not the proposed 1999 schedule can be met. Further design modifications and additional costs may be necessary to respond to lessons learned from the yet-uncompleted operational verification test at JACADS.

[2]The cost and production estimates were not included in the required annual reports, but they were provided to the Congress in separate program reports.

Because of the program's estimated cost growth and schedule slippages, we believe that the Department of the Army should determine whether other faster and less costly alternatives exist for disposing of the chemical stockpile. To a large degree, the Army's decision to use the reverse assembly, high-temperature incineration process was based on the limited knowledge of disposal technologies in the 1980s. More information on the feasibility of using cryofracture technology is expected soon.

We believe the Army's annual report to the Congress could contain more information about the estimated costs and schedule to complete the disposal program. While complying with legislative reporting requirements, the Army's annual report to the Congress could be more informative if it contained detailed analyses of the program's estimated costs and destruction schedules and factors that could affect the reliability of the estimates. We believe that such information will help the Congress assess the progress of the Army's destruction of the chemical stockpile.

Recommendations

We recommend that the Secretary of the Army determine whether faster and less costly technologies exist for destroying the stockpile. Particular attention should be given to the Army's earlier decision to use the reverse assembly, high-temperature incineration disposal process.

We also recommend that, to better inform the Congress on the progress of the Chemical Stockpile Disposal Program, the Secretary of the Army include the following information in future annual reports:

- estimated life-cycle costs of the disposal program that are based on both actual and projected destruction rates,
- causes of any growth in projected life-cycle costs,
- major events or problems that could materially affect program costs and goals, and
- estimated completion dates for the disposal projects that are based on both actual and projected destruction rates.

JACADS' Disposal Process

JACADS' reverse assembly and incineration process, which is fully automated, is executed in several stages. The Johnston Atoll chemical stockpile is stored in munitions magazines in an area adjacent to the disposal facility. The stockpile will be destroyed in groups by munitions type (for instance, one "type" includes all rockets filled with one type of nerve agent, and another includes all ton containers with mustard agent) using a three-stage process involving (1) unpacking, (2) disassembling and draining, and (3) incinerating.

The chemical weapons are transported from munitions magazines to the facility's unpacking area. Before the chemical weapons are removed from storage for disposal, the magazine is inspected for leaks. Leaking munitions are stored in vapor-proof containers. The weapons are placed on trucks and transported to the disposal facility for unpacking. In the unpacking area, munitions are manually removed from the transport containers and pallets. Non-leaking munitions are automatically conveyed from the unpacking area to the processing rooms for disassembly and drainage. Leaking munitions are unpacked by personnel wearing protective clothing and are placed on conveyors leading to the processing rooms.

In the processing rooms, munitions are automatically disassembled and drained of chemical agents by computer-controlled machines. Rockets, projectiles, and land mines will be disassembled in rooms capable of containing accidental explosions.[1] Rockets are drained of the liquid agent and mechanically sheared into seven segments. For the projectiles, machines will remove the explosive components and convey the nonexplosive projectiles into a room where they will be drained of agent. Land mine disassembly machines will punch out booster explosives from the mines and then drain them of agents. Bombs and ton containers have no explosives; therefore, they will be conveyed from the unpacking area directly to a bulk drain station, where they will be punctured and drained of agents.

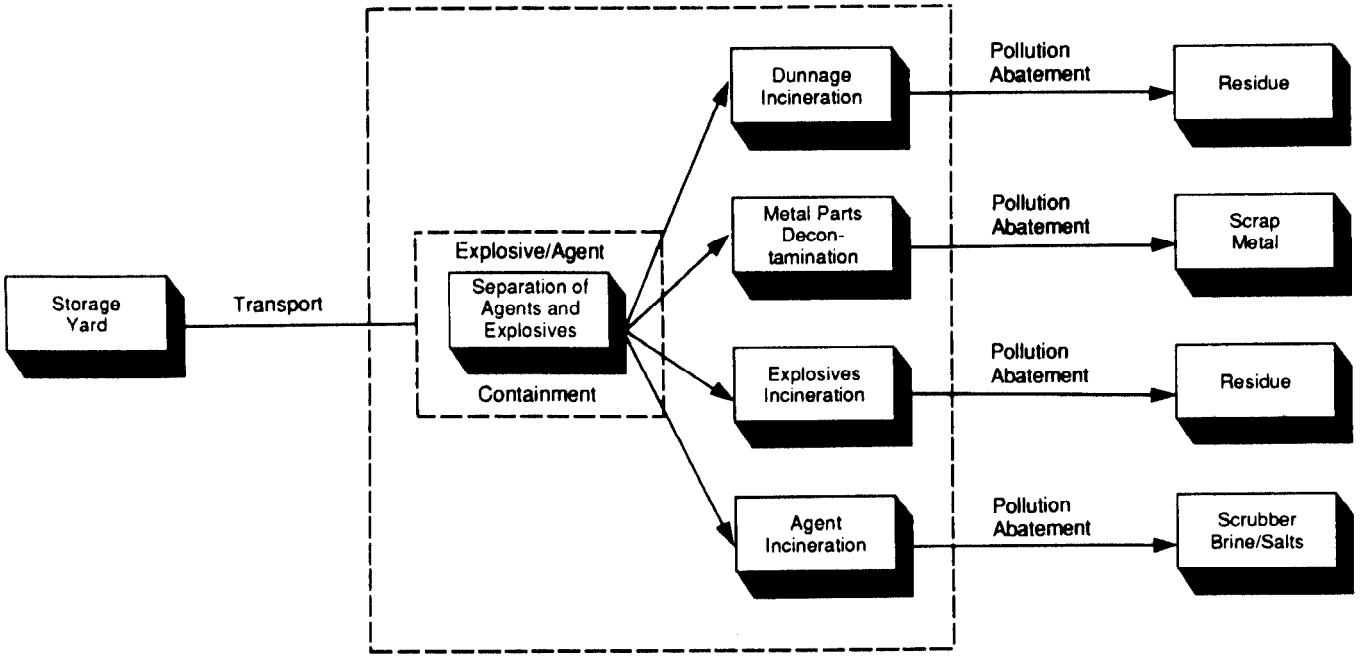
After the munitions are disassembled and drained of agents, the munitions components, metal parts, chemical agents, and packaging will be destroyed or decontaminated in four different furnaces. Rocket segments, land mines, and explosive components will be destroyed in a deactivation furnace capable of containing explosions and surges of agent. Projectiles and bulk items will be decontaminated in a metal parts furnace. Liquid agents and solutions used to decontaminate equipment

[1] As of September 1991, rockets were the only chemical weapons processed at JACADS.

will be destroyed in a liquid incinerator. Pallets and packing materials will be burned in the dunnage furnace.

The disposal process results in by-products, which must be certified agent-free. Each furnace contains a pollution abatement system, which cools and neutralizes acidic components and residue from exhaust gases. Residue from the dunnage and deactivation furnaces is packaged for disposal in an approved landfill. Brine solution from the liquid incinerator is evaporated through a heating process, and the remaining salts are loaded into containers for disposal in an approved landfill. Figure I.1 illustrates JACADS' disposal process.

Figure I.1: JACADS' Disposal Process



JACADS' Air Filtration System

Before the start of the operational testing of JACADS, the Senate Committee on Governmental Affairs received an allegation that JACADS' air filtration system did not meet industry standards. The air filtration system was one of the last systems the contractors had to test and accept before the plant could go operational. Initially the filter system could not pass the test because of welding leaks, inadequate filter clamps, and gaps in the charcoal trays. The operations and maintenance contractor and the air filtration contractor corrected these problems, and the system has performed according to the Army's specifications with no breakdowns affecting destruction rates. The air filtration contractor has also won the contract to provide similar systems for the follow-on facilities in the continental United States.

Allegation That JACADS' Air Filtration System Did Not Meet Standards

In a letter dated June 5, 1990, to the Chairman of the Senate Committee on Governmental Affairs, an engineer alleged that the air filtration contractor—the builder of JACADS' air filtration system—had produced a substandard system. The engineer stated that the design and fabrication of the system fell short of meeting industry standards and that factory and field tests specified in the contract had not been performed. Because of these alleged problems, the engineer expressed concern that safety, environmental, operational, and cost problems would be experienced at JACADS. The engineer also alleged that the Army's process of awarding the air filtration contract was based on the lowest bid, not on technical competency to meet the contract's requirements.

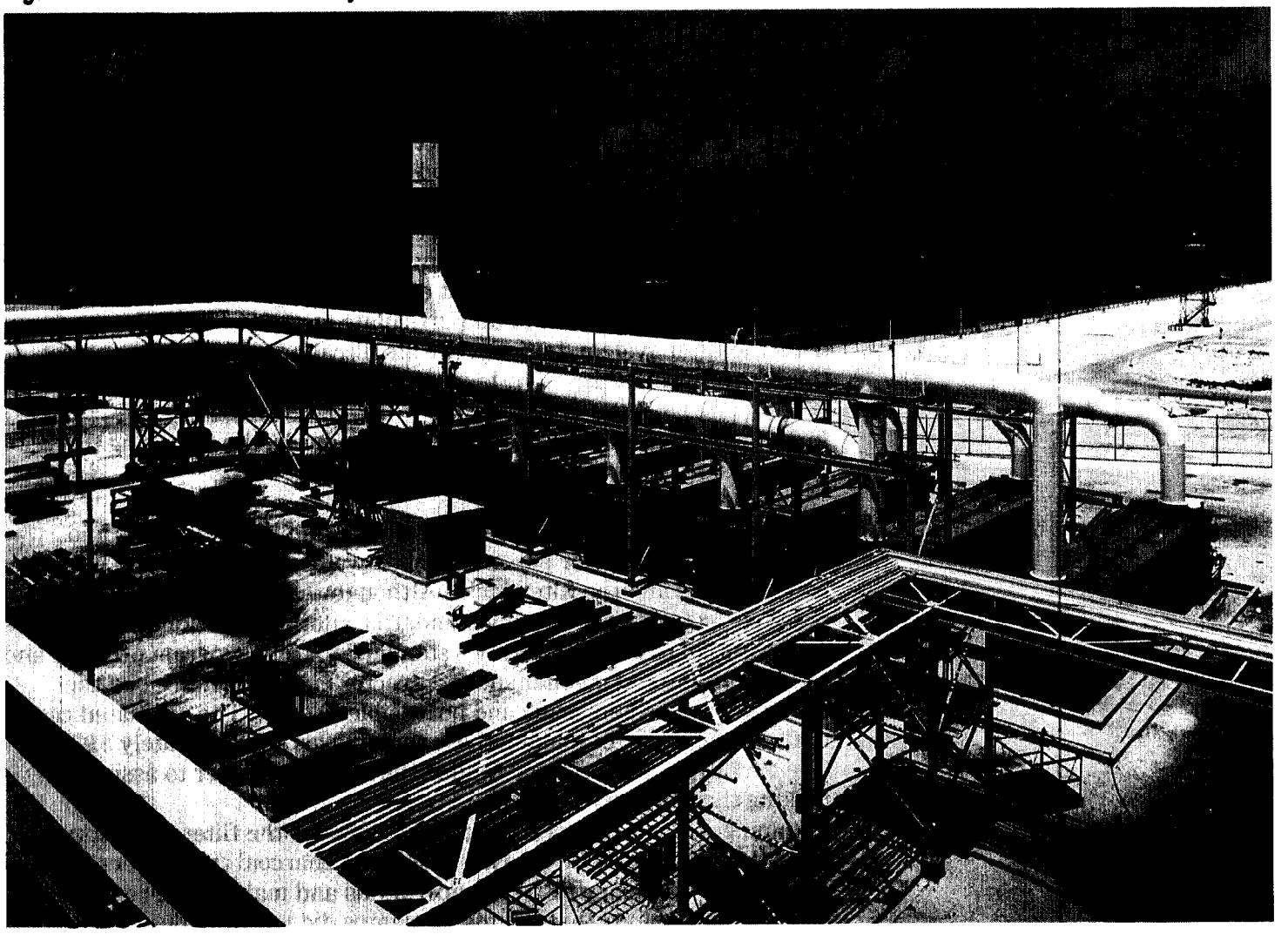
Air Filtration System Is Complex

The air filtration system is one example of the complex and unique systems operating at JACADS (see fig. II.1). The filter system reduces the concentration of toxic agents in the ventilated air to levels that are harmless to operating personnel, the environment, and the surrounding population. The system consists of ten filter units. Each filter unit contains

- a pre-filter, which removes gross particulate matter such as dust;
- a high efficiency air filter, which removes particulate matter down to 0.3 microns in size;
- six banks of activated charcoal filters, which remove the chemical contamination through the process of absorption;
- a bank of air filters to remove fine charcoal particles; and
- a fan to exhaust the air up an exhaust stack.

The system and other areas around that plant are electronically controlled and monitored at the central control room. With the 2,304 trays of charcoal, the air ventilation system is designed to provide every hour up to 30 complete air changes in each area of the munitions demilitarization building, as compared with one or two air changes in a normal environment.

Figure II.1: JACADS' Air Filtration System



Contractor's Performance on the Air Filtration System

In 1985, the operations and maintenance contractor awarded the air filtration contractor, by competitive bidding, a subcontract totaling $2.9 million to fabricate and install JACADS' air filtration system. After the units had been fabricated and delivered to JACADS, the operations and maintenance contractor awarded the air filtration contractor a $1.3 million sole-source contract to expand for safety purposes the original filters from two banks of charcoal each to a total of six.

The air filtration system was one of the last systems on which the operations and maintenance contractor had to perform testing and acceptance before the contractor could begin operational testing of JACADS. The system could not be fully tested until all the processing equipment had been installed, the building and duct work had been sealed off, and the plant's painting had been completed. The testing began in January 1990 and was completed in May 1990. The principle tests focused on showing that the units were airtight and that the charcoal filter trays sufficiently absorbed the chemical agents. Army standards stipulated that the filtration system meet an 99.99-percent efficiency rate (allowing only 1 part in 10,000, or 0.01 percent of all particulate matter, to bypass or penetrate the filter system. Initially, the air filtration system did not meet the Army's standards.

In order to meet the Army's efficiency standards, the following three fixes were necessary:

- Welding joints: The air filtration contractor and the operations and maintenance contractor personnel made welding repairs to the filter housing units and the filter racks. Although the units passed the original pressure tests within industry standards, additional welding of the units was required to meet the Army's standards. Army program officials and the operations and maintenance contractor engineers described the welding leaks as minuscule and not visible to sight. The estimated cost to the government of making these repairs was approximately $93,000. The air filtration contractor funded the cost of a welder to assist in making the welding repairs.
- Clamping devices: The design specifications for the filter units stipulated that toggle clamps be used to seal the charcoal tray covers. In conducting the efficiency tests, the operations and maintenance contractor officials determined that the toggle clamps did not provide sufficient pressure to allow for a proper seal of the charcoal trays without manual manipulation of the clamps. The Army decided to replace the clamps with metal straps. The air filtration contractor provided the straps at no

charge to the government. The cost of labor and material assumed by the government was estimated at $131,000.

- Charcoal trays: During the transportation of the charcoal trays from the loading station to the filter housing, the charcoal had settled, leaving gaps in the trays. As a result, each charcoal tray had to be manually topped off. The estimated cost to the government to correct this problem was approximately $165,000.

A May 16, 1990, memo signed by the operations and maintenance contractor's program director and Army officials noted that all the air filters met or exceeded the Army's acceptance standards. The total estimated cost to the government to fix the filter units was almost $389,000. The air filtration contractor contributed approximately $44,000 in labor and materials to assist in fixing the filters. Since the Army started operational testing of JACADS on July 16, 1990, the air filters have performed according to safety and efficiency specifications with no breakdowns affecting destruction rates.

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