Warhead Dismantlement Programs and Plans 3

When weapons are returned by the Department of Defense (DOD) to the Department of Energy (DOE), they are transported to the DOE Pantex Plant for dismantlement. Dismantlement begins with removal of all the nonnuclear components, including the chemical high explosives (HE) that surround the nuclear materials. Dismantlement also includes the management of waste materials, which comprises such steps as separation, characterization, demilitarization, sanitization, and disposal. Some materials are temporarily stored. The storage of plutonium and highly enriched uranium is discussed in chapter 4. The final disposition of nuclear materials removed from weapons has not yet been determined.

Point

"From a global security point of view, I would argue that—the fact that the Department of Energy is doing the best it can with existing dismantlement procedures until it can finalize new ones-is the only responsible approach for them to take."

National Academy of Sciences staff reviewer of OTA report

Counterpoint

"I continue to worry that the dismantlement train has left the station probably headed in the wrong direction but running on previous policies in light of the lack of new policies."

Retired DOE manager and reviewer of OTA report

PRESENT DOE ACTIVITIES AND PLANS

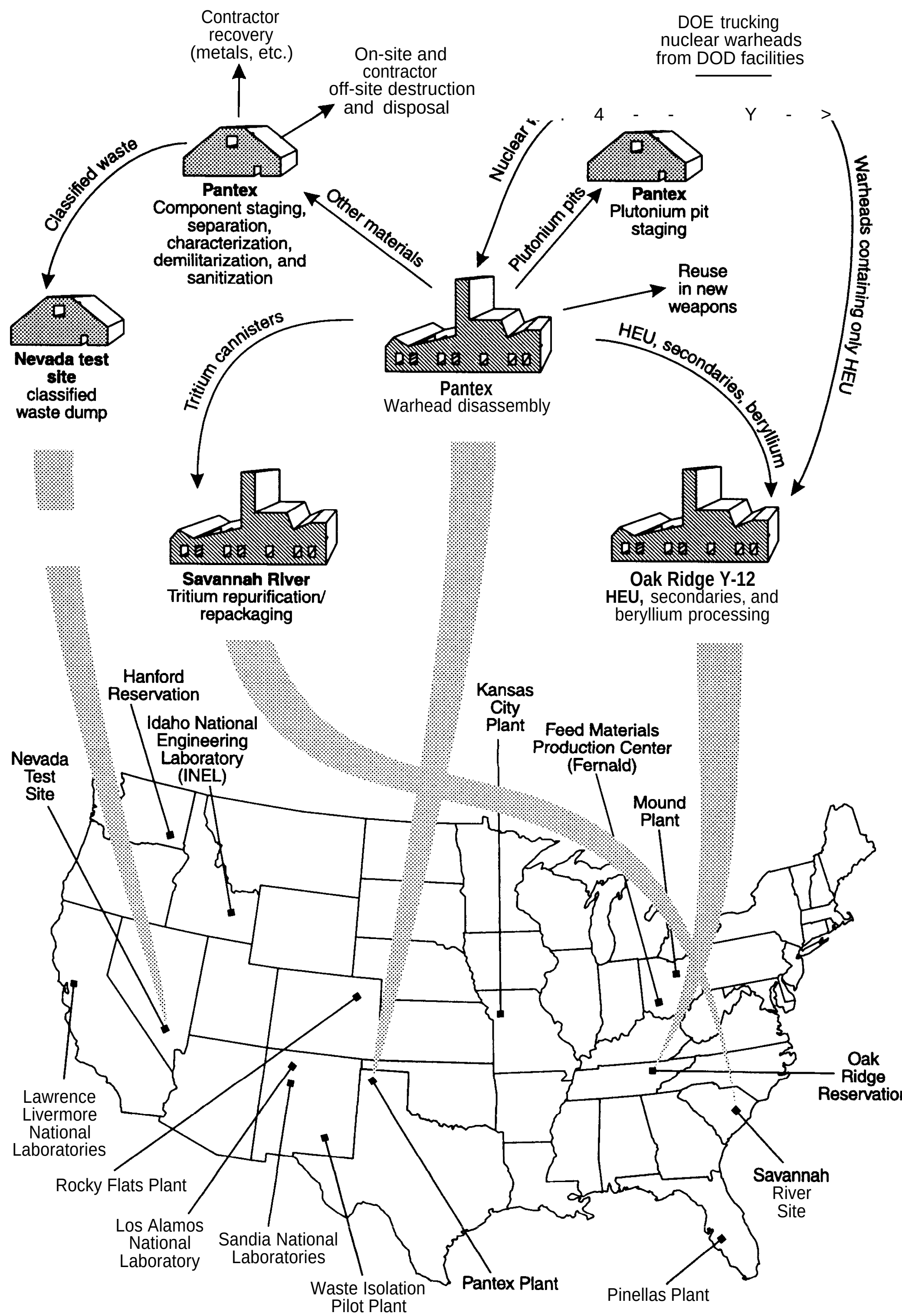
Overview

Several DOE facilities are currently engaged in the warhead dismantlement process, with **major** activities centered at Pantex, Y-12, and Savannah River (see figure 3-l). Plutonium pits[1] are removed from warheads and temporarily stored in bunkers at Pantex. Other parts and wastes are stored, characterized, and disposed of in a variety of ways that have been developed and used by DOE in the past. Secondaries[2] are shipped to the Y-12 Plant at Oak Ridge, Tennessee for further disassembly or storage. Tritium canisters are shipped to the Savannah River Site. Figure 3-2 illustrates the steps involved in dismantlement at Pantex.

[1] A plutonium pit is the primary explosive nuclear core of the warhead package.

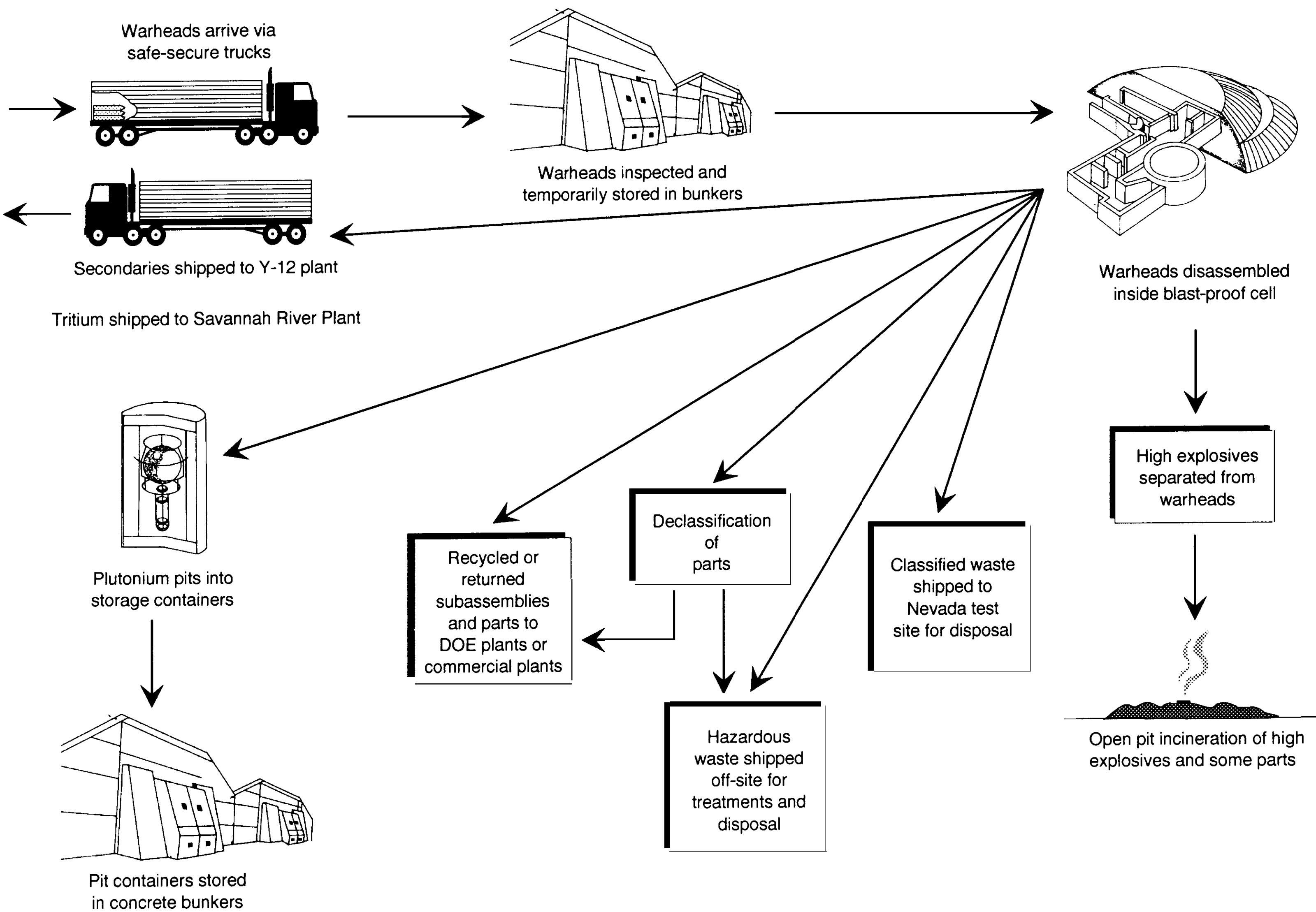
[2] A **key** (self-contained) **subassembly** of the nuclear warhead package.

Figure 3-I—DOE Facilities Involved in Nuclear Weapons Dismantlement



SOURCE: Office of Technology Assessment, 1993.

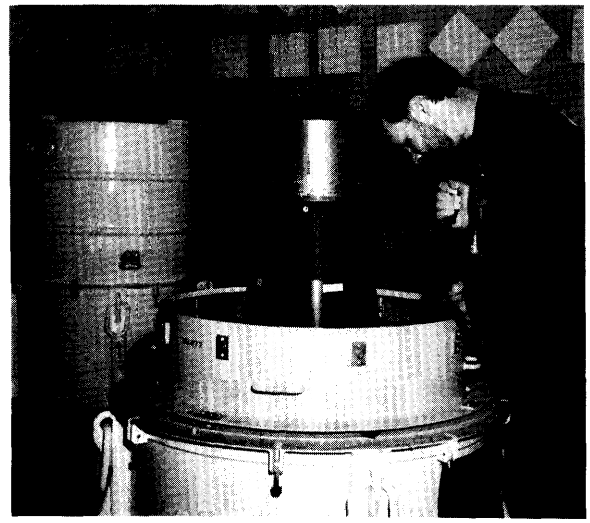
Figure 3-2—Warhead Dismantlement at Pantex with Flow of Parts, Materials, and Waste



SOURCE: Office of Technology Assessment, 1993.

In the past, DOE has dismantled nuclear warheads as a part of operations to maintain the active and inactive stockpiles, and to retire obsolete weapons systems (32). However, during this earlier activity, most nuclear and nonnuclear components were returned to the DOE plants in which they were made. Now, some facilities have ceased operations and can no longer accept materials. For example, plutonium pits can no longer be returned to Rocky Flats, so these pits must be stored at Pantex. The focus of DOE's activities has changed from warhead production to warhead dismantlement. During FY 1991, 1,546 warheads were dismantled at Pantex. In FY 1992, even though the total number dismantled by DOE was much larger, the number at Pantex decreased to 1,274 because one type was of such design that it could be sent directly to the Y-12 Plant and dismantled there. As of summer 1993, DOE estimates that about 1,400 warheads will be dismantled at the Pantex Plant during FY 1993 (83). The pace of dismantlement and the difficulty of dismantlement work are affected by management, political, and technical challenges.

Management challenges involve integrating environmental, safety, and health improvements into dismantlement operations. DOE has asserted its commitment to protection of the environment, safety, and health (89). This commitment represents a distinct change from the traditional DOE culture, and efforts to establish a "new culture" have been spurred in large part by recognition of the widespread contamination resulting from past DOE production practices and revelations about safety hazards at DOE facilities. Environmental, safety, and health practices at Pantex and other plants involved in dismantlement have been strongly criticized by both internal and external reviews (1, 17,23,59,67,68,82). Improvements have been noted in followup reviews, yet much remains to be accomplished (16,84). Another management challenge is to maintain an aggressive schedule of warhead dismantlement while solving logistics problems in the safest practical way. DOD now has a backlog of retired weapons and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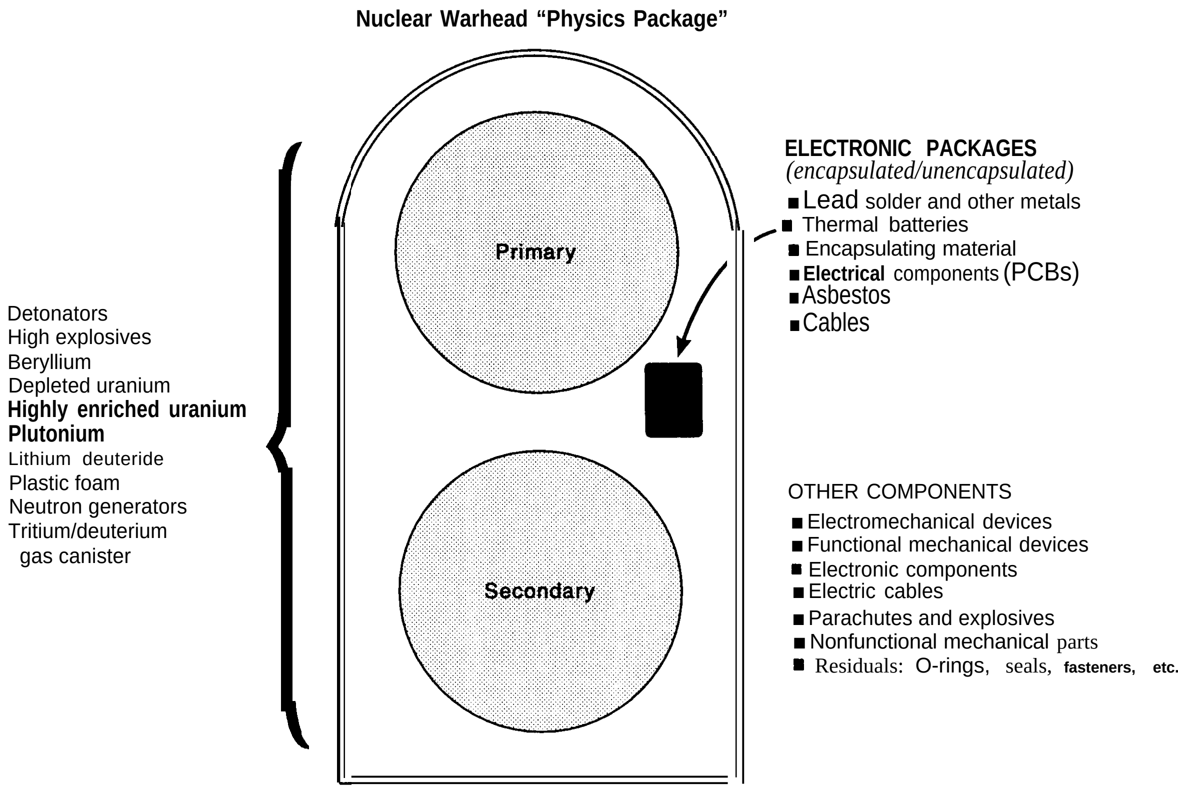
A Pantex Plant worker removes a nuclear warhead from a shipping container.

has assigned priority ranking to different types for return to DOE. DOE management must serve DOD needs and handle particular weapons systems without sacrificing safety, efficiency, and effectiveness.

Political challenges include the increased interest of the States and the public in activities at the Weapons Complex. Recent requirements for DOE to comply with State environmental regulations provide greater opportunities for States and public interest groups to oversee DOE operations, and give these groups additional leverage in affecting dismantlement activities. For example, the State of Texas is responsible for hazardous waste at Pantex under the Resource Conservation and Recovery Act (RCRA) and for issuing air quality permits governing emissions associated with the burning of HE at Pantex. However, fragmented regulatory responsibilities among different State and Federal agencies, as well as lack of jurisdiction over some materials, may limit oversight.

Technical challenges associated with dismantlement stem from the complexity of nuclear warheads. There are many components in a warhead—including nuclear materials, other toxic

Figure 3-3-Materials Generated from Dismantling a Typical Nuclear Warhead



SOURCES: Adapted from briefing by Johnny Grant, Project Leader for Nuclear Weapons Retirement and Disposal for the U.S. Department of Energy (Mar. 17, 1992); and from the National Research Council, ***The Nuclear Weapons Complex, Management for Health, Safety, and the Environment*** (Washington, DC: National Academy Press, 1989).

and hazardous materials (chemicals and metals), and classified materials (switches, electronic components)—all of which require careful handling and attention to environmental, safety, and health issues (see figure 3-3 for a list of materials contained in nuclear warheads). Although weapons have engineered safety features to prevent inadvertent detonation, some of the explosives in the older warheads are sensitive to shock and require controlled conditions. Newer weapons are more resistant to unintentional detonation of the explosives. Most, if not all, weapons slated for dismantlement are older, more sensitive warheads, as are some weapons that are still deployed.

Finally, each weapons type is unique, requiring different dismantlement tools and procedures, and possibly different methods of component disposal. Each change in weapons type requires extensive planning, operations reviews, safety reviews, worker training, and special tests. The time required for these can vary significantly depending on the type and design of weapon. DOE has estimated that the time required for only the main disassembly tasks for several warheads could vary by a factor of four (83). Information on whether certain components, such as capacitors, contain hazardous materials is not always available to DOE. Thus some materials will have to be tested to identify the chemicals present, prior to dismantlement and disposal.

Although most recent problems with dismantlement appear to be minor, some have been of particular concern and have affected DOE's schedules. In April 1993, DOE reported that the outer layer of a plutonium pit had cracked open during disassembly of a W48-type warhead. The actual incident occurred in November 1992. The pit had to be removed from the normal process for examination and testing. DOE stated that the incident resulted in minor contamination of the work area. Since this related to one specific weapons type, further work on that system was discontinued until investigations could be completed and new procedures developed. Because of the time required to shut down one line and start up another, this type of problem can have a significant effect on schedules and rates of dismantlement. Any future problem can be expected to have similar effects (24,78).

Steps and Facilities in Dismantlement

Nuclear warheads are disassembled into components at the Pantex facility, in Amarillo, Texas. Parts from the weapons are, in general, returned to the facility where they were originally produced. An exception is that plutonium pits remain at Pantex in temporary storage, rather than being returned to Rocky Flats, which has been closed. Chemical explosives removed from a warhead's pit are burned at Pantex. Individual plutonium pits are put in steel containers resembling oil drums, which are then placed in earth-covered concrete bunkers.

Warheads arrive at Pantex's Shipping and Receiving Building in specialized vehicles, and undergo several inspections and safety checks. They are then unloaded at 1 of 60 storage facilities (bunkers) contained in the secured area about 1 mile from the assembly/disassembly area (91). As of March 1992, approximately 42 bunkers were used for weapons or weapons component staging (51).

The steps required to assemble nuclear warheads are reversed for dismantlement (79). Thus, after conducting several inspections and safety checks on a warhead, disassembly personnel remove the warhead's cover followed by all

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Aerial view of the Pantex Plant, near Amarillo, Texas.

electrical components and other hardware. Inspection of warheads includes the use of radiography to verify the configuration and condition of warhead components. Additional tests may be conducted to determine, among other characteristics, actual mass properties, dynamic balance, and center of gravity (91).

Removal of the protective case containing high explosives and nuclear materials (e.g., physics package) is generally followed by actual separation of the nuclear and HE components. To reduce the potential for large radionuclide releases in case of the accidental explosion of conventional chemical high explosives (used in most of the U.S. nuclear stockpile), these activities are conducted in assembly/disassembly cells or "Gravel Gerties" (79). Most of the 13 assembly cells found at Pantex are used, or could be used, for disassembly of the physics package (91). Weapons containing insensitive high explosives may be assembled or disassembled in "bays," which do not have the same level of explosive containment as cells.

The disassembly of weapons results in parts containing HE, special nuclear materials, components containing hazardous and nonhazardous chemical constituents, and certain other materials that, because of the classified nature of their design, must be declassified or "sanitized" prior to treatment and disposal. Weapons disassembly also generates solvents, classified metal components, and other regulated hazardous materials (75). A variety of hazardous wastes may be generated by this process, and their proper management (treatment, storage, and disposal) represents a technical challenge.

Pantex bunkers are used for temporary storage of special nuclear materials. Most radioactively contaminated wastes and classified or nonclassified weapons components gathered during disassembly are shipped off-site for treatment and disposal (91). High explosives are burned at Pantex (79,91). The majority of recoverable material generated during the weapons dismantlement process is shipped to commercial vendors for recycling (91). Commercial waste handling facilities are used to handle the off-site disposal of nonnuclear waste from warhead dismantlement (5,61).

The Y-12 Plant at the Oak Ridge Reservation in Tennessee is a major weapons component manufacturing facility. Built in 1943, the plant initially separated fissile uranium-235 from natural uranium. As the Nation's weapons programs changed over the years, so did the capabilities of Y-12. Lithium separation became a mission of the plant in the 1950s. Presently, Y-12 has facilities to fabricate weapons components from uranium, beryllium, and lithium, and the plant has played a major role in producing nearly every nuclear weapon in the Nation's arsenal.

Secondaries from warheads disassembled at Pantex are shipped to Y-12, and many of them are now stored intact. The Y-12 Plant receives highly enriched uranium from disassembled weapons. Other components from warheads are also shipped to the site. Uranium is stored at Y- 12, and other parts are either stored or treated as waste and disposed. Some fabrication continues, however, and Y-12 currently supports the DOE laboratories, nuclear reactor projects, and the Navy's Nuclear Submarine program.

DOE's Savannah River Site in South Carolina recycles tritium, a radioactive isotope of hydrogen used to boost the explosive yield of nuclear weapons. In the past, the Savannah River Site also produced tritium and plutonium. Tritiurn from dismantled weapons is stored at Savannah River and purified for reuse. Because of its short half-life, tritium must be resupplied to weapons.

Management and Oversight Structure for Dismantlement

Dismantlement is currently the responsibility of the DOE Office of Defense Programs (DP). Actual warhead dismantlement is conducted by the management and operations (M&O) contractor, Mason & Hanger-Silas Mason Co., Inc. (M&H), for the Pantex Plant. The DOE Amarillo Area Office is located at Pantex and reports to the Albuquerque Operations Office. The Albuquerque Operations Office reports to the DOE Assistant Secretary for Defense Programs. Technical support is provided by several of the national laboratories that originally designed the warheads now scheduled for dismantlement. DP has responsibility for developing and implementing environmental, safety, and health policies for its operations. DP receives policy guidance and oversight from other DOE headquarters offices such as the Office of Environment, Safety, and Health (EH) (85).[3]

To address new challenges in dismantlement operations, on December 31, 1991, DOE established a special task force, the Executive Management Team for Dismantlement (EMTD), with broad oversight of nuclear warhead dismantlement operations (62). The Albuquerque Operations Office was designated to establish and chair EMTD (5). EMTD activities include: 1) establishment of materials identification and disposal teams; 2) characterization of materials for disposal; 3) development and procurement of specific tools; 4) identification and resolution of

[3] EH now includes the formerly independent Office of Nuclear Safety.

environmental, safety, and health concerns; 5) definition of treatment and disposal methods for materials from weapons dismantlement; 6) updating retirement disposal instructions; 7) detailing specific operating procedures; 8) training operators; 9) evaluating nuclear safety; and 10) conducting a final program review (5).

Despite the preliminary stage of some EMTD activities, several Weapons Complex facilities are undertaking warhead dismantlement tasks using existing operating procedures, in part because DOE considers weapons dismantlement to be a logical extension of past operations. According to this view, dismantlement has merely changed the emphasis from assembly to disassembly, but the same techniques, personnel, facilities, and skills are involved.

Although EMTD is addressing new challenges in Pantex dismantlement operations, DOE still relies on many conventional methods. It continues to dispose of components or materials from dismantled warheads as usual, rather than waiting until new methods are developed (44). EMTD recommendations are integrated into ongoing operations only if the site operations manager determines a change is needed.

Internal DOE oversight functions were changed during the tenure of former Secretary of Energy James D. Watkins, and new policies and guidance are being developed (85). It has been difficult in the past to ensure that environmental, safety, and health guidelines were being followed, and the internal oversight office (EH) currently has insufficient mechanisms to require specific compliance or to enforce its requirements. In addition, EH lacks the personnel to review progress at field offices. Hiring personnel with expertise in occupational safety and health has been difficult not only for the oversight office but for DOE line organizations as well.

The Cost-Plus Award Fee (CPAF) process was established to help increase emphasis by M&O contractors on environmental, safety, and health factors. This process provides a mechanism for evaluating progress on meeting some defined objective, but there is little evidence **that it actually increases** management's attention to health and safety issues (65).

External advisory oversight, with particular emphasis on nuclear safety issues (e.g., criticality safety, training of radiation workers) is provided by the Defense Nuclear Facilities Safety Board (DNFSB). Regulatory oversight on environmental matters at Pantex is provided by the Environmental Protection Agency (EPA) and the State of Texas. Sirnilar management, contractor, and oversight arrangements prevail at other dismantlement sites (e.g., Y-12 in Tennessee, Savamah River in South Carolina).

The DNFSB is a relatively new external advisory oversight mechanism. It was created by Congress in 1989 to provide advice and recommendations to the Secretary of Energy on public health and safety at DOE defense nuclear facilities (12). In 1991, Congress amended the enabling act and broadened its jurisdiction to include the assembly, disassembly, and testing of weapons, thus expanding DNFSB oversight to Pantex operations. DNFSB reviews facilities, operations, practices, and occurrences at DOE facilities. It examines the safety practices of both DOE and the M&O contractors. DNFSB also reviews and evaluates the content and implementation of health and safety standards, including DOE orders, rules, and other safety requirements. Table 3-1 lists the orders subject to DNFSB oversight.

DNFSB's primary tool for gaining the attention of DOE is to issue recommendations to the Secretary of Energy that require a response or a report. Some DNFSB recommendations are specific to DOE facilities (e.g., recommendations 91-2, Closure of Safety Issues Prior to Restart of the K-Reactor at the Savannah River Site; and 90-7, Safety at Single-Shell Hanford Waste Tanks). Others apply broadly to all DOE defense nuclear facilities (e.g., 91-1, Strengthening the Nuclear Safety Standards program for DOE's Defense Nuclear Facilities; 91-6, Radiation Protection for Workers and the General Public at DOE Defense Nuclear Facilities). Recommendation 91-6 (11)

Table 3-l—DOE Orders Subject to DNFSB Oversight

Part 1. Weapons-Sensitive DOE Orders

Order number	Subject
5530.1 A	Response to Accidents and Significant Incidents Involving Nuclear Weapons
5530.2	Nuclear Emergency Search Team
5530.3	Radiological Assistance
5530.4	Aerial Measuring
5600.1	Management of DOE
5610.1	Weapons Complex Packaging and Transportation of Nuclear Explosives, Nuclear Components, and Special Assemblies
5610.10	Nuclear Explosives and Weapons Safety
5610.11	Nuclear Explosive Safety
5610.13	Joint DOE/DOD Nuclear Weapons System Safety, Security, and Control

Part II. Safety-Related DOE Orders

Order number	Subject
1300.2A	Department of Energy Technical Standards Program
1360.2A	Unclassified Computer Security Program
1540.2	Hazardous Materials Packaging for Transport-Administrative Procedures
1540.3	Base Technology for Radioactive Material Transportation Packaging Systems
1540.4	Physical Protection of Unclassified, Irradiated Reactor Fuel in Transit
4330.4A	Maintenance Management Program
4700.1	Project Management System
5000.3A	Occurrence Reporting and Processing of Operations Information
5400.1	General Environmental Protection Program
5400.2A	Environmental Compliance Issue Coordination
5400.3	Hazardous and Radioactive Mixed Waste Program
5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements
5400.5	Radiation Protection of the Public and the Environment
5440.1 D	National Environmental Policy Act Compliance Program
5480.1 B	Environmental, Safety and Health Program
5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes
5480.4	Environmental Protection, Safety and Health Protection Standards
5480.5	Safety of Nuclear Facilities
5480.6	Safety of DOE-Owned Reactors
5480.7	Fire Protection
5480.8	Contractor Occupational Medical Program
5480.9	Construction Safety and Health Program
5480.10	Contractor Industrial Hygiene Program
5480.11	Radiation Protection for Occupational Workers
5480.15	DOE Laboratory Accreditation Program for Personnel Dosimetry
5480.17	Site Safety Representatives
5480.18A	Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities
5480.19	Conduct of Operations Requirements for DOE Facilities
5480.20	Personnel Selection, Qualification, Training, and Staffing Requirements at DOE and Nonreactor Nuclear Facilities
5480.21	Unreviewed Safety Questions
5480.22	Technical Safety Requirements
5480.23	Nuclear Safety Analysis Reports
5481.1 B	Safety Analysis and Review
5482.1 B	Environment, Safety, and Health Appraisal Program
5483.1 A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities
5484.1	Environmental Protection, Safety, and Health
5500.1 B	Emergency Management System
5500.2B	Emergency Categories, Classes, and Notification and Reporting Requirements
5500.3A	Planning and Preparedness for Operational Emergencies
5500.4	Public Affairs Policy and Planning Requirements for Emergencies
5500.7B	Emergency Operating Records Protection Program
5500.10	Emergency Readiness Assurance Program
5700.6C	Quality Assurance
5820.2A	Radioactive Waste Management
6430.1 A	General Design Criteria

SOURCE: Defense Nuclear Facilities Safety Board, 1992.

led to the development of DOE's new Radiological Control Manual (RADCON) (80), discussed later in this chapter.

Another mechanism used by DNFSB to effectuate change at DOE facilities involves the discussions and technical exchanges that are an integral part of site visits. The interaction between DNFSB and DOE/contractor staffs often leads to improvements that are not reflected in formal recommendations. This mechanism and the lack of public access to the Board's work have been criticized. Some critics claim that the Board is not truly independent-that DNFSB lacks adequate authority because it merely advises the Secretary of Energy and has never really solicited broad public input (9,55).

On the other hand, DNFSB identifies a variety of examples of public participation, including correspondence with STAND (Serious Texans Against Nuclear Dumping) and the State of Texas in response to concerns about staging configurations for special nuclear materials and other safety issues at Pantex, as well as public access to DNFSB recommendations, annual reports, notices of public meetings/hearings, and material available after public meetings in accordance with Sunshine Act and Freedom of Information Act rules. These rules were developed in response to litigation.[4] Results of this litigation are that DNFSB has complied with these regulations but that meetings involving formal recommendations to the Secretary of Energy or the President maybe closed (21). The Supreme Court declined to review this case in a ruling on May 17, 1993 (90).

Many DNFSB recommendations and site visits focus on increasing the formality of written procedures and directions in DOE operations and in its training of workers. This emphasis may be a reflection of the background of many DNFSB staff in commercial and naval nuclear reactors. The DNFSB advisory role has been taken very seriously by DOE. All recommendations, to date, have been accepted. Some commentators within DOE have expressed concern that this effort to satisfy DNFSB may divert attention from more comprehensive needs. They claim that the resources needed to improve overall training activities are sometimes directed into the narrower areas identified by DNFSB. These individuals contend that DNFSB plays a very powerful, almost regulatory, role, yet its recommendations are not subject to the outside review and scrutiny faced by regulatory bodies. For example, the Nuclear Regulatory Commission has formal mechanisms for rulemaking and public comment, including publishing *drafl* recommendations in the *Federal Register.* DNFSB recommendations are issued *final* form for public comment.

Between May 1992 and June 1993, DNFSB conducted numerous site visits at weapons dismantlement facilities. Most of this effort focused on Pantex, with additional visits to Y-12 and Los Alamos National Laboratory, as well as some review of the DOE Amarillo Area Office and the Albuquerque Operations Office. The visits resulted in correspondence with DOE concerning various safety issues, including training, procedures, conduct of operations, compliance with orders, safety analysis, criticality safety, dosimetry, Operational Readiness Review process, radiation control practices, and safety of nuclear explosives. DNFSB has required reports on criticality safety at Pantex (17) and radiation control practices, and plans to remedy DOE order compliance deficiencies at Y-12 (23). DNFSB has also made specific recommendations applicable to dismantlement facilities (Recommendation 93-1, Standards Utilization in Defense Nuclear Facilities) (19).

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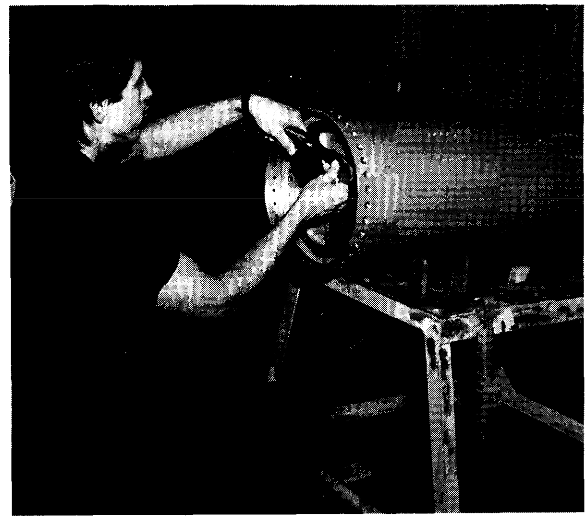
[4] ***See Energy Research Foundation v. Defense Nuclear Facilities Safety Board, 734*** F. Supp. 27 (D.D.C. 1990); ***Energy Research Foundation v. Defense Nuclear Facilities Safety Board, 917*** F.2d 581, 585 (D.C. Cir. 1990); ***Natural Resources Defense Council/Energy Research Foundation v. Defense Nuclear Facilities Safety Board, No. 91-1199*** (D.C. Cir., July 24, 1992); ***Natural Resources Defense Council/Energy Research Foundation v. Defense Nuclear Facilities Safety Board, No. 91-1199*** (D.C. Cir., Oct. 9, 1992).

Dismantlement Procedures

DOE management and the national laboratories jointly produce the standard operating procedures for nuclear weapons dismantlement at Pantex (32). However, the laboratories have final approval authority. The national labs have designed all U.S. nuclear weapons. Consequently, Sandia, Lawrence Livermore, and Los Alamos constitute a unique source of information about the nuclear weapons slated for dismantlement (34).

Some procedures for reviewing and approving dismantlement activities for particular weapons programs are in place. The three principal steps involved are: 1) Operational Readiness Review, 2) Operational Readiness Evaluation, and 3) Qualification Evaluation for Dismantlement Release. These procedures are internal to DOE and do not involve public or outside scrutiny. However, DNFSB has taken an active role in reviewing this process at Pantex and other DOE facilities.

The Operational Readiness Reviews (ORRs) are conducted by a team of contractor engineers at the dismantlement facility (Pantex or Y-12). These internal reviews are intended to ensure that the procedures and equipment necessary to begin dismantlement operations are in place. After the ORR, DOE conducts an Operational Readiness Evaluation (ORE), which is a critique of the ORR and confirms whether the activity is ready to go. The Qualification Evaluation for Dismantlement Release (QED) is an additional review by national laboratory design engineers to verify the DOE critique. This step was added as a result of concerns expressed by DNFSB about the ORR-ORE process for a particular weapons system at Pantex. In that example, the ORE found the ORR to be insufficient. DNFSB conducted an independent review of the ORE, and noted deficiencies in the process used and in safety factors (18). In particular, DNFSB expressed concern about continuing deficiencies in the Safety Analysis process at Pantex, an issue that has been raised repeatedly by both internal and external reviewers since 1989. DNFSB had also criticized the ORR-ORE process at Pantex in July 1992 (14).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Pantex Plant worker begins warhead disassembly.

In practice, many of the informal mechanisms used in the past to guide M&H dismantlement operations are still in effect. M&H engineers meet with their counterparts at the national laboratories to discuss technical challenges. Laboratory personnel then work on solutions to these problems. If promising technologies are developed, it is often up to M&H to determine whether or not to pursue a new approach, unless it is ordered to make a change by the DOE Albuquerque Operations Office. Some national laboratory personnel who have worked closely with M&H are part of EMTD; others are not.

Recent work on the use of robotics in dismantlement operations has been supported by EMTD. Some efforts have explored the application of robotics to reduce human radiation exposure from dismantlement activities. These methods are being evaluated by Sandia National Laboratory (see box 3-A). They are examples of some of the dismantlement process design work sponsored by DOE. There is no clear connection, however, between such design work and any overall assessment of dismantlement technology needs within the Pantex management organization.

Box 3-A—Using Robotics to Improve the Dismantlement Process

Although the complete dismantlement of nuclear warheads by robots is unlikely, they could be used in certain steps in the dismantlement process. Robots have been developed and used to improve commercial nuclear reactor safety through reducing human radiation exposure and operations in inaccessible areas (93). However, it is unlikely that humans will be completely replaced in warhead dismantlement operations at Pantex because safety considerations dictate that the initial handling and disassembly operations be done manually (39). Nuclear warheads were designed to be assembled and disassembled by humans, and therefore have idiosyncratic variations—such as the positioning of wire bundles—that make robotics programming very complicated and continue to require humans for the safety of some operations (93).

To evaluate opportunities for robotics to improve warhead dismantlement operations, Sandia National Laboratory conducted studies to identify the most risky parts of dismantlement. The Sandia robotics group did risk and exposure assessments and then developed robotics systems to replace human personnel in the more dangerous operations (35). One study looked at issues including the use of remote sensing, verification, and specialized robotics for nuclear warhead components staged in bunkers at Pantex (35).

DOE and the national laboratories have identified weapons disassembly; the handling, storage, and transportation of nuclear materials; and nuclear materials monitoring, accountability, and inventory as areas in which robotics could play a part, largely by using existing commercial technology (39).

Robotics could reduce human radiation exposure during dismantlement: one example is the packing and unpacking of plutonium pits in steel storage containers. This occurs several times during dismantlement of a single warhead and represents a substantial proportion of the exposure risk (39).

Other examples in which robotics may be useful are the removal of detonators; the removal of chemical high explosives; pit processing; "swiping" (surface sampling) the pit to detect radioactive contamination; cleaning; weighing the pit; and checking for leaks (39). One robotics system under development accepts the warhead explosive assembly, cuts the explosive charge by using high-pressure water jets, applies hydraulic pressure to separate the pieces, and packages the remains for storage—all with remote human supervision (93).

A specific example of Sandia's robotics projects is "Project Stage Right," with involvement of contractors Mason & Hanger and Battelle. The project is designed to avoid worker radiation exposure from regular inventory inspections, which would increase under DOE's proposed double plutonium pit stacking plan (7). DOE is interested in avoiding human inventory inspection by allowing remote inspection via robotics (31). DOE's Pantex double pit stacking plan envisions staging and regular monitoring of 15,000 plutonium-pit-containing steel drums in 38 bunkers (7). The project will reduce worker radiation exposure from plutonium pits during loading and unloading, handling, and inventory operations through the use of manned, radiation-shielded forklifts to handle pallets of steel drum pit containers; an unmanned remotely controlled autonomous forklift that can handle and inventory pallets; and an automatic system for inventorying plutonium pits on a regular basis, with or without physical entry into the bunker (7).

SOURCE: Office of Technology Assessment, 1993.

Costs of Dismantlement

Because there is no requirement or procedure for separating dismantlement costs from other production and surveillance costs within DOE Defense Programs, very little integrated information is currently available that reflects the total cost of this new mission. The DOE Albuquerque Operations Office has, however, responded to Office of Technology Assessment (OTA) requests for available dismantlement cost data. In FY 1993, direct costs are estimated to be about $25 million, and in FY 1994 in excess of $30 million. At least two-thirds of these costs are attributed to Pantex activities and about one-eighth to Y-12. Estimates represent direct costs only and do not include many other items that would need to be considered, such as security, maintenance, and oversight activities. For example, in FY 1993, operation of the weapons and materials transportation system by DOE is expected to cost about $79 million, most of which is used for dismantlement activities. This system is used to transport all warheads from military bases to the Pantex Plant and secondaries from Pantex to Y-12 (42,43,75,76,92).

Such cost figures probably fall far short of the totals for the comprehensive mission of dismantlement. The total operating budgets for the two sites most engaged in dismantlement—Pantex and Y-12—are $240 and $460 million, respectively, for FY 1993. Managers at each of these sites have said that at least two-thirds of their current efforts are devoted to the dismantlement mission or related work. Thus, current expenditures for dismantlement activities at these two sites alone would be almost half a billion dollars. If work at other sites, research and support activities at the weapons design laboratories, transportation and security, and oversight and management efforts are included, the FY 1993 DOE budget allocated to warhead dismantlement and materials disposition is in the range of $500 million to $1 billion (42,43,75,76,92).

Future costs of the dismantlement and management of weapons materials are unknown at this time. DOE is now preparing a plan for reconfiguration of the Weapons Complex that will likely incorporate these activities. If new facilities are to be built, their capital costs must also be considered. Such costs would need to include the provision of improved health and safety conditions for workers, as well as improved waste management practices that might accompany state-of-the-art facilities. Perhaps DOE will include estimates of dismantlement and materials management costs as part of its reconfiguration plan. If so, the increase in future costs could be evaluated in light of the need to replace many old facilities. However, there is no firm indication that construction of new facilities will be part of DOE's plan, and some contend that new facilities are not needed (30). In addition, costs to cleanup the current contamination and dispose of wastes that accumulated from past practices should be factored into overall dismantlement costs.

ENVIRONMENTAL, HEALTH, AND SAFETY ISSUES IN DISMANTLEMENT

Numerous environmental, safety, and health deficiencies have been identified at Pantex and other dismantlement facilities during the past few years, and efforts are under way to address these problems. As discussed below, some outside observers are critical of past practices and skeptical of DOE's ability to significantly improve the environmental, safety, and health aspects of its operations. Certain improvements have been made, however, and changes in DOE's management approach could bring results.

Health and Safety issues

Specific steps, processes, materials descriptions, and other aspects of dismantlement work are classified. Only general outlines of operations and worker responsibilities can be described without citing classified information. In this unclassified study, OTA did not review specific dismantlement procedures to evaluate worker hazards. OTA analysis of health and safety issues is based on unclassified information and data associated with warhead dismantlement, general principles of occupational and radiological health and safety, and unclassified evaluations of health and safety programs at dismantlement facilities by internal and external oversight groups. Box 3-B describes some basic, unclassified facts about dismantlement related to worker health and safety.

Standards and operating procedures governing the health and safety of workers undertaking dismantlement operations are developed and enforced by DOE. DOE is exempted from regulatory oversight by the Occupational Safety and Health Administration (OSHA). However, DOE is planning a transition to external regulation by OSHA over the next 3 to 5 years (72). New guidance from DOE is being developed in nonnu-

Box 3-B—Worker Health and Safety Issues in Current Dismantlement Processes

- Dismantlement occurs in highly secure cells and bays.
- Dismantlement workers handle a variety of materials that can potentially cause health and safety problems, including radionuclides, explosives, and toxic metals or organics (see figure 3-3, list of weapons components).
- Many warheads slated for disassembly lack modern safety devices, which might increase the risk of accidental detonation. The disassembly bays (Gravel Gerties) are designed to contain any plutonium released if an accidental detonation were to occur, but such an accident could have severe consequences for workers inside the bays.
- Each weapons system requires different procedures and unique tooling.
- In some procedures, workers must rely on personal protective equipment such as respirators, rather than preferred methods of engineering controls, for protection,
- Different processes are used to remove explosives from pits, some involving solvents, hydrojets, and/or thermal treatment.
- Workers are trained and certified for dismantlement work.
- Review of operating procedures by safety and health experts is a relatively new measure.
- Health and safety are governed by DOE and implemented by contractors.
- Employees have been unexpectedly exposed to radiation and hazardous chemicals.
- Unexpected radiological contamination has been detected during routine monitoring activities.
- Employees have failed to follow correct procedures.
- Work has stopped because of employee uncertainty about procedures.

SOURCE: Office of Technology Assessment, 1993.

clear health and safety areas, as well as radiation protection. The new rules are an outgrowth of numerous critical reviews of environmental, safety, and health practices at DOE facilities by both internal and external oversight groups (e.g., Tiger Teams, Advisory Committee on Nuclear Facility Safety, Defense Nuclear Facilities Safety Board).

Key issues for worker health and safety are whether efforts by DOE to exercise health and safety oversight responsibility are adequate and whether sufficient resources are being devoted to worker protection. Various reviews of DOE and contractor performance on health and safety issues are discussed below along with new initiatives to improve radiation control programs at Pantex and Y-12.

PANTEX PLANT

During dismantlement, workers must handle a variety of materials, some of which are toxic, hazardous, and/or radioactive. Box 3-C lists examples of unclassified exposure incidents involving dismantlement activities at Pantex over the past few years.

Numerous health and safety problems at Pantex were identified by the Tiger Team sent there from DOE headquarters in October 1989, including:

- inadequate radiation protection;
- inadequate hazard identification and communication;
- insufficient resources to accomplish environmental, safety, and health goals;
- inadequate policy guidance toward these goals; and
- insufficient management attention to environment, safety, and health (68).

This investigation indicated that compliance was difficult to evaluate, given the confusing array of DOE requirements and the lack of routine operations at the site during the field investigation. Responses to specific problems identified in the Tiger Team report are documented in the 1990

Box 3-C—Examples of Unclassified Worker Exposure Incidents at Pantex During Dismantlement

Beryllium Incident

According to a Tiger Team assessment, the Occupational Safety and Health Administration (OSHA) has documented an example of appropriate attention to health and safety matters involving employee exposure to hazardous material. The Pantex Industrial Hygiene Department identified employee exposures to beryllium during cleanup operations at Firing Site 23 that exceeded the OSHA Permissible Exposure Limit (PEL). Its response was to ensure the use of appropriate personal protective equipment (PPE) followed by construction of a permanent decontamination chamber (under construction during the OSHA visit). Remonitoring was planned to determine the effectiveness of a decontamination chamber in reducing employee exposure levels. Pantex management will consider further engineering controls, if necessary to meet the PEL (68).

Depleted Uranium-238 and Other Metal Residues

During the Tiger Team visit, OSHA investigated an exposure incident that occurred on February 28, 1989, about which the Metal Trades Council was concerned (68). The incident occurred during a disassembly operation. An employee was determined to have alpha contamination on his coveralls. Visible contamination in the bay was identified as depleted uranium-238, lead, aluminum, chromium, manganese, nickel, zinc, and cadmium. The Council concerns included: 1) the lack of instructions to employees on the use of personal protective equipment such as respirators; 2) inadequate biological monitoring in that only some of the employees who were potentially exposed were provided blood lead monitoring, and then only several months after the incident; and 3) the delay in providing whole body radiation counts to the affected employees.

OSHA's investigation revealed inadequate instructions and oversight in the use of PPE for the disassembly activity; inadequate monitoring of metals and radiation; inappropriate work practices involving PPE, which may have resulted in additional contamination of areas both inside and outside the disassembly bays; and inadequate recordkeeping of monitoring results. OSHA was unable to follow up its investigation by conducting air monitoring of a similar disassembly operation, which would be standard practice in investigating this type of complaint, because this sort of disassembly operation was not scheduled during the OSHA visit. OSHA did not comment about the Council's concerns regarding medical surveillance response to this incident.

Radiation-Contaminated Scrap Parts

Unexpected radiation contamination of scrap parts of weapons was detected during routine monitoring of a shearing step to declassify the parts on April 23, 1992 (77). Operations were stopped, access to the area was controlled, personnel were checked for contamination, and none was detected. The area was monitored for radiation, and contamination was found on the shearing equipment. The material was followed upstream and traced to the Burning Grounds, where contamination was located and removed. Additional surveys were conducted with no detection of further contamination. The reason for the contamination was not identified. However, steps are being taken to minimize the impact of similar incidents in the future through early detection and control of contamination at the source by additional monitoring of the Burning Grounds.

SOURCE: Office of Technology Assessment, 1993.

Action Plan preparedly Mason & Hanger and the corrective actions tracking system that includes a formal certificate of completion. The effectiveness of some corrective actions documented in the Pantex tracking system has been questioned by certain reviewers. In general, Pantex reported to OTA that it has responded to health and safety problems identified by the Tiger Team, through a variety of measures, including:

- increased personnel and budgeting;
- new policies to integrate health and safety into operations (environmental, safety, and health review system; computer tracking system);
- development of a site-specific RADCON manual and implementation plan to comply with new DOE requirements; and
- increased opportunities for communication between labor and management, and improved responsiveness of management to labor concerns (6).

A Progress Assessment of Pantex actions to address Tiger Team findings was conducted by DOE headquarters Office of Environment, Safety, and Health in March-April 1993. This assessment focused on four issues: 1) worker safety, 2) transportation of hazardous materials to and from Pantex, 3) high explosives, and 4) management of criticality safety. It concluded that Pantex has accomplished much in setting up new procedures at the facility, but the efforts are not well coordinated and implementation is lagging. One of the problems noted was a lack of independent DOE review of explosives safety. Lack of a program for transporting hazardous materials was also considered a problem. The lack of a formal program description for criticality safety was cited as an issue, although no workplace problems were identified in complying with procedures established by the nuclear weapons design laboratories. Regarding worker safety, M&H was considered to have an excellent program, and major improvements were identified in industrial hygiene; however, many safety problems were identified in construction projects managed by the U.S. Army Corps of Engineers (2).

DOE's own efforts at reviewing progress at Pantex have been constrained and fragmented in the past. Responsibility for internal oversight was divided between the Offices of Environment, Safety, and Health and Nuclear Safety (NS). Differing priorities of these two offices led to difficulties in coordinating facility reviews (25). Furthermore, beginning in September 1992, EH was required to give 60 days notice before inspecting a facility (71). This requirement delayed the Tiger Team Progress Assessment of Pantex (25).

Under the Clinton administration, Secretary of Energy Hazel R. O'Leary has made some changes. Nuclear Safety is again part of the Office of Environment, Safety, and Health, and the 60-day notice requirement for assessments has been rescinded. A number of other initiatives are under way to increase the independence and effectiveness of EH.[5] These initiatives and changes in headquarters oversight responsibility should be followed to see if they improve the ability of DOE to address important matters that cross the boundary between nuclear and nonnuclear issues, such as high explosives contaminated with radioisotopes, mixed waste, and the overall conduct of safety analyses and criticality safety.

A review of recent contractor performance evaluations can provide an understanding of environmental, safety, and health concerns at the dismantlement sites. DOE field offices routinely conduct performance evaluations of their M&O contractors (73). The Pantex evaluation for April-September 1992 reveals improvements as well as continuing deficiencies. The most notable improvements are in radiation safety and management attention to areas that can affect future operations at Pantex, including public affairs, environmental restoration, and nonradiological health and safety of workers. With regard to radiological protection, measures have been taken

[5] **The May 5, 1993,** Health and Safety Initiative includes developing a departmental safety and health policy; establishing the authority of the Assistant Secretary for Environment, Safety, and Health to force cessation of unsafe operations; rescinding the 60-day notice requirement for environmental, safety, and health assessments; developing a departmental "fatality policy" with strengthened investigation procedures; establishing employee-management health and safety committees for all Department sites; accelerating issuance of Price-Anderson nuclear safety rules; and initiating consultation with OSHA with the aim of establishing OSHA regulation of all Department sites (72).

to reduce employee exposures and waste handling requirements associated with dismantlement operations.

Improvements were made in radiation safety records, radiation worker training, and Radiological Assistance Team capabilities for emergency response operations. However, the evaluation report criticized other aspects of the emergency response program.

Some problems noted in the report illustrate how a lack of management attention to environmental restoration program activities affects worker health and safety. For example, a cleanup operation was delayed because of workers' not following the approved Health and Safety Plan, inadequate quality assurance for sampling, and improper placement of groundwater monitoring wells. These problems were attributed to inadequate oversight of a subcontractor. Also, potential noncompliances with RCRA were noted that could result in enforcement action from the Texas Water Commission.

DNFSB devoted considerable resources to Pantex in 1992, including several site visits and a full-time on-site representative (14,15). Site visits in March and August 1992 critiqued the status of safety analyses and criticality analysis at Pantex, and found that only a few Pantex facilities were covered by these programs. DNFSB also found that DOE's explosive safety guidelines did not give sufficient emphasis to nuclear material releases resulting from operational accidents that could occur in the disassembly cells. DNFSB identified concerns with the overall safety attitude during dismantlement operations, given the apparently wide latitude of disassembly workers to use their judgment instead of consulting a supervisor in the case of abnormal situations. DNFSB noted that disassembly technicians do not appear to be trained to question an operation that is not proceeding as expected. DNFSB also noted a need for criticality experts at Pantex to participate in the Nuclear Explosive Safety Study Group (NESSG) that reviews and approves all weapons assembly/disassembly procedures.

DNFSB staff has found both DOE and M&H to be responsive (40). One formal recommendation has been issued as a result of this review. It notes that there is now a discrepancy in nuclear safety requirements between facilities that produce and process fissile materials, and those such as Pantex that assemble, disassemble, and test nuclear weapons. DNFSB has recommended that DOE review its nuclear safety orders and directives, develop a plan to make nuclear safety assurances comparable at both types of facilities, and give priority to a site-wide compliance review at Pantex (13).

Y-12 PLANT

Numerous health and safety problems at Y-12 were identified by the DOE Tiger Team in its February 1990 report, including:

- slow progress in correcting procedural problems,
- slow progress in correcting training problems,
- radiation protection deficiencies,
- inability to attract and retain competent staff,
- numerous OSHA violations and a failure to follow basic safety guidance, and
- insufficient management attention to the environment, safety, and health (67)

The Tiger Team noted that Y-12 management paid insufficient attention to safety and health because it believed that new requirements were not cost-effective or necessary to protect worker health and safety, or that DOE did not really expect strict compliance with health and safety orders. Managers pointed to minimal DOE oversight, insufficient budgets from headquarters for health and safety, and the age and condition of Y-12 facilities, which make process alterations costly.

In February 1992, DOE returned to Y-12 for a selective review of environmental, safety, and health management systems and programs (84). In general, this assessment concluded that significant progress had been made in improving health and safety programs since the Tiger Team review, although some programs were still not in compliance with DOE requirements. Two key concerns were identified during this review: 1) insufficient formality and rigor in DOE and contractor oversight activities to ensure that environmental, safety, and health problems were identified and addressed effectively; and 2) inadequate use of available management tools by the contractor to correct environmental, safety, and health problems in this area.

The DOE Progress Assessment Team also identified some strengths at Y-12, including a Self-Assessment Program (lessons learned and alert system, division-level self-assessments, training curriculum), the ORR, and the Quality Assurance plan for the Nuclear Criticality Safety Department (84). However, the ORR process was found deficient by the DNFSB, as discussed below.

Y-12 has responded to Tiger Team criticisms by reorganizing and creating a new branch responsible for the environment, safety, and health. A new mission statement and strategic plan were as developed by the prime M&O contractor, Martin Marietta Energy Systems (MMES), in June 1991. Under the new organization and with the use of the ORR process that the Tiger Team identified as a strength at Y-12, environmental, safety, and health reviews are now integrated into the procedure for obtaining an internal license to begin a new operation. In the past, criticality safety was a major part of the review for new operations, but other health, safety, and environmental provisions were handled independently and often were not explicitly included in operating procedures. Training was the mechanism relied on to ensure workers were protected, but there were weaknesses in training too.

As of January 1993, Y-12 had established policies for integrating health and safety procedures into its operations. It is in the process of updating operating procedures, but this is time-consuming. In the dismantlement program, a project management team is established for each new weapons system that comes to Y-12 for dismantlement. Teams are composed of engineers, industrial hygienists, and health physicists, who define operating procedures, including health and safety. Updating procedures for dismantlement is expected to be completed in 1995-96. In the meantime, procedures are not considered to be ‘‘audit ready, ’ and the health and safety aspects of operations depend on worker training (36).

In the performance evaluation of the Y-12 Plant (April to September 1992), DOE noted that-overall-safety and health programs were satisfactory, effective, and cost-efficient, consistent with DOE orders and applicable Federal, State, and local regulations providing protection for workers and the public (81). Individual health and safety programs were rated as good for industrial hygiene, nuclear facility safety, industrial safety/OSHA upgrades, nuclear criticality safety, and fire protection. Satisfactory ratings were also given for general safety and health, health physics/radiation protection, occupational medicine, and transportation safety.

However, implementation by direct line managers of programs, policies, and procedures to ensure protection of the environment, safety, and health, as well as quality, was rated as marginal. A marginal rating indicates a poorer performance than expected and has the potential to reduce the CPAF that could be received. Line management’s commitment to a safe and healthy work environment was questioned because of the number, severity, and frequency of deficiencies in the implementation of safety and health programs, especially in radiation protection and contamination control.

For example, significant deficiencies identified included: 1) inadequate posting of respirator areas, which allowed personnel to enter areas without proper respiratory protection; 2) reentry of areas evacuated due to loss of ventilation, without respiratory protection or survey by health physics and industrial hygiene; and 3) criticality safety deficiencies associated with assessments

that do not accurately reflect actual storage conditions, criticality safety procedures that do not incorporate actual requirements, and lack of review or approval of procedures (81).

On the other hand, there has been some notable progress in health and safety at Y-12 on the specific aspects of dismantlement of one weapons system (W-33). A new procedure was developed for dismantling a system that used existing chemical processes to remove protective coatings from parts, eliminating the generation of a new mixed RCRA waste (81).

To date, DNFSB has devoted fewer resources to Y-12 than to Pantex, and it conducted four site visits at Y-12 in 1992. Site visits in early 1993 identified continuing problems and lack of improvement in many areas. Staff concerns included compliance with orders/standards especially for radiological control, the ORR process, and training.

The problems with ORRs are notable because this area had been identified as a strength by the DOE Progress Assessment described above. The DNFSB criticized the ORR process at Y-12 in a March 1993 site visit. Inconsistencies with Board recommendation 92-6 were noted in several areas, including independence of senior members, scheduling, review criteria, and review team makeup (22).

There are other apparent discrepancies between DNFSB and internal DOE reviews. Despite satisfactory ratings in radiation protection in the April-September 1992 performance evaluation discussed above, DNFSB has identified continued deficiencies in radiological control practices at Y-12 vis-a-vis requirements found in DOE orders. The DNFSB requested a report from DOE evaluating the technical adequacy of radiological control practices compared with DOE and consensus standards, and a second report on plans to address longstanding problems of compliance with DOE orders (23).

Radiation Protection

Radioactive materials in nuclear warheads require measures to control health risks from occupational or environmental exposures for thousands of years. The radioactive half-lives (i.e., the time required for one-half of the material to undergo radioactive decay) of uranium-235 (the principal isotope in highly enriched uranium), plutonium-239, and plutonium-240 (the principal isotopes of plutonium in weapons) are approximately 700 million, 24 thousand, and 6.5 thousand years, respectively. The actual risk posed by a radioactive material is a combination of the material's half-life, the radiation emitted during decay, and its quantity. All three of these isotopes decay by the emission of an alpha particle accompanied by the emission of very weak x-rays. Uranium decay is also accompanied by the emission of some moderately energetic gamma-rays. There may also be some quantities of plutonium-241 present that decay to americium-241, which has x-ray and garoma-ray emissions accompanying its decay. The health effects of different types of ionizing radiation are described in box 3-D.

Alpha particles are easily stopped by materials as thin as a piece of paper, and x- or garoma-rays are shielded by the structural material surrounding intact warheads. Although there may be some exposure to penetrating external radiation from x-or garoma-rays during disassembly, the primary hazard arises from internal deposition of these isotopes via inhalation or ingestion, where the alpha particles are able to expose cells in internal organs, such as those lining the lung. Once inside the human body, alpha particles are much more damaging to surrounding tissue than other forms of penetrating radiation.

Harmful health effects are not likely to occur from being near plutonium unless one inhales or swallows it (88). Absorption through undamaged skin is limited, but plutonium can enter the body through wounds. Exposures are not likely from intact pits, which are usually clad with a protective coating. However, plutonium metal oxidizes rapidly in moist air or moist argon, forming a powdery surface coating. The corrosion or oxidation of plutonium does not always occur in a predictable manner and is affected by many variables, including the surrounding atmosphere, moisture content, and alloys or impurities present in the metallic plutonium (60). Uranium metal also oxidizes in air to form a coating that is easily removed as dust during handling of the metal (60). Plutonium oxide and fine particles of uranium metal can be a fire hazard because they are pyrophoric. Both the dust and the fires can result in inhalation hazards.

If ingested with food or water, most plutonium is poorly absorbed by the stomach and excreted. If inhaled, the amount remaining in the lungs depends on the particle size and form. Forms that dissolve easily may be absorbed and move to other parts of the body. Forms that dissolve less easily are often coughed up and possibly swallowed. Plutonium may remain in the lungs or move to the bones, liver, or other organs. It generally stays in the body for decades and continues to expose the surrounding tissues to radiation, which may eventually cause cancer. Cancer risks are naturally related to the level of exposure, but studies on the effects of low levels

Box 3-D-Health Effects of Ionizing Radiation

Radionuclides, such as the plutonium and uranium used in nuclear weapons, produce ionizing radiation that has the potential to cause biological damage. The material below represents a synthesis of information obtained by OTA (27,28,38,56,58,64).

Ionizing radiation is the transfer of energy through space in the form of either electromagnetic waves (e.g., x-rays, gamma-rays) or subatomic particles (e.g., alpha particles, neutrons) that are capable of separating electrons from their atomic or molecular orbits. Biological systems are highly structured and specific at the molecular level. The consequence of changes due to ionizing radiation is usually damaging to the function of the cell, tissue, or organ involved.

Cell damage from ionizing radiation maybe reparable and cause no long-term problems, be imperfectly repaired and cause cel death, or be imperfectly repaired and lead to a modification in the ceil, as discussed below. There is scientific controversy about the quantitative probability of adverse health effects due to lowdose exposure.

Reparable ceil damage from ionizing radiation implies the existence of a dose threshold, or safe dosage, below which cells incur no damage from radiation exposure. This is a controversial issue in terms of low doses of radiation from gamma- and x-rays. There is solid scientific evidence that repair is far from perfect for high radiation doses and for doses from alpha particles.

Cell death may or may not adversely affect the functioning of tissues and organs. Most are unaffected **by** losses of even large numbers of cells. Radiation damage leading to cell death primarily affects nuclear DNA. Tissues that normally divide all the time (i.e., gastrointestinal tissue and bone marrow) are the most radiosensitive. These effects are nonstochastic or *deterministic:* the severity of the effect increases as the radiation dose increases.

Health effects on modified cells from ionizing radiation are best studied for cancer and birth defects. These effects are also sfochastic the likelihood that such an effect will occur increases as the radiation dose increases. Other effects have not been well studied (e.g., radiation that initiates inflammatory reactions in blood cells).

ionizing radiation is classified into different categories for purposes of determining health **effects** and appropriate protection measures. Penetrating *or external radiation,* including x-rays, gamma-rays, and neutrons, can travel long distances and penetrate dense materials. To protect tissues from such radiation, shielding is used. *Particu/ate radiation* includes electrons, protons, alpha particles, neutrons, negative pi mesons (used for therapeutic radiation treatment), and heavy charged ions. Much particulate radiation is easily stopped by thin

barriers, such as apiece of paper or skin, and can do biological damage only if deposited within tissue where it is referred to as an internal emitter. (Neutrons are an exception because they are also a form of penetrating radiation.)

Internal emitters are radionuclides that are taken into the body via inhalation, ingestion, or **skin wounds. Once** absorbed, the radioactive particles, depending on their half-life and decay chain, continue to emit radiation **and potentially** kill or alter cells for askmg as they are lodged in the body. Internal emitters maybe metabolized in ways that result in the radionuclide's becoming deposited in tissues for long periods.

The biological effects of internal emitters and penetrating radiation depend on the type and amount of radiation involved. Consequences of internal emitters also depend on the physical and chemical form of the radionuclide, the route of exposure, and metabolism. Small, soluble particles are generally the worst. Large particles are often removed from the body by natural processes, depending on the exposure pathway.

It is very difficult to determine the doses, effects, and risks associated with exposure to radiation. The biological effect of radiation correlates with dose but also depends on several other factors. **Identical doses of** different types of radiation, delivered in identical temporal patterns, produce different biological effects, even though the same amount of energy is delivered.

The type of radiation is especially important because of variations in the spatial distribution of the energy released. The "track" of a radioactive particle or wave is the set of all transfers of energy produced. Linear energy transfar (LET) is the amount of energy transferred and its spatial distribution per unit length of particle track (i.e, the amount of energy transferred **per unit path traveled).** Low-LET radiation (x-rays and gamma-rays) deposits energy throughout the cell in a diffuse pattern. High-LET radiation (alpha particles and neutrons) deposits energy in a much smaller volume, along fewer narrow, but dense, tracks. Biophysical data suggest that the ability of radiation tracks to produce damage in closely adjacent atoms and molecules determines the biological effect. Radiation types that produce dense patterns of ionization do more damage than those that spread the ionization over larger areas. Thus, alpha particles and neutrons will cause more damage than the same dose of gamma-rays, x-rays, and most beta radiation. A single track from a low-energy x-ray will produce about 1,000 ionizations along its length. High-i&T radiation, such as an alpha particle, will produce about 1,000 times more ionization **per unit distance, and large amounts** of energy will be delivered to a very small molecular volume of tissue. High-LET radiation tracks cart produce energy deposition patterns and concentrations that are improbable or impossible for low-LET tracks. Such patterns could translate into qualitatively different molecuiar biological effects.

SOURCE: Office of Technology Assesetment, 1993.

of plutonium exposure are inconclusive. Animal studies link plutonium exposure to cancer and decreased ability to resist disease (88). It is not clear whether plutonium causes birth defects or reproductive problems.

The ingestion and inhalation hazards associated with weapons-grade uranium are considered the primary radiation hazard. Cancer risks due to enriched uranium are not known; however, there is some evidence that very long-term, low-level exposure to insoluble uranium causes increased risk of lung cancer (88). The chemical toxicity of uranium is a health concern, especially for soluble compounds that can cause kidney damage, but this is not the paramount concern when handling weapons-grade uranium metal, which is relatively insoluble (37).

Protecting workers and the public from exposure requires effective programs to prevent:

- criticality,
- unnecessary radiation exposures, and
- the unplanned release of radioactive material **(60).**

This can best be accomplished with well-trained workers functioning in well-designed, maintained, and monitored facilities with programs and policies that emphasize health and safety. DOE has recently upgraded its programs for radiation protection with the development of a new manual for radiation control. The new manual is a response to criticisms levied against DOE by numerous oversight bodies, including the Advisory Committee on Nuclear Facility Safety and the DNFSB (1,11,80).

Each DOE facility has been required to develop a compliance assessment and implementation plan (70). DOE progress in implementing this recommendation has been criticized repeatedly by DNFSB, although part of the problem may simply be associated with changing leadership of the Department (20). Major criticisms relate to DOE efforts to make organizational changes to ensure that excellence in radiation protection is a continuing priority and that the RADCON manual is not just a one-time effort to upgrade DOE programs (10). DNFSB is particularly concerned that appropriately trained people and adequate resources for radiation protection are available at all levels of DOE. Apparently, part of DNFSB's difficulty in evaluating the adequacy of DOE's response to its recommendation on radiation protection involves problems of access to the implementation plans of individual facilities.

OTA was able to obtain a draft copy of the implementation plan for Y-12. According to the plan, implementation of the DOE RADCON manual will require significant changes in Y-12 Plant facilities, equipment, and operational procedures (47).

Substantive changes are necessary for radiological assessment of the workplace, control of contamination, and employee awareness and understanding of radiological conditions and events. Y-12 does not anticipate being in substantive compliance until 1997. Although the plan lays out priorities and cost estimates, some significant costs are not included. Funding needed to address the requirements for containment and ventilation of existing equipment and facilities does not appear in the plan.

The DNFSB reviewed progress in implementing the RADCON manual at Y- 12 in March-April 1993 (23). It noted a lack of technical justification for actions taken and for decisions made to defer or take no action. Major problem areas identified included contamination control (personnel monitoring, anticontamination clothing, break areas, personnel decontamination); training (facility-specific and core radiation worker); and occurrence reporting (skin contamination, clothing contamination, and compliance with a revised DOE order). Apparently, the DOE Oak Ridge Operations Office and its major contractor do not believe they have the resources to implement many of the mandatory requirements in the RADCON manual. DNFSB notes that Y-12 lags behind other DOE facilities in implementing the manual (23).

Worker Concerns About Health and Safety

The change in DOE culture to emphasize health, safety, and environmental concerns rather than production goals has been under way for several years. Internal and external oversight reports note accomplishments and the need for continuing improvement. Few of these reports, however, identify the views of workers and their sense of cultural change. OTA sought worker opinions on these changes through interviews by an anthropologist with labor representatives at DOE facilities (see appendix E).

Workers identified a number of areas as evidence that DOE and site managers are truly committed to improving health and operational safety, including more active DOE presence at individual facilities, greater contact with the union, and willingness to shut down a line if employees have a problem with a standard. Workers also cited more opportunities to resolve health and safety complaints, as well as greater responsiveness from management. Training improvements were noted.

However, several topics were identified as needing improvement, including unclear leadership and inconsistent enforcement; limited worker participation in developing improved procedures;

insufficient interaction between DOE and labor; budget limitations for implementing needed improvements in facilities; overburdened health and safety staff; continued fear of retribution for raising problems; deficiencies in health physics programs, policies, and instrumentation; and training problems.

A key question for many workers is whether all changes in health and safety practices are necessary, and whether increased oversight may at times contribute to the level of stress experienced by workers and thereby reduce overall job safety. Many of the changed procedures appear to be paperwork exercises that do not clarify the job of the worker. At the Pantex Plant, improvements are under way to make the standards more user friendly: for example, engineers visit the work floor, and workers participate in some procedure validation teams. Greater worker involvement in the development of procedures is desirable. Worker involvement has led to improvements that have reduced employee radiation exposures during dismantlement activities, and in one case, problems were encountered during a test of dismantlement procedures because of insufficient consultation with workers who had operational experience (73,81).

From a worker perspective, the change in emphasis from production only to concern for health, safety, and the environment can be aided significantly by improving opportunities for worker involvement in all levels of decisionmaking. The use of specially trained workers as health and safety representatives is viewed as a key to making worker concerns known to managers who have the authority to correct a problem. Worker empowerment is one of the new safety and health initiatives announced by the Secretary of Energy in May 1993. Guidance from EH to program offices and operations offices on establishing meaningful employee-management safety committees is planned to be implemented late in 1993.

I Environmental Issues

Widespread environmental contamination with special nuclear materials during dismantlement activities is considered by DOE to be highly unlikely. Potential sources of such widespread contamination-however unlikely-include an inadvertent nuclear detonation, a criticality accident, or the scatter of nuclear materials from an explosion that does not cause a nuclear chain reaction. This conclusion is based on the record of handling and dismantling weapons in the past, analyses of risks conducted in Safety Analysis Reports (SARs), and criticality studies conducted by Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL).

Although no major releases of special nuclear materials have been documented from Pantex dismantlement activities, because of the potential impact of major environmental contamination from dismantlement operations, there is concern that DOE should be far more aggressive in reducing the likelihood of such an occurrence. Reviewers of DOE operations have found fault with existing SARs, noting that they require updating (67,68), and have criticized some of the assumptions made about risk factors (e.g., the airplane crash scenario in the new SAR draft for double stacking plutonium pits in Pantex bunkers). DNFSB has formally expressed its reservations with Pantex SARs on two separate occasions and continues to review the SAR program at Pantex (15,18).

There is also concern by DNFSB about criticality safety at Pantex. The concern is primarily whether Pantex has sufficient rapid response capability to take care of any off-normal conditions associated with a warhead that may not be intact (41). DNFSB concerns stem from a lack of progress at Pantex on implementing DOE's own recommendations to improve criticality safety, which were identified in Defense Program's Technical Safety Appraisal (TSA) of Pantex in March 1992 (17). DNFSB required a report from DOE on progress in implementing TSA recommendations. The DOE response emphasizes that the design laboratories have not identified any credible potential for a criticality incident. However, DOE will implement its orders for SARs and criticality safety at Pantex, which were previously considered nonapplicable. Satisfactory implementation of these DOE orders, according to DNFSB, will result in significant upgrading of these areas. Pantex is also actively recruiting additional criticality staff. The ability to independently review design laboratory criticality analyses is delayed until the completion of a facility for classified computer operations scheduled for November 1993 (4).

A more recent review of criticality safety at Pantex was included as part of a Tiger Team Progress Assessment conducted by DOE's Office of Environment, Safety, and Health in March-April 1993. This assessment concluded that there were no workplace problems with criticality procedures (defined by the nuclear design laboratories); however, neither was there a good program description as called for by industry standards (2).

Experts at LANL conclude that the risks of a criticality accident at Pantex are extremely low, given that plutonium is present as a metal in well-defined shapes and stored in canisters in well-defined configurations (54). Criticality accidents are much more likely to occur during processing or management of liquid forms of plutonium or uranium as opposed to solids.

At Pantex, removing high explosives from intact weapons is one of the operations posing the highest risk of an accident that could scatter nuclear materials. However, these activities occur in special enclosures designed to contain explosions and releases. Once the nuclear materials have been separated from the explosives and detonators, the risks of explosion are significantly reduced.

The more likely sources of environmental contamination from dismantlement activities include:

- operational emissions,
- waste management practices,
- contamination from past practices, and
- contamination from old facilities.

The following discussion of environmental issues at Pantex and Y-12 offers examples from the sites most involved in dismantlement and is illustrative of the entire Weapons Complex.

PANTEX PLANT

One of the most likely sources of environmental contamination from projected warhead dismantlement operations at Pantex is the continued open burning of chemical explosives. This practice is used to separate some chemical explosives from other warhead materials that may be recycled or handled as waste, as well as to destroy some chemical explosives. Since 1943, Pantex has operated the Burning Grounds Facility for the combustion of high explosives or waste materials contaminated with high explosives, and for the disposal of scrap metal and other salvable weapons components (26,48). Liquid materials, including solvents, have also been burned there (52).

After burning, the remaining residue or ash from HE materials that are hazardous, and therefore subject to RCRA regulation, is collected and shipped off-site to a permitted facility for disposal (26,53). The scrap metal recovered after the burning of high-explosive materials and weapons components is collected for inspection and subsequently transported to another Pantexbuilding for processing.

Emissions limits have been established for open burning operations. To reduce future emissions, RCRA permit conditions may become more restricted (45,63). Not all of the contaminants contained in materials burned at Pantex are covered by such permits. Radioactive emissions are subject to DOE orders within the facility boundary. Additional emissions from an increased rate of burning chemical explosives will also bean issue if certain warhead dismantlement activities are accelerated. Since 1988, however, DOE has taken action to keep the total amounts below annual permitted emission levels (29).

Another concern about continued open burning of chemical explosives is the release of toxic, volatile forms of fluorine. These are produced from burning chemical explosives that contain a fluorine-based plastic binder (3). Control measures have been implemented to reduce fluorine emissions, but the contamination potential may continue to exist within the Burning Grounds since fluorine limits apply to the entire facility rather than to individual burning units.

Pantex has traditionally handled disposal of some of the waste materials generated from dismantlement activities itself and shipped other materials off-site, either to different DOE facilities or for commercial disposal. Figure 3-2 shows the general disposition of waste materials from Pantex. Proper handling of wastes from dismantlement to prevent environmental contamination is now a Pantex responsibility that, at least for some materials, is subject to the scrutiny of State regulators.

Ongoing nuclear warhead dismantlement at Pantex generates parts that contain chemical explosives, special nuclear and hazardous materials, and classified components. From a regulatory perspective, dismantlement waste can be categorized as hazardous, radioactive, mixed (combined radioactive and hazardous), and nonhazardous. Nonhazardous waste includes scrap metal and trash. Scrap metal parts are collected and transported off-site by 'outside bidders' for recycling (26), and trash is disposed of in landfills (75). Box 3-E describes how Pantex handles waste categories. Nuclear materials including plutonium, highly enriched uranium, and tritium are not classified as waste because they are currently considered assets by DOE (29).

Activities of M&H that involve the packaging and transportation of hazardous materials and wastes must comply with applicable DOE guidance. Recent inspections by DOE have raised concerns about M&H's inability to segregate wastes adequately, to provide clear shipping documentation, and to provide safe storage for radioactive mixed waste at certain facilities (50). M&H's methods of tracking stored explosives ". . . do not permit verification that explosive limits in storage areas are not exceeded," and written procedures for operations involving explosives lack review or expiration dates, and may not be reviewed as often as required. "Documentation seems to be the weakest point of M&H's explosive safety program" (49).

Environmental monitoring is being upgraded at Pantex in response to Tiger Team criticisms. The State of Texas and M&H are expanding environmental monitoring for both air and groundwater quality. However, there is still some controversy associated with new sampling strategies and quality assurance procedures (83).

One example of increased monitoring involves investigations to evaluate the potential contamination from past practices at the Burning Grounds. As part of the RCRA permit issued to the Pantex Plant in 1991, the Texas Water Commission requested DOE to investigate about 110 facilities, including the Burning Grounds, at which hazardous wastes were or are currently being managed, stored, or disposed. After a recent visual inspection of sites (e.g., percolation/evaporation pit, burn pads, and landfills) at the Burning Grounds (87), DOE plans to submit a RCRA Facility Investigation report to State regulators in July 1994 (57,66).

The start of this investigation has been delayed by the need for DOE to obtain permit modifications for mixed waste storage capacity to handle any waste from drilling mud (57). Depending on the extent of environmental impacts identified in the final report, the Texas Water Commission will recommend specific measures for DOE to solve any contamination problems (79). Pantex officials also plan to complete by September 1993 a report on closing certain operations at the Burning Grounds in accordance with National Environmental Policy Act requirements (75).

Box 3-E—-Waste Disposal at Pantex

Classified **Waste**

Classified parts must be declassified prior to treatment, recycling, or ultimate disposal to avoid disclosure of restricted data (8). Such parts are processed to declassify them at Pantex and then transported for recycling or ultimate disposal. Parts that cannot be declassified are transported to other DOE sites for disposal (e.g., the Nevada Test Site). The increasing cost of off-site management of such classified components has led to a plan to build a treatment processing, and declassification facility at Pantex. Before its construction, a classified hazardous waste staging facility will be used there.

RCRA-Regulated Hazardous Waste

Pantex warhead dismantlement activities generate RCRA-regulated hazardous materials. The largest RCRA-regulated waste streams include chemical explosives and chemical explosives-containing parts. Chemical explosives and parts are burned in the open at the Burning Grounds, and the ash is collected and **disposed at an** approved off-site RCRA Hazardous Waste Disposal Facility. Other contaminated materials are burned, and RCRA hazardous residues are accumulated at a permitted storage area. Mixed waste or radioactive waste residues are not expected from Burning Ground operations.

Radioactive and Mixed Waste

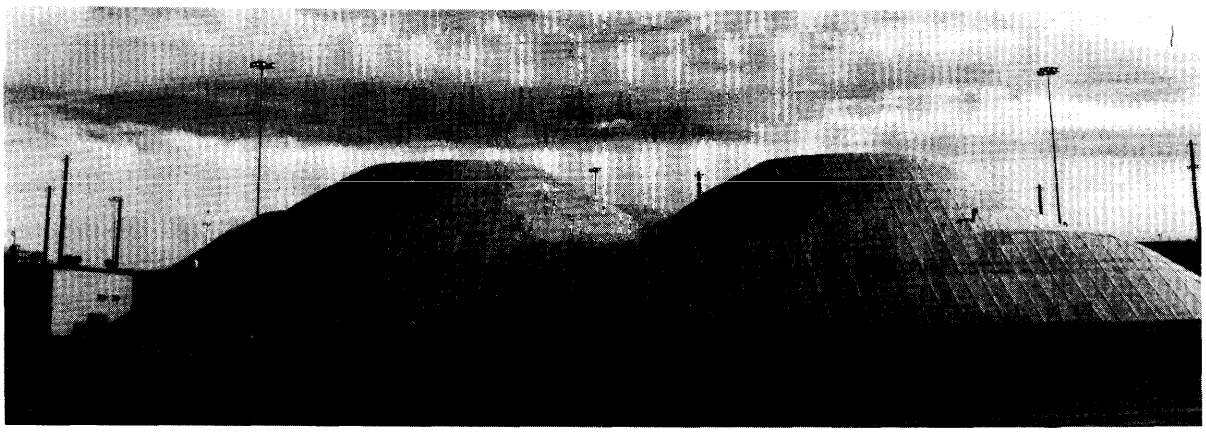
With the exception of waste **known to contain hazardous materials regulated under RCRA, all radioactive waste is transported** to the Nevada Test Site for disposal. Low-level radioactive waste generated at Pantex production and disassembly areas is generally in solid form. It is collected, packaged, labeled, and moved to storage bunkers to await off-site transportation. Mixed wastes are **currently** being stored on-site in permitted areas, pending development of treatrnent options. Little information is available about current storage capacity limitations, the management of mixed waste, the potential implications of increased weapons dismantlement, and costs associated with off-site treatment and disposal of mixed waste.

SOURCE: U.S. Department of Energy, 1993.

Most of DOE's Weapons Complex facilities, including those used for warhead dismantlement, were built more than 30 years ago. The facilities in use today have generally been upgraded, but some still employ processes and technologies that are inefficient and create large amounts of waste. Some are also burdened by the safety and environmental legacy of past operations. Identification of obsolete or inefficient DOE facilities and technologies will be critical for ensuring long-term safe management of the materials from warhead dismantlement. Determiningg which facilities must be upgraded or replaced will be a challenge. DOE has indicated that "piecemeal improvements have proven inadequate" (69).

The Burning Grounds at Pantex constitute a specific example of an obsolete and potentially dangerous facility used in the current warhead dismantlement program. Since 1943 it has been operated for incineration of high explosives, salvable weapons components, and materials contaminated with high explosives (including foams, plastics, metals, solvents, and trash) (48,63). Although the facility is permitted to operate through 2001, there are serious concerns about future and continued operation. Several studies are under way to evaluate current conditions and identify possible upgrades. However, it seems that extensive and costly modifications may not ensure long-term environmentally safe management of high explosives, and compliance problems could result.

The dilapidated condition of the Pantex underground sewer system is also a problem. In



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Explosion-resistant warhead disassembly cells at Pantex (Gravel Gerties).

addition to cracked or broken pipes, it suffers from excessive sediment deposits and blockages. The Pantex Tiger Team reported that the sewer system is obsolete and inadequate because it was originally constructed during World War II to accommodate the extensive flows associated with ammunition production, as opposed to the much smaller flows generated by current activities. Work is under way to replace some pipes; however, additional funding is required to support the program (33).

Y-12 PLANT

The Y-12 Plant at Oak Ridge, Tennessee is an industrial center that processed uranium and other materials for weapons production. Present activities also include processing and storage of uranium coming from warhead dismantlement. Like Pantex dismantlement activities, Y-12 processes generate classified, radioactive, hazardous, and nonhazardous wastes. Examples include machine turnings and metal fines; uranium- and beryllium-contaminated trash; waste solutions from metal plating; liquid waste and sludge generated by processing operations or waste treatment activities; and waste oils and solvents derived from machining and cleaning activities (86). These wastes are handled at Y-12 or transported off-site for treatment and final disposition.

The **list** of chemical substances—both radioactive and nonradioactive-used at Y-12 is extensive. This complicates monitoring of possible environmental releases into the air or water of contaminants from disposal operations at the plant. Some releases of toxic materials have been monitored. The processing and waste treatment operations at Y-12 discharged 884 pounds of uranium in 1990 to nearby surface water bodies and 46 pounds into the atmosphere in compliance with State permit conditions. Even though a new treatment facility has replaced depleted uranium land disposal, contamination from past land burial practices remains unresolved. Another source of uranium emission is accidental ignition of enriched uranium chips or saw fines stored in nonprocess areas at uranium production buildings. For example, in December 1985 a basket containing nearly 8 pounds of enriched uranium chips caught fire, leading to the release of enriched uranium.

Operations at Y-12 have generated large quantities of low-level radioactive solid waste. In 1990, DOE reported generating 4.3 million pounds of low-level radioactive waste, or about 22 percent of the total volume of all contaminated waste (including hazardous waste) produced at Y-12 that year (86). Uranium is the most common radioactive waste material, but other radioactive contaminants were reported, including fission products, thorium, and transuranic elements. Mixed waste storage is a problem at Y-12 because of the limited availability of treatment technologies, storage capacity limitations, and an increasing inventory of mixed waste from site cleanup activities.

The generation and management of hazardous waste at Y-12 are regulated by the Tennessee Department of Conservation under RCRA authority. Because treatment and storage of this waste are conducted at several buildings under State or Federal permit, waste inventories are recorded in several different databases. As a result, making a quantitative estimate of plant-wide waste is difficult. Similarly, predicting future generation rates, or estimating current compliance status at Y- 12, is problematic because of the lack of consistent databases. Plans to adopt a comprehensive tracking system are under development.

RCRA compliance has been the most challenging environmental requirement for Y-12.[6] According to the Performance Evaluation Report for April-September 1992, Y-12 received outstanding or good ratings for all other environmental laws and a satisfactory rating for RCRA. The internal RCRA inspection program conducted by the M&O contractor has had difficulties obtaining adequate data and ensuring that RCRA is applied consistently (81).

Although operations at Y-12 have recently been reduced, it still faces several environmental problems based on past practices, including human and environmental health impacts of past radioactive emissions, adequate retrofitting of old facilities or building of new environmentally safe facilities, and provision of appropriate treatment technologies and storage for current waste inventories. There are growing numbers of interim and long-term cleanup projects under way at Y-12 to address environmental contamination from past activities. These remediation activities will have to be conducted concurrently with warhead dismantlement.

Ongoing environmental problems could impact future warhead dismantlement activities at Y-12. For example, ambient air levels of radioactive, inorganic, and organic materials are an ongoing problem. The 1990 Tiger Team assessment noted a lack of emission control and monitoring devices at several nonprocessing areas in uranium processing buildings. It also noted a lack of adequate documentation and control of radiological conditions at the Y-12 Plant; an incomplete survey of operational and radiological areas that are potential sources of worker exposure to radiation; and limited documentation to verify compliance with air emission regulations. There are no non-DOE Federal or State standards specifically for atmospheric emissions of uranium, although total radionuclide levels axe regulated through the Clean Air Act.[7] Future warhead dismantlement operations could affect ambient levels of radionuclides at Oak Ridge. Recent reports have noted a very slight increase in local airborne concentrations of radionuclides (86).

In addition, beryllium, processed at Y-12 in both metallic and oxide powder form, is a potential health hazard and environmental contaminant. Although ambient air levels of beryllium are below State regulatory standards, the Y-12 Tiger Team recommended that a new beryllium monitoring system be installed because the existing system was outdated (67). In addition to uranium and beryllium at Y-12, the release of volatile organic compounds, such as chlorinated solvents used as degreasers (mostly perchloroethylene), cleaners, and machining coolants, has

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6 Until the mid-198@ DOE maintained that the Atomic Energy Act exempted the hazardous potion of mixed waste from regulation under RCRA. A Federal court rejected DOE's position. See ***Legal Environmental Assistance Foundation v. Hodel*, 586** F. **Supp.** 1163 **(E.D.** Term. 1984).

7 **U.S.C.A.** (1251-1376 (West 1983, **Supp.** 1990)).

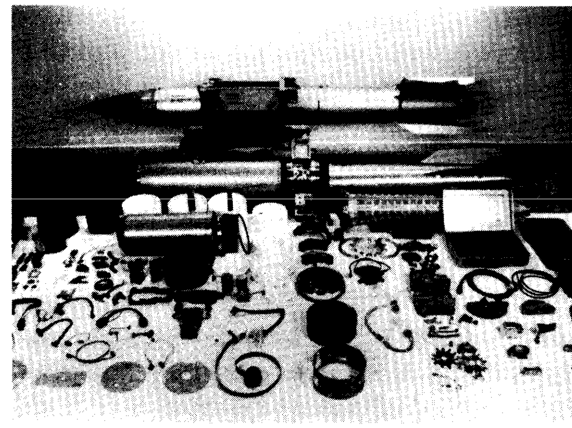
been reported. Substantial emission reductions have been accomplished at the plant since 1985, in part due to substituting less hazardous materials in certain Y-12 operations, as well as overall cutbacks in production (46).

CONCLUSIONS

Nuclear warhead dismantlement activities are ongoing at several sites in the DOE Nuclear Weapons Complex. The rate of dismantlement at the Pantex Plant has been reasonably constant over the past few years and is expected to increase only moderately in the future. The current rate of about 1,400 warheads per year has not put undue strains on the physical facilities, but material flows and waste streams have changed the focus of the operating plants. A key issue is whether or not the new systems now in place and under development to address environmental, safety, and health issues are sufficient to manage the dismantlement program. Clearly, there have been problems with past practices at dismantlement facilities. Many of these problems have been publicized in recent years, and efforts have been made to improve the situation. Improvements have been achieved in some areas, yet problems continue to be documented by both internal and external oversight activities. Several years will be required to integrate new policies and procedures into some operations, and DOE will need to continually review whether adequate progress is being made.

Resource requirements to implement environmental, safety, and health programs will be demanding and will continue for many years. Capital expenditures are needed to establish environmental monitoring programs and to improve plant conditions for workers. It will be important to ensure that these improvements are well planned and efficiently implemented.

The repeated criticism of lack of line management attention to environmental, safety, and health issues has been particularly troublesome. Improvements in programs for health physics,



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Many of the more than 6,000 parts contained in a B-61 nuclear bomb are displayed here, along with an intact weapon and its four major subassemblies,

industrial hygiene, and occupational safety are commendable, but it is unlikely that these programs will ever have enough resources and authority to get the job done without the additional support of the DOE Office of Defense Programs, which needs to devote more resources and attention to environmental, safety, and health issues. Providing support for greater worker involvement in the development of new procedures, more opportunities for worker control of health and safety during operations with the expansion of the Health and Safety Representative program, and additional opportunities for workers to communicate with DOE, not just with M&Os, may help DP become more proactive on these issues.

Nuclear weapons production history and recent developments in DOE operations have demonstrated that although some change is evident, continued scrutiny by outside parties will be necessary to ensure that progress continues in improving protection of the environment, safety, and health during dismantlement activities. Routine review or approval of plans by DNFSB prior to initiating new weapons dismantlement programs is desirable and may require legislative action to broaden the statutory scope of the Board. Additional resources to expand external Federal or State oversight into areas, such as health issues and environment monitoring, which are currently not the primary concern of DNFSB, are also desirable. Oversight by outside parties can add to the credibility of the review, given that there have been examples in which DNFSB has been more critical than DOE internal reviews.

Public credibility has the potential to become a major issue affecting the progress of dismantlement. Although DOE has acknowledged the importance of this in its evaluation of the Pantex program, no significant changes have been made in methods to communicate with the public, to understand public concerns, or to involve the public in decisions. Major attention must be given to this issue to ensure that public participation programs are effective. Not only must DOE and its contractors involve the public in their activities and decisions, but outside oversight bodies such as the DNFSB must also provide expanded opportunities for public participation.

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