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# Review of the Safety of Storing Plutonium Pits at the Pantex Plant

## Defense Nuclear Facilities Safety Board

### Technical Report



November 25, 1997

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## **Review of the Safety of Storing Plutonium Pits at the Pantex Plant**

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## Preface

In accordance with its enabling statute, the Defense Nuclear Facilities Safety Board (Board) continues to review the design and construction of new Department of Energy (DOE) defense nuclear facilities. This report is part of a continuing, long-term effort by the Board's staff to review plutonium pit storage facilities and related activities at the DOE Pantex Plant. This report reflects key events during the last 5 years, through November 1997.

In December 1997, the Board conducted an on-site review at Pantex and discussed issues related to safe pit storage with DOE and its weapon design agencies. During these discussions, DOE identified several new initiatives that are not covered in this report but could affect safe pit storage. The main body of this report was written before the December 1997 review, and so it does not reflect the changes in plans that were revealed during that review. The changes include the following:

- On November 4, 1997, the design agencies issued a draft pit storage specification with moisture controls. These controls, coupled with active cooling in facilities, will minimize pit corrosion and will likely require the pits to be stored in sealed containers. The latter would provide a second barrier against release of plutonium during postulated accidents.
- On December 3, 1997, and again on December 10, 1997, DOE informed the Board of DOE's goal to have all the pits in a dry environment within 3 to 4 years.
- On December 3, 1997, DOE also informed the Board that decisions regarding design modifications to the current pit containers (AL-R8) had been delayed by 2 months. Although this means that pits received from Rocky Flats will need to be repackaged, the delay provides DOE an opportunity to develop a consistent set of requirements.
- On December 5, 1997, DOE decided to increase the number of Zone 4 magazines with active cooling and to discontinue efforts to consolidate surplus pit storage in a single building in Zone 12 (Building 12-66). Despite intensive study since the January 1997 record of decision on fissile material storage and disposition, DOE has not shown that this consolidation would have provided a net safety improvement. Providing additional actively-cooled magazines will slow pit corrosion and protect temperature-sensitive pits.
- On December 10, 1997, DOE provided the Board an outline for an integrated pit storage program plan. Key elements of the plan are (1) assumptions and constraints, (2) requirements and success criteria, (3) program elements needed to meet those requirements, (4) organizational interfaces, and (5) deliverables, schedule, and cost. DOE expects to have a draft plan by the end of January 1998.

These initiatives will address some of the issues raised in this report, if they are implemented in a timely manner. The process of developing an integrated program plan also provides DOE an opportunity to systematically consider the remaining issues, which may ultimately improve the safe storage of pits.

## EXECUTIVE SUMMARY

A pit is the central core of a nuclear weapon, and typically contains an inner shell of plutonium and an outer shell of stainless steel or beryllium. This report examines the safety of the storage of plutonium pits at the Department of Energy (DOE) Pantex Plant by systematically considering pit containers, environmental controls, storage facilities, and surveillance programs. Taken together, these components, systems, facilities, and programs serve to protect the pits from damage and to contain any special nuclear materials that may be released from a breached pit. Failure of the pit outer shell, or clad, would allow corrosion of plutonium metal and formation of powdery oxides that could then contaminate the workers, the facilities, and the environment, if not contained.

DOE is currently using a new container design for some pits, developing another, less expensive container for the remaining pits, and making preparations to move thousands of pits to different storage facilities at Pantex. These efforts are not well integrated. For example, it appears that DOE has not evaluated completely how changes in container design affect storage facility requirements. Likewise, DOE has not assessed whether the near-term cost savings that result from implementing the less expensive containers, which are not certified for off-site shipment, will be outweighed by the costs and risks of possible repackaging later if off-site shipments are ultimately required.

In addition, DOE has not thoroughly evaluated the overall change in safety posture at Pantex that will result if, as planned, thousands of pits are moved from their current storage locations to different Pantex facilities. The current course of action being pursued by DOE could result in a Pantex facility being used to store the largest plutonium inventory in the DOE complex, but the chosen facility is not clearly adequate. A systematic review of the requirements for this storage facility needs to be performed.

Environmental controls are essential to preserve the integrity of several temperature-sensitive pit types. The lack of authorization basis controls for the storage of these pits renders at least three temperature-sensitive designs vulnerable to cladding failure. Pantex has implemented in procedures the safety-related temperature limits identified by the design agencies, but formal authorization basis controls would better ensure that the temperature control systems and practices are effective and reliable.

The relatively new surveillance program for pits stored at Pantex does not appear to be sampling the pits at a rapid enough rate to characterize in a timely manner the real potential for corrosion of the stored pits. Only about 30 pits per year are inspected, even though more than 10,000 pits of various designs are stored at Pantex. The resolution of corrosion and packaging issues is hindered further by the lack of a formal project to improve understanding of pit cladding corrosion and identify corrective actions that may be required.

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## 1. INTRODUCTION

A pit is a major nuclear weapon component and typically contains plutonium within an outer metal shell or clad. The Department of Energy (DOE) currently stores in excess of 10,000 pits at the Pantex Plant near Amarillo, Texas.

Since 1989, the pits stored at Pantex have been not only growing in number but also aging. Nearly all the pits are in containers that are not hermetically sealed, and most of these containers are stored in passively cooled magazines with essentially no confinement features. Therefore, the outer metal shell, or clad, of the pit functions as the primary confinement for plutonium, and for pits in magazines, the only reliable confinement.

Cladding failure would allow air to enter the pit, resulting in corrosion of the plutonium within. Normal Pantex operations do not involve unencapsulated plutonium, so a cladding failure would present several potential new hazards: (1) internal and external contamination of facility workers who might unknowingly open a package containing a failed pit; (2) potential facility contamination outside of an unopened pit storage container, since most containers are not hermetically sealed; and (3) an increase in the releasable quantity of plutonium if a major facility accident breached the clad. It is important that pits with breached clad be promptly recognized and mitigated, since plutonium oxides are much more dispersible than plutonium metal.

This report examines the safety issues associated with storing plutonium pits at Pantex by systematically considering pit containers, environmental controls, facilities, and surveillance programs. Section 2 provides background information and describes recent DOE activities related to pit storage and integrity. Design features and systems that prevent release of the plutonium from the stored pits are discussed in Section 3. Section 4 describes the surveillance programs intended to ensure the adequacy of pit storage conditions. Issues related to pit storage are discussed in Section 5. Conclusions are presented in Section 6.

## 2. BACKGROUND

This section provides an overview of pit storage programs and relevant correspondence between DOE and the Defense Nuclear Facilities Safety Board (Board).

### 2.1 OVERVIEW OF PIT STORAGE PROGRAMS

Nuclear weapons returned from the stockpile for inspection or dismantlement are shipped to the Pantex Plant, where the pits are removed. Until 1989, most pits removed from weapons at Pantex were eventually shipped to the Rocky Flats Plant (since renamed the Rocky Flats Environmental Technology Site) to be recycled into new weapon components. Plutonium operations at Rocky Flats were curtailed in 1989, and pits from dismantled weapons have been accumulating at Pantex since then. The increasing number of older pits has raised questions involving their safe storage at Pantex, particularly with regard to temperature-related failure modes for the pit clad, the lack of confinement for containers and facilities, and the capability of facilities to withstand externally driven accidents.

In 1992, DOE initiated several activities to ensure continued safe pit storage. These activities included (1) relocating most of the pits with identified safety-related temperature limits to two magazines with active cooling, (2) planning a surveillance program focused on pits removed from the stockpile and placed in storage, and (3) planning a repackaging program to place pits in a new type of container (AT-400A) that features a welded inner containment vessel filled with an inert gas. The AT-400A containers would protect the pits from corrosion and provide containment if the pit clad should fail. DOE also planned to certify these containers for off-site shipment. Eventually, DOE intended to repackage all pits into these containers for an interim period of approximately 20 to 40 years until a final disposition option is chosen and implemented. As discussed later, these initiatives have generated mixed results.

In 1994, DOE completed a plutonium vulnerability assessment that included pits at Pantex.<sup>1</sup> The final report states that the most significant plutonium vulnerability at Pantex is total reliance on the outer metal shell of a pit as the only barrier to prevent plutonium oxidation and release (Summary, p. 52). Furthermore, the report states that pits have not been tested or qualified for extended storage, and that detailed surveillance data are needed to understand potential failures involving joint designs, fabrication variations, and characteristics of aged material. At the time the DOE report was prepared, repackaging of pits into the sealed AT-400A containers was expected to mitigate many of these concerns. The Pantex-specific assessment indicated that repackaging was expected to start in 1995 and to be completed within 5 years (Volume II, Part 12, p. 9).

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<sup>1</sup> DOE/EH-0415, "Plutonium Working Group Report on Environmental, Safety and Health Vulnerabilities Associated with the Department's Plutonium Storage," November 1994.

In parallel with pit surveillance and repackaging activities, DOE has been developing plans to remove pits from Zone 4 and consolidate pit storage at Pantex in upgraded facilities in Zone 12. DOE described these plans in December 1996 in a programmatic environmental impact statement for fissile material storage and disposition (the storage and disposition PEIS), which was followed by a record of decision in January 1997.

The storage and disposition PEIS, the record of decision, and other program documents state that strategic reserve pits will be consolidated into the Special Nuclear Material Component Staging Facility (12-116) starting in May 1998, and that non-strategic-reserve pits (i.e., surplus pits waiting to be dispositioned) will be moved into an upgraded facility (12-66) by 2004, and possibly as early as 2001. Within about two decades, the surplus pits would be permanently dispositioned using facilities that could be built either at Pantex or at another site. The DOE storage and disposition strategy is, however, subject to a number of uncertainties.<sup>2</sup>

The upgraded Zone 12 pit storage facilities are required to protect the pits from postulated external threats ranging from earthquakes to tornadic missiles and airplane crashes. The planning documents cited above indicate that AT-400A containers will be relied upon to provide part of this protection. For example, the storage and disposition PEIS, under preferred alternative (p. 2-53), states that "...pits would be placed in storage in Zone 4 West pending availability of AT-400A containers and relocation to upgraded facilities in Zone 12 South." Another example is the discussion related to aircraft crash accidents in the 1996 Pantex Plant Final Environment Impact Statement (p. 4-309), which states "In the future, pits will be stored in a new container, the AT-400A, that will provide additional thermal and impact protection."

## **2.2 PREVIOUS DOE/BOARD CORRESPONDENCE ON PITS**

In 1995, DOE established the position that authorization basis controls on the pit clad, including temperature limits, are not required. The authorization basis is defined as those aspects of the facility design basis and operational requirements that are important to safety and relied upon by DOE to authorize operation. DOE based this position on the fact that analyses of accidents involving combined plutonium and high explosive assume no clad is present. DOE acknowledged, however, that the clad acts as a defense-in-depth barrier to release during long-term storage.

Beyond the clad, the next possible barrier to release is the container. In the same correspondence, DOE stated that safety classification for containers should be based on the results of contractor-supplied safety analyses.<sup>3</sup> Specifically, classification would depend on whether the containers fulfill a preventive or mitigative function that limits public exposure below

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<sup>2</sup> GAO/RCED-97-98, "Department of Energy Plutonium Needs, Costs, and Management Programs," April 1997.

<sup>3</sup> L. D. Rigdon (DOE-AL) memo to G. W. Johnson (DOE-AAO), dated October 26, 1995.



evaluation guidelines for postulated accidents. At Pantex, the evaluation guideline is interpreted to require that the maximally exposed off-site individual receive less than 25 rem committed effective dose equivalent because of an accident.

In a letter dated May 10, 1996, the Board commented to DOE that the pit clad is an important safety barrier, particularly for the protection of workers and the environment, and that implementing appropriate technical safety requirements (TSRs) would be consistent with the previous DOE plutonium vulnerability assessment. This assessment reflected the fact that Pantex safety analyses for operations involving pits but no high explosive routinely assume that the clad prevents plutonium oxidation before an accident occurs.

On July 15, 1996, DOE responded to the Board's May 1996 letter. The response stated that the pit clad is a design feature of the nuclear weapon and provides defense-in-depth, that clad breaches have been rare and resulted in insignificant consequences, that pits from sealed weapons examined as part of the Stockpile Evaluation Program have shown no corrosion, and that a surveillance program has been developed for pits in interim storage at Pantex.

In the same letter, DOE also stated that the Pantex contractor, Mason and Hanger Corporation (MHC), is monitoring and, in some cases, controlling pit storage temperatures as a prudent measure. Furthermore, there are air conditioners installed in two Zone 4 magazines to control temperatures in W48 pits—the only pit type considered at that time to require special environmental controls (as discussed later, two other pit types with safety-related temperature limits have subsequently been identified). DOE stated that controlling pit temperatures will provide the necessary assurance against clad failure during staging until the pits are repackaged in AT-400A containers or otherwise dispositioned.

### **3. THE PIT STORAGE SYSTEM**

The pit storage system at Pantex can be considered as a series of barriers to release (e.g., the clad, container, vault, and building) and the programs and controls associated with maintaining those barriers. In the past, DOE has required that at least one barrier be a confinement barrier for material that is not readily dispersible, such as monolithic plutonium metal (DOE Order 6430.1A). The degree of confinement is required to suit the most restrictive hazard anticipated. Typically, the clad or container is considered the primary confinement and is required to withstand normal operations, anticipated operational occurrences, and design basis accidents.

Pantex currently stores in excess of 10,000 pits. Most pits are stored in non-hermetically sealed AL-R8 containers in Zone 4 magazines that also provide little confinement. Several hundred pits in AL-R8 containers are staged in Zone 12 facilities (e.g., 12-44 Cell 8).

Although some pits reportedly have been at Pantex for decades, in the past most pits were returned to Rocky Flats to be recycled into new weapon components. Since 1989, when Rocky Flats discontinued receiving and remanufacturing pits, the Pantex pit population has been growing and aging. As a result, new questions involving long-term pit integrity have been raised, particularly for conditions beyond previous experience, such as long-term exposure to the environment outside of a sealed weapon.

#### **3.1 PIT INTEGRITY**

A pit contains an inner metal shell, typically plutonium, and an outer metal shell or clad, typically stainless steel or beryllium. The clad provides a hermetic seal, protects the plutonium metal from oxidizing, and prevents plutonium from migrating beyond the clad. In addition to confinement requirements, the pit clad designs are controlled by weapon design requirements that result in robust shells protecting the plutonium.

After a pit has been removed from a weapon, the pit clad is the only remaining confinement for the plutonium inside the pit. If the clad is intact, the predominant hazards involve external radiation exposure during normal handling or during an unlikely event, such as an inadvertent criticality. Pantex addresses these hazards by using shielding and administrative controls.

The pit clad has several potential failure modes. Corrosion by pitting can occur in the presence of moisture and chlorides, even though the pit clad is made of corrosion-resistant materials. Galvanic corrosion is also possible at joints involving dissimilar metals if the pits are not kept in a dry environment. Differential thermal expansion can induce stresses that could cause the clad for some pit designs to fail. Lastly, mechanical damage can occur during operations

involving pit handling or during postulated transportation and facility accidents. The design agencies have reported that most observed instances of pit damage have been due to mishandling.

If the pit clad were to fail, the plutonium inside would oxidize, become dispersible, and represent an inhalation hazard. These oxides could also swell and strain the clad since the oxides are less dense than plutonium metal. This process could lead to continued cracking of the clad and further oxidation of the plutonium. Atmospheric humidity would accelerate this degradation. This type of hazard has rarely been encountered at Pantex.

## **3.2 PIT CONTAINERS**

This section describes the containers commonly used to store or ship pits: the AL-R8, the AT-400A, and the FL containers.

### **3.2.1 AL-R8 Containers**

The current pit storage container used throughout Pantex, Rocky Flats, and elsewhere in the weapons complex is the AL-R8. The AL-R8 is an unsealed drum containing fiberboard packing material (Celotex) and a metal support fixture for the pit. The drum is made of carbon steel that is coated to minimize corrosion. The AL-R8s offer little confinement since they are unsealed and prone to corrode if the coatings are missing or become degraded.

AL-R8s are still used for on-site movement of pits, but are no longer certified for off-site transportation. For certification, the Nuclear Regulatory Commission now requires sequential application of a series of tests of hypothetical accidents, including (1) a 30 ft drop of the container, (2) a dynamic crush caused by dropping a 1100 lb load 30 ft onto the container, (3) a 40 inch drop of the container onto a 6 inch diameter steel bar, (4) a half-hour fuel fire, and (5) immersion under 3 ft of water (10 CFR 71.73). Pantex facility design documentation indicates that the AL-R8 does not meet the dynamic crush test.

### **3.2.2 AT-400A Containers**

In recognition of the fact that the AL-R8 is neither a reliable confinement nor a certified shipping container, DOE has developed an improved container, the AT-400A. The AT-400A is a stainless steel drum with a welded stainless steel inner containment vessel filled with an inert gas. The containment vessel would protect the pit from corrosion and prevent plutonium from migrating outside the container if the pit clad were to fail. DOE has intended but has not yet obtained certification of the AT-400A containers for off-site shipment.

DOE originally planned to repackage most pits into AT-400A containers. During 1997, DOE and MHC continued preparations for this effort. Major obstacles encountered late in the project included the need to design and install engineered safety features to prevent burn-through

of the inner containment vessel during automatic welding, which would potentially damage the pit. These obstacles have been overcome, and the first pits were repackaged in August 1997.

Over time, the scope of the AT-400A project has narrowed. At various times, the project's scope included manual, mechanical, and robotic packaging lines at Pantex, with a total capacity of about 2000 pits per year. At present, the maximum estimated throughput is about one-tenth of that. The project now consists of one manual line, rated at 20 pits per month, which may be replaced in the future by a mechanical line, rated at 40 pits per month. Current DOE program plans include repackaging only one pit type, the W48, into the AT-400A containers and only completing certification of the W48 configuration for off-site shipment. At current repackaging rates, it could take more than 2 years to repackage just the W48 pits.

The shift in scope of the AT-400A program from all pits to only the W48s was apparently driven by the high container costs, the recent decision to dispose of surplus pits within roughly two decades, and the uncertainty regarding whether future facilities for the final disposition of pits will be located at Pantex or elsewhere. To compensate, DOE has started to design a sealed inner container for the existing AL-R8s. Since neither the original nor the modified AL-R8 design is being certified for off-site shipment, this alternative is likely to require either overpacking current containers or repackaging pits (again) if facilities required for pit disposition are not located at Pantex.

### **3.2.3 FL-Type Containers**

Since 1991, the FL-type container has been the only design certified for off-site pit shipments. FL containers have stainless steel inner and outer vessels, separated by Celotex. The inner vessel has a bolted closure and a dual concentric elastomer seal. Because of the small number of FL containers (less than 300) and concerns about long-term degradation of the elastomer seal, these containers have not been considered for use for long-term storage.

## **3.3 PIT STORAGE FACILITIES**

This section describes pit storage facilities at Pantex. Currently, most pits are stored in the Zone 4 magazines. In 1996, a concept was proposed that would involve closing Zone 4 after 2002 and consolidating all the pits in Zone 12 facilities, thereby reducing Pantex security costs. As recently as August 1997, the driving motivation for this concept was a perceived need for only a few magazines past 2002. More recently, Pantex personnel have stated that Zone 4 closure in the near future may not be possible. Specifically, because of treaties now under consideration, magazines may still be needed to store weapons that are to be dismantled after 2002. Under this scenario, Pantex personnel consider that there may not be enough magazines to hold all the returned weapons and the surplus pits.

Regardless of the precise reason, DOE is now planning to consolidate all the pits in Zone 12 facilities, as identified in the storage and disposition PEIS and the corresponding record of decision. Strategic reserve pits, numbering up to 4000, would be stored in the Special Nuclear Material Component Staging Facility (12-116). The remaining pits, possibly as many as 12,000, would be moved to a hardened warehouse, the 12-66 facility.

### 3.3.1 Zone 4 Magazines

Zone 4 has 60 magazines used to store pits, nuclear weapons, and other major components. The magazines are of two designs: 18 are modified Richmond (MR), and 42 are steel arch construction (SAC). Approximately half the magazines are now used for pit storage.

An MR magazine is essentially a concrete box, with a center dividing wall and a 3 ft earth overburden. These magazines were built in 1944 and upgraded in 1961. The roofs are prestressed concrete. The internal dividing walls and the exposed front wall are reinforced, while the back and side walls are unreinforced. Both the MR and SAC magazines have doors made of steel plate that are blocked by massive reinforced concrete barriers. Each of the two sections of an MR magazine can hold 212 pits.

The SAC magazines were constructed in 1965 to U. S. Air Force specifications in adjacent groups of three or five. Each magazine consists of reinforced concrete end walls and a corrugated steel arch that is covered by a 3 ft earth overburden. The steel arch rests on reinforced concrete stem walls. Each SAC magazine can hold 252 pits.

Capacity to mitigate an aircraft crash remains an open question for many Pantex facilities, including the magazines. MHC has been evaluating this hazard at the site level using the approach from a DOE standard on aircraft crash accident analysis (DOE-STD-3014-96). MHC has already completed evaluations indicating that the magazines can withstand other design basis and beyond design basis events (e.g., 220 mph tornadic winds, a 0.33 g earthquake, and an accidental external blast).

Decay heat from pits results in magazine heat loads in the low kilowatt range. The magazines rely on passive cooling, except for two air-conditioned MR magazines that contain most of the W48 pits. In 1993, the design laboratories began defining maximum allowable storage temperatures above which the laboratories could not guarantee pit integrity or quality. In a parallel and coordinated effort, MHC initiated a temperature monitoring program for the pit magazines. This program has been one of the better managed and coordinated activities involving pits at Pantex. However, there are no authorization basis controls on pit or magazine temperatures or on maintaining active cooling for the two magazines containing W48 pits.

### **3.3.2 Special Nuclear Material Component Staging Facility (12-116)**

The 12-116 facility was designed in 1988, and initial construction was completed in 1993. The hazards associated with this facility will be attached to staging and inspection of pits, secondaries, and tritium reservoirs. The facility has never operated. A backfit design has been initiated to add new capabilities and correct existing design and construction deficiencies.

Operations are planned to begin in May 1998, but the need to resolve open safety questions will limit the facility's pit inventory until post-startup modifications have been completed. These modifications would also add capabilities such as the use of automated guided vehicles in the vaults to minimize personnel radiation exposure.

During the last 2 years, there have been major perturbations in the 12-116 backfit process. The major change since initial design has been a roughly five-fold increase in the intended pit inventory. The facility's primary mission has shifted from staging pits for weapon assembly to providing longer-term interim storage for as many as 4000 strategic reserve pits. During this time, other major functions and capabilities, such as a robotic pit packaging system for AT-400A containers, have also been planned and then withdrawn.

In general, the 12-116 structural design criteria were equivalent to or more rigorous than recent DOE requirements (see the Appendix). When completed, the 12-116 building design was controlled more by enhanced security requirements than by design basis accidents. This resulted in robust features such as concrete walls that are 2 ft thick with four layers of rebar reinforcement. Analyses have shown that the building would remain elastic and intact during design basis accidents, such as tornadoes, earthquakes, or blasts from nearby explosive facilities.<sup>4</sup> Furthermore, a DOE-sponsored review indicated that the building structure could meet code requirements for safety-class structures with only minor deviations.<sup>5</sup> The margin of safety that resulted from the enhanced security requirements is sufficient to compensate for these deviations.

### **3.3.3 Prospective Surplus Pit Storage Facility (12-66)**

The 12-66 facility was built in 1973 and is currently used to store weapon secondaries and other components. MHC is preparing a conceptual design for upgrading 12-66 to a surplus pit storage facility by 2002. Preliminary design (Title I) was expected to start in November 1997 but is now on hold. If 12-66 is upgraded as currently envisioned, it may potentially contain more plutonium than any other facility in the DOE complex.

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<sup>4</sup> Engineering Research and Applications Division, Brookhaven National Laboratory, "Structural Evaluation of Building 12-116 SNM Component Staging Facility at Pantex Plant, Amarillo, Texas," November 1995.

<sup>5</sup> Science Applications International Corporation, "Review of Pantex Building 12-116 Structure for Compliance with Current Codes for Safety Class Design and Construction," November 1995.

This facility is basically a hardened warehouse with outer walls made of 1 ft thick concrete with two layers of rebar reinforcement (i.e., half the wall thickness of 12-116). The roof is constructed of reinforced concrete and is supported by the outer walls and 21 internal columns. Other than the columns, the facility has no internal structure that could resist the lateral loads typical of accidents such as tornadoes and seismic events.

According to a 1996 MHC safety analysis report, the building was designed to meet 1970 Nuclear Regulatory Commission requirements for a tornado-resistant structure (i.e., 360 mph tornadic wind, 54 lb timber missile at 125 mph, and 3 psi differential pressure, dropping at 1 psi/sec). The safety analysis report indicates that the structure would not fail during a 0.1 g earthquake, but concrete cracking and spalling could occur. This loading corresponds to that of a Uniform Building Code essential facility, such as a fire station, with no confinement function. Some structural failure modes, such as column collapse, are not included in this evaluation.

## **4. PIT SURVEILLANCE ACTIVITIES**

This section summarizes routine pit inspections and pit surveillance programs at Pantex. DOE conducts several surveillance programs to evaluate the condition of pits. The extent of surveillance for each pit type depends on whether that type represents an active or retired weapon, or is considered to be a strategic-reserve pit. Historically, the principal purpose of pit surveillance was to ensure that the stockpile environment and aging of materials did not adversely affect weapon safety and reliability. However, as the number of pits from retired weapons stored at Pantex has grown in recent years, there has been a new emphasis on ensuring safe pit storage. This concern is particularly important because the precise condition of each pit after weapon disassembly is not well documented, and the long-term behavior of pits stored outside of weapons is not well characterized or understood.

### **4.1 ROUTINE INSPECTIONS AT PANTEX**

After each weapon is dismantled at Pantex, limited inspections are performed to assess the integrity of the pit before it is transferred to a storage facility. Each pit is inspected visually and checked for external contamination. Some specific pit types are routinely weighed. Some are leak checked, but only a fraction of the pits now in Zone 4 were leak checked before being moved to Zone 4.

Required periodic inspections of pit magazines at Pantex are unlikely to detect pits that have suffered cladding failures unless contamination migrates out of the pit container. Although the magazines are surveyed periodically for contamination, pit containers are not opened during these inspections.

### **4.2 PIT SURVEILLANCE PROGRAMS**

The design agencies, Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL), manage several programs that assess the condition of pits both in weapons and in storage containers at Pantex. The three key programs are (1) the cycle testing of weapons; (2) the shelf-life program, involving pits representative of active weapons and strategic-reserve pits; and (3) the storage surveillance program, involving pits stored at Pantex. Additionally, under the Enhanced Surveillance Program, DOE has been developing a methodology for predicting pit lifetimes. This work centers on age-related changes in special nuclear materials, and how aging phenomena affect the performance of weapons.



#### **4.2.1 Cycle Testing of Weapons**

Weapons undergo surveillance on a 1-year cycle. Active weapons are sampled for surveillance at the rate needed to provide a 90 percent confidence level for detecting 10 percent defectiveness during a 2-year period. This equates to a sample size of approximately 11 units per year for each of the weapon types in the active stockpile. This sampling frequency has proven adequate to ensure that pits remain intact in the stockpile environment.

Weapons selected for cycle testing are disassembled and inspected at Pantex. The nature and extent of inspection applied to a particular weapon depend upon weapon design characteristics and information needs. When the pit is inspected, some combination of the following examinations may be performed: visual inspection, inspection for external contamination, radiography, leak testing, weighing, and vapor sampling. For each weapon type, one pit per year is destructively evaluated by the design agency.

For inactive weapons, the sampling protocol is different. For retired weapons awaiting dismantlement, surveillance is left to the discretion of the design laboratories. Every 5 years following retirement status, the DOE Albuquerque Operations Office (DOE-AL) formally requests the design agency to certify the safety of these systems. If dismantlement is scheduled within 2 years, surveillance inspections are not done unless the design agency considers them to be necessary. This means a disassembly campaign may begin following a multiple-year hiatus in pit surveillance. However, not all weapon systems have been subject to surveillance at even these frequencies. More frequent surveillance may be appropriate from the perspective of hazard identification and control implementation as the Pantex Plant prepares for a disassembly campaign that may involve hundreds of weapons.

#### **4.2.2 Shelf-Life Testing**

The shelf-life testing program is intended to evaluate the stability of properly sealed pits for as long as they are representative of weapon components in the active stockpile or the strategic reserve. About 80 pits are stored at LANL for this program. The pits are identical to actual weapon components, except for special tubing and valving added to facilitate routine gas sampling. As the name implies, this program allows these pits to age on the shelf, with periodic nondestructive testing to ensure that the gases inside the pit remain stable and that the interior of the pit is not degrading. The principal test is vapor sampling to check for changes in the gas composition inside the pit. The pits are also weighed and subjected to tests such as radiography and ultrasonic inspection.

#### **4.2.3 Storage Surveillance Programs**

Cycle testing provides excellent information about pits that have been maintained in a weapon environment. However, the environment in a non-hermetically sealed pit storage container at Pantex is considerably different from that inside an assembled nuclear weapon. The

storage surveillance program is a relatively new effort intended to assess the condition of pits stored at Pantex. It addresses concerns such as the potential for breaches of the pit cladding due to corrosion, exposure to elevated temperatures, or damage incurred during weapon dismantlement. This is also the only program that addresses the thousands of non-strategic-reserve (surplus) pits stored at Pantex.

The design agencies have devised sampling strategies that group the surplus pits by their basic design features, such as materials of construction and gas fill. The number of pits inspected each year is based on design agency expectations that pits will degrade slowly and on the available resources at Pantex and the design agencies. It is not based on a statistical protocol. About 30 pits are removed from storage each year and nondestructively evaluated at Pantex. A smaller number of pits (one or two for each laboratory) are returned to the design agencies for more comprehensive nondestructive and destructive evaluation.

The exact inspections vary depending on the type of pit being tested. Nondestructive evaluation typically includes visual inspection, swiping for external contamination, leak testing, gas sampling, radiography, and weighing; however, some pit types are only inspected visually and checked for external contamination. Examinations of pits selected for destructive evaluation typically include visual inspection followed by metallography, chemistry, and tensile testing. When inspections reveal abnormal conditions, more pits of that type are sampled. For example, B54 pits have been visually inspected based on conditions discovered during surveillance testing.

## 5. ISSUES

This section reviews issues associated with safe storage of pits at the Pantex Plant, including issues related to pit surveillance and integrity, containers, and storage facilities. Virtually every pit-related project at Pantex needs improvement in planning, resource loading, and development of a complete and logical set of functions and requirements. Also, many projects have a long-standing dependence on the success of the AT-400A repackaging effort to ensure safety, but the AT-400A project is now being scaled back. This may have broad implications that are not being addressed comprehensively by DOE. In fact, many decisions that affect the continued safe storage of pits at Pantex have been made in an apparently disjointed manner by various elements within DOE.

### 5.1 PIT SURVEILLANCE AND INTEGRITY

The required scope of the pit surveillance program is closely coupled with the adequacy of pit storage conditions. However, the number of surplus pits sampled for surveillance each year (about 30) is small compared with the thousands of such pits stored at Pantex. Considering the variety of surplus pit types, it will take some time to gather an adequate amount of data to support an informed judgment about all such pits. However, several issues related to pit storage and surveillance can be identified, as detailed in the following sections.

#### 5.1.1 Pit Corrosion

The slow sampling rate at Pantex might be acceptable if the storage conditions were known to be adequate. However, characterization of the condition of surplus pits stored at Pantex began only recently, so the active degradation mechanisms involved and their rates are not well understood for pits stored outside intact nuclear weapons. For example, past inspections, cleaning, or other operations involving pits may have used chemicals with constituents (e.g., halides) that could initiate corrosion of the pit outer metal shell or joint.

Furthermore, the design agencies have concluded that the current pit storage container, the AL-R8, is not suitable for long-term use, for several reasons. The Celotex fiberboard packing material used in the AL-R8 is made from sugar cane, paper, starch, and wax, and can contain significant moisture and more than 0.1 weight percent chlorides. Since the AL-R8 containers are not sealed, the pits inside are also exposed to the humidity of the ambient air. The combination of moisture and chlorides is damaging to many metals, including the beryllium cladding used for some pit types.

The design agencies have determined that galvanic corrosion near welds is a potential degradation mechanism for beryllium cladding in a humid environment, such as that inside an AL-R8. Additionally, inspections by LANL have shown that beryllium pit cladding is subject to

pitting corrosion in an aqueous chloride environment. Corrosion could penetrate completely through the cladding. LANL has also shown that pitting reduces the strength and ductility of beryllium test coupons because of the notch sensitivity of beryllium. This in turn could render corroded pits more vulnerable to failure as a result of temperature excursions or mechanical damage. Field experience with actual weapon components has confirmed that beryllium-clad pits are vulnerable to chloride pitting. Based on this information, the design agencies have concluded that the AL-R8 is not suitable for long-term pit storage, and that pits, particularly strategic-reserve pits, need to be removed from contact with Celotex as soon as possible.

The design agencies detailed these problems in letters to DOE-AL on August 22, 1995, and to the Pantex Plant on May 16, 1997. Key assumptions include infrequent pit handling and limited temperature excursions. The recommendations made by the design agencies are as follows:

- No pits should be stored in AL-R8 containers. Strategic-reserve pits should be removed from AL-R8 containers as soon as possible.
- If AL-R8s are used for an extended period (5 years for strategic-reserve pits, 10 years for surplus pits), an aggressive sampling and monitoring program is required, i.e., 100 percent inspection every 5 years.
- Humidity control is needed if strategic-reserve pits will be stored in AL-R8 containers for 5 years or more.
- Shrink-wrapping plastic around the Celotex packing material may be an acceptable interim solution.

Efforts to address the above issues are hindered by the fact that there is no formal project devoted to resolving pit corrosion issues. It was long expected that the AT-400A would be available to resolve corrosion issues in a timely manner, but this now appears unlikely.

Pantex has been working to establish a pit surface characterization laboratory that will provide local capabilities for nondestructively evaluating pit surface topography and chemistry. This laboratory was to include a stereo microscope, white light interferometer, scanning electron microscope, auger electron spectroscope, Fourier transform infrared spectrometer, and x-ray photoelectron spectroscope. Although some equipment has been procured, it is not clear whether funding will be available to finish outfitting the laboratory.

Despite the fact that the first design agency letter on the need for improved pit packaging was sent to DOE-AL in 1995, little was done at Pantex to address pit corrosion concerns until very recently. Funding is problematic, and efforts to characterize or repackage pits at Pantex are resource limited. Moreover, the key design agency participants in pit corrosion evaluations have other duties. As of October 1997, basic tests such as evaluation of the corrosion of chloride-

contaminated beryllium in humid air instead of water had not been initiated. Definitive resolution of corrosion and other packaging issues will require augmented efforts and a more formal and integrated approach.

### **5.1.2 Pit Environmental Controls**

The design agencies have recommended maximum allowable storage temperatures for each pit design. The limits for some pits are intended to guard against cladding failure; the limits for other designs are intended to preserve pit quality. The design agencies have stated that storage temperature is particularly important to maintaining the integrity of some non-strategic-reserve pit types (W48, B54, and W55).

Pantex has implemented these safety-related temperature limits in procedures, but the controls are not part of the formal authorization basis for pit storage facilities. There are two reasons for this: (1) MHC is in the preliminary stages of developing authorization basis controls (e.g., TSRs), and (2) MHC assumes that pits involved in accidents will not have been breached beforehand.

The latter assumption leads MHC to the conclusions that little plutonium oxide will be available for immediate release and that accident consequences will not be severe. Typically, these bounding analyses have not addressed scenarios such as pit breaches that may have gone unrecognized for a long period of time. Such breaches could result in continuing generation of plutonium oxides that would be available for release during either normal handling or an accident. The resulting consequences for workers could be significant, particularly if a number of pits have failed.

Given the potential consequences of pit breaches in storage, the implementation of authorization basis controls appears warranted. Doing so would ensure high visibility for any future changes to monitoring, maintenance, or surveillance programs and systems that ensure continued pit integrity and operator safety.

### **5.1.3 Pit Storage at Other Sites**

A large number of pits are presently stored at the Rocky Flats Environmental Technology Site. With the exception of a small number of pits being sent to the design agencies, all pits at Rocky Flats are planned to be shipped to Pantex. The pits will be visually inspected before and after shipment, so gross corrosion or other damage should be detected before the pits join the general inventory at Pantex. If any pits remain at Rocky Flats for an extended period of time, it would be prudent to implement consistent environmental controls and include them in the storage surveillance program (or develop a separate surveillance plan) to ensure that any problems are detected in a timely manner. Likewise, storage and surveillance criteria for the significantly smaller number of pits stored at other sites (e.g., the Savannah River Site and the design agencies) ought to be equivalent to the criteria applied at Pantex.

## **5.2 PIT CONTAINERS**

The container is the next barrier beyond the clad and plays an important safety role. For example, the 1996 Pantex Plant Final Environmental Impact Statement assumes that only a quarter of the pits in a magazine would be affected by an aircraft crash with fuel fire (p. 4-309). The containers limit the number of pits involved in this type of postulated accident. The following subsections describe issues associated with the pit containers that may prevent them from compensating for the weaknesses in pit surveillance programs and environmental controls discussed earlier.

### **5.2.1 Existing Design Containers**

The AL-R8 containers currently provide mechanical and thermal protection, but no confinement since they are unsealed and susceptible to corrosion. Also, the internal Celotex packing is a source of chlorides and moisture, which can accelerate container corrosion. Pit surveillance and other inspection activities have found some AL-R8 containers to be significantly corroded. Many of these carbon steel containers have been poorly preserved. Pantex has determined that up to 3000 AL-R8s were procured without the required corrosion-resistant coating on the inner surface of the carbon steel container.

### **5.2.2 New Design Containers**

The AT-400A pit packaging line at Pantex began operations in August 1997, but only W48 pits are currently planned to be packaged in these containers. B54 pits are strong candidates to succeed the W48s, followed in turn by strategic-reserve pits, but it is not clear what further repackaging will be done or when. If pits are not repackaged expeditiously, Pantex lacks the resources to implement the monitoring program recommended by the design agencies. At the current repackaging rate, it will take more than 2 years to repackage the W48s and would take in excess of 40 years to repackage all the pits now at Pantex.

DOE and MHC are considering replacing the manual AT-400A repackaging line in building 12-99 with a mechanical line. A mechanical line is expected to improve throughput from about 20 pits per month to about 40. At this time, it appears that Pantex is planning to place the new line in the same bays as the existing line. There are at least two potential problems with this choice: (1) DOE and MHC will have lost the opportunity to transfer pit operations to a more appropriate location and reclaim the bays in 12-99, which are some of the most modern and robust at Pantex, for nuclear explosive operations, and (2) the manual line will have to be suspended during installation of the mechanical line, which will further delay repackaging of pits.

### **5.2.3 Modified Design Containers**

Early in 1997, MHC began developing an improved, sealed version of the AL-R8 as an interim solution to resolve the concerns of the design agencies. This effort was narrowly focused

on pits being received from Rocky Flats, to avoid later repackaging of these pits and thereby minimize personnel exposure. Extra pit handling would increase cost, risk, and radiation exposure.

The MHC design for an improved AL-R8 would retain the existing internal fixturing, Celotex packing, and external container. The key change would be the addition of a mechanically sealed stainless steel inner vessel filled with an inert gas. The inner vessel would separate the pit from the Celotex. The primary seal would be a copper gasket compressed between the lid and a large flange. A valve would be built into the lid for inerting of the vessel and for future vapor sampling. The gasket, flange, and valve would be industry-standard designs intended for use in high-vacuum applications. MHC and the design agencies believe these seals are more than adequate for interim storage. The main question being addressed is whether the new design has adequate heat transfer to prevent temperature-sensitive pits from overheating under normal storage conditions.

Since May 1997, all three design agencies, as well as DOE-AL, have initiated their own designs (six designs total) for sealed AL-R8 inserts, focusing on the general population of pits. In September 1997, DOE-AL down-selected from these options to three competing designs, one of which is the original MHC concept. DOE was intending to select a single design by early December 1997 but has delayed this decision by two months. In a further complication, Pantex was informed in early October that there is no FY98 funding for the Pantex share of this effort.

All of the designs are based on a set of functions and requirements, assembled by MHC specifically for Rocky Flats pits, that appears to be incomplete for the general pit population. As of September 1997, some recent applicable Safety Analysis Reports, as well as AT-400A design documentation, had not been screened for functions and requirements that might be applicable to the modified AL-R8. Under these conditions, some important container functions and requirements, such as the container's role in protecting pits during postulated on-site transportation accidents, are being neglected or inadequately addressed.

Even if an improved AL-R8 is qualified and used for storage at Pantex, there is a distinct possibility that surplus pits will need to be repackaged again in the future. The AL-R8 is no longer certified as an off-site shipping container, and there are no plans to certify an improved AL-R8. Therefore, if surplus pit disposition activities are performed at a site other than Pantex, the pits involved will need to be repackaged in certified shipping containers. The AT-400A was designed to meet all requirements for certification for off-site shipments, but is not yet certified. Another option might be to develop and certify an overpack for a complete AL-R8 or for the new sealed inner vessel, but this is beyond the scope of the current set of requirements for the improved AL-R8.

In summary, as of September 1997, the modified container designs appear to be an improvement compared to the current AL-R8s, but there is no present DOE commitment to pursue any of these improved designs. Also, the current designs are proceeding without complete

definition of the requirements. Under these conditions, some important container functions may be neglected. Finally, it does not appear that DOE has thoroughly considered the ramifications of the container modifications for the Pantex authorization basis.

### **5.3 PIT STORAGE FACILITIES**

#### **5.3.1 Zone 4 Magazines**

Most pits at Pantex are stored in AL-R8 containers in Zone 4 magazines. Neither the magazines nor the containers provide confinement. Maintaining adequate environmental control of the pits, as discussed earlier, has been a particular concern since most magazines rely on passive cooling.

The capability of Pantex facilities, including the magazines, to mitigate the consequences of an aircraft crash remains an open question. Because of the proximity of Pantex to Amarillo International Airport and to local navigational aids, an aircraft crash into either a Zone 4 magazine or Zone 12 facility is credible, though extremely unlikely (estimated probability is  $3 \times 10^{-5}$  per year).<sup>6</sup> Evaluations to date indicate that an impact by an air carrier or military aircraft could perforate most magazines and facilities. Impacts by smaller, slower aircraft, while not penetrating the walls, could still cause concrete scabbing, showering internal spaces with debris. Although the containers provide some protection, the number of pits likely to be damaged, resulting in a plutonium release, is uncertain. DOE has implemented a corrective action plan to reduce aircraft overflights, although the effectiveness of this program is not yet known. MHC is also evaluating aircraft crash consequences on a site-wide basis.

In recent years, MHC has initiated a magazine temperature monitoring program that has generally been run well. The program has shown that during the summer, pit temperatures can approach the limits specified by the design laboratories for some pits. This has occurred in the past, but the likelihood of recurrence has been reduced for two reasons. First, nearly all of the pits of greatest concern (W48s) are stored in the two air-conditioned magazines. Second, magazine temperature monitoring can be used to detect elevated temperatures, so that corrective actions can be taken before temperature limits are exceeded. Temperatures inside the passively cooled magazines change slowly because of the thermal lag provided by the earth overburden, so there should be adequate time for response. However, the response may involve additional container handling and associated risk.

Currently, there are no authorization basis controls related to controlling pit or magazine temperatures or maintaining active cooling for the two magazines with W48 pits. For at least three pit types, there are identified temperature-related failure modes. The consequences of

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<sup>6</sup> DOE/EIS-0225, "Final Environmental Impact Statement for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapons Components," Section 4.15, November 1996.



overheating several hundred pits could be significant. As discussed in Section 5.1.2, it would appear appropriate to implement authorization basis controls on pit temperatures.

### **5.3.2 Special Nuclear Material Component Staging Facility (12-116)**

The 12-116 facility has never been used and is undergoing a backfit to accommodate up to 4000 strategic reserve pits. The backfit project has made progress during the last 2 years, but has been subjected to continual changes in the facility's mission, intended inventory, functions and requirements, resources, and work scope.

A recent example is a last-minute change to the backfit work scope to delete pit vault humidity controls and thereby reduce costs. DOE and MHC consider that the humidity controls will not be needed if pits are eventually stored in sealed containers. This decision was made at some risk, because strategic-reserve pits are unlikely to be repackaged soon in sealed containers. The design agencies consider these humidity controls to be quality requirements and not safety requirements for strategic-reserve pits.

Within 12-116, there are systems that appear well engineered, but their specified functions and requirements may not have kept pace with facility changes. An example is the robotic weight and leak check system designed by Sandia National Laboratories for inspecting pits in the current AL-R8 containers. The utility of this system for pits in the long-intended AT-400A containers was never clear. It remains to be seen how this system can be made compatible with a modified AL-R8 design.

As of September 1997, few systems within 12-116 had been designated by MHC as requiring authorization basis controls and safety classification. The pit container staging system is one such safety system that has been missed. It consists basically of stacked pallets, each containing four or six horizontally oriented pit containers. The staging system needs to resist structural loads that could result from a facility accident. It is not clear how the facility would recover if these pallets toppled or collapsed. The role of the staging system in mitigating an accident would be apparent if potential safety systems had been thoroughly screened using the DOE standard approach (DOE-STD-1021-93).

The need to resolve certain open safety questions will limit the facility's pit inventory until post-startup modifications have been completed. Building response to an aircraft crash remains an open question to be addressed in the safety analysis report. Other major open questions include criticality safety, the seismic capacity of the pit staging system, and heat load and temperature variation in the vaults. Some of these open questions are interrelated. For example, criticality analyses assume that the pit staging system would not collapse during an earthquake. MHC plans to qualify a staging system using shake-table test results; however, part of the final staging system may include shelving that is not part of these tests.

In summary, there have been major perturbations in the 12-116 backfit process. These have been caused by uncertainty in inventory, seismic requirements, criticality safety, temperature and humidity controls, AT-400A programmatic direction, resource availability, and backfit work scope. Identification of facility systems that require authorization basis controls and safety classification also remains an open issue.

### **5.3.3 Prospective Surplus Pit Storage Facility (12-66)**

Significant design questions must be addressed for the 12-66 facility before it would be appropriate for use as a pit storage facility. Many of the issues identified above for 12-116 apply also to the 12-66 facility, but on a larger scale because of the larger inventory being placed in a weaker facility.

The 12-66 warehouse is not likely to provide a level of protection comparable to that of other major plutonium facilities in the DOE complex without significant structural modifications or a high reliance on container toughness. For example, 12-66 does not have the thick internal walls of 12-116, which can carry the significant lateral loads that would be common to many externally driven accidents. Also, the 12-66 outer walls are half as thick and have less than half the reinforcement of the outer walls of 12-116. It is unlikely that 12-66 would perform nearly as well as 12-116 during a tornado, aircraft crash, or other major accident.

Whether 12-66 is acceptable as a pit storage facility depends on what functions and requirements it is expected to meet. At this time, no systematic review of other major plutonium storage facilities across the DOE complex has been performed to ensure that a complete and logical set of requirements has been defined. The lack of such a review has resulted in inconsistencies in the effort to date, for example, in safety system selection, assumed accident loads, and structural analysis methods.

Pantex personnel have indicated that reduced accident loads may be considered for this facility's design in the future (i.e., equivalent to those required by the Uniform Building Code for an essential facility, such as a fire station, with no confinement function). In 1996, DOE proposed reduced accident loads for 12-116, based on a revised DOE standard, but MHC ultimately did not use them. The 12-116 proposal was based on bounding accident analyses predicting off-site consequences below evaluation guidelines. However, few accident evaluations have considered the full range of possible consequences to on-site personnel, including those who would respond to a major facility accident. Further information is provided in a previous staff report.<sup>7</sup>

The Zone 12 consolidation appears to be driven by conflicting future scenarios. There will either be so little demand for magazines that Zone 4 can be closed or so much demand that there will be no space in Zone 4 for surplus pits. There are aspects of this relocation that have not been clearly addressed in the decision-making process.

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<sup>7</sup> Keilers (Board staff) memorandum to G. W. Cunningham (Board Technical Director), December 2, 1996.

Regardless, it appears that adequate safety evaluations were not available to support the DOE decision to move surplus pits from Zone 4 magazines to 12-66. For example, the storage and disposition PEIS includes a section on facility accidents at Pantex (PEIS, Appendix M), but this was not a comprehensive safety evaluation. In fact, key accident scenarios described in that document apply only to containers and facilities that exist at other sites and not at Pantex. There appears to have been no MHC-sponsored safety analysis prior to a hazard analysis completed in August 1997 by Westinghouse Savannah River Company. Several externally driven accident scenarios, such as an aircraft crash or an earthquake, need to be addressed further.

Based on the above observations, it is not yet apparent that moving pits out of magazines and into 12-66 represents a net safety improvement. Building 12-66 does have advantages, such as proximity to pit facilities and active cooling for temperature-restricted pits. However, the Zone 4 magazines also have advantages, such as a lower accident source term for single-magazine events, better-understood criticality safety, and possibly better thermal performance (particularly if the magazines are backfit with active cooling or if temperature-sensitive pits are removed). Improved, sealed containers could provide secondary confinement in both cases.

## 6. CONCLUSIONS

From a safety standpoint, the pit storage system at Pantex ought to be considered as a combination of interrelated barriers to radioactive release, as well as the associated controls needed to maintain those barriers. A change in one barrier or control will affect the others and can be appropriately addressed only through an integrated systems approach.

Since 1989, a number of questions related to continued safe storage of pits have been raised. In 1992, DOE initiated several proactive programs to ensure continued safe pit storage. The most successful of these programs resulted in relocation of nearly all the W48 pits (the type of most concern) to temperature-controlled magazines. In August 1997, MHC began repackaging the W48 pits into the best containers available, the AT-400A, albeit at a very slow rate.

However, other deficiencies in the overall pit storage system (i.e., the clad, containers, and facilities) have never been fully addressed, and recent activities appear to achieve short-term goals and cost reductions without fully considering the long-term implications for pit storage. Some of the issues that result from this situation are as follows:

- For most pits, the clad is the only reliable confinement, but resolution of clad corrosion issues is hindered by a lack of resources and of a formal project to understand failure mechanisms and identify corrective actions.
- The storage surveillance program is aimed at evaluating the condition of pits stored at Pantex. However, the number of pits sampled for surveillance each year is small compared with the thousands of pits stored at Pantex and is not statistically based.
- The lack of authorization basis controls for pit storage temperatures renders at least three pit designs vulnerable to cladding failure. Pantex has implemented temperature limits identified as safety related by the design agencies, but these controls are not enforced by the authorization basis.
- The most commonly used pit storage containers (the AL-R8s) contribute to, rather than mitigate, the above concerns with the pit clad. For years, DOE has indicated that all the pits would be repackaged in new containers, the AT-400A, that would prevent pit corrosion, improve accident mitigation, and compensate for the lack of authorization basis controls related to pit integrity. DOE no longer appears committed to repackaging of pits other than the W48s in these containers.
- To compensate for scaleback of the AT-400A, efforts have been initiated to design improved containers; however, these efforts appear confused and lack complete requirements and a formal DOE programmatic commitment.

- The planned changes in pit storage facilities appear unlikely to compensate for the above weaknesses in the surveillance program, authorization basis controls, and containers. In particular, the proposed transfer of pit storage from Zone 4 to Zone 12 will not clearly result in a net safety improvement.
- Although the strategic reserve facility (12-116) appears robust, the surplus pit storage facility (12-66) may require either significant structural modifications or a high reliance on container toughness. A systematic review of other major plutonium storage facilities may be worthwhile to ensure that a complete and logical set of design requirements has been defined.

Many of the issues discussed in this report can be addressed only by applying a systems approach and comprehensively considering the interrelationships among the barriers to release and the programs and controls needed to maintain them.

## APPENDIX

### COMPONENT STAGING FACILITY (12-116) DESIGN CRITERIA

In general, the structural design criteria for the 12-116 facility were equivalent to or more rigorous than recent DOE requirements for natural phenomena hazards mitigation (DOE Order 5480.28). DOE defines required structural performance in terms of performance category (PC), which basically is a measure of the annual probability of unacceptable behavior during an accident. Facility structures at different sites may be assigned the same performance category (e.g., PC-3), but then be designed to different accident loads based on the site-specific probability of each hazard. For example, Pantex is susceptible to more severe winds/tornadoes but a less severe earthquake than the Nevada Test Site (NTS). As a result, the same PC-3 facility located at Pantex and at NTS would be required to withstand different winds (132 and 87 mph, respectively) and different seismic accelerations (0.13 and 0.34 pga, respectively) to achieve similar probabilities of unacceptable behavior during an accident.

Table 1 compares some specific 12-116 criteria with DOE requirements for reactors (PC-4) and for major plutonium facilities (PC-3). The assumed tornadic wind would result in a pressure on the building nearly twice as great as DOE would now stipulate for a reactor if one were sited at Pantex. Also, the original suite of design tornadic missiles includes automobile and timber missiles that are factors of 1.3 and 4, respectively, more energetic than would be stipulated for a reactor. The assumed seismic event is less than specified for a reactor, but comparable to that now specified for a major plutonium facility at Pantex.

**Table 1. Comparison of 12-116 Design Criteria with Current DOE Criteria**

| Pantex Criteria      | 12-116 (original)                    | PC-3   | PC-4  |
|----------------------|--------------------------------------|--|---|
| Seismic acceleration | 0.14 pga                             | 0.13 pga   | 0.21 pga  |
| Tornadic wind        | 250 mph                              | 132 mph  | 182 mph   |
| Tornadic missile     | 139 lb timber<br>(4 x 12") @ 100 mph | 15 lb timber (2 x 4")<br>@ 100 mph H &<br>70 mph V | 15 lb timber (2 x 4")<br>@ 150 mph H &<br>100 mph V |
|                      | 4000 lb automobile<br>@ 25 mph       | 75 lb (3") pipe @<br>50 mph H & 35 mph V           | 75 lb (3") pipe @<br>75 mph H & 50 mph V            |
| Pressure change      | 1.13 psi @ 0.41 psi/s                | 0.28 psi @ 0.14 psi/s                              | 0.87 psi @ 0.35 psi/s                               |