DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

October 29, 2003

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: H. Massie

SUBJECT: Glovebox Fire at Rocky Flats Environmental Technology Site

This report documents a review by the staff of the Defense Nuclear Facilities Safety Board (Board) of the fire that occurred on May 6, 2003, in Glovebox 8 during decommissioning activities in Building 371 at the Rocky Flats Environmental Technology Site (RFETS). This review encompassed information obtained during telephone discussions with the Department of Energy (DOE) and its RFETS contractor, Kaiser-Hill, during May–September 2003; site visits conducted by the Board's staff during July 7–10, 2003, July 28–August 1, 2003, and September 8–11, 2003; and a briefing to the Board provided by DOE and Kaiser-Hill on August 8, 2003.

Background. Building 371 is scheduled to be the last building decommissioned at RFETS under the accelerated site closure contract between DOE and Kaiser-Hill. The primary activities under way in Building 371 in May 2003 were packaging of the remaining plutonium materials for off-site shipment and removal of gloveboxes and other contaminated systems. Glovebox 8 formerly served as a dumbwaiter to transfer plutonium-bearing materials to the basement level of Building 371 from the floor above. On May 6, 2003, a fire broke out in Glovebox 8 during the initial attempt to cut a hole through the metal side of the glovebox to establish ventilation flow (reported in occurrence report RFO-KHLL-371OPS-2003-0011). In a conference call with the Board's staff on May 8, 2003, DOE's Rocky Flats Field Office (RFFO) and Kaiser-Hill reported that the fire was a small one that had been put out by the decommissioning workers and the site fire department. Kaiser-Hill reported that it was conducting a fact-finding investigation of the fire.

On May 16, 2003, the Board's staff received and reviewed a summary of Kaiser-Hill's investigation. On May 28, 2003, the staff held a conference call with representatives of RFFO and Kaiser-Hill to discuss apparent inconsistencies in the time line of the response to the fire. RFFO then reported that it had initiated an independent review of the fire and that its review team had already been to the site. The staff received the report of DOE's review on June 26, 2003, and learned from this report that the fire had been much larger than previously indicated (flames up to 15 feet tall) and that the workers' response to the fire had seriously endangered their safety. The staff determined that DOE's review had not adequately explored the factors that led to the fire and the deficiencies in the response to the fire. As a result, the staff undertook the series of reviews documented in this report.

Results of Staff's Reviews. The reviews by the Board's staff revealed that the events leading up to the fire, the problems occurring in the response to the fire, and the inadequate investigation of the fire represented a wholesale breakdown in the implementation of Integrated Safety Management (ISM). As summarized in this report, the staff found fundamental deficiencies in each of the five core functions of ISM—define the scope of work, analyze the hazards, develop and implement hazard controls, perform work within those controls, and provide feedback and continuous improvement. The staff also identified numerous specific issues related to this event. The attachments to this report summarize the events that occurred on the day of the fire and identify specific issues that warrant resolution.

Based on the initial results of the staff's review, the Board issued a letter to DOE on July 31, 2003, imposing a 15-day reporting requirement regarding the immediate corrective actions needed to ensure that conditions leading to the fire did not exist elsewhere at RFETS. DOE replied with a letter on August 15, 2003, identifying prompt corrective actions to ensure that such conditions did not exist elsewhere at RFETS. Areas in which further corrective actions are needed to address weaknesses in the programs designed to protect the health and safety of workers and the public are summarized below.

Definition of Work Scope—Kaiser-Hill approached the removal of Glovebox 8 as part of a standard work package that covered the removal of seven gloveboxes in Room 2325. The work package lacked any detail regarding the work to be performed and relied on the repetition of work and the skills of the workers. Essentially all of the gloveboxes in Building 371 were of horizontal construction, with large viewing ports, bag ports, and a significant number of glove ports. The work package did not address the factors that made Glovebox 8 unique: vertical construction; the need for in situ size reduction; limited glove port access; very limited visibility for verifying conditions; guillotine doors on primary openings; and the presence of various materials in the glovebox, some of which were known to be combustible.

The applicable work instructions stated: "Referencing engineering guidance documented in Section 4, size reduce equipment/component/glovebox per Supervisors direction." Section 4 contained no direction on size reduction of Glovebox 8, but instead relied on a walkdown of the job after completing work planning and shortly before starting work. Although it was obvious that this was a unique job, mock ups were not conducted, and no task-specific approach was outlined in the work package for Glovebox 8 as required by the site's Integrated Work Control Program (IWCP) and DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees.*

This situation occurred despite the fact that the Board had issued a letter to DOE on March 19, 2002, identifying the need for improvements in activity-level work planning and conduct of RFFO's oversight of Kaiser-Hill's work planning. DOE replied in a letter of June 25, 2002, that committed to mentoring of work planning personnel and to enhancement of RFFO's oversight of work planning, among other actions. During its review of the circumstances surrounding the fire in Glovebox 8, the Board's staff determined that these actions were no longer being pursued with appropriate vigor, despite recent commitments made to the Board by

Kaiser-Hill and RFFO in a February 2003 video conference. Furthermore, site personnel informed the staff that use of a standard work package for glovebox removal in Room 2325 was not questioned because the work package had been approved in January 2002 and authorized for use in February 2002, prior to the correspondence between the Board and DOE.

Analyze the Hazards—The standard work package approved for the removal of Glovebox 8 did not include an adequate analysis of the hazards associated with this work, as required by the site's IWCP. The work package used a standard Job Hazard Analysis (JHA) to identify hazards associated with glovebox removal and recommend controls for the planned work. A JHA dated July 2002 was included in the work package. This JHA did not address the specific or unique characteristics of any of the seven gloveboxes covered by the work package. The hazards identified in the JHA were generic in nature and involved routine injuries from tools, heavy loads, falling from scaffolding, and criticality. Particular hazards associated with Glovebox 8, including hazards related to materials in the glovebox and the guillotine doors where Gloveboxes 9 and 10 were attached, were not discussed. The report of RFFO's review of the Glovebox 8 fire cited these issues, and also faulted the work crew for not noting shortcomings of the JHA and work package with regard to identified hazards. The site's IWCP specifically requires that the JHA address unique activity-specific hazards and have associated controls to handle these hazards.

In addition to failing to recognize that the standard JHA was inappropriate for removal of Glovebox 8, Kaiser-Hill did not note a key indicator suggesting that unanalyzed hazards were present in the glovebox. Specifically, the staff found that plutonium holdup surveys for Glovebox 8 showed a potentially significant increase from October 2001, when a holdup of 105 grams ± 62 grams was estimated, to January 2003, when 278 grams ± 149 grams was estimated. Although the large uncertainty in these estimates may have cast doubt on whether there truly was an increase in plutonium holdup, a conservative approach would have been to assume the indication was correct or attempt to make a more accurate measurement. An increase in the quantity of plutonium in Glovebox 8 would most likely have resulted from the addition of combustible waste materials (e.g., plutonium-bearing rags) from the decontamination of Glovebox 10. Allowing such materials, which include combustibles and potentially reactive chemicals (e.g., the cerium nitrate decontamination solution), to enter Glovebox 8 was prohibited by site procedures.

Further investigation by the Board's staff led to the discovery that photographs of the materials removed from Glovebox 8 after the fire showed that towels and at least one bottle of the type used in glovebox decontamination work had been present inside Glovebox 8. The debris also included combustible materials that appeared to date back to as early as 1986, when the glovebox was sealed off at the ceiling. The fire hazards associated with these materials were not considered in this glovebox removal activity.

Develop and Implement Hazard Controls—The failure to tailor the standard JHA to the specific work to be performed led to the identification of only general industrial safety requirements (e.g., gloves, proper lifting techniques, exercising care on scaffolding, and

packaging parts) as controls. Another related and important control was the Building 371 combustible control program, which included weekly inspections for combustible materials in gloveboxes. However, no control was identified to remove the combustibles or otherwise compensate for their presence in Glovebox 8. The cutting activity on Glovebox 8 was to be performed with a mechanical tool (a nibbler) instead of a torch or other "hot" cutting tool, so no additional fire safety precautions were taken.

One additional control became relevant when waste materials from the decontamination of Glovebox 10 were introduced into Glovebox 8. This control was to be implemented through the procedure used to reduce and neutralize the cerium nitrate solution used in glovebox decontamination.

Perform Work Within Those Controls—Despite the inadequacies in defining the scope of work, analyzing hazards, and identifying controls, the fire could have been avoided if other site and facility controls had been implemented properly. Furthermore, the response to the fire could have been safer if the work crew and their supervisor had complied with site training and procedures for reporting and responding to the fire.

First, the combustible control program for Building 371 was not implemented adequately. The program requires that any combustibles inside a nonoperating glovebox be either removed by the end of the shift, placed into a metal container, or covered by a fire blanket, unless approved by the Fire Safety Officer/Fire Protection Engineer. The configuration of Glovebox 8 made it difficult to identify whether materials were present in the lower portions of the glovebox; a conservative approach would have been to question whether there were unacceptable materials in the inaccessible area. Instead, combustibles had been allowed to remain in Glovebox 8 since 1986 without this condition being identified, and as discussed above (and subsequently confirmed by Kaiser-Hill management), further combustibles were added during the decontamination of Glovebox 10 and not removed.

Discussions with the personnel involved in glovebox removal work in Room 2325 revealed other violations of the combustible control program. These personnel informed the Board's staff that during glovebox decontamination work, combustibles were allowed to remain in the gloveboxes overnight without approval by the Fire Safety Officer, and were left uncovered to facilitate drying in preparation for the next day's work. Workers explained that this was done because there was no perceived danger and because it would facilitate meeting the schedule; it would have taken too much time to bag the material out at the end of a shift, only to have to bag in needed materials (e.g., towels) at the beginning of the next day.

Second, discussions with the decommissioning operators performing work in Room 2325 revealed routine noncompliance with the procedure for decontaminating gloveboxes using cerium nitrate, including the specific steps required to render the materials safe for disposal. Noncompliance included not adhering to the specified process for stabilizing combustibles soaked in cerium nitrate solution, not following requirements for measuring the quantities of some reagents, and diluting reagents inside the glovebox instead of outside. No evidence could

be provided to show that the stabilization method being used had been evaluated by appropriate chemical experts and responsible managers to ensure proper neutralization of the acids and reduction of the cerium. This problem occurred despite the fact that the cerium nitrate decontamination procedure clearly highlighted the safety hazards associated with leaving unreduced cerium nitrate in contact with combustibles.

As a result, the wastes that were allowed to enter Glovebox 8 might have been unstable. Furthermore, it was not clear that wastes from other cerium decontamination operations had been rendered safe and stable. The Board's July 31, 2003, letter requested that DOE address this issue. DOE and Kaiser-Hill are pursuing stability testing of surrogate waste materials to determine whether the presence of cerium nitrate in Glovebox 8 contributed to the fire and to evaluate whether a broader safety issue exists regarding improperly reduced cerium nitrate wastes.

Finally, the response by the workers and their supervisor to the fire did not comply with site procedures, and training was deficient. The actions taken by Kaiser-Hill personnel unnecessarily exposed workers to hazards and likely contributed to the severity of the fire. The most serious violations are summarized below:

- Personnel at the scene of the fire did not call the fire department after the fire started. Instead, the supervisor called the shift manager for Building 371 (known as the Configuration Control Authority (CCA), who in turn called the fire department. This added time to the fire department's response and did not allow the fire department to ascertain the nature of the fire before arriving at the building. The workers informed the Board's staff that they knew the formal requirement was to call the fire department, but they believed they were expected to call the CCA instead.

- Workers at RFETS are trained that if they encounter a small fire and do not believe their safety is threatened, they may apply one or two fire extinguishers after the fire department has been notified before evacuating the area. However, site training for the use of air-fed "bubble suits" of the type worn by these workers stresses that those wearing such equipment should evacuate the scene of an emergency. Despite this training, the two operators working on Glovebox 8 engaged in a concerted effort to fight the fire, including applying water (which should not have been done without an evaluation of the potential for criticality and without knowing whether water was an appropriate extinguishing agent for the unidentified burning materials), opening up various access paths to the lower part of the glovebox (providing a source of air that likely increased the rate of combustion), expending about seven fire extinguishers, and prodding the fire with a metal pole.

- Neither the job supervisor nor the radiological control personnel on the scene intervened to stop the work crew's firefighting efforts. In fact, they facilitated the workers' efforts by continuing to supply them with more fire extinguishers.

- Potential industrial hazards were not addressed before workers reentered the building following the fire. An industrial hygienist was not called to evaluate the air quality in Building 371 until several hours after personnel had returned to the facility to resume work. It also appears that air sampling was not done proactively, but was instead performed in response to workers' complaints.

In fighting this fire, the firefighters entered into an area with conditions that were not adequately covered in the pre-fire plan. Only proper planning (e.g., in the pre-fire plan) for fighting fires from contaminated combustibles would be helpful in reducing potential harm to the firefighters and other workers. Also, the report of a "small" fire to the CCA exacerbated the situation. The staff believes that this is an area requiring further attention, guidance, and planning by RFFO and Kaiser-Hill for the remaining decommissioning work at RFETS.

The staff believes that the widespread failure to follow safety-related procedures and abide by safety training indicates inadequate oversight of these activities by RFFO and by senior Kaiser-Hill management. In particular, the RFFO Facility Representatives assigned to Building 371 acknowledged that they had failed to provide any oversight of the decommissioning activities in the building, instead focusing their attention on plutonium stabilization and packaging operations that were also ongoing in the building. This decision represents a failure to cover the majority of work in Building 371 and a failure to recognize that the constantly changing conditions inherent in decommissioning work warrant continuing scrutiny to ensure that safety is preserved.

Provide Feedback and Continuous Improvement—DOE's report of the independent review performed by RFFO, issued on June 23, 2003, identified numerous problems and recommended that Kaiser-Hill take action to address the deficiencies in work planning and in the combustible control program, the inappropriate firefighting efforts of the decontamination workers, the supervisor's failure to control the crew's response to the fire, the delayed building evacuation, and the lack of a comprehensive plan for safe reentry into the building. Kaiser-Hill is implementing corrective actions to address RFFO's recommendations. However, the Board's staff determined that there were significant omissions in those recommendations and in Kaiser-Hill's corrective actions. DOE's report was structured to recommend actions to prevent another fire under similar circumstances, and did not address the fundamental problems in ISM that had been revealed. It was also apparent that the corrective action plan established by Kaiser-Hill was limited to the specific recommendations of DOE's report and did not address generic aspects of the noted problems.

RFFO was not self-critical concerning its failure to recognize the weaknesses in Kaiser-Hill's implementation of ISM prior to the fire and the failure of the Facility Representatives to provide appropriate oversight of work planning and execution for decommissioning work in Building 371. The staff found that RFFO management had provided no direction to RFFO personnel regarding expected performance to ensure that appropriate oversight will be performed in the future. When questioned by the staff regarding RFFO's actions to continue implementing the improvements in the oversight of work planning identified to the Board in DOE's letter of

June 25, 2002, and in the February 2003 video conference, the Assistant Manager for Safety Programs stated that RFFO lacked the resources to meet those commitments. While the RFFO Manager subsequently disagreed with this statement, it appears that the manager responsible for these actions had not carried them out.

RFFO deferred determination of the cause of the fire to an investigation being performed by the Kaiser-Hill fire department. Instead of coordinating with the fire department prior to disturbing the scene of the fire, Building 371's management directed workers to dismantle Glovebox 8, package the pieces of the glovebox and the materials it contained in waste containers, and place the containers in the queue for off-site disposal in June 2003. This action destroyed the scene of the fire and may greatly hinder determination of its cause. Only very limited samples of materials in the glovebox were taken, and the fire investigators did not request to be present when those samples were taken. It does not appear that a detailed inventory of the materials in the glovebox was documented before they were packaged as waste; for example, the waste materials from the decontamination of Glovebox 10 were not identified as such until the Board's staff obtained and evaluated photographs taken of Glovebox 8 after the fire. After these issues were raised by the staff, Kaiser-Hill hired a professional fire investigator and stated that it will retain the waste containers on site until the fire investigator determines that no further sampling is needed.

The Kaiser-Hill fire department did not appear to have been given sufficient access to personnel involved in the incident to support an effective fire investigation. Representatives from the fire department attended interviews conducted by RFFO in which the workers involved in the fire participated in groups with their management present, an approach that could inhibit the free exchange of information. In addition, some of the fire department investigators reported that they were refused additional interviews with personnel when questions arose after the initial interviews.

On August 8, 2003, following two site visits by the Board's staff and receipt of the Board's letter of July 31, 2003, senior managers from RFFO and Kaiser-Hill briefed the Board on their actions in response to the problems identified by the Board and its staff. RFFO and Kaiser-Hill stated that they believe the fire was actually the third in a series of events that demonstrated problems in safety management at RFETS. The other two events were the vandalism of high-efficiency particulate air filters by decommissioning workers in Building 771 in May 2003 and a major spread of contamination in Building 776/777 caused by a ventilation flow reversal. Kaiser-Hill stated that these events highlighted weaknesses in maintaining a self-critical attitude and understanding the broader safety implications beyond the immediate event, a state of complacency, underreacting to events, and the need for more rigor in its safety management programs.

The staff agrees with the assessment provided to the Board on August 8, 2003. However, the corrective actions identified by Kaiser-Hill and RFFO remained focused on the immediate problems associated with the fire, and did not address the fundamental weaknesses in implementing the site's ISM System. Furthermore, it is not clear that even these corrective

actions are being pursued appropriately. Specifically, DOE's letter of August 15, 2003, stated that actions under way to address the Board's concerns included suspension of decontamination using cerium nitrate while the procedure was being revised and improved, and that RFFO would evaluate the appropriateness of the revised procedure and verify procedural compliance. The staff later found that Kaiser-Hill had begun using the revised procedure in Room 1115 of Building 371 on August 7, 2003, without any review by RFFO. RFFO did not begin to review the procedure until August 18, 2003, and revisions to incorporate RFFO's comments were not made until August 20–21, 2003. RFFO missed the opportunity to verify procedural compliance in Room 1115, and instead began its verification when the next job was started in Room 3206 on September 9, 2003. During the site visit of September 8–11, 2003, the Board's staff identified numerous areas for improvement in the revised procedure, and Kaiser-Hill agreed to address these issues.

Conclusion. A comprehensive evaluation of the implementation of the ISM System at RFETS, including safety management within both Kaiser-Hill and RFFO, is warranted to identify the full extent of the problems revealed by the fire of May 6, 2003. A correspondingly comprehensive set of corrective actions is needed to resolve identified problems and ensure that the remaining decommissioning work at RFETS can be performed safely.

Attachments

Attachment 1
Detailed Description of Fire Event and Issues Regarding Fire Response

Decommissioning of Building 371 was started in late 2001. As of August 2003, approximately 40 percent of the gloveboxes and 90 percent of the tanks had been removed from the building. Material is being segregated and shipped to various locations for storage or processing. A significant nuclear operation ongoing in Building 371 at the time of the fire was operation of the Plutonium Stabilization and Packaging System (PuSPS) for stabilizing plutonium metal and oxide and packaging it into containers for long-term storage. RFFO announced on July 16, 2003, that all work with PuSPS was complete.

Glovebox 8 was in Room 2325 in the basement of Building 371. It was designed to be a dumbwaiter and was used to transport materials from the ground floor to gloveboxes in Room 2325. Other gloveboxes in Room 2325 were used to dissolve ash using nitric acid as part of a process to reclaim plutonium. After cessation of operations in Building 371 in 1986, Glovebox 8 was sealed at the basement ceiling using steel and concrete. It was connected to two other gloveboxes (Gloveboxes 9 and 10). No operations are known to have occurred in any of these gloveboxes after the 1986 shutdown. Glovebox 8 was known to be highly contaminated from the past operations. Glovebox 9 had been removed by the end of 2002. Glovebox 10, which contained a significant amount of plutonium contamination, had been chemically decontaminated using a cerium nitrate process by the end of 2002. Glovebox 10 was removed in early 2003. Covers were taped over the openings in Glovebox 8 left by the removal of Gloveboxes 9 and 10. Removal of Glovebox 8 began in May 2003.

In preparation for removing Glovebox 8, a soft-sided containment was built around the glovebox, with portable air movers and high-efficiency particulate air filters to provide ventilation to the work area. A portable air mover was attached to a glove port on the glovebox to provide negative pressure inside the box, but no air inlet existed. The contractor planned to cut a hole near the top of the glovebox to establish a ventilation path, uncover one of the openings remaining from the removal of a previous glovebox, remove the transition piece and guillotine door associated with this opening, remove material at the bottom of the glovebox (the amount and type of material were not fully known), then cut the glovebox apart. The contractor had no plans to decontaminate Glovebox 8 using the cerium nitrate process, nor was there any history of cerium use in this glovebox.

Work started on Glovebox 8 on May 5, 2003. Workers used a hole saw to cut four holes near the top of the box. These holes were made to document the interior contamination levels and allow a contamination fixative to be sprayed into the glovebox. The next day, two workers dressed in supplied air suits cut a hole (about 4 feet by 2½ feet) in one of the steel sides of the glovebox near the ceiling to provide a ventilation path. The cut was made with a nibbler used to cut metal plate; the nibbler's operation was not considered to be hot work, so no special fire protection measures (e.g., fire watch) were implemented. The hole was made by removing material in small sections for future ease of handling. These plates were allowed to fall into the

glovebox. Soon after the work started, personnel in other areas in Building 371 noted a burning smell and alerted the Configuration Control Authority (CCA). The CCA has the responsibility and control of a shift supervisor. Shortly thereafter, the operators working on Glovebox 8 realized that what they had thought to be dust raised by the falling plates was in fact smoke. They reported the fire to the job supervisor, who in turn reported the fire by telephone to the CCA. The CCA notified the fire department by phone. The fire department arrived at Building 371 in approximately 3 minutes and were on scene in Room 2325 in 11 minutes.

The workers first poured about 2 liters of water from a bottle onto the fire through the hole they had cut. No prior permission was sought to add water to Glovebox 8, which was known to contain fissile material. The workers also had no way of knowing whether water was an appropriate extinguishing agent for the fire. Discussions with the supervisor and workers indicated that the supervisor tried to tell the workers not to add water to the fire, but a miscommunication occurred. Subsequently, the workers returned to floor level and removed gloves from glove ports and a plate and plastic sleeve from the opening where another glovebox had been attached to Glovebox 8. This action opened a large pathway to supply air to the fire. The workers proceeded to apply four dry-chemical fire extinguishers to the fire through these openings and stirred the fire with a pole. At one point the fire appeared to be out, and this information was reported to the CCA, who then relayed it to the firefighters. Subsequently, the workers saw the fire reflash and become much stronger than before, with flames reaching close to 15 feet and coming out of the upper openings they had created. This was not reported to the CCA or the fire department. The workers expended several more fire extinguishers through the openings, then exited the area.

Upon arriving at Building 371, the fire department responders were informed by the CCA that the fire had been extinguished. As a result of reports that the fire had been small and had been extinguished, the firefighters left some of their equipment at the facility entrance to minimize the potential for contaminating it. While proceeding to the scene, they were informed of the reflash of the fire. After the equipment that had been left at the entrance was brought to the scene, the firefighters donned their equipment and entered Room 2325 as the workers were exiting the soft-sided containment . There is no record, nor was there any measurement, of the airborne radiological conditions faced by the firefighters in such close vicinity to Glovebox 8. At this time, the visibility in the soft-sided containment was about 1 to 2 feet because of fire extinguisher chemicals and smoke.

The firefighters left equipment at the facility entrance based on reports from personnel inexperienced in firefighting. The decision to leave equipment at the entrance to avoid contamination was not thoughtful since the possibility of significant contamination was very low until entering the room at the scene.

Attachment 2
Combustible Control Procedure

Fire prevention during decommissioning operations in Building 371 relies primarily on work planning and combustible material controls. The combustible material controls program is described in Administrative Control 5.4 in the Building 371/374 Technical Safety Requirements (TSRs). This administrative control establishes controls for combustible materials and hot work, and includes surveillance requirements. The TSR also specifies a Fire Protection Program that includes periodic fire prevention inspections, fire watches, fire department response, and provision for documented waiver of specific program requirements if they are determined to be ineffective for implementing the relevant safety analysis.

The administrative control is implemented through procedure PRO-1638-FIRE CTRL-371, *Buildings 371/374 Combustible Control*, which provides, among other things, inspection criteria for operating and nonoperating gloveboxes. The procedure contains an inspection sheet for weekly inspections of operating gloveboxes. The inspection sheet requires either that nonoperating gloveboxes contain no combustibles, that combustibles be placed into a metal container or be covered by a fire blanket, or that they be removed before the end of the shift unless approved by the Fire Safety Officer/Fire Protection Engineer. The procedure relies on the Configuration Control System Status Binder to identify operating and nonoperating gloveboxes. After the fire, Rocky Flats Field Office (RFFO) found that Glovebox 8 had been identified as "removed" since January 2003, which was clearly incorrect and may have contributed to the failure to address the accumulation of combustibles in the glovebox. RFFO's independent review team concluded that the documentation of the inspections for combustibles was inadequate, and that the inspection results did not record the presence of combustibles or the inability to perform the inspections adequately (e.g., the difficulty of seeing into Glovebox 8 through dirty windows with low light levels to check for combustibles).

The RFFO review team recommended that the implementation of this administrative control be evaluated to ensure that future surveillances would generate auditable documentation identifying specific gloveboxes inspected and their status concerning the presence of combustible materials. In response, Kaiser-Hill agreed to assess the implementation of this control, review procedures of the combustible control program, and clarify requirements for glovebox inspections.

Based upon discussions with workers and management who were involved in the removal of Gloveboxes 9 and 10 (which were adjacent to Glovebox 8), the Defense Nuclear Facilities Safety Board's (Board) staff has concluded that the established combustible controls were not always followed. Combustibles were routinely left in the gloveboxes overnight without the Fire Safety Officer's permission, and were left uncovered at times to facilitate drying in preparation for the next day's work. Building 371 workers explained that this was done to facilitate meeting the schedule; it would take too much time to bag the material out at the end of a shift, only to have to bag it back in at the beginning of the next day. In addition, the

combustibles introduced into the gloveboxes were not closely monitored. It is obvious from photographs taken after the fire that combustible materials were placed in Glovebox 8 during the decontamination and removal of the adjacent gloveboxes. The weekly inspections performed to verify adherence to combustible material controls were ineffective in ensuring that combustible materials in Glovebox 8 were controlled in accordance with the procedural requirements.

Although the RFFO review team identified problems with implementation of the administrative control, its recommendations did not clearly identify and address the failure of the workers to comply with combustible material controls. The staff concluded that a broader effort was needed to (1) ensure that similar accumulations of combustible materials did not exist in other difficult-to-inspect areas, and (2) determine whether there were similar problems in the implementation of other administrative controls required by the TSRs. This urgent need was addressed in the Board's letter of July 31, 2003, to the Department of Energy.

The Board's staff walked down Buildings 371 and 707 on July 30, 2003, to evaluate the safety of ongoing operations. All areas accessible using a respirator were visited. No gloveboxes with a construction similar to that of Glovebox 8 were observed. Discussions with various personnel revealed that Glovebox 22 in Building 371 (an enclosed chainveyer previously used to transfer containers of material from one work area to another) was the only known containment without clear visibility for verifying the absence of combustible material. Some inaccessible areas associated with the stacker-retriever (which had been used to store packaged plutonium) were identified in Building 371.

No significant issues associated with combustible materials were noted during this visit, in either gloveboxes undergoing work or idle ones. Procedure PRO-1514-CC-707/707A, *Fire Inspection and Combustible Control, Buildings 707/707A*, sets forth the combustible control program for Building 707. This procedure is different from that used in Building 371 in that it does not differentiate between operating and nonoperating gloveboxes and has controls based on allowed fuel package size and distribution. No requirement exists for complete cleanout of the nonoperating gloveboxes at the end of each shift. The staff noted combustibles in the gloveboxes, but none appeared to exceed the allowed 1 cubic foot of material with a 5-foot separation.

Attachment 3
Results of Nondestructive Assays

The Defense Nuclear Facilities Safety Board staff reviewed the history of the nondestructive assay (NDA) of Glovebox 8 for determining the amount of plutonium holdup. This information is important for assessing the potential for criticality during decommissioning activities and during the response to the fire in the glovebox. A holdup survey performed by the contractor in 2001 indicated the presence of 105 grams (± 62 grams) of plutonium in Glovebox 8, while a survey performed in January 2003 (after the removal of Glovebox 9 and chemical decontamination of Glovebox 10) resulted in an estimate of 278 grams (± 149 grams). The 2001 survey also showed a holdup of 8 grams (± 22 grams) for Glovebox 9 and 964 grams (± 304 grams) for Glovebox 10.

The staff's review of the detailed data revealed that two of the measurements made of the lower part of Glovebox 8 in 2003 had increased by a factor of 10 or more compared with measurements made in 2001. The staff discussed this observation with Kaiser-Hill work planners. The work planners had several explanations for why these results might not indicate an increase in plutonium in the glovebox. However, the planners did not take a conservative approach and question actions that might have caused this increase. This represented a missed opportunity to realize that plutonium-bearing combustibles from Glovebox 10 might have been added to Glovebox 8 in violation of procedures. This failure to adequately assess the hazards of each specific work site was a violation of site-wide procedures and of DOE Order 440.1A, *Worker Protection for DOE Federal and Contractor Employees*. This aspect of the breakdown that took place in the planning for removal of Glovebox 8 was noted by Rocky Flats Field Office's (RFFO) independent review team, but RFFO did not make a recommendation concerning this problem, and no corrective action was generated.

The staff also identified two issues regarding how the NDAs were performed and evaluated. First, relatively short counting times (20 seconds in one survey and 50 seconds in another) were used to perform the assays, despite the fact that the resulting measurement uncertainties were large. The large measurement uncertainties may have been a factor leading Kaiser-Hill personnel to discount the significant increase in the measured plutonium content of Glovebox 8 that occurred between 2001 and 2003. Had a more accurate measurement been available, personnel might have recognized the likelihood that combustible wastes from the decontamination of Glovebox 10 had been moved into Glovebox 8.

Second, it does not appear that the effect of the large quantity of miscellaneous materials inside Glovebox 8 was considered in developing the plutonium holdup estimates. The miscellaneous materials could have shielded the signature gamma signals measured during the assay, leading to underestimation of the plutonium inventory, and it is not clear that the assumption of homogeneity used in the NDA calculations was valid. Materials retrieved after the fire included 4-liter bottles containing caustic solutions of plutonium and lead-lined gloves. The contractor has not attempted to correct or recalculate the inventory of Glovebox 8 to

determine with greater certainty whether the use of water while fighting the fire posed a criticality concern. A precise inventory that considered the positions and types of material found was never generated.

These issues raise questions about the adequacy of NDA measurements supporting criticality determinations for upcoming decommissioning activities and possibly for future fire response activities as well. In cases where there is a large safety margin, further effort to reduce uncertainty is not warranted, but there may be instances in which a more accurate measurement or more realistic calculations are required. The staff believes it would be appropriate for the contractor to establish criteria for determining when reanalysis is needed based on such factors as the estimated safety margin for criticality, the uncertainty of an NDA measurement, or the unexpected disparity between measurements for selected gloveboxes.

Each solid waste box is assayed using gamma scans before shipment to the Waste Isolation Pilot Plant. As a check, the staff requested data concerning the amount of plutonium measured for the 14 solid waste boxes associated with the removal of Glovebox 8. The assays of the 14 waste boxes indicated that they contained a total of 445 grams of plutonium (at the 2-sigma uncertainty level). NDA measurements performed before the fire for Glovebox 8 and the Glovebox 10 transition (attached to Glovebox 8 at the time of the fire) indicated 427 grams and 215 grams, respectively, for a total plutonium value of 642 grams (at the 2-sigma level). These data indicate that the original measurements made in Building 371 were conservative, although this was not known on the day of the fire.

Attachment 4
Radiological Controls and Building Reentry

It is common practice at the Rocky Flats Environmental Technology Site (RFETS) to have radiological control technicians (RCTs) observe work being performed from either inside or outside a tent such as that used for the job on Glovebox 8; however, the RCTs on the job did not recall any individual directly observing the job. The lack of an RCT observing the job could compromise implementation of the radiological controls established for the task.

After the fire, RCTs sampled and surveyed the building within a 2-hour period, and work had resumed in the building by 1:00 p.m. The hallways in the basement and first floor were surveyed for radiological contamination and potential airborne radiation, found to be clean, and released for general reentry, except for Room 2325 and the surrounding hallways. No industrial hygiene surveys were conducted for potentially harmful products of combustion until workers in the building complained.

The independent review performed by the Rocky Flats Field Office (RFFO) revealed that reentry of the building occurred without sampling by an industrial hygienist or significant involvement by the fire department or Configuration Control Authority, but RFFO's report made no recommendations in this regard. No procedure existed to provide direction concerning actions to be taken so the building could be safely reentered after an evacuation. The Kaiser-Hill corrective action plan prepared in response to the RFFO report provided no corrective action for the issues concerning reentry. The Board's staff believes a more thoughtful approach would have been advisable to ensure that the magnitude of the fire was understood and that all appropriate safety precautions were taken prior to reentry. An improved reentry plan is needed to ensure that future events are handled more appropriately.

Attachment 5
Cerium Nitrate Decontamination Procedure

Cerium nitrate is used to chemically decontaminate the gloveboxes in Building 371. Typically, the decontamination process reduces plutonium contamination sufficiently to allow the glovebox to be disposed of as low-level waste. The procedure for chemical decontamination in use at the time of the glovebox removal work in Room 2325 includes the following precaution to workers:

> Cerium (IV) [i.e., the +4 oxidation state] nitrate may ignite combustibles or flammable materials. Avoid contact with cellulose (e.g., paper). Follow the combustible control program requirements for combustible loading and spacing requirements. Any wipes (e.g., Kimwipes™) used during cerium decontamination process must be neutralized prior to disposal.

Cerium is one of a group of elements known as the rare earth metals, or lanthanides, which exhibit nearly all the same chemical characteristics. In aqueous solution, all of the rare earth metals exhibit a +3 oxidation state. In the +3 state, salts of rare earth metals exhibit small oxidation potential. Cerium is the only rare earth metal for which the stable +4 oxidation state (as a ceric ion) can also exist in aqueous solutions. The ceric ion is a powerful oxidizing agent, but is easily reduced by halogen salts (e.g., sodium chloride), with the adverse side effect of the release of halogen gas (e.g., chlorine). Ceric salts are usually reduced to the benign +3 state without side effects with a small amount of hydrogen peroxide or, in the case of the Rocky Flats Environmental Technology Site (RFETS) chemical decontamination procedure, ferrous sulfate. The oxidizing power of ceric salts is great enough to remove the tightly adherent protective film on stainless steel even at room temperature. However, because of this powerful oxidizing potential, unreduced ceric salts can cause fires if they make contact with cellulose (e.g., rags, paper) in the presence of air. The advantage of using acidic ceric solutions rather than more aggressive acids, such as chloroplatinic acid, to decontaminate stainless steel is that the ceric solution need be reduced only with a small amount of a ferrous sulfate solution instead of the large amount of neutralizing solution needed for other acids.

RFETS procedure PRO-1470-DECON-371/374, *Chemical Decontamination of Equipment or Gloveboxes Contaminated with Plutonium*, in use at the time of the glovebox removal work in Room 2325, sets forth the process for conducting decontamination operations. The procedure includes detailed instructions for preparing chemicals (e.g., cerium nitrate, ferrous sulfate, and sodium hydroxide solutions), applying the decontamination chemical, cleaning surfaces, rinsing surfaces, wiping surfaces, neutralizing rags, and repeating decontamination operations as necessary.

Discussions with the operators and supervisors associated with decontamination operations in the two gloveboxes connected to Glovebox 8 revealed several violations of the decontamination procedure. The preparation of chemicals was not in accordance with the

procedure. The procedure directs that the cerium nitrate solution be measured into a container and diluted prior to bagging into the glovebox. Instead, a full container of cerium nitrate was bagged into the glovebox, and the solution was diluted in a spray bottle inside the glovebox. The procedure directs the use of a scoop and scale to measure a predetermined quantity of ferrous sulfate that is to be placed in a container. Instead, the workers filled a quart plastic bag with ferrous sulfate and bagged it into the glovebox. The procedure directs the use of a scoop and scale to measure a predetermined quantity of sodium hydroxide to be placed in a 1-liter container and filled with water. The workers instead used a line on a 1-liter container to determine the amount of sodium hydroxide to use.

The workers described a process for applying and cleaning the internal surfaces of a glovebox that was consistent with the procedure. However, the process for neutralizing and reducing the cerium nitrate solution on the rags was not accomplished in accordance with the procedure. The procedure requires wringing out the wet rags over the bottle containing ferrous sulfate. The rags were to be thoroughly wetted with sodium hydroxide solution and again wrung out over the same bottle. Instead, the workers placed wet rags on the floor of the glovebox, sprinkled a handful of ferrous sulfate on the rags, and wetted the rags with sodium hydroxide. These rags were kneaded, and a pH measuring paper was touched to the rags or placed in a pool of solution to verify that the solutions were neutralized. The procedure does not address the use of pH paper and does not provide an allowed range of readings for this measurement. The operators said they obtained measurements close to pH 7, but did not know of any requirement for this reading. The workers expressed the belief that the pH paper provided sufficient indication that the ferrous sulfate had converted the cerium nitrate to the stable +3 form and therefore were not concerned about the amount of ferrous sulfate used in the stabilization process. No evidence could be provided to show that this method of stabilizing the rags had been evaluated to ensure proper neutralization of the acids and reduction of the cerium.

During a September 8–11, 2003, visit to RFETS, the Defense Nuclear Facilities Safety Board's (Board) staff met with representatives of Kaiser-Hill and the Rocky Flats Field Office to discuss detailed comments resulting from a review of a revised version of the cerium nitrate decontamination procedure that had been prepared following the fire. The staff's comments focused on the need to ensure that the instructions regarding the preparation of reagents and the method for neutralization/reduction of the cerium nitrate are sufficiently clear and specific. The staff also observed performance of the cerium nitrate decontamination procedure on Glovebox 44 in Building 371. The staff observed satisfactory performance by the operators, who followed the procedure as directed by the job supervisor.

Currently, Kaiser-Hill staff are not certain about the hazards associated with unreduced cerium nitrate, particularly the necessary conditions for combustion. It is not yet clear whether the wastes from decontamination of Glovebox 10 were involved in the initiation of the fire in Glovebox 8, nor is it clear whether similar materials packaged as waste are stable enough for safe interim storage and disposal. This issue was identified in the Board's letter of July 31, 2003, which imposed reporting requirements related to safety issues raised by the fire in Glovebox 8. During the staff's September 8–11, 2003, visit to RFETS, Kaiser-Hill personnel

informed the staff that self-heating tests conducted in Building 559 provided a preliminary indication that rags (with and without cerium nitrate) could be safely packaged and disposed. Kaiser-Hill has contracted with a private laboratory to perform further tests to evaluate the safety of storage and disposal of materials in contact with unreduced cerium. The results of these tests should allow RFETS to determine whether any action is necessary to ensure that previously packaged decontamination wastes pose no safety hazard.

Attachment 6
Ventilation

During the course of the fire on May 6, 2003, Kaiser-Hill personnel aligned the Zone II room air recirculation system (two independent systems that perform the same function, one for the north side of Building 371 and one for the south side) so that they exhausted directly to the atmosphere. This is called an emergency dump mode. During this mode of operation, the exhaust passes through high-efficiency particulate air filters on a once-through basis before being vented to the environment. Realigning both systems simultaneously causes various rooms in the basement to have a positive differential pressure relative to the hallways. A worker had to physically hold the doors to Room 2325 shut to prevent contaminated air from exhausting into the hallway. Once the problem had been recognized, the air system for the unaffected part of the building was returned to the recirculation mode, and the differential pressure problem was resolved. Operators and the Building 371 Configuration Control Authority (CCA) should have realized that the double alignment would cause this problem.

The Rocky Flats Field Office (RFFO) independent review team did not comment on this problem or make any recommendations regarding the proper method for aligning the ventilation systems during an event such as a fire. It would be appropriate for Kaiser-Hill and RFFO to further evaluate the use of ventilation during events such as fires, and provide appropriate training for personnel, particularly the building CCA.