ROCKY FLATS CLOSURE LEGACY

SAFETY INTEGRATION

WORKING SAFELY WAS ACHIEVED IN LARGE MEASURE WHEN MEANINGFUL DIALOGUE OCCURRED BETWEEN THE WORKERS AND THEIR SUPERVISORS AND MANAGERS. MANY SAFETY IMPROVEMENTS AND PROCESS EFFICIENCIES ORIGINATED WITH THE WORKERS.

SAFETY INTEGRATION

INTRODUCTION

As the Site transitioned from weapons production through an indeterminate standby mode and finally to the decontamination and decommissioning (D&D) activities associated with closure, there was a substantial change in the type of work performed and the hazards encountered. Nuclear operations, characterized by a stable, trained group of employees following routine procedures, using equipment of a known configuration, decreased as Special Nuclear Materials (SNM) and plutonium residues were stabilized and placed in safe storage awaiting offsite transfer or disposal. Construction-type work, characterized by sometimes-different contractors doing constantly changing work under evolving conditions, replaced the routine production operations. Change was a fact of life. Facility conditions changed on a daily basis, Site traffic patterns changed routinely, and the inventory and location of SNM and waste was dynamic. It was clear that the safety infrastructure existing at Rocky Flats that had been created for the nuclear production era was not designed for the constantly changing environment associated with the cleanup mission. But it was also clear that the cleanup mission could not be successful if it were not accomplished safely.

It was clear that the safety infrastructure existing at Rocky Flats, and created for the nuclear production era, was not designed for the constantly changing environment associated with the cleanup mission.

What evolved over the course of Site Closure was a proactive safety culture embraced by the DOE and contractor management, and most importantly, the hourly workforce performing the actual hazardous work. The safety culture combined the incentivized desire to accomplish work with the discipline to identify hazards and ensure that adequate controls were in place before starting that work. This was partly due to the Site's development and implementation of a streamlined and efficient Integrated Safety Management System (ISMS) that workers understood and could utilize efficiently. A related factor was the eventual realization that unauthorized and unreviewed "shortcuts" did not accelerate work due to the fact that work stoppages were inevitable when safety was not built into the process from the beginning.

The final site safety culture did not develop either quickly or easily. The Contractor received $610,000 in penalties under the Closure Contract and additional fines under the Price-Anderson Act for various safety violations. Several events described below provide further details on these safety violations. However, over time both Contractor and DOE's Rocky Flats Field Office (RFFO) management came to understand that safety was not only a requirement but also a powerful tool to enable and improve the project performance. This final safety culture was captured in the statement "If we don't work safely, we don't work."

DISCUSSION

Rocky Flats Workforce Before the Closure Mission

The Site's path to closure required the safe accomplishment of three major types of physical closure work. The first type was similar to weapons production operations in that these activities were typically performed in gloveboxes. Initially the highest priority closure work, it involved reducing legacy risks such as draining tanks, stabilizing plutonium materials, and packaging SNM and residues for safe, long-term storage or disposal. A second major type of closure work was the decommissioning of plutonium processing equipment such as gloveboxes, tanks, and ventilation systems. The third major closure work type was the decommissioning and subsequent demolition of facilities and the remediation of environmental media. This third type of closure work involved a wide variety of activities but with much lower levels of radioactivity. Although the Site passed through phases when one type of work was predominant, the work was mostly concurrent. Support work, such as waste management and disposal, proceeded in parallel to these major types of closure work. Each of these closure work types represented different safety challenges.

When plutonium manufacturing activities were shut down in 1989 for operational and safety deficiencies, it was anticipated that those activities would be resumed within a matter of weeks. Consequently, no efforts were made to process and/or package materials for prolonged storage. As additional systematic operational and safety deficiencies were uncovered it became clear that such processing and packaging activities would require significant analysis, planning, facility controls, process development, equipment modification, and personnel training. Putting these elements in place became the goal of "Resumption." Resumption originally focused on putting the systems in place to safely and compliantly restart weapons production activities. Subsequently, when the Site's weapons mission was canceled, the resumption activities focused on resuming only those operations necessary to reduce risks and stabilize the nuclear materials in preparation for Site closure.

It was clear that safely decommissioning over 1,000 gloveboxes represented perhaps the greatest challenge for Site closure

After the 1989 shutdown, substantial efforts were made to train the workforce in the principles of Conduct of Operations and to the new procedures that were being generated as part of the resumption process. While these efforts never produced the intended products (i.e., pits), the workforce did receive valuable training and an improved physical and work control infrastructure to improve the safety and compliance of Site activities. Formality of operation and procedural rigor was substantially enhanced over the pre-shutdown condition at the Site.

Initiation of Risk Reduction Work

After the production mission was canceled, the primary Site efforts focused on the removal and stabilization of hazardous materials. One of the first activities to be undertaken was the draining of plutonium bearing liquids from process tanks and piping. This activity (and other efforts involved with stabilizing SNM and residues and improving the immediate safety posture of the facilities) had some similarities to activities that hourly workers had performed during weapons production. The work involved performing a variety of carefully controlled operations in gloveboxes, observing criticality safety limits (i.e., Criticality Safety Operational Limits and Nuclear Materials Safety Limits), maintaining material control and accountability, and working to procedures.

DOE's Rocky Flats Field Office (RFFO) also began to redirect its effort from active management of the Site to overseeing contractor performance and began to develop qualified Facility Representatives to carry that oversight into the actual work areas.

Despite its overall similarity to previous production operations the work contained significant differences. The execution of the risk reduction activities required new equipment and processes. Long term storage requirements or disposal requirements for residues and SNM differed substantially from previous practice. Residues were packaged to meet strict Waste Isolation Pilot Plant Waste Acceptance Criteria (WIPP WAC). The SNM packaging required a completely new packaging concept. The startup of these processes required the infrastructure and processes developed during resumption to be integrated with the new equipment and procedures. Readiness reviews and assessments were necessary to verify that the systems were ready to operate. The work was undertaken under the oversight of the Defense Nuclear Facility Safety Board (DNFSB), DOE HQ, and numerous internal reviewing organizations. The majority of the workers that performed these activities were the same individuals that had performed the Site's production mission and were familiar with the hazards of glovebox work and attendant procedural controls.

The workforce, although largely nuclear trained and familiar with glovebox operations, was not trained to perform deactivation and decommissioning activities.

Initiation of Closure Work

The award of the 1995 Performance Based Integrating Management Contract[37] to Kaiser-Hill LLC (K-H) initiated a change in the Site's view of safety. The new contractor focused more aggressively on closure and was incentivised to accomplish closure work and achieve safety goals. RFFO also began to redirect its effort from active management of the Site to overseeing contractor performance and began to train and deploy qualified Facility Representatives to carry that oversight into the actual work areas.

Authorization Basis Changes

In order to respond to the authorization basis problems for both residue processing and risk reduction activities, the Site developed new Authorization Basis (AB) documents for the production buildings. In some buildings these replaced the Final Safety Analysis Reports (FSARs) prepared in the late 1980's to enable production and R&D missions. The first iterations of the new ABs were two Basis for Operation (BFO) documents, one for Building 771/774 and one to support transuranic waste storage in Building 440. While the Building 771/774 BFO[58] enabled the necessary activities to proceed for draining liquids and stabilizing materials, it was not suited for full scale decommissioning activities and was cumbersome to implement. Following the BFOs were facility Basis for Interim Operations (BIOs), developed to allow residue processing, material stabilization, and facility modification activities. These documents were developed with the understanding that they would eventually be replaced by documents specifically tailored to the decommissioning mission.

The Decommissioning Challenge

While the Site's primary focus after the cancellation of the production mission was risk reduction, it was clear that safely decommissioning over 1,000 gloveboxes and the associated process equipment represented the greatest challenge for Site closure. Removing plutonium processing equipment is inherently hazardous, with workers spending long hours in personal protective equipment (PPE), working in confined conditions, and using hand-held cutting tools to dismantle equipment that may contain hundreds of grams of plutonium. With the knowledge that the plutonium equipment removal work would be such a challenge, the Site initiated pilot projects to begin to develop the physical approaches and safety controls to support the effort.

The Site was not ignoring safety but tended to view the prevention of incidents as the responsibility of the safety organization.

Decommissioning Pilot Projects

One of the challenges identified during these pilot projects was the fact that the workforce, although largely nuclear trained and familiar with glovebox operations, was not trained to perform deactivation and decommissioning activities. It was essential to ensure that the workers, regardless of their background and past experience, attained the specific training necessary to ensure a consistent understanding of Site requirements and Conduct of Operations at a nuclear facility. This was especially difficult when new employees were hired to supplement the existing workforce. The majority of construction workers hired had little-to-no familiarity with the Rocky Flats safety requirements. Additional

oversight of deactivation and decommissioning activities was necessary to mitigate the lack of experience.

One pilot project in 1997 involved removing a lathe glovebox in Building 707's Module A to allow the installation of a new glovebox to be used for salt stabilization. Removal of this single glovebox took approximately five months and identified many safety issues that allowed future similar efforts to be performed more effectively. This glovebox was dismantled in place while other glovebox operations continued within Module A, presenting a significant challenge since deactivation and decommissioning activities were occurring alongside nuclear production operations. Additional gloveboxes were removed in Building 779, most of which had been used for Research & Development activities.[60] This allowed the work crews to start with uncontaminated gloveboxes and progress to more contaminated equipment. These initial activities helped develop the processes and provided the training that was later transferred to the decommissioning of the larger plutonium facilities.

Safety Impacts as Closure Progressed

With an increased level of activity on Site, there were an increasing number of safety incidents. The Site workforce was not ignoring safety but tended to view the prevention of incidents as the responsibility of the safety organizations. Also, the Site did not view safety as an inherent part of the work but rather as a list of requirements that were imposed on the work by the safety professionals. Additional problems included the need to inculcate new workers with the safety culture and devise better methods of coordinating conflicting activities within buildings where the conflict might result in unsafe conditions.

Changes to the Safety and Authorization Basis Approach During Closure

The Closure Contract awarded to K-H in 2000 initiated the final change to the safety culture at Rocky Flats. The contract contained substantial rewards for safe, compliant, and timely Site closure, but also contained unprecedented penalties for unsafe performance. The modified contract, combined with increasing expertise in safe work practices and the understanding that "If we don't work safely, we don't work" allowed the Site to dramatically accelerate its closure work. Inevitably there were still safety incidents due to the natural human tendency to become complacent over time. The Site management, DOE and contractor, had to continually reinforce the importance of a questioning attitude towards work conditions and methods and to empower workers to stop work if there was any uncertainty regarding safety or compliance.

The contract contained substantial rewards for safe, compliant, and timely Site closure, but also contained unprecedented penalties for unsafe performance.

Removal of plutonium process equipment was initially performed within the framework of existing AB documents. It quickly became apparent that these documents would be tremendous barriers to full scale decommissioning. Building on the experience of the BIOs, the Site developed the Decommissioning Basis for Interim Operations (DBIOs) to facilitate full-scale decommissioning.[61] The DBIOs incorporated increased use of administrative controls, functional system requirements in lieu of specified hardware, and criteria for "stepping out" of Technical Safety Requirements (TSRs) when pre-determined conditions, such as "Operationally Clean," were satisfied. The Site Safety Analysis Report (SAR)[62] was developed to provide the AB coverage for activities not addressed under building-specific AB documents.

Decontamination and Demolition of Structures - Safety Impacts

Initiating decommissioning and demolition of structures immediately created new safety risks for what may have been a stable safety environment. This could occur for plutonium facilities after the building's (or sometimes an area of the building) process equipment had been removed. For non-plutonium facilities or uncontaminated structures, work could begin once all classified items, accountable materials, and/or personal property had been removed. Most often the work was performed by subcontractors hired for the project to provide additional labor and a lower (competitively bid) price. This resulted in safety challenges associated with new workers and contractors that did not understand or embrace the Site's safety culture and/or did not have experience with the larger scale use of large hydraulic excavators and construction equipment.

Safety Trending and Oversight

The Site's lessons-learned program had been marginally successful at sharing lessons from one building (positive or negative) with the other building projects. Major incidents were widely publicized both on Site and throughout the DOE complex. Unfortunately, many valuable lessons were not receiving the attention deserved and were not formally promulgated. While this was somewhat mitigated by the sharing of worker resources between projects, a more proactive lessons-learned infrastructure was required across the Site to ensure faster and more comprehensive incorporation of lessons learned.

A more proactive lessons-learned infrastructure was required across the Site to ensure faster and more comprehensive incorporation of lessons learned.

In 2001, based on an increasing trend of safety concerns based on what it believed to be K-H's excessive focus on schedule acceleration, RFFO directed K-H to develop and implement initiatives to improve safety performance.[10] RFFO required that the K-H initiatives address overall management performance, the work control and planning process, worker

and supervisor performance, lessons learned and corrective actions to prevent recurrence, and independent safety oversight.

The Safety Analysis Center (SAC) was established in 2001[63] as a fundamental tool for sharing informal lessons learned and presenting the facts for Site safety events at all levels of significance. It was intended to complement the lessons learned program - not to replace it. All events were reported to the SAC on a daily basis, from minor slips and scratches to highly significant safety events such as the Building 371 glovebox fire. Events of significance were discussed so that both DOE and those K-H projects that were not directly involved in an event could understand the nature of the event, its significance, and the path forward. The projects had the authority to pursue actions on their own if they believed an event or the response to an event could be used to create improvements in their own project. Some events, following discussion in the SAC, resulted in site-wide actions being directed by senior management. An example of this was a directed walk-down of all gloveboxes to identify combustible materials instituted after the Building 371 glovebox fire in May 2003. The SAC also provided a forum for discussing general safety issues, sharing safety improvements achieved in one project or another, and for follow-up on past items discussed in the SAC. The SAC was often criticized for its ad hoc, informal approach. It compensated for the informality by responsiveness; the ability to analyze, decide, and implement corrective actions in near real time. The aspect that made this tradeoff work was the continuous level of senior management commitment to the SAC and its functionality. The SAC started each day with the focused attention of the contractor management team on issues involving safety.

The Safety Analysis Center started each day with the focused attention of the contractor management team on issues involving safety.

SIGNIFICANT SAFETY EVENTS

- In the fall of 1994, an unauthorized tank draining evolution was performed in Building 771. The draining activity involved liquids with a much higher plutonium concentration than had been authorized and personnel subsequently tried to hide their errors, creating additional significant safety concerns. Virtually all of Building 771's risk reduction activities were shut down for nearly a year while the event was analyzed and systems were implemented to prevent reoccurrence. (EM-RFO--EGGR-771OPS-1994-0062)[64]

- A sawzall cut and uptake event during glovebox size reduction in Building 779 occurred in 1999. The worker had disabled several of the sawzall's safety features and no immediate supervision was provided during the work. The response to this event led to the Site's commitment to using an "Inner Tent Chamber" approach for size

reduction in Building 771, an approach for glovebox size reduction that was eventually superceded by glovebox decontamination technology and the use of more conventional soft-sided containment systems that were more ergonomically efficient. (EM-RFO--KHLL-779OPS-1999-0006)[65]

- In 2002, a consistent pattern of safety incidents and near misses was identified by the RFFO Facility Representatives in Building 865 during the initial activities of a competitively-procured decommissioning subcontractor, resulting in the building activities being shut down and the subcontractor being terminated. The longer-term result was a tightening of procurement requirements for decommissioning subcontractors and an increase in K-H supervision of subcontractor safety practices. (EM-RFO--KHLL-NONPUOPS1-2002-0002 through -0007)[66,204,205,206,207,208]

- Plutonium uptake in Building 771 was not so much an event as it was a discovery process. In Building 771 a number of employees experienced uptakes as documented by consistently elevated plutonium bioassay levels. This was eventually determined as caused by several extremely small releases, some so small that they did not trigger a Continuous Air Monitor (CAM). This chronic, low-dose exposure to multiple workers required a reexamination in 2000 of the entire contamination control strategy for a highly contaminated building undergoing decontamination. One of the primary results from this was the decision to require decommissioning workers to wear respirators for most jobs in any area where releases could routinely occur. (EM-RFO--KHLL-771OPS-2000-0057)[67]

- In May 2003 a fire in a Building 371 glovebox occurred after a nibbler began cutting into one of the upper sides of a 20-foot tall glovebox. A significant amount of combustible material had accumulated in a marginally-accessible portion of the glovebox, some as a result of workers tossing rags from decontamination efforts on other previously-attached gloveboxes (that had since been removed) instead of bagging them out. Building and Site management response was neither sufficiently rapid nor comprehensive given the severity of the incident. The root cause was worker and supervisor complacency and negligence, despite and maybe because the crew was familiar with the area and very experienced. The immediate area was shut down while the incident was being investigated, but unrelated work continued in the building. Subsequent assessments determined that K-H resumed decommissioning activities prior to developing an adequate understanding of the causes of the event, a point reiterated by the DNFSB. (EM-RFO--KHLL-371OPS-2003-0011)[68]

The Site made numerous changes to decontamination practices as a result of further investigations into the event and extensive testing on materials used to perform decontamination. Combustible loading inspections became more rigorous and pre-job walk-downs focused on identifying the presence of combustibles and unusual conditions. The Integrated Work Control Program was revised to strengthen the planning and feedback processes. Personnel across the Site were trained to these and other safety processes. The desired response to a fire was re-evaluated, procedures updated and personnel trained accordingly. Self Assessment and Independent Assessment programs were upgraded to become more effective. Numerous other corrective actions were undertaken and are described in K-H's Comprehensive Corrective Action Plan (2003-04).[69] RFFO performed a detailed self assessment and causal analysis of its own safety oversight program (issued in January 2004) in response to a December 2003 DNFSB letter, and implemented a corrective action plan to address and document the correction of the identified deficiencies. DNFSB staff visited the Site during 2004 to verify closure of actions described in both the DOE and K-H corrective action plans.

- A fire occurred while filling the Building 991 tunnels with expansive foam that cures exothermically. While foam had been used routinely for filling smaller void spaces, the heat resulting from the quantity used to fill a larger underground tunnel caused it to spontaneously combust. This fire had no flames, released no radioactivity, and the response was deliberate and controlled showing the positive effect of the lessons learned from the Building 371 glovebox fire. However, it also identified a weakness in the control of work processes and the ability of a single subject matter expert to waive work restrictions. (EM-RFO--KHLL-D&DOPS-2004-0003)[70]

SAFETY PROCESSES

"If we don't work safely, we don't work"

After the resumption period, the Site had an extremely risk averse attitude. This resulted in a perception extending from management to hourly workers that the corporate or personal benefit derived from successfully accomplishing physical work was outweighed by the negative consequences of a potential accident or actual or perceived safety incident. This extremely risk-averse culture did not support a healthy work environment or worker mindset and would not support closure. As closure progressed and work began to accelerate, the workers and management began viewing safety processes as an impediment to actual work.

Ultimately, as management and workers learned the value of safe work practices, familiarity with the processes, and the ISMS process of examining completed work for improvement in subsequent work, the culture evolved to getting work done efficiently and safely. This was summarized by the phrase "If we don't work safely, we don't work."

Failure of Safety Performance Measures to Improve Safety

In 1995 Kaiser-Hill was awarded what became known as the 1995 Performance Based Integrating Management Contract (PBIMC). A product of the DOE Contract Reform initiative, it focused on "performance measures" to incentivize contractor performance. Although in some ways an improvement on the Management and Operating (M&O) contract model, the 1995 PBIMC contained over 60 performance measures with many relating to safety. These included quarterly safety metrics such as recordable injuries, criticality violations, and occurrence reports. These metrics flowed down through the contractor team to second and third-tier subcontractors as a basis for their share of the performance fee.

In practice, the concept of trying to incentivize safety through safety performance measures did not result in improved performance but in the contractors' gaming the system.

In practice the concept of trying to incentivize safety through performance measures resulted not in improved safety performance but in the contractors' gaming the system. Occurrences were not reported or were designated as "incidents" and thus not impacting the performance measure. Higher tiered contractors did not include adverse subcontractor metrics. The result was continued disagreement between RFFO and the contractor on whether the letter of the performance measure was met, and a perceived improvement in the process metrics with little-to-no actual improvement in safety at the working level.

Closure Contract Requirements

The Closure Contract awarded to K-H in 2000[33] contained unprecedented ability for the contractor to earn fee and equally unprecedented penalties for poor safety performance. It placed graded penalties for poor safety performance; including potential total loss of virtually all incentive fee for a major accident or incident such as a worker fatality. While cutting back on DOE's responsibility to manage daily work, it emphasized DOE's role in safety oversight and improved access for RFFO Facility Representatives and other safety oversight.

A secondary safety focus was the recognition by both RFFO and K-H that DOE's unilateral and unquestioned ability to stop work for safety would impact the contractor's ability to earn fee. Since fee is earned based on closure project earned value, if a portion of the Closure Project was stopped for recovery from a safety incident, it would result in a larger loss

of performance fee than might be likely to result from contractual penalties from that safety incident.

Approach to DOE's ISMS Initiative

One of the major benefits of the DOE's ISMS initiative was that the workers were much more involved and empowered in the entire safety process. Ultimately, management and workers recognized that the only way to accelerate closure was to integrate safety into every aspect of Site operations. If the work could not be done safely then the closure would be (and many times was) delayed until safety improvements were implemented. The rigorous ISMS approach to pre-job planning and walkdowns was aggressively implemented.[71,72]

One of the major benefits of the DOE's ISMS initiative was that the workers were much more involved and empowered in the entire safety process.

DOE Facility Representative Oversight

The original Facility Representative (FR) charter envisioned the FRs as the "eyes and ears" of the RFFO Manager. The FRs were in the buildings to ensure that operations were conducted "safely and efficiently" and to "observe, evaluate, and report" to DOE management concerning the contractor's compliance with DOE orders, federal regulations, and any other applicable requirements. As the RFFO's oversight role evolved, the FR role also evolved. The most significant challenge for both DOE and the contractor was to manage to the contract, not manage the contractor. The FRs continued in their role of "observe, evaluate, and report" but they learned that their oversight must start with the contractual requirements and not specific technical direction (i.e., What, not How). When technical direction was required the FRs learned to channel that direction through a Contracting Officer or Contracting Officer's Technical Representative. The working relationships between contractor building management and DOE FRs became much more collaborative, focused on accomplishing the closure mission safely and compliantly. The FRs still retained shutdown authority consistent with their first priority: Safety. However, the best FRs learned how to improve the contractor's compliance by showing how the improvement supported the contractor's bottom line: Safe, compliant closure ahead of schedule and under budget. Other sections describe multiple examples where technical or procedural improvements made for safety also significantly improved productivity.

The most significant challenge for both DOE and the contractor was to manage to the contract, not manage the contractor.

Development of the Decommissioning BIO (DBIO)

The Authorization Basis process originally focused on operations–type activities and tended to be equipment based for ease of implementation in a relatively unchanging facility. AB documents often dictated hardware and system requirements in lieu of functional requirements (e.g., "have

exhaust fans F-X1 and F-X2 running at all times" instead of "maintain a minimum differential pressure of 10 inches w.g. with respect to atmosphere"). However, during the removal of process equipment during decommissioning, there was constant change in equipment conditions and additional requirements such as using of the building ventilation system for contamination control in soft-sided containment structures. The BIOs were developed to allow residue processing, material stabilization, and facility modification activities to be performed with the understanding that they would eventually need to be replaced by documents specifically tailored to the decommissioning activities. As part of accelerated closure, decommissioning work was often initiated prior to the completion of risk reduction and waste packaging work. This work was addressed under the Unreviewed Safety Question Determination or "page change" processes. Finally, at the completion of the glovebox operations-type activities, the DBIO would be implemented to allow more efficient full-scale decommissioning.

The DBIOs incorporated increased use of administrative controls and functional system requirements in lieu of specifying hardware requirements. They included recision plans and criteria for "stepping out" of TSR requirements when pre-determined conditions were met (such as "Operationally Clean") and the follow-on controls that would apply once the TSRs were discontinued. The DBIO also shifted responsibility to the building shift manager for activity coordination and configuration control.

The 2000 Closure Contract incorporated specific review times for RFFO to review AB documents based on K-H concerns that a prolonged approval process could impact closure. In fact, RFFO became progressively more flexible in supporting the closure process and more comfortable in accepting risk as a result of less rigorous analysis, as the magnitude of those risks decreased. RFFO management, as the responsible regulator for Site nuclear activities, evaluated and approved the control strategies applied at the Site.

After a building was determined to be "Operationally Clean," the principal ongoing AB requirement was a continued screening of work control documents against the DBIO requirements.

DBIO "Step Out" Criteria

It was a difficult and time-consuming process to downgrade a large Nuclear Facility (with its facility-specific AB) to a Radiological Facility (which operated under the authorization of the Site SAR). This was because even after the process and ventilation equipment was removed, measurement uncertainties associated with the characterization of the walls and floors would result in substantial roll-up of material at risk at a facility level.

The DBIO was intended to authorize all decommissioning activities through the building demolition and avoided the issue of downgrading the facility by providing an appropriately graded AB approach. After the building or building area was determined by RFFO to meet easily-definable "step out" criteria the efficiency of decommissioning under the DBIO was virtually the same as for a radiological facility. For example, the "Operationally Clean" criterion was based on a visual inspection of straightforward physical conditions, not characterization or gram measurements. After a building was determined to be "Operationally Clean," the principal ongoing AB requirement was a continued screening of work control documents against the DBIO requirements.

Different Company and Subcontractor Safety Systems

An ongoing safety problem at the Site was the difference in safety culture between the Site personnel and commercial subcontractor personnel. Subcontracting the decommissioning of uncontaminated and less contaminated buildings to commercial construction subcontractors was expected to both save money and ensure that sufficient hourly workers with plutonium work experience were available for the higher-risk work in plutonium facilities. There was also the belief that DOE facilities had developed inherently inefficient work practices. This led to the corollary that having commercial subcontractors manage complete projects, as opposed to performing limited activities like asbestos abatement, would allow the Site to identify and eliminate unnecessary processes and result in an overall improvement in Site efficiency.

An ongoing safety problem at the Site was the difference in safety culture between the Site personnel and commercial contractors.

Two initial projects, the demolition of Building 111 and the decommissioning of Building 865, contaminated with asbestos and uranium/beryllium respectively, were subcontracted as complete projects to commercial subcontractors. The results identified the safety deficiencies in the subcontractors. In Building 111, the subcontractor was lax in its enforcement of normal occupational safety regulations. In Building 865, the subcontractor exhibited a consistent pattern of safety violations and a persistent lack of understanding of safety practices necessary to work in a facility with radioactive contamination. In this case, the subcontractor scope was changed to remove the responsibility to manage the project and K-H management assumed project management responsibility.

Two significant modifications were introduced to address this conflict of cultures. The first was to modify the procurement process to emphasize the need for subcontractors with nuclear experience and include more safety compliance requirements in subcontract documents. The second was to recognize the need for additional K-H staff to better oversee the

subcontractors. Additionally, with the Site's overall improvement in efficiency, K-H and its team of subcontractors maintained a greater degree of management control and typically subcontracted smaller project elements, allowing better control of the safety environment.

Tracking of Building Availability

As the DBIOs became active and risk reduction work accelerated, maintaining the building infrastructure in compliance with its AB became a complex effort. It became increasingly difficult to maintain ventilation operability at all locations and manage the interacting impacts of administrative controls and compensatory measures. This resulted in the facility being outside its safety envelope and the consequent shut down of processing operations. Thus the risk reduction process availability (and hence residue and SNM stabilization throughput) was less dependent on the process activities and more dependent on the building infrastructure being compliant and available to support operations.

The contractor instituted a process to track the causes of building downtime to identify routine causes and fix both the immediate cause and, in some cases, underlying systematic issues. It invested the Configuration Control Authority (CCA) with additional authority to assure daily coordination of activities and properly evaluate impacts that might result in shutdowns and allow for better coordination. The CCA proved to be a very effective coordination approach to assure compliance with the building AB.

... maintaining the building in compliance with its AB became a complex effort. ... risk reduction (activities became) dependent on the building infrastructure being available to support operations.

Conduct of Operations Process

Following basic conduct of operations principles, the Site required that all activities occurring in a facility be authorized and coordinated with the CCA. This proved crucial in assuring that activities occurring in one portion of a facility did not cause safety problems elsewhere in the facility, particularly when work affected building ventilation systems. The importance of this is best described by two failures of the work release process. In the first, a Building 559 laboratory employee vented gas through the Building 776 ventilation system. The employee made some assumptions when performing this task and although he did check in with the Building 776 CCA he failed to disclose the details of his activities. Building personnel that had knowledge of the activity failed to exercise a questioning attitude – including the CCA. The result was fumes being circulated throughout many occupied portions of the facility. Two years later an employee not assigned to Building 707 went to collect a sample from the building's ventilation system and failed to check in with the CCA. He subsequently breached a system that was in use and caused a

spread of contamination through much of the first floor of the facility. Both events involved personnel not normally assigned to a building, but familiar with it, failing to follow established Conduct of Operations principles or facility procedures for obtaining approval to work.

Resolution of Safety Incidents/Occurrences While Minimizing Shutdowns

During Resumption, systemic problems with the operations and safety infrastructure demanded that when problems or incidents occurred, all related activities needed to be shut down and examined. This typically included all activities in a given facility and possibly similar activities in other facilities. As the operations infrastructure improved, incidents and occurrences less often identified fundamental systemic deficiencies, but it was still practice to shutdown the immediate operation and often the facility until the corrective actions could be implemented.

As the Site moved towards closure this process was reexamined. This resulted in carefully evaluating the incident and shutting down only those activities that were directly related to the problem. Attempts were made to accelerate the identification and implementation of corrective actions. Often, activities were continued with compensatory measures in place until specific corrective actions could be identified and implemented. This approach had several safety benefits. First, it provided better management focus on the real safety issue. Second, workers outside the immediate affected operation didn't feel like they were being "punished" for the failings of others. Streamlining the process did not preempt the identification and implementation of safety corrective actions but, it did recognize that shutting down activities was not always necessary. RFFO always maintained oversight of the corrective action process, and could shut down any activity that was not being performed safely.

The worker at all levels of the project must feel a sense of ownership for their results and accountability for their individual contributions to the mission.

Personal, Organizational, and Corporate Accountability

As the Closure Project progressed, the Site projectized all activities. The projectization usually improved accountability for work activities within a specific project. There were some exceptions, such as SNM Operations, waste operations, and some support functions that were matrixed to the user organization. Fundamentally, the key lesson is that of "ownership." Responsibility for SNM Removal was ultimately transferred to Building 371's project manager because the Building was not focused on the SNM Removal Project when it was "owned" by another organization. The Execution Project Manager had an Execution Project-specific safety organization and had personal responsibility for the safety performance of his project.

The safety lesson is that individuals must be accountable for their actions and accountability requires empowerment. The workers at all levels of the project must feel a sense of ownership for their results and accountability for their individual contributions to the mission. This ownership, accountability, and empowerment was strengthened by the contractors' incentive program that allowed workers to reap the monetary benefits of accelerated closure and share in the monetary loss from the results of safety failures. Senior management routinely encouraged employees to have a questioning attitude and to elevate issues up the management chain if they did not feel the issue was properly addressed. Eventually this became automatic as workers believed in management's commitment to "safety first".

Safety Trend Degradation

Tracking and analysis of safety metrics is a useful tool in identifying areas for greater safety emphasis. Typically, an adverse trend is noted due to either an increase in the frequency of an event or the initial measurement and tracking of a particular type of event. Following its identification, corrective actions are developed and invariably include briefings or training for workers and procedure changes were made in an attempt to preclude future occurrences. As time passes, trends in other safety area are identified and the same process is implemented. At Rocky Flats, it was observed that certain metrics varied periodically. The specific metrics exhibiting this trend were electrical events, radiological posting violations, and powered industrial truck (PIT) activities. The periodicity for these metrics varied, but they were generally between eight to twelve months. In an attempt to interrupt these cycles, safety pauses were initiated periodically as an adverse trend was beginning an upward cycle. In the case of PIT activities the contractor held an annual "rodeo" that allowed drivers to demonstrate their proficiency while reinforcing the safety aspects of their jobs. Electrical safety was always high on the radar screen. Refresher briefings and electrical safety assessments were performed with regular frequency. Also, safety pauses were used around major holidays or other events that could cause a distraction for the workers. The approach was captured in the Site Safety Continuous Improvement Plan.[74]

In an attempt to interrupt the cyclical increase in accidents, safety pauses were initiated periodically as an adverse trend was beginning an upward cycle.

Training

The original pre-closure Rocky Flats hourly personnel were highly trained in the processing and manufacturing areas. Performing decommissioning, although related due to the presence of radionuclides, was a significantly different skill set. Additionally, the scope of closure work exceeded the existing capacity of the hourly workforce, so new personnel needed to be

hired. Therefore, the training challenges were to broaden the skill set of the original workers, to provide those skills to new hires as well as to re-instill the radiological precautions that were familiar to the original workers, and to inculcate the safety process and culture into all of their daily activities.

The new staff had some training advantages because they had no preconceived work patterns that required modification. Conversely, it was also noted that training had limitations that could not match practical work experience – particularly when dealing with radioactive material in the variety of forms encountered at Rocky Flats. New hires were training rigorously to perform a variety of jobs, yet they had inherent shortcomings due to their lack of experience in working with plutonium. To remedy this problem management trained the new employees using a variety of formal courses, visual aids, and toolbox safety presentations, and also kept reinforcing the safety culture. The Site developed a hands-on course ("Safety 101") with simulated work environments where workers practiced tasks with ladders and common tools in simulated contaminated spaces. Management also had success by seeding new employees in with experienced teams.

Several incidents revealed that what was identified as process knowledge was sometimes more like "urban legend"…

Over-Reliance on Process Knowledge

Process knowledge can be useful in avoiding unnecessary characterization, but has its own risks and uncertainties. Process knowledge was a useful tool in planning the decommissioning efforts, but it was subsequently recognized as a limited data source. Process knowledge also varies significantly from operator to operator. Several incidents revealed that what was identified as process knowledge was sometimes more like "urban legend" with no individual able to give a first-person account of the condition. Planning activities relied heavily on hold-up measurement scans performed prior to initiating an activity. Inputs from the hold-up measurement team became vitally important and the team's gram estimation techniques were state-of-the-art. Utilizing the information provided by process knowledge supplemented with characterization data allowed the hazards associated with decommissioning work to be better quantified and controlled.

Process Startup

DOE Order 425 (or its predecessor 5480.31) required an Operational Readiness Review or Readiness Assessment (ORR/RA) prior to starting qualifying activities. In the post 1989 environment at Rocky Flats, the ORR/RA requirements drove project and subproject managers to create the infrastructure to perform the planned activities in a safe manner. The

ORR/RA process ensures that the appropriate equipment is available, that procedures accurately and comprehensively describe the work to be performed with the appropriate integrated safety controls, and that personnel are trained to the procedures. As more and more activities successfully passed their ORRs or RAs, more and more personnel were needed to perform the operations. Personnel who had demonstrated their ability to learn new procedures and handle the scrutiny of an ORR/RA were often moved to other "new" projects that would require an ORR/RA, and the new hires were trained and qualified to backfill the positions that were being vacated. By this time, the existing processes were generally running smoothly, as process and procedural improvements tended to occur early in the operating phase. The more skilled operators were thus allowed to bring their expertise to new and higher risk (relatively speaking, not necessarily quantified by a risk analysis) activities.

Traffic Safety Committee

Traffic routes were established to separate large construction type vehicles as much as possible from smaller passenger vehicles.

By early 2004 demolition, environmental remediation, and waste shipping were becoming predominant Site activities. As more activities were being performed simultaneously across the Site it became necessary to evaluate and manage the significant increase in vehicle traffic. The Traffic Safety Committee was established to address this need. This committee consisted of representatives from each of the Site projects, the Site safety organization, security organization, communications organization, and union representatives. Traffic routes were established to separate large construction type vehicles as much as possible from smaller passenger vehicles. The committee also evaluated and established pedestrian routes. Maps of these routes were prepared and distributed to the Site population and visitors. Numerous communication mechanisms were employed to get traffic safety messages and real time status of traffic routes to personnel to include email, Site web page, worker toolbox briefings, periodic traffic safety bulletins, dedicated phone number to call for updates, broadcast messages to Site landlines, and text messages to Site cell phones. Since many of the committee members were key personnel in their organizations, committee meetings and activities tended to foster integration not just in matters of traffic safety, but across the closure project as a whole. The efforts of the members of the Traffic Safety Committee contributed significantly to safety across the Site.[75]

Safety Improvement for Non-Closure Activities

As contractual requirements for safety improvement were implemented there was a recognition that the improvement in safety needed to extend to routine activities. A substantial percentage of Site safety incidents were associated not with construction or industrial activities but with what are

commonly thought of as everyday routine activities. Examples included automobile accidents, slipping while walking in winter weather, etc. The Site emphasized safety for these routine activities by aggressively monitoring and enforcing speed limits, sanding walkways, and by focusing on specific safety topics at weekly meetings. Regardless of whether onsite incidents occurred during industrial/construction or "everyday routine" activities, they all counted against the contract safety metrics and therefore individual and company incentives.

Closeout of Fire Protection and Emergency Response

The Rocky Flats fire department had historically focused on addressing fires and emergency response in an operating environment. As the Site work became more construction-like, the fire department needed to adjust for the increased fire potential from activities such as vehicle refueling, thermal cutting, and the change in infrastructure (e.g., shutdown of sprinkler and Site domestic water systems).[76] Toward the end of the closure process the Site fire protection needs were more effectively addressed using offsite resources.[77,78]

SAFETY AS THE REAL TOP PRIORITY

Early on safety was viewed as a goal, later as a requirement, and finally as a project tool to increase worker productivity and morale.

The perspective on safety by management and workers at the Site evolved over the term of the closure project. Early on safety was viewed as a goal, later as a requirement, and finally as a project tool to increase worker productivity and morale. The Site Safety Continuous Improvement Plan that followed the Building 371 glovebox fire (referenced earlier), viewed safety from an entirely different perspective than previous corrective action plans. Worker involvement in safety issue resolution was increased, additional union representatives were added as safety inspectors, event response was skewed more toward action than analysis, and the overall focus turned toward improving the minute-by-minute safety of the worker. As an example, K-H sponsored several "Safety Fairs" where vendors demonstrated all manner and style of PPE. K-H purchased PPE best suited to the task and worker preferences without question or budget limitation. These actions demonstrated to the workforce that management was truly committed to safety and their welfare, and in turn produced greater trust and overall improvement in morale. Although difficult to quantify, anecdotal evidence suggests that this commitment to safety as the true top priority in the final years of the project, resulted in the unprecedented worker productivity and ability to complete the closure without serious worker injury.

SAFETY TECHNIQUES

Process Equipment Removal Safety

Initially, soft-sided containments were vented directly to the surrounding room through HEPA filtration, but as more tents were built they were subsequently connected to the building ventilation system (usually Zone II) via flexible ducting (i.e., elephant trunks). The construction of the soft-sided containments and their ventilation created additional safety issues since they frequently changed the airflow patterns in the rooms in which they were constructed. This required diligent planning to ensure that airflow testing was performed throughout the construction process and that continuous air monitors (CAMs) were properly relocated based upon the test results. Connecting airmovers to building ventilation systems was used to provide greater airflow; however, an airflow reversal event in Building 776 highlighted the need for careful analysis of the actual physical configuration. A damper was partially (predominantly) closed, but its broken position indicator showed it was fully open. When the airmover was connected and turned on, the partially closed damper caused the contaminated air from the soft-sided containment to be forced back out into the surrounding rooms.

Safety improvements most often occurred as incremental improvements, often initiated by the hourly workforce...

Other changes were made to soft-sided containments, including the construction of multiple rooms to aid the doffing of supplied air suits and overall contamination control. However, as the glovebox decontamination techniques improved, the need for size reduction diminished, eliminating the need for more complex soft-sided containment features.

Safety improvements most often occurred as incremental improvements, often initiated by the hourly workforce or as a collaborative process between the hourly workforce, management, and technical organizations. Two examples of high-tech processes that were justified in the name of safety, the Inner Tent Chamber for directing airflow and the Robotic Size Reduction System (ROSARS) proved to be less useable and hence of less actual safety value. The Inner Tent Chamber became the less-used process for size reduction in Building 771 as glovebox decontamination, conventional soft sided containment systems, and size reduction tooling and procedures improved. The ROSARS process was never actually completed. In each case the drive for safer performance of work and reduced accidents concurrently improved overall performance.

Electrical Safety

As old known hazards were eliminated or brought under control new hazards were identified. For example, early in the decommissioning

process major safety initiatives were implemented with the goal of preventing workers from being shocked while removing installed wiring from being shocked. However, several times workers cut energized electrical lines while performing approved engineered work packages. The lines were energized due to "sneak circuits," i.e. undocumented sources of power to a panel or piece of equipment. Extensive efforts were made to train personnel to positively verify that wiring had been de-energized prior to cutting.[79] The end result was a significant reduction in this type of event. Later in the decommissioning process temporary electrical cabling was brought into facilities to power equipment still required to perform work. This created new hazards that had to be analyzed and addressed. In Building 771 a worker using a hydrolance cut into a 480-volt temporary power line. Other events occurred involving electrical cords being cut or damaged by the equipment it powered. These events required supplemental corrective actions different from the previous electrical events.

Improvements in Personal Protective Equipment (PPE) Application

Building 771 uptakes resulted in precautionary use of respirators as opposed to reliance on CAMs in work areas where contamination releases could easily occur. In the dynamic conditions encountered during process equipment removal and decontamination (as compared to an operating environment) relying solely on worker response to CAM alarms was insufficient to avoid chronic uptakes of small quantities of airborne contamination the was still sufficient to show up in routine bioassays. The wearing of respirators became mandatory in a room in which work was being conducted regardless of CAM readings.

To avoid heat stress, one of the primary lessons learned was to use the more impenetrable materials only on the parts of the body most likely to receive a skin contamination (i.e., forearms, knees)...

The selection and use of Personnel Protective Equipment (PPE) other than respirators was also an ongoing safety concern. DOE placed an emphasis on reducing the number of skin contaminations complex-wide and listed excessive skin contaminations as a specific performance measure under the closure contract. PPE is a major component in the suite of tools used to prevent skin contaminations; unfortunately, some types of PPE have several drawbacks including the inability to dissipate body heat. Consequently, heat stress concerns had to be weighed against contamination concerns. A significant amount of analysis, research and deliberation was put into developing criteria for selecting PPE. One of the primary lessons learned was to use the more impenetrable materials (such as saranex) only on the parts of the body most likely to receive a skin contamination (i.e., forearms, knees), but not on the remainder of the body.

KEY SUCCESS FACTORS

1. It all begins with safety. Efficiency improvement and project accomplishment all occur because the work is performed safely. Safety needs to be viewed as a powerful enabler for improved project performance.

2. Real progress was made when management listened and acted on workforce safety concerns. More importantly, it was necessary for the workers to believe that the DOE and K-H management were listening to their concerns. Once this climate was established, money spent on safety always had returns greater than the investment.

3. Performance-based incentives for safety are not effective for changing safety culture and making long-term improvements. Incentivizing total project performance is effective at cementing management commitment to safety and understanding its importance.

4. The safety systems at former production sites were not built for the changing environment of a closure site. There needs to be continual innovation, adjustment, and evaluation to adjust for the changing conditions. At the same time adjustments need to remain within a formal system, so that the discipline of work control is not lost to informality.

5. The DOE has expectations for safety performance that are much higher than the commercial sector. Extra caution and management attention is necessary to utilize workers or contractors unfamiliar with DOE safety expectations.

6. Safety must have strong, visible, and consistent support from the highest levels of Contractor and DOE management. Anything less is a hollow commitment that will be quickly discounted by the workforce.

REFERENCES

Citation	Ref. No.
Barbara A. Mazurowski ltr. (01-00021) to Robert G. Card, Safety Concerns, January 5, 2001.	10
Contract No. DE-AC34-00RF01904, US Department of Energy ROCKY FLATS FIELD OFFICE and KAISER-HILL COMPANY, LLC, February 2000.	33
Contract No. DE-AC34-95RF00925, US Department of Energy ROCKY FLATS FIELD OFFICE and KAISER-HILL COMPANY, LLC, April 1995.	37
Building 771/774 Basis For Operations, December 1999.	58
Decommissioning Closeout Report for the 779 Cluster Interim Measure/Interim Remedial Action, February 1998.	60
Rocky Flats Environmental Technology Site Building 707/707A Decommissioning Basis for Interim Operation (DBIO), Revision 4, February 2002.	61
Rocky Flats Environmental Technology Site Safety Analysis Report, February 2001.	62
Site Safety Improvement Plan, Revision 6, April 16, 2001.	63
EM-RFO--EGGR-771OPS-1994-0062, A Pu-containing liquid was drained from a process line. Line draining was not within the scope of procedure being used, August 1995.	64
EM-RFO--KHLL-779OPS-1999-0006, D&D Worker in Building 779 Received Finger Laceration While Working in Glovebox 955 in Room 133, September 1999.	65
EM-RFO--KHLL-NONPUOPS1-2002-0002, Beryllium Sample Results Above Action Level, September 2002.	66
EM-RFO--KHLL-771OPS-2000-0057, Bioassay Results On Eleven Workers Above Decision Level, October 2001.	67
EM-RFO--KHLL-371OPS-2003-0011, During D&D Operations Combustibles In Glovebox Ignited Causing A Fire Which Was Contained Inside of The Glovebox, December 2004.	68
Kaiser-Hill Comprehensive Corrective Action Plan, January 2004.	69
EM-RFO--KHLL-D&DOPS-2004-0003, Declaration of Operational Emergency Alert-Star: Fire Department Response to Report of Smoke From B991, December 2004.	70
Rocky Flats Baseline Performance Review Report, June 2005, Appendix A, LL - 16 Walk-down of job site prior to initiation of work.	71
Rocky Flats Baseline Performance Review Report, June 2005, Appendix A, LL - 17 Review standard work packages prior to start of work.	72
Site Safety Continuous Improvement Plan, Revision 1, February 13, 2002.	74
Rocky Flats Baseline Performance Review Report, June 2005, Appendix A, LL - 15 Separation of Private Vehicles and Commercial Traffic.	75

Rocky Flats Baseline Performance Review Report, June 2005, Appendix A, LL - 24 Site Directives.	76
Rocky Flats Baseline Performance Review Report, June 2005, Appendix A, LL - 22 Mutual Aid Agreements.	77
Rocky Flats Baseline Performance Review Report, June 2005, Appendix A, LL - 23 Fire Services.	78
Rocky Flats Closure Project Weekly Toolbox, May 17, 2004.	79
EM-RFO--KHLL-NONPUOPS1-2002-0003, Building 865 Rigging Incident October 2002.	204
EM-RFO--KHLL-NONPUOPS1-2002-0004, Active Fire Suppression Line Cut During Equipment Dismantlement, November2002.	205
EM-RFO--KHLL-NONPUOPS1-2002-0005, Improper Respiratory Protection in Beryllium Area, December 2002.	206
EM-RFO--KHLL-NONPUOPS1-2002-0006, Personal Injury While Size Reducing Metal, January 2003.	207
EM-RFO--KHLL-NONPUOPS1-2002-0007, Load Slipped Out of Rigging During Lift, December 2002.	208