DOE/ORO-2212

U. S. Department of Energy
Oak Ridge Office

Type B Accident Investigation Board Report

Bechtel Jacobs Company LLC Employee Fall Injury on January 3, 2006, at the K-25 Building East Tennessee Technology Park Oak Ridge, Tennessee

February 2006

CRCC1590

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INDEPENDENT REPORT

This report is an independent product of the Type B Accident Investigation Board (Board) appointed by Gerald Boyd, Manager, Oak Ridge Office, U.S. Department of Energy. The Board was appointed to perform a Type B investigation of the accident and prepare an investigation report in accordance with DOE Order 225.1A, *Accident Investigations*.

The discussion of the facts, as determined by the Board, and the views expressed in this report are not necessarily those of the U.S. Department of Energy and do not assume and are not intended to establish the existence of any legal causation, liability, or duty at law on the part of the U.S. Government, its employees or agents or contractors, their employees or agents or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

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RELEASE AUTHORIZATION

On January 11, 2006, I appointed a Type B Accident Investigation Board to investigate the January 3, 2006, fall injury that occurred during decontamination and decommissioning activities in the K-25 Building at the East Tennessee Technology Park. The responsibilities of the Accident Investigation Board have been satisfied with respect to this investigation. The analyses and the identification of the contributing causes, the root cause, and the Judgments of Need resulting from this investigation were performed in accordance with DOE O 225.1A, *Accident Investigations*.

I accept the report of the Accident Investigation Board and authorize release of this report for general distribution.

Gerald G. Boyd, Manager
Oak Ridge Office

Date Accepted: 2/10/06

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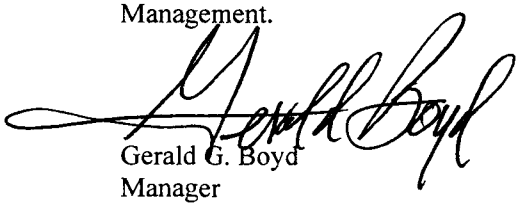
PROLOGUE

This Type B Accident Investigation is an important reminder that the activities we carry out every day have important safety and health implications. Much of the work performed for the Oak Ridge Office (ORO) involves routine industrial activities to accomplish the work. These activities have the potential to cause serious personal injury and property damage unless appropriate safety measures are implemented. Therefore, it is imperative that the guiding principles and core functions of Integrated Safety Management are carried out from the highest level of the organization down to the work being performed.

This Type B Accident Investigation report is important in improving safety at Oak Ridge. The lessons learned contained in this report are applicable to all types of work activities. The report provides lessons on many aspects of conducting work safely and represents ORO's continued commitment to support the U.S. Department of Energy's *Safety Management System Policy*.

I trust that all Federal employees and contractors supporting ORO will take the time to read this report, think about its applicability to their work, and recognize that every piece of equipment represents a unique challenge to identify and negate its hazards. I encourage all Federal and contractor employees to vigorously continue their efforts to fully implement Integrated Safety Management.



Gerald G. Boyd
Manager
Oak Ridge Office

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TABLE OF CONTENTS

TABLES

FIGURES

ACRONYMS

AHA	Activity Hazard Analysis 2005-02987
BJC	Bechtel Jacobs Company LLC
Board	Accident Investigation Board
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
EM	Environmental Management
ES&H	Environment, Safety, and Health
ETTP	East Tennessee Technology Park
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
JON	Judgment of Need
LifeStar	LifeStar air ambulance
ORO	Oak Ridge Office
ORR	operational readiness review
PPE	personal protective equipment
Project	K-25 and K-27 Buildings D&D Project
PSS	Park Shift Superintendent
RCAAS	Radiation/Criticality Accident Alarm System
STARRT	Safety Task Analysis Risk Reduction Talk
Work Package	Standing Work Package K25-05-03-1201-00

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EXECUTIVE SUMMARY

The Accident

On Tuesday, January 3, 2006, at 1:55 pm, a Bechtel Jacobs Company LLC (BJC) iron worker accidentally fell through a degraded concrete floor panel while working in the K-25 Building at the East Tennessee Technology Park (ETTP). After the floor panel collapsed under him, he struck a fire main pipe and a monorail steel support structure before landing on the concrete floor 29 ½ feet below. Even though he sustained serious fractures to his right lower leg and right upper arm, he is extremely fortunate to have survived this fall.

A member of his work crew responded immediately with a radio call for emergency medical assistance, and another co-worker applied a C-spine control to immobilize his neck and head to prevent further injury. The injured worker remained conscious throughout the event and did not sustain head injuries. Emergency medical personnel arrived at the scene about three minutes after the worker fell. An hour later, a LifeStar air ambulance transported him to the University of Tennessee Medical Center in Knoxville, Tennessee. He was admitted to the Trauma Center, and the next day he underwent open reduction, internal fixation surgery for his arm and leg fractures. He is now recovering at home and undergoing physical therapy. Further surgery has been scheduled.

This U.S. Department of Energy (DOE) Type B Accident Investigation Board (Board) was appointed by the Oak Ridge Office (ORO) Manager on January 11, 2006, and the Board convened on January 17, 2006, after the holiday weekend.

Through the deliberative process prescribed in DOE Order 225.1A, *Accident Investigations*, the Board investigated this accident. The Board took recorded testimony from many BJC and ORO employees at ETTP, reviewed relevant documents, and conducted multiple tours of the accident scene to perform detailed examinations of the physical evidence. Factual accuracy reviews by ORO and BJC personnel enabled the Board to refine its collection of facts. The Board analyzed the facts, reached conclusions, and then developed companion Judgments of Need.

Background

Enrichment of uranium at the K-25 Site Gaseous Diffusion Plant (now called ETTP) began in 1945 and continued until 1964, after which 2 of about 54 units in the K-25 Building were used as purge cascades until 1977. After production ended, the K-25 Building has been closed for almost 30 years. The K-25 Building is a U-shaped building whose east and west legs are about a half-mile long and are connected by a much shorter north leg. This building spans about 44 acres under its roof. The roof was replaced in 1977. Since the late 1990s, the roof has been allowed to deteriorate, and many pieces of gypsum and debris have fallen onto the operating floor below. The concrete panels of the operating floor have been exposed to rain and freezing and thawing conditions. This has corroded the steel reinforcement inside the panels and caused the concrete to crack and spall (break apart).

Since 1995, visual inspections of the undersides of these panels have identified degraded floor panels, and the defective panels have been painted on the top surface with cross-hatched markings. There are 133,532 panels on the operating floor. Based on these visual inspections, only about 3% of all panels have been declared degraded. In March 2005, the wheels of a cart punched through the operating floor, and site

contractor management declared the operating floor unsafe for personnel traffic.

Access to the installed Radiation/Criticality Accident Alarm System power supply panels and fire protection equipment located on the operating floor was necessary for equipment surveillance and maintenance. Because the structural integrity of the operating floor was suspect and management had declared the floor unsafe for personnel traffic, the site contractor designed a system of steel grating walkways in a north-south direction in the east and west wings of the K-25 Building. This work was completed in August 2005. The contractor decided to install lateral branches of grating in east-west directions from the main north-south walkway, with additional short branches running north-south to enable workers to get to this equipment without wearing fall protection. Work under this particular Work Request of Standing Work Package K25-05-03-1201-00 (Work Package) began on December 7, 2005. The installation of this lateral grating in building unit 309-1 was part of the job on January 3, 2006, and this is where the employee fell 29 ½ feet to the cell floor below.

Analysis and Results

The Board employed barrier analysis, change analysis, events and causal factors charting, and human performance improvement analysis to analyze the facts surrounding the fall. These analyses revealed deficiencies in work planning and control, engineering design, job supervision, and safety oversight. Multiple management barriers failed, which resulted in conditions, adverse changes, and events that in combination led to this accident.

For example, there were violations of the Work Instructions, such as the worker carrying a piece of grating that weighed more than the stated limit of 50 pounds per worker, but craft supervision did not enforce this requirement. Safety oversight failed to detect the lack of fall protection use by the work crews installing the grating. The design of both the north-south and east-west lateral branches of this walkway grating was not compliant with the Occupational Safety and Health Administration regulations for walking/working surfaces (Title 29, Code of Federal Regulations, Part 1926.501(a)(2)).

Communications among the principal players involved in development and execution of the Work Package, which preceded the accident, appeared to be unclear, misinterpreted, informal, and not documented. The Work Instructions and the Activity Hazard Analysis (AHA) contain conflicting statements. Specifically, the Work Instructions contain the following warning:

> "PERSONNEL SHALL NOT STAND ON OPERATING FLOOR PANELS WITHOUT FALL PROTECTION. TO AVOID THE USE OF FALL PROTECTION PERSONNEL MAY STAND ON THE PREVIOUSLY INSTALLED DECKING AND SLIDE THE ONE BEING INSTALLED IN PLACE."

The AHA states the following:

> "All Operations Floor panels have suspected integrity problems. 100% fall protection required when walking on Operations Floor until plate/grating established."

This led to informal work change methods that allowed workers to discontinue the use of fall protection during grating installation. The formal change control process was not followed, and the Safety organization was not notified. The Work Instructions do not contain a method for distinguishing established safe walkways from grating being installed but not yet established, inspected, or certified as a safe walkway.

During its barrier analysis, the Board noted that a validation checklist was developed in

response to the BJC Operational Readiness Review (ORR) for the K-25/K-27 High-Risk Equipment and Other Process Gas Equipment Removal, which was performed in August–September 2005. This checklist was not applied to the operating floor grating installation Work Package, which had been originally issued in April 2005, well before the ORR. Had this checklist been used to review the grating installation Work Package, the conflict between the Work Instructions and the AHA would likely have been identified and resolved. This situation indicated that the grating installation job had a low priority with respect to management attention and safety oversight, where the primary focus was high-risk equipment removal and nuclear safety.

Conclusions

The Board concludes the BJC K-25 and K-27 Buildings Decontamination and Decommissioning (D&D) Project (Project) failed to follow its work control process and allowed informality in the execution of its Integrated Safety Management Program. This was the root cause of the accident. Several latent organizational weaknesses contributed to the worker being injured. The Work Package is inadequate, and the Project's change control process was not followed. The work on the day of the accident was not performed within the hazard controls for fall protection that were prescribed in the AHA, which conflicted with the Work Instructions for this phase of grating installation. The Integrated Safety Management core function "Feedback and Improvement" was deficient in that corrective actions from the previous operating floor panel failure were not effective. Furthermore, corrective actions from a BJC ORR performed in September 2005 and lessons learned from previous BJC Type B Accident Investigations that dealt with work control deficiencies were not applied to installation of grating on the operating floor.

The floor panel that collapsed had little or no load-carrying capability because the lack of roof maintenance had exposed the panel to moisture and extreme environmental conditions. There were no engineered barriers to prevent personnel from accidentally stepping off the grating. Also, the most recent floor panel inspection report, which states that general foot access is acceptable for the entire operating floor and that care should be taken to avoid marked panels, provided a false sense of panel integrity. The marked panels were not perceived as little more than open holes to the cell floor 29 ½ feet below.

The Board questions the overall strategy, work methods, and work design for the Project. The work processes for equipment removal from the newer K-29 and K-33 Buildings may have been adequate for those buildings, but the structural degradation of K-25 Building adds additional risks. An evaluation of the current strategy, work design, and methods for D&D of the K-25 Building should lead to a decision whether to accept the risks of continuing work on the operating floor or, alternatively, to redesign the D&D strategy.

It is fortunate that the worker survived this fall. The Board personally extends its best wishes to him for a full recovery from his injuries. This accident did not have to happen.

Table ES-1 on the following pages contains the Board's conclusions and the resulting Judgments of Need.

Table ES-1. Conclusions and Judgments of Need

Conclusions	Judgments of Need
• The Work Package was inadequate because the Project planning team did not work interactively to develop clear Work Instructions consistent with the controls in the AHA. The Project did not perform an adequate review of the Work Package, and conflicting requirements regarding fall protection use while installing the grating were issued to the field. • During the planning job walkdown, a work package checklist (BJCF-764) to identify the procedural hold points for inspections was not used. • No post-job review was conducted for the grating installation activities.	JON 1 – BJC needs to enforce and verify compliance with its work control process and: • Increase rigor to ensure the Work Instructions (including all warnings, cautions, and notes) and the AHA are compatible and appropriately integrated. • Identify and correct work packages for the Project that have not undergone a review for ambiguity and consistency. • Ensure consistent worker involvement during the work planning process. • Ensure adequate post-job reviews are conducted.
• When a request for resolution of the fall protection requirements was raised to Construction management, the formal work change control process was not followed. The informal process used resulted in a breakdown of communications and a poor decision to discontinue use of fall protection. • Communication between Construction management and Safety did not occur.	JON 2 – BJC needs to develop and implement a documented process whereby line management is required to coordinate any change in the use of safety controls with a representative of the functional safety organization prior to the change being implemented.
• As the work was performed after fall protection use was discontinued (approximately July 14 to August 9, 2005, and December 7, 2005, to January 3, 2006), several opportunities to identify the conflict were missed by the Project, BJC oversight, and ORO oversight. • Factors potentially leading to slips, trips, and falls were: (1) the workers not adhering to the Work Package requirements not to lift in excess of 50 pounds, (2) the catching and tearing of the rubber shoe covers on the grating, (3) poor lighting, (4) the operating floor was wet and slick, and (5) the workers standing on grating that had not been validated as spanning the structural steel. These factors would not have significantly, if at all, increased the fall hazard had fall protection been used. • Although ORO's and BJC's oversight initiatives have been implemented, each of these initiatives was less than adequate in observing grating installation work that required fall protection.	JON 3 – ORO and BJC need to improve Project oversight to ensure work is understood and performed in accordance with the Work Package requirements.
• There were no engineered barriers that met Title 29, Code of Federal Regulations, Part 1926.502(b), to prevent personnel from stepping off the grating. • The decision to relax the fall protection requirements did not account for the likelihood of irrecoverable acts such as slips, trips, and falls that could cause a worker to come off the grating.	JON 4 – BJC needs to implement a strategy to identify and mitigate the consequences of human error in the design, planning, and execution of work.

Table ES-1. Conclusions and Judgments of Need

Conclusions	Judgments of Need
• BJC has not implemented a qualification process to identify personnel who exceed the weight limit for fall protection equipment in order to prevent them from being assigned work that requires using such equipment.	JON 5 – BJC needs to develop and implement a screening process to ensure compliance with the fall protection weight restriction requirements.
• The corrective actions have not been effective in eliminating or reducing work control issues. • BJC has feedback systems in place to capture workers' concerns, but the systems are not used effectively.	JON 6 – ORO and BJC need to ensure that corrective actions related to work control in response to accident investigations, ORRs, self-assessments, and lessons learned are implemented and verified as effective.
• The failed panel had little or no load-carrying capacity due to deteriorating conditions caused by the infiltration of water and exposure to extreme environmental conditions. • The lack of roof maintenance in the K-25 Building is the major contributor to the operating floor panel deterioration. • The contractor's report recommendation that "General foot traffic access is acceptable for the entire operating floor within Bldg. K-25. Care should be taken to avoid the marked panels." provides a false sense of security relative to the structural integrity and load-carrying capacity of the floor panels.	JON 7 – BJC needs to evaluate the safety risk of continuing to access the K-25 Building operating floor versus the risk/benefit of implementing alternative D&D strategies.
• The emergency response, event notification, and event categorization were timely and appropriate.	None

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1.0 INTRODUCTION

1.1 Background

At approximately 1:55 pm on January 3, 2006, a Bechtel Jacobs Company LLC (BJC) iron worker on the operating floor of the K-25 Building in the East Tennessee Technology Park (ETTP) fell 29 ½ feet to the cell floor below. The employee was installing floor grating for a walkway on the operating floor when he caught his foot on the grating and slid onto a degraded floor panel, which collapsed under him. He fell through the operating floor, striking a fire protection pipe and then a monorail steel support structure before landing on the cell floor. The on-site Fire Department responded to the scene within three minutes. The emergency medical responders conducted an initial assessment at the scene, placed the employee on a backboard, and transferred him to the closest exit where a more detailed assessment was conducted. It was determined the employee suffered a broken leg and possible broken arm. The employee's personal protective equipment (PPE) was removed, he was surveyed for radiological contamination, and a splint was placed on his leg. The employee was transported by the on-site ambulance to the ETTP helipad, where he was loaded into the LifeStar air ambulance (LifeStar), which departed at 2:57 pm for the University of Tennessee Medical Center.

On January 9, 2006, U.S. Department of Energy (DOE) Oak Ridge Office (ORO) management categorized the accident as a Type B. On January 11, 2006, the ORO Manager formally appointed a Type B Accident Investigation Board (Board) to investigate the event in accordance with DOE Order 225.1A, *Accident Investigations* (see Appendix A). This report documents the facts of the accident and the conclusions of the Board.

The organizations involved in this event were BJC and ORO. A brief description of each organization is provided below.

Bechtel Jacobs Company LLC

BJC is a prime contractor for ORO's Environmental Management (EM) Cleanup Program, which includes work at ETTP, the Y-12 National Security Complex, and the Oak Ridge National Laboratory. BJC's contract with ORO (DE-AC05-98OR22700) includes environmental restoration, decontamination and decommissioning (D&D), and waste treatment and disposal activities. The mission at ETTP is environmental cleanup and reindustrialization/reuse of the assets (i.e., facilities, equipment, materials, utilities, and trained workforce). This mission is being accomplished by cleaning up the site under a DOE cost-plus-incentive-fee contract that was renegotiated in 2003 from an existing cost-plus-award-fee contract.

U.S. Department of Energy Oak Ridge Office

Based in Oak Ridge, Tennessee, ORO dates back to World War II when the organization played a major role in the production of enriched uranium for the Manhattan Project. Since then, ORO has expanded far beyond that first mission and today is responsible for major DOE programs in science, EM, nuclear fuel supply, and national security and provides support to Office of Science laboratories and facilities operated by DOE throughout the United States. ORO also provides support to national security activities managed by the National Nuclear Security Administration.

1.2 Facility Description

ETTP was previously known as the DOE Oak Ridge K-25 Site and the Oak Ridge Gaseous Diffusion Plant. It supplied enriched uranium for nuclear weapons production as part of the Manhattan Project. Construction of the site began in 1943, with partial production initiated in February 1945 and full operations achieved by August 1945. Uranium was enriched by gaseous diffusion, during which uranium hexafluoride was passed through thousands of diffusion separator elements and

associated pumps and piping. Each diffusion separator element is called a stage, and the stages are connected together form a cascade. Uranium enrichment in the K-25 Building ceased in 1964. Two units of the K-25 Building remained in operation as a purge cascade until 1977, at which time the purge cascade was moved to the K-27 Building. The entire site ceased enrichment operations in 1985.

The K-25 and K-27 Buildings are presently part of a D&D program being conducted as a non-time-critical removal action under the Comprehensive Environmental Response, Compensation, and Liability Act. The approach is to remove, segment, stabilize, and package items for shipment and disposal to meet the physical security, nuclear materials control and accountability, and criticality limits for the identified items of high-risk equipment. High-risk equipment is identified as process gas equipment or components containing uranium masses greater than the allowable mass of 350 grams of Uranium-235. Other process gas equipment removal will continue with a similar approach to remove, characterize, stabilize, reduce, size, and package for disposal, as necessary. See Figure 1-1 on the following page for an aerial view of the K-25 and K-27 Buildings and the accident location.

The K-25 Building, which is a mile-long U-shaped building, is a shutdown Hazard Category 2 Nuclear Facility undergoing D&D totaling 4.45 million square feet on three levels. The building consists of 54 individual building units. The operating floor where the grating was being installed forms the top level of the K-25 Building and is located directly below the facility's roof. The building levels from top to bottom are as follows:

- Operating floor – Location of cell instrument panels, coolant recirculation pumps, and turning wheels for the protruding long stems of valves located in the pipe gallery below.
- Pipe gallery – Location of process piping and valves, which are primarily enclosed in sheet metal housings and accessed by the use of expanded metal catwalks. The steel structure supports instrument lines, electrical conduit, and cable trays.
- Cell floor – This level has areas referred to as the truck alley, withdrawal alley, and escape alley. The cell housings at this level, on an elevated stage floor, enclose the multiple stages of the process equipment.
- Basement – Referred to as the vault level because it is also the location of the electrical transformer vaults. This level contains the cold trap rooms, transformers, ventilation fans, lubrication oil tanks, and coolant drums.

Approximately 75% (39 building units) of the operating floor is constructed of 2-foot by 5-foot precast concrete panels supported at each end by steel beams and columns. The remainder of the operating floor structure is constructed of a reinforced, poured-in-place concrete slab supported by steel beams and columns. The concrete slab area of the operating floor is located on the west wing of the building and extends from building unit K-305-8 to unit K-312-3. See Figure 1-2 for an underside view of the operating floor concrete panel layout/installation. This photograph is not typical of the condition of the concrete panels and is included only to reflect the typical installation.

Figure 1-1. Aerial view of the K-25 and K-27 Buildings and the location of the accident

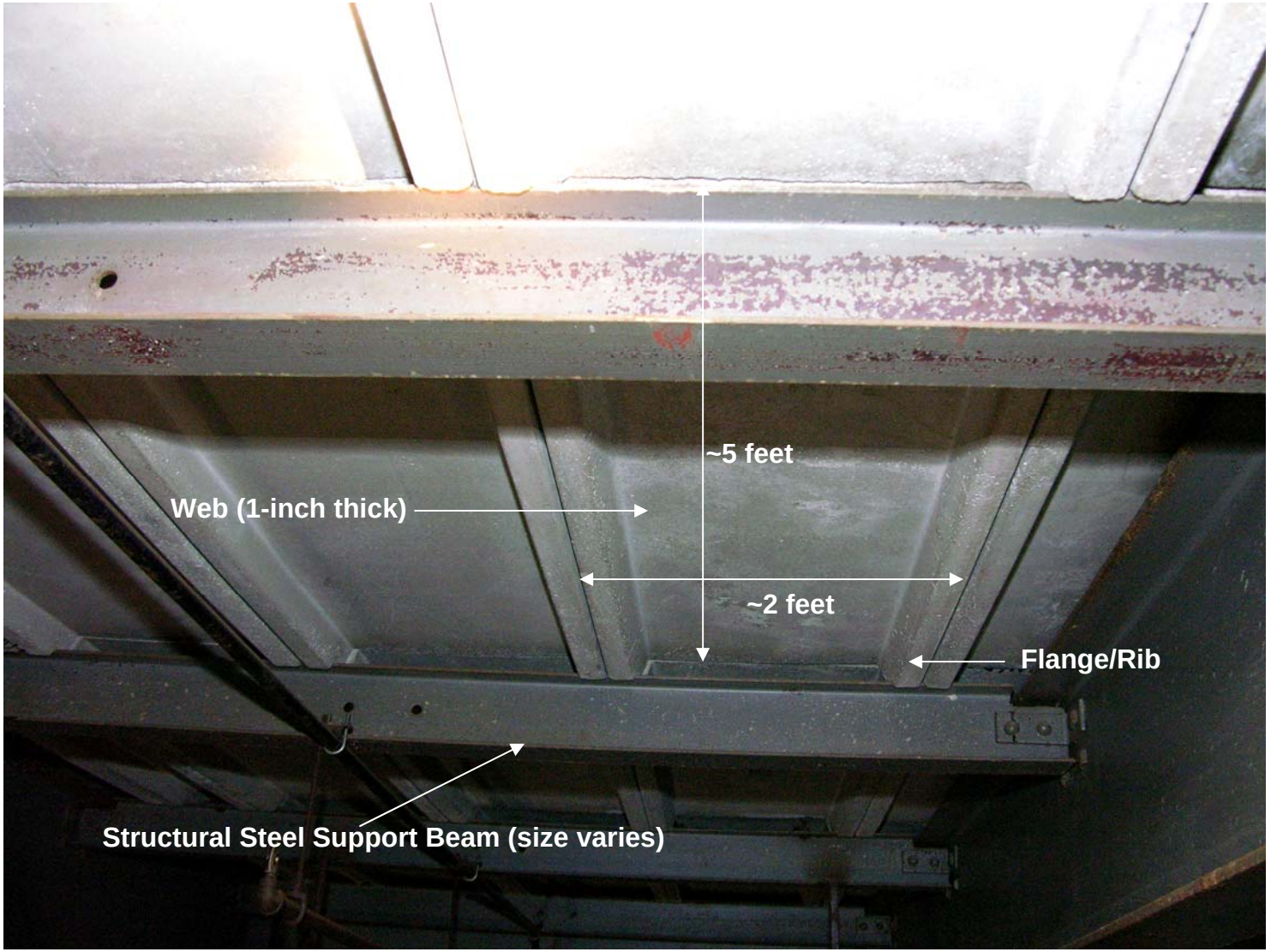

Figure 1-2. Underside view of the operating floor concrete panel layout/installation

(Note: This photograph is not typical of the condition of the concrete panels and is included only to reflect the typical installation.)

There are no heating or cooling systems in operation in the K-25 Building. Temporary lighting consists of overhead fixtures, portable light stands, and light stringers. Along the exterior walls at the operating floor level, natural light enters the building where the transite wall panels have been removed.

1.3 Scope, Conduct, and Methodology

The Board began its activities on January 17, 2006, and completed its investigation on February 10, 2006. The scope of the Board's investigation was to identify all relevant facts; analyze the facts to determine the direct, contributing, and root causes of the accident; develop conclusions; and determine Judgments of Need (JONs) that, when implemented, should prevent recurrence of the accident. See Figure 1-3 for an explanation of accident investigation terminology. The investigation was performed in accordance with DOE Order 225.1A, *Accident Investigations*, using the following methodology:

- Facts relevant to the accident were gathered through interviews, reviews of documents, and examination of the physical evidence.
- The accident scene was inspected, and photographs were taken of the scene.
- The facts were analyzed to identify the causal factors using event and causal factors analysis, barrier analysis, root cause analysis, change analysis, and human performance improvement analysis.
- JONs for corrective actions to prevent recurrence were developed to address the causal factors of the accident.

Accident Investigation Terminology

A causal factor is an event or condition in the accident sequence that contributes to the unwanted result. There are three types of causal factors: direct cause(s), which is the immediate event(s) or condition(s) that caused the accident; root cause(s), which is the causal factor that, if corrected, would prevent recurrence of the accident; and the contributing causal factors, which are the causal factors that collectively with the other causes increase the likelihood of an accident but which did not cause the accident.

Event and causal factors analysis includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the accident to occur), and the use of deductive reasoning to determine the events or conditions that contributed to the accident.

Barrier analysis reviews the hazards, the targets (people or objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or administrative.

Change analysis is a systematic approach that examines planned or unplanned changes in a system that caused the undesirable results related to the accident.

Human performance improvement analysis addresses human error related to individual behavior, management and leadership practices, and organizational processes and values.

Figure 1-3. Accident Investigation Terminology.

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2.0 THE ACCIDENT

2.1 Background

In June 2005, BJC began installing metal grating on the operating floor of the K-25 Building to establish safe walkways to access the operating floor. These safe walkways allow access to the Radiation/Criticality Accident Alarm System (RCAAS) electrical panels and fire protection equipment without the use of fall protection. The grating spans the building's structural beams, and the grates are lashed together to form a continuous walkway. This work was accomplished under Standing Work Package K25-05-03-1201-00 (Work Package). The portion of the work associated with the accident began in December 2005. Figure 2-1 is a photograph of the grating walkway.

Figure 2-1. Grating walkway on the operating floor.

The workers installing the grating accessed the operating floor via the stairs leading up from the cell floor. Once they were at the top of the stairs, they tied off their fall protection gear to anchor points while on the operating floor. At unit 309-2, the grating was lifted up to the level of the operating floor from outside the east wall through a wall opening in the side of the building using a variable-reach forklift. This location is opposite the west wall where the stairs are located and where the north-south walkway was being installed. The workers installed grating from the wall opening across to where the north-south walkway was being installed to provide a walkway for transport of the grating material. After being laid down on the operating floor, the grating was lashed together at the ends using steel cable and crimps. These walkways are marked on both sides with stanchions, plastic boundary chains, and warning signs that read: "DANGER, Damaged Floor Panels, Do Not Leave Walkway, Floor Load Limit 70 lbs Per Sq. Ft." See Figure 2-2.

Figure 2-2. Warning sign on the operating floor.

Level 1 PPE is required access into the K-25 Building Controlled Limited Area (the fenced area) and includes the following:

- Safety shoes
- Hard hat
- Safety glasses with side shields
- Long pants that reach the ankles
- Shirts with sleeves at least four inches long

Work crews are required to have flashlights, radios, and at a minimum, a half-face-piece filtering mask. Additional PPE for general work inside the K-25 Building in accordance with the Radiation Work Permit includes the following:

- Two layers of latex gloves
- One set of plastic shoe covers
- One set of rubber shoe covers
- Tyvek suit

Additional PPE is added based on the hazard of the work activities, and this PPE may include leather gloves and fall protection equipment. See Figure 2-3 for an example of an employee wearing Level 1 PPE and fall protection equipment.

The grating installation for the north-south walkways was completed in August 2005. The walkways were installed by iron workers and laborers wearing Level 1 PPE, leather gloves, half-face-piece filtering masks, and the PPE required in the Radiation Work Permit as listed above. At the beginning of the task, the workers installing the grating used fall protection. On approximately July 13, craft supervision requested clarification of the Work Instructions regarding fall protection use. This resulted in follow-on discussions with Construction management. Based on interview testimony, there were conflicting recollections of the decision that came out of this discussion. The information provided verbally to the work crew that afternoon was that the Work Instructions allow the installation of grating without using fall protection. Discussions were not conducted with the Safety organization.

The next day, the iron workers were allowed to discontinue using fall protection while installing the grating, and work continued in this manner until Work Request 003 was completed on August 9, 2005. In December 2005, the grating installation resumed, and the workers began installing grating laterally from the main north-south walkways to access the RCAAS electrical panels at units 305-7 through 303-3.

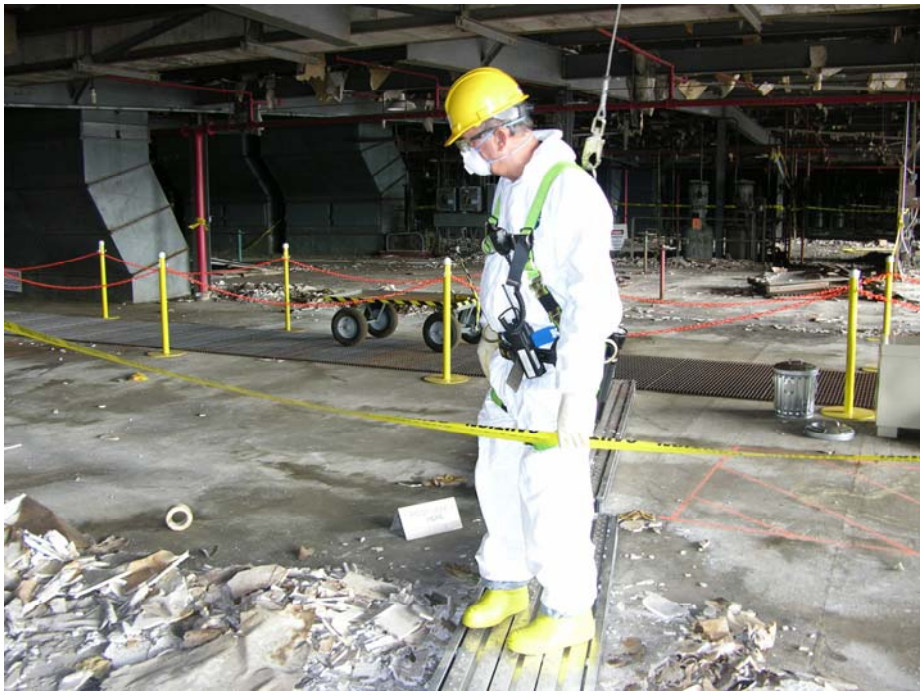

Figure 2-3. Employee wearing Level 1 PPE and a full-body harness with a retractable lifeline.

The lateral grating installation in December was performed by iron workers and laborers. After the lateral (east-west) walkway from the loading area was installed, fall protection was not used by the workers installing the lateral grating in the other building units. The workers accessed the operating floor via the stairs leading up from the cell floor. They entered the operating floor on the north-south walkways. The grating material was lifted up to the level of the operating floor from outside through the wall opening with a variable-reach forklift. The workers within 6 feet of the wall opening who were retrieving the grating from the forklift were required to wear fall protection.

When the grating was lifted to the wall opening, workers loaded it onto wagon-like carts with pneumatic tires. The walkways leading from the wall opening to the main north-south walkways were used to transport the grating to the location where the lateral grating was to be installed to enable access to the RCAAS electrical panels and fire protection equipment. The lateral grating was installed one piece at a time in the direction leading to the target equipment. A worker stood on the previously placed grating to lay down the next piece. At some later time, the grating was aligned and lashed together.

2.2 Accident Description

Lateral grating walkways were being installed on both the west and east sides of the K-25 Building operating floor, with each work crew typically consisting of six to nine iron workers and one laborer. On Tuesday, January 3, 2006, the workers planned to install grating on the operating floor. The work was conducted in the morning and then resumed again shortly after lunch. Nine workers comprised the work crew:

- One laborer swept debris off the floor panels where the grating was to be installed.
- Three iron workers off-loaded grating from the forklift.
- Four iron workers used carts to haul the grating and then install it.
- One iron worker aligned and lashed the grating together.

On the day of the accident, two workers assigned to a cart would load it with grating, move the cart from the loading area to the installation location, lift the grating pieces off the cart, and lay them on the operating floor to advance the walkway. At approximately 1:55 pm, the iron worker who fell was installing grating when he caught his foot on the grating and slid onto a degraded concrete floor panel. The floor panel collapsed under his weight, and he fell through the floor, striking a fire protection pipe and then the monorail steel support structure on the way down, and landing on the cell floor 29 ½ feet below. Figures 2-4, 2-5, and 2-6 on the following pages provide different views of the accident scene.

Emergency Response

A co-worker instructed the fallen worker not to move and made a radio call for help. The other workers on the operating floor proceeded down to the cell floor to the injured worker's location. One of the workers applied a C-spine control on the fallen worker until the Fire Department personnel arrived and applied a cervical immobilization device.

The Wackenhut Services, Inc.–Oak Ridge protective force personnel shut down the entrance/exit portals to the K-25 Building Control Limited Area to allow rapid access by the emergency responders. The Fire Department personnel arrived within three minutes. The Incident Command Post was set up outside the building, and a Commander established an Interior Operations Sector Command at the location of the fallen worker.

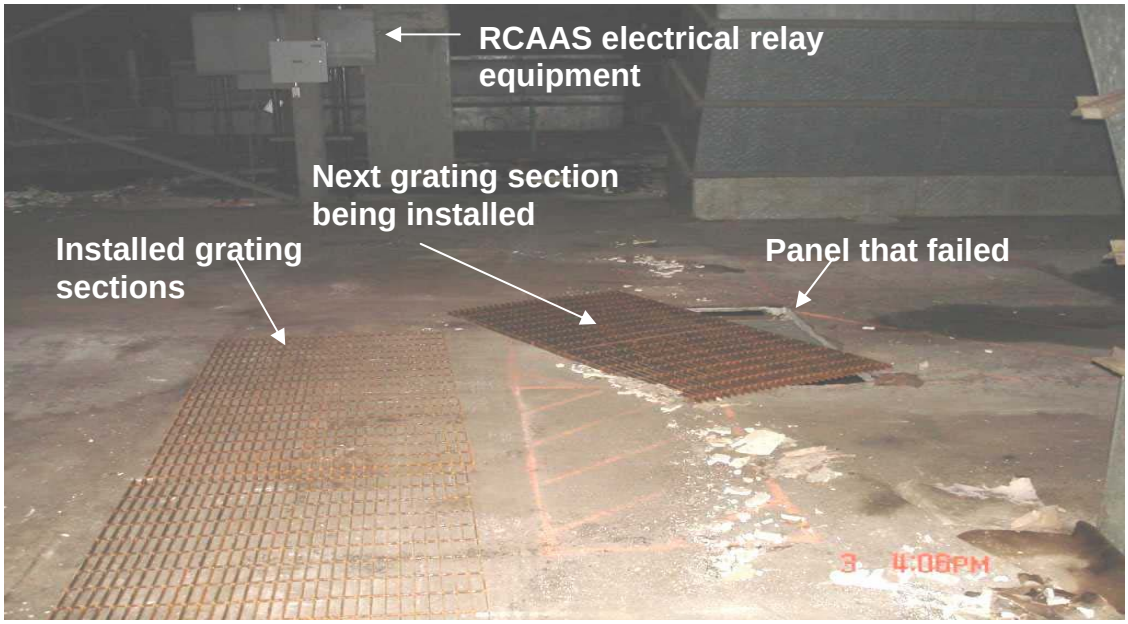

Figure 2-4. Accident scene – view from the operating floor.

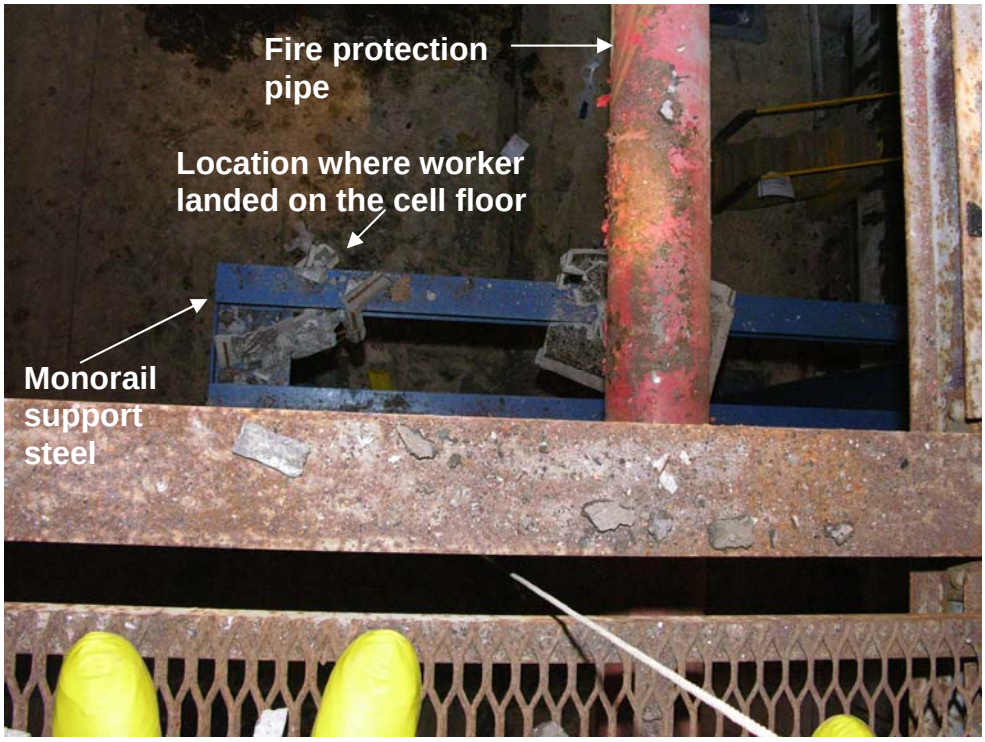

Figure 2-5. Accident scene – view looking down from the pipe gallery catwalk.

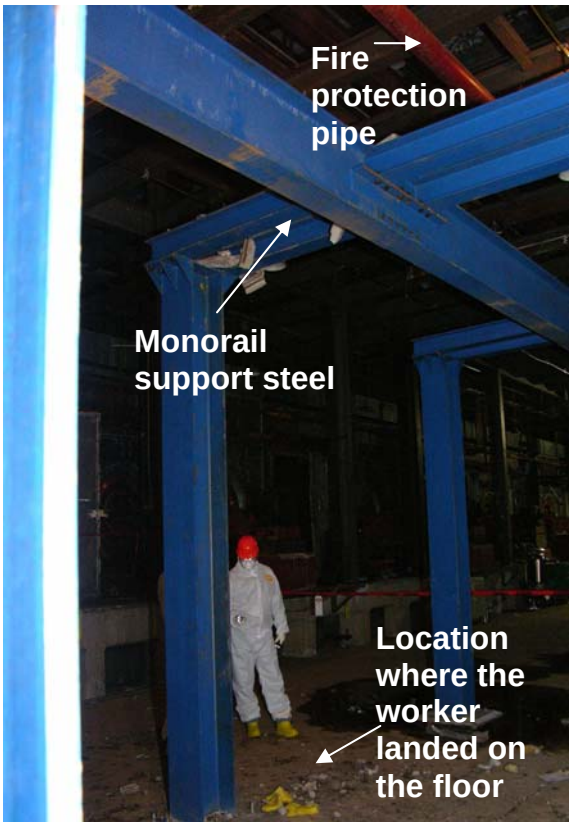

Figure 2-6. Accident scene – view from the cell floor.

The Fire Department emergency medical personnel conducted an initial assessment that included a trauma assessment and made sure the injured worker's airway was clear. They placed the worker on a backboard, summoned the assistance of several workers in the area, and carried the worker to the exit doors for further evaluation.

Once at the exit door, where there was better lighting, the Fire Department personnel conducted a more detailed assessment of the injured worker. They executed the hot patient removal process, which involved rolling out G-Flex™ tarp, removing the worker's Tyvek suit, transferring him to a clean backboard, and applying a clean cervical immobilization device and a leg splint. The Radiation Control Technician surveyed him for radiological contamination and found no contamination. The injured worker was loaded into the ambulance and transported to the helipad.

Protective force personnel established traffic control points around the helipad. The Fire Department readied the helipad by using a fire engine with its lights turned on to provide a visual reference point for LifeStar. LifeStar landed at 2:29 pm.

The protective force personnel cleared the portals to facilitate the egress of the ambulance to the helipad. The ambulance arrived at the helipad about 2:36 pm. The LifeStar paramedics entered the ambulance and spent about 13 minutes assessing the worker before loading him into the helicopter. Pain medication was also administered. LifeStar departed ETTP at 2:57 pm en route to the University of Tennessee Medical Center.

In summary, the emergency radio call was made at 1:55 pm, and the injured iron worker was transported from the site via LifeStar at 2:57 pm.

Event Notification and Categorization

The Park Shift Superintendent (PSS) notified the Oak Ridge Operations Center at 2:05 pm of the incoming LifeStar flight over the Oak Ridge Reservation. The Oak Ridge Operations Center notified ORO management.

BJC categorized the accident as a Significance Category 3 occurrence at 3:43 pm, which is within the 2-hour time limit prescribed by DOE Order 231.1, *Environment, Safety, and Health Reporting*. The category was elevated to a Significance Category 2 at 6:20 pm. Notification to the Tennessee Emergency Management Agency is required for Significance Category 2 and higher occurrences. The PSS notified the Tennessee Emergency Management Agency at 7:26 pm.

The ORO Assistant Manager for EM reported the accident to the DOE Headquarters EM Program representatives both verbally and by electronic mail.

The Board concludes that the emergency response, event notification, and event categorization were timely and appropriate.

2.3 Medical Summary

After the accident, LifeStar airlifted the injured worker to the University of Tennessee Medical Center in Knoxville, Tennessee. He was admitted to the Trauma Center, and the next day he underwent surgery for his arm and leg fractures. The injured worker also suffered a laceration to his lower lip that required sutures. After seven days in the hospital, the employee is now recovering at home and undergoing physical therapy. Further surgery has been scheduled.

2.4 Event Chronology

Table 2-1 on the following pages provides the events leading up to and immediately following the accident on January 3, 2006.

Table 2-1. Event Chronology

Date	Time	Event
7/24/1995		An employee noticed a cracked panel on operating floor and tapped it with his foot. It collapsed onto the cell floor below.
1995		The site operating contractor performed visual inspections to identify and mark defective panels (paintball markings, etc.).
1997		The Fire Protection Specialist observed concrete spalling (breaking apart) and falling from the operating floor to the cell floor below. This is documented in Occurrence Report EM-ORO-LMES-K25ENVRES-1997-0005, *Falling Floor Deck Pieces – Project Execution*.
1998		The Oak Ridge EM contract changed from Lockheed Martin Energy Systems to BJC.
1998 – 2004		The contractor performed annual floor panel inspections.
Late 1990s to 2006		The roof of the K-25 Building was allowed to deteriorate.

Table 2-1. Event Chronology (continued)

Date	Time	Event
2/2003		ORO performed a Type B Accident Investigation of the BJC subcontractor PPE ignition incident. ORO cited issues relevant to work control.
5/2004		ORO performed a Type B Accident Investigation of the BJC subcontractor release of radioactive waste during transportation activities. ORO cited issues relevant to work control.
7/2004		Headquarters EM performed an assessment of the implementation of ORO's oversight program.
2/2005		The contractor performed the last panel inspection during this month. Degraded floor panels were marked on the top and bottom.
Prior to 3/2005		K-25/K-27 Buildings D&D Project (Project) personnel performed work on the operating floor under the general requirement to stay off the marked panels due to degradation, but no fall protection was required and grating was not installed. There was general agreement that everyone understood that workers were to stay off the marked panels.
3/15/2005		The latest operating floor visual inspection report was issued.
3/2005		BJC personnel performed RCAAS inspections.
3/22/2005	2:45 pm	Workers on the operating floor were removing transite panels on a cart. Under the weight of the cart, the front wheels punched through one of the panels located between units 303-3 and 303-4 (east side against the wall). (Occurrence Report ORO-BJC-K25ENVRES-2005-0006)
3/23/2005		Project upper management made the decision to declare the operating floor unsafe without fall protection.
3/2005		The RCAAS inspections were interrupted. Other groups also needed access to the operating floor.
		The Field Engineer was tasked to establish a means whereby the inspections could continue.
		The Project held an operating floor walkdown planning meeting to develop a work package for placement of a safe walkway.
		The Planner conducted a second meeting to resolve comments on the draft work package.
4/1/2005		The BJC Structural Engineer established the "Operating Floor Allowable Loading Criteria" for the grating for inclusion in the Work Package.
4/6/2005		Project management approved the initial (Revision 1) Activity Hazard Analysis 2005-02987 (AHA), which contained the requirement for 100% fall protection when walking on the operating floor until the grating walkways were established.
		Project management approved the Work Package. The Work Instructions contain a warning that "Personnel shall not stand on operating floor panels without fall protection, to avoid the use of fall protection, personnel may stand on previously installed decking and slide the one being installed in place."

Table 2-1. Event Chronology (continued)

Date	Time	Event
4/6/2005 continued		Project management approved Work Request 001 of the Work Package, requiring 100% fall protection.
4/6–8/2005		The Project conducted prejob briefings. The scaffold decking was installed using 100% fall protection.
4/19/2005		The Field Engineer began ordering grating material.
4/20/2005		The agenda for the DOE/BJC Functional Meeting contains a handwritten note that states "Safe walk zones."
6/1/2005		Project management approved Work Request 002, requiring 100% fall protection.
6/2/2005		The Project conducted a prejob briefing for Work Request 002. The scaffold decking was installed using 100% fall protection.
6/6/2005		Project management approved Work Request 003, requiring 100% fall protection. This was the first Work Request to install grating.
6/7/2005		The Project conducted a prejob briefing on Work Request 003, and grating installation started with the workers using 100% fall protection.
6/8/2005		Project management issued Revision 2 of the AHA. It incorporates lessons learned and scissor lift requirements that are unrelated to the accident.
6/13/2005		The Project conducted a prejob briefing for the new work crew members.
6/15/2005		The Project conducted a prejob briefing for the new work crew members.
		An ORO industrial safety subject matter expert performed a walkthrough but did not access the operating floor.
		The Safety Representative from the Project Environment, Safety, and Health (ES&H) organization performed a walkdown of the east operating floor and completed the "ES&H Walkdown Questionnaire" form.
6/21/2005		The Project conducted a prejob briefing for the new work crew members.
6/22/2005		The agenda for the DOE/BJC Functional Meeting states "Ops floor metal deck work practices look good."
7/7/2005		The Project Safety Representative performed a walkdown of grating installation on the operating floor and completed the "ES&H Walkdown Questionnaire" form.
7/13/2005		The agenda of the DOE/BJC Functional Meeting states "Grating personnel observed off walkway near grating on loading station."
		The General Foreman checked out pages 1–9 of the Subdivision Log, Section 5, "Work Instructions."

Table 2-1. Event Chronology (continued)

Date	Time	Event
~7/13/2005		Approximately 25% of the grating installation was complete at this point. The job was on schedule.
		The General Foremen raised the issue to Construction management of the Work Instructions warning and sought clarification.
		Construction management discussed the warning in the Work Instructions to seek resolution.
		Through oral communication, the work crew was told that the fall protection requirements could be relaxed.
~7/14/2005		A toolbox meeting was held with the workers that covered the change in the fall protection requirements.
7/19/2005		The Project conducted a prejob briefing for the new work crew members.
7/20/2005		The Project Safety Representative walked down the east operating floor (unit 302-1 grating) and completed the "ES&H Walkdown Questionnaire" form.
7/25/2005		The Project conducted a prejob briefing for new work crew members.
7/27/2005		The Project Safety Representative walked down installation of safe walkways on the operating floor and completed the "ES&H Walkdown Questionnaire" form.
7/29/2005		BJC closed the occurrence report on the operating floor panel failure.
8/9/2005		Work Request 003 for grating installation was completed.
10/2005		ORO performed an operational readiness review of the BJC high-risk equipment and process gas equipment removal activities.
11/3/2005		The BJC employee involved in the accident was hired as an iron worker.
12/5/2005		Project management approved Work Request 005 to install additional grating.
12/6/2005		The Safety Representative signed Work Request 003 for the June through August work, stating that the stanchions were completed.
12/7/2005		The Project conducted a prejob briefing for Work Request 005. The relaxation of the fall protection requirements was carried forward.
		The employee involved in the accident passed the BJC fall protection training course.
12/12/2005		The Project Safety Representative walked down the west operating floor grating installation and completed the "ES&H Walkdown Questionnaire" form.
Mid-12/2005		The new Field Superintendent on the Project recognized the conflict between the AHA and the Work Instructions.
		The Field Superintendent raised the issue with the General Foreman and the work crew.

Table 2-1. Event Chronology (continued)

Date	Time	Event
Mid-12/2005 continued		The General Foreman told the Field Superintendent that the issue had been addressed. The Field Superintendent accepted the explanation.
12/19/2005		The BJC Occupational Safety Manager sent a site-wide electronic mail message with MSA Rose Technical Brief No. 2302-01, *Requirements applicable to personal fall arrest equipment used by workers weighing more than 310 pounds (including personal weight and weight of clothing, tools, and objects borne by the worker)*.
1/3/2006	~6:00 am	The workers arrived at the job trailer.
	6:30 am	Work started for the day with separate safety meetings for the east and west work crews
	7:30 – 8:00 am	The workers signed in on the Radiation Work Permit and dressed out.
	~ 8:00 am	Work started on the operating floor.
	~11:00 am	Two workers from the west crew arrived to assist the east crew.
	~11:30 am	The workers stopped for lunch.
	1:00 pm	The workers resumed grating installation in unit 309-1 after their lunch break.
	1:55 pm	The employee involved in the accident was installing grating on the operating floor when he caught his foot on the grating and slid onto a degraded floor panel, which collapsed under him. He fell through the operating floor, striking a fire protection pipe and then the monorail steel support structure on the way down before landing on the cell floor below.
		A co-worker stepped across the grating and yelled down through the open floor panel to the injured employee. The injured employee responded.
		An iron worker made an emergency radio call notifying the PSS and the Foreman of the accident.
		The PSS notified the ETTP Fire Department and Wackenhut Services, Inc.–Oak Ridge.
	1:56 pm	Engine 1, Medic 2, Rescue 1, Engine 3, and the Fire Commander responded.
		Fire Department personnel arrived at the K-25 Building.
		Commander 1 transferred command to Commander 2.
		Commander 1 entered the building with the firefighters to assume Interior Operations Sector Command.
	2:01 pm	Commander 1 requested LifeStar.
	2:02 pm	The PSS transmitted the “Manager’s Page” on the initial ETTP ambulance response to unit 309-1 of the K-25 Building.

Table 2-1. Event Chronology (continued)

Date	Time	Event
1/3/2006 continued	2:03 pm	The radio report indicates that the iron worker fell from unit 309-1 of the K-25 Building operating floor to the cell floor below.
	2:06 pm	The Fire Department readied the helipad southwest of the Portal 4 parking lot for LifeStar.
	2:09 pm	The PSS initiated a "Manager's Page" on LifeStar's response to ETTP.
	2:16 pm	In accordance with the request from the K-25 Building Facility Manager, a radio announcement was made to Project personnel to clear everyone off the operating floor of the K-25 Building.
	2:29 pm	LifeStar landed at the ETTP helipad.
	2:36 pm	The Medic 2 ambulance arrived at the helipad with the injured worker.
	2:43 pm	The PSS authorized entry for BJC personnel initiating the contractor's Type C Accident Investigation. They verified that Facility Management personnel were securing the accident scene.
	2:57 pm	LifeStar departed ETTP en route to the University of Tennessee Medical Center.
	3:05 pm	The PSS transmitted the "Event Notification" page.
	3:15 pm	The PSS provided a verbal update to the DOE ETTP Closure Project Office.
	3:43 pm	BJC categorized the event as a Significance Category 3 occurrence.
	6:20 pm	BJC elevated the occurrence category to a Significance Category 2.
	7:26 pm	The PSS provided the "Prompt Notification of Event" electronic mail message to Tennessee Emergency Management Agency and the Oak Ridge Operations Center.

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3.0 FACTS AND ANALYSIS

3.1 Hazards, Controls, and Related Factors

3.1.1 Engineering

Background

The K-25 Building operating floor is the top floor of the building and is constructed primarily of precast, reinforced concrete panels which nominally measure 2-feet-wide by 5-feet-long, with a 1-inch-thick reinforced web and approximately 2-inch by 3-inch flanges that run the entire length of the panel. The panels are supported by steel beams attached to the steel columns and are held in position by placing the panels adjacent to each other. The panels are not mechanically attached to the steel beams. The tops of the panels are covered with a rubberized coating that is approximately ½-inch thick. Figure 3-1 provides the typical dimensions of a concrete floor panel.

The panels were originally constructed to support uniform or concentrated loads as determined by testing in accordance with provisions of Federal Specification SS-R-531, *Roofing-Slabs: Concrete Precast*. However, due to the deteriorating conditions of the roof structure and exposure to the elements, the load-carrying capacity of the panels is extremely suspect. The following events document the failing condition of the K-25 Building operating floor.

On July 24, 1995, a Fire Department employee was testing inspection test valve devices on the operating floor when he noticed a cracked floor panel. He tapped the panel with his foot, and the panel collapsed and fell to the cell floor below.

In 1995, the site contractor initiated an inspection program to identify and mark panels determined to be in poor condition. The program consisted of walking the cell floor, the catwalks, and the tops of the cell housings to visually inspect and mark the underside of suspect/degraded panels on the operating floor above using paintballs. See Figure 3-2 for an example of the degraded floor panels. Once the degraded panels were identified from below, a map of the degraded panels was developed.

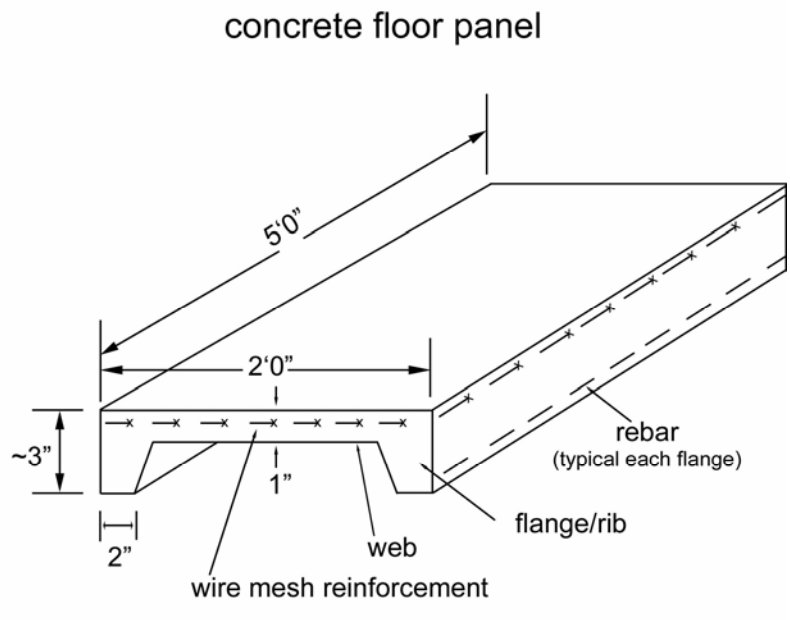

Figure 3-1. Typical dimensions of a concrete floor panel.

Employees then accessed the operating floor and marked the tops of the panels to identify them as degraded. The contractor initially planned to perform the inspections every two years.

However, on June 18, 1997, a sprinkler crew performing sprinkler tests inside units K-309-1 and K-309-3 of the K-25 Building observed 2 to 3-inch pieces of concrete falling from the operating floor to the cell floor below. Also, on November 20, 1997, Fire Protection Specialists observed cracks in the operating floor which were 2 to 3 inches wide and 5 to 20 feet long. These were observed in several locations. Both of these occurrences were documented in Occurrence Report EM-ORO-LMES-K25ENVRES-1997-0005.

Figure 3-2. Degraded floor panels and the accident scene viewed from the pipe gallery catwalk below.

As a result of these events, the inspections were changed from every two years to annually. Thus, visual inspections were conducted in 1995, 1998, 1999, 2000, 2001, 2002, 2003, and 2004 by various contractors. The *Facility Management, Surveillance, Inspection, and Testing – Annual Inspection Report for the K-25 Building Operating Floor Structural Evaluation*, dated March 2005, includes the results of all previous inspections, as well as the results of the 2004 inspection performed by the contractor. The results of the inspections were documented by marking the degraded panels, which are color-coded by year of inspection, and are delineated on Drawing S1E7025000A041, Revision 6.

Based on the contractor's 2004 visual inspections, the contractor's report states that "general foot traffic access is acceptable on the operating floor, but care should be taken to avoid the marked panels." In addition, the report recommends that inspections on the operating floor should be suspended and that the workers removing large pieces of equipment should not use the operating floor concrete panels to transfer loads to the steel framing.

On March 22, 2005, BJC employees were removing transite panels and transporting them across the operating floor using steel carts with four small, hard rubber wheels/tires. The loaded cart weighed approximately 240 pounds. While pushing the cart across the floor, the two front wheels "punched" through one of the floor panels. Based on discussions with the BJC Structural Engineer, the panel had not been identified as a degraded panel by the previous visual inspections. Figure 3-3 supports this fact. At this point, BJC restricted all access to the operating floor, and no one was allowed on the floor without fall protection. In addition, BJC initiated actions to develop a plan whereby personnel could access the RCAAS electrical panels and the fire protection equipment to perform inspections, tests, and surveillance and maintenance activities.

Personnel from the Project Safety, Construction, Planning, and Engineering organizations met to discuss options to address the situation. Initially, "pic boards" (temporary scaffold decking) were installed until a more economical solution could be developed. In addition to considering the use of pic boards, steel plating and steel grating were considered. The steel plating was determined not to be acceptable due to its lack of stiffness and inability to span between the structural steel members.

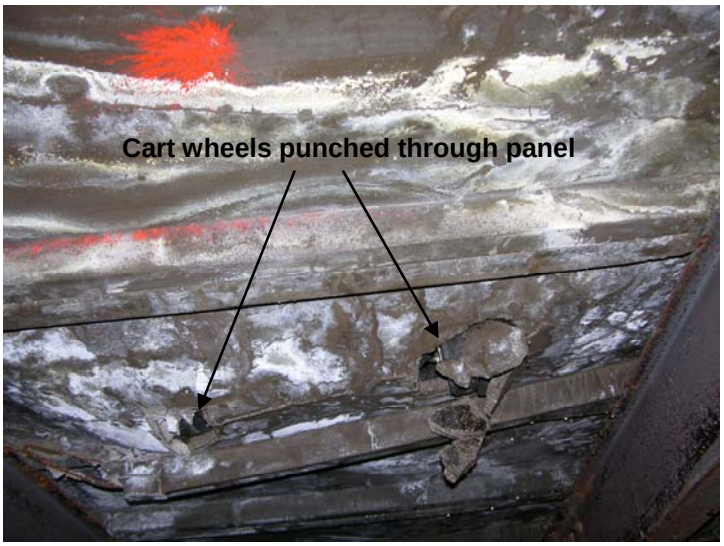

Figure 3-3. Cart wheels punched through the operating floor viewed from below.

Ultimately, the team decided to use 1-inch steel grating due to its load-carrying capacity, ease of installation, and ability to span between the structural steel members. The design consisted of (a) installing grating in a manner overlaying the existing concrete panel floor such that the ends of the grating were directly above the structural steel beam, (b) lashing the grating panels together with steel cable and crimps, and (c) installing stanchions and plastic chains to serve as a visual boundary for personnel using the steel grating as a walkway. Upon completion of the grating installation, Engineering personnel were to review and approve the installation.

Panel Failure

Based on the deteriorating condition of the facility, radiological issues, and the fact that historical documents, as well as recent events, indicate the operating floor panels are in poor condition, the Board did not attempt to conduct physical testing of the failed panel or any other panels on the operating floor. The panel that failed on January 3, 2006, had been previously identified as a degraded panel based on the contractor's visual inspections and markings. Figures 3-4 and 3-5 are views of the reconstructed panel. In addition, visual inspections and photographs of portions of the failed panel support the conclusion in the visual inspection report that the panel was degraded. The longitudinal rebar in each flange was corroded to the point that the flexural strength of the panel was nonexistent and the concrete surrounding the rebar had spalled (broken apart).

Figure 3-4. View 1 of the reconstructed panel.

Figure 3-5. View 2 of the reconstructed panel.

Additional Observations

- The panel inspection program relied primarily on visual inspection criteria.
- After the cart punch-through incident on March 22, 2005, BJC management directed the installation of safe walkways for work activities on the operating floor. The panel that failed was not marked on either side as a degraded panel.
- The deteriorated condition of the roof and the associated water infiltration have accelerated the deterioration of the floor panels and their subsequent indeterminate load-carrying capability. See Figure 3-6 for a photograph of the deteriorated roof of the K-25 Building (view from underneath). For example, Standard SS-R-531 requires a minimum of ¼-inch concrete cover, which is not adequate in the wet environmental conditions introduced from the deteriorating roof.

The Board concludes that:

- *The failed panel had little or no load-carrying capacity due to deteriorating conditions caused by the infiltration of water and exposure to extreme environmental conditions.*
- *The lack of roof maintenance in the K-25 Building is the major contributor to the floor panel deterioration.*
- *There were no engineered barriers that met Title 29, Code of Federal Regulations, Part 1926.502(b) to prevent personnel from stepping off the grating.*
- *The contractor's report recommendation that "General foot traffic access is acceptable for the entire operating floor within Bldg. K-25. Care should be taken to avoid the marked panels." provides a false sense of security relative to the structural integrity and load-carrying capacity of the floor panels.*

Figure 3-6. Deteriorated roof viewed from the operating floor.

3.1.2 Work Planning and Controls

March – April 2005

In the days immediately following the cart punch-through incident, the Project held a tabletop planning meeting and conducted a limited walkdown to develop a means whereby the electrical panels feeding the RCAAS equipment could be safely accessed. The Field Engineer from the Construction organization outlined the scope of work to representatives from the Planning, Safety, and Engineering organizations and other Project representatives. The concept was to construct a safe walkway consisting of either pic boards or metal grating that would span the structural steel so that no load other than bearing would be placed on the concrete panels. The grating would be lashed together using steel cable and crimps to form a continuous walkway on top of the existing floor. Stanchions, plastic boundary chains, and warning signs would be placed along the edge of the grating to provide a visual reminder to stay off the concrete panels. Attendees left the meeting with the actions that the Planner would prepare the Work Package (inclusive of the Work Instructions), the Safety organization would prepare the AHA, and the Construction organization would order the material. See Figure 3-7 on the following page for a simplified organization chart for the Project.

On March 31, 2005, the Facility Manager and the Project Manager granted approval to develop the Work Package. Comments on the draft Work Instructions were discussed with members of the planning team during a second meeting. The AHA was developed in parallel by the Safety organization during this period. The Work Instructions define a process whereby Work Requests for installing either permanent or temporary scaffolding and/or grating can be issued against the Work Package as the need arises. During development of the AHA and the Work Instructions, conflicting work requirements for fall protection were introduced, resulting in an inadequate Work Package.

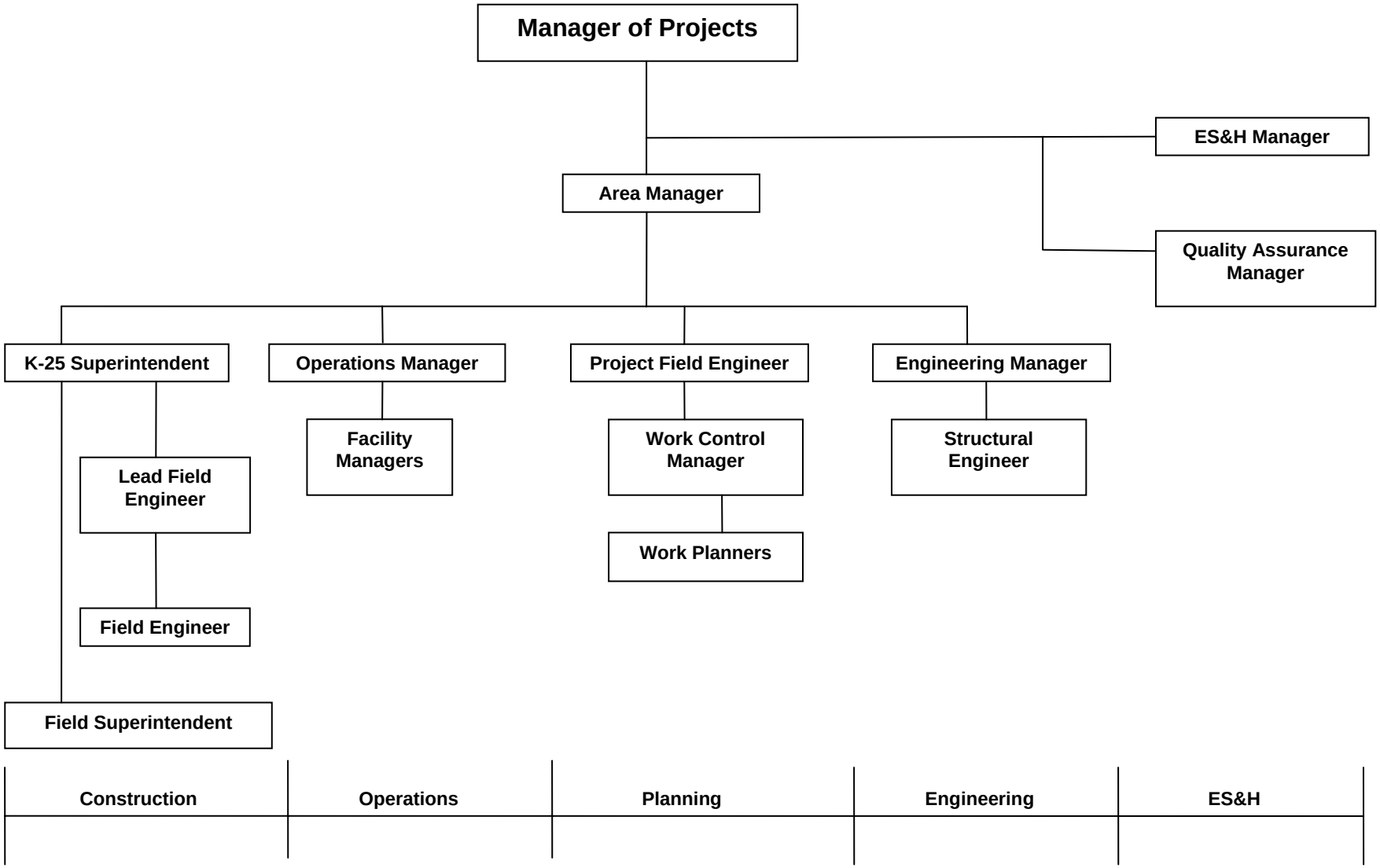

Figure 3-7. Simplified K-25/K-27 Buildings D&D Project Organization Chart.

The Board noted several additional issues that affected the work planning and the resulting Work Package:

- There was no worker involvement in either of the planning processes.
- The Work Instructions did not include fall protection in the "Safety Controls" section.
- The walkdown checklist (BJCF-764) was not used, and procedural hold points were not identified.
- The term "established grating" was not defined in the AHA and Work Instructions.
- The Planner was about to leave for vacation.
- The AHA preparer had multiple jobs going on at the same time.
- A user validation of the Work Package was not required or conducted for Work Request 005.
- A review by the BJC Project Review Committee was not required or conducted. The Project Review Committee process was not required for this Work Package because it did not directly impact the Documented Safety Analysis, the Technical Safety Requirements, or the Nuclear Criticality Safety Evaluations.

The Board also determined that BJC did not recognize the actual floor integrity for the final design of the safe walkways that would be utilized for the RCAAS and fire protection inspections because the design consisted of grating walkways with stanchions and plastic chains to serve as administrative barriers. The Project Planners failed to recognize the degraded panels as having inadequate strength and structural integrity covered by Title 29, Code of Federal Regulations, Part 1926.501(a)(2); therefore, the Project planning did not account for human error and the potential for slips, trips, and falls in the walkway design.

On April 6, 2005, the AHA and the Work Package were approved for use in the field. The AHA contains the requirement for 100% fall protection when walking on the operating floor until the grating walkways are established. The Work Package also contains the first Work Request (001) to install temporary scaffolding to support access to the RCAAS electrical panels. The Project conducted prejob briefings for this Work Request during April 6–8, 2005. The Work Instructions and the AHA are briefed to the work crew, and the AHA is signed by the work crew as part of the prejob briefing. Based on interviews, the Board determined that the installation of the pic boards was conducted while wearing full fall protection in accordance with the AHA. As originally written, the Work Package required the use of nominal 8-foot sections of grating. Change Notice 1 was issued in mid-April 2005 to allow lengths "as specified by Engineering." As long as the grating sections were long enough to span the supporting steel, smaller lengths would be permitted. This is the only Change Notice issued against the Work Package.

June – July 2005

The second Work Request (002) was prepared and approved between May 31 and June 1, 2005, to again use pic boards to service the RCAAS. The Project conducted prejob briefings for this Work Request. Based on interviews, the Board determined that 100% fall protection was used by workers throughout the installation task in accordance with the AHA.

Work Request 003, dated June 7, 2005, was the first request made to install grating on the east and west operating floor of the K-25 Building. As part of the approval, the Structural Engineer established the load limits for the structural steel and the carts. Four pieces of grating were identified as the

maximum pieces of grating that should be stacked on either the cart or the operating floor. The Project conducted prejob briefings for this Work Request.

As the installation of grating progressed through June into July, the workers were in full fall protection gear. According to personnel who worked on the job, the expectation was that the work would be completed in about three months, and the work generally stayed on schedule. On approximately July 13, 2005, the General Foreman requested clarification from the Field Engineer on the requirements for fall protection as delineated in the Work Instructions contained in the Work Package. In particular, the Work Instructions contain the following warning:

> "PERSONNEL SHALL NOT STAND ON OPERATING FLOOR PANELS WITHOUT FALL PROTECTION. TO AVOID THE USE OF FALL PROTECTION PERSONNEL MAY STAND ON THE PREVIOUSLY INSTALLED DECKING AND SLIDE THE ONE BEING INSTALLED IN PLACE."

However, the AHA states:

> "All employees working on the Operations Floor shall use a personal fall arrest system consisting of Harness, anchor point/hardware, & retractable lifeline. This includes unloading & installation of plate/grating/scaffolding & stanchions."

In addition, the AHA contains other language regarding the control measures to be followed during installation of the grating:

> "All Operations Floor panels have suspected integrity problems. 100% fall protection required when walking on Operations Floor until plate/grating established."

According to the testimony received from Construction management and craft supervision, the request for clarification of the Work Instructions resulted in follow-on discussions with Construction management about whether workers were required to use fall protection while installing the grating. Several factors influenced the request: (1) the Work Instructions allowed it, (2) the summer heat was an issue, and heat stress controls were being used, and (3) it was more efficient to work without fall protection. On the afternoon the question was raised, the interpretation provided back to the work crew was that the Work Instructions allow the workers to install grating without using fall protection. Although the Board could not identify any written record of this decision/ interpretation, the Board received corroborating testimony during interviews. This decision was in direct conflict with the intent of the AHA. According to the AHA, a fall arrest system must be used "during the installation of plate/grating/scaffold board and stanchions."

On the following morning, according to the interview statements, the work crew was briefed on the revised fall protection requirements. This change was not communicated to the Safety organization, and no revision was made to the AHA to reflect the change in fall protection use. This informal management approach to render a decision that affected the Work Package did not follow the work control process. The Board was unable to locate any Safety Task Analysis Risk Reduction Talk (STARRT) cards from the July 2005 timeframe to evaluate if the change in work methods was documented during the daily safety briefing. The craft foreman, together with the work crew, completes these cards as a daily reminder to work safely.

Grating installation continued through the rest of the summer and was completed on August 9, 2005. During this time, the only personnel using fall protection were (1) those loading or unloading grating within 6 feet of the wall opening, (2) iron workers installing the initial grating from the loading/unloading area on the operating floor, and (3) the laborers who walked on the floor panels to clear the path for the grating to be installed. The installed walkways were being utilized as "established," although approval of the installation was not documented as required in the Work Package. This ambiguity in work control existed because the Project failed to identify procedural hold points in the Work Package for inspection of the grating.

On July 20 and 27, 2005, the Project Safety Representative walked down the grating installation on the operating floor. The work he observed did not involve installation of grating; therefore, he did not have the opportunity to see installation performed without fall protection.

The ORO Facility Representative documented in meetings on June 22 and July 13, 2005, that they observed work activities on the operating floor. Based on interview discussions, the work they observed did not involve installation of grating. There is no evidence that ORO oversight observed grating installation after July 14, when the work crew discontinued the use of fall protection. The grating installation was conducted without fall protection from July 14 to August 9, 2005, and December 9, 2005, to January 3, 2006.

BJC Form-788, "Work Package Post-Job Checklist" was not utilized at the completion of Work Request 003. This review was another opportunity to provide formal feedback regarding the efficiency of the Work Instructions to enable the safe performance of the work.

December 2005 – January 2006

Grating installation work under the Work Package did not occur again until December 7, 2005. Work Request 005 was issued to install grating from unit 305-7 to unit 303-3. (Work Request 004 was rescinded and not worked.) This walkway would provide access to other RCAAS electrical panels. The Board noted that the stipulations regarding cart load limits established by the Structural Engineer in Work Request 003 are not identified on Work Request 005, even though testimony indicated that the limits are still applicable.

The workers were not utilizing fall protection while installing the grating under Work Request 005. During the latter half of December 2005, a new Field Superintendent was assigned to this work activity. While becoming familiar with the job, he identified the fall protection discrepancy between the AHA and the Work Instructions. He questioned the General Foreman and the work crew and was told that the issue had been addressed earlier and that an interpretation had been rendered (i.e., follow the warning in the Work Instructions). No further inquiries were made.

Interviews with the craft employees indicated that poor lighting and the rubber shoe covers tearing were a problem during this grating installation. Feedback regarding these issues was not documented on the STARRT cards. On December 12, 2005, the Safety Representative walked down the west operating floor grating, but grating installation was not observed. The grating installation work commenced under Work Request 005 and continued until the accident occurred on January 3, 2006.

Additional Observations

The following additional facts were identified by the Board with regard to work implementation and controls:

- The workers installing the grating were not using fall protection as required by the AHA.

- The workers (including the injured worker) were handling loads in excess of 50 pounds per person, which is prohibited in the AHA.

- Appendix 5 of the Work Package contains multiple Work Requests. The "Installation and Approval" sections (Section 3) were not completed for these Work Requests.

- The Board determined that the ends of the grating sections (in the vicinity of the accident) were not aligned with the support steel. The sections were approximately 18 inches out of alignment.

- Access to the cell floor and the pipe gallery beneath the grating installation activities was not barricaded to control the overhead hazards as required by the AHA.

- The cart used to transport the grating on the operating floor (as evidenced by photographs) was loaded in excess of the maximum four pieces of grating specified in the Work Package. See Figure 3-8.

Conclusions

The Board concludes:

- *The Work Package was inadequate because the Project planning team did not work interactively to develop clear Work Instructions consistent with the controls in the AHA. The Project did not perform an adequate review of the Work Package, and conflicting requirements regarding fall protection use while installing the grating were issued to the field.*

- *When a request for resolution of the fall protection requirements was raised to Construction management, the formal work change control process was not followed. The informal process used resulted in a breakdown of communications and a poor decision to discontinue use of fall protection.*

- *As the work was performed after fall protection use was discontinued (approximately July 14 to August 9, 2005, and December 7, 2005, to January 3, 2006), several opportunities to identify the conflict were missed by the Project, BJC oversight, and ORO oversight.*

Figure 3-8. Overloaded cart at the accident scene.

- *The decision to relax the fall protection requirements did not account for irrecoverable acts such as slips, trips, and falls that could cause a worker to come off the grating.*

- *Factors potentially leading to slips, trips, and falls are: (1) the workers not adhering to the Work Package requirements not to lift in excess of 50 pounds, (2) the catching and tearing of the rubber shoe covers on the grating, (3) poor lighting, (4) the operating floor was wet and slick, and (5) the workers standing on grating that has not been validated as spanning the structural steel. These factors would not have significantly, if at all, increased the fall hazard had fall protection been used.*

- *No post-job review was conducted for the grating installation activities.*

3.1.3 Feedback and Improvement

Recent Investigations and Reviews

The Board reviewed information from various sources to analyze feedback and improvement. The Board's sources included information from previous accident investigations involving BJC's activities, oversight activities (both external and internal sources), occurrence reports, lessons learned, and issues management. Several recent accident investigations of BJC and a DOE operational readiness review of the high-risk equipment and process gas equipment removal activities for the Project identified issues concerning work process control and oversight. The findings related to work control, oversight, and feedback and improvement are listed in Table 3-1 on the following page.

The Type B Accident Investigation in 2003 identified a root cause that BJC's and MACTEC's work control processes were inadequate. In 2004, the Type B Accident Investigation identified two root causes: (1) the BJC subcontractor, Safety and Ecology Corporation D&D, had inadequate work control and (2) BJC oversight was inadequate. The operational readiness review process was initiated for the K-25/K-27 high-risk equipment and other process gas equipment removal in 2005. Both the BJC and DOE readiness review reports identified major issues with BJC's implementation of work controls. In addition, these reports provided a number of lessons learned from which BJC could have benefited if they had been implemented. BJC developed corrective actions to address the JONs from the accident investigations and the pre-start findings identified in the review reports. Although the corrective actions were implemented for the work control issues, the Board determined that work control issues continue be a recurring problem for BJC. Furthermore, issues management, which includes identifying corrective actions and assuring that the corrective actions are accurate and effective, is a major concern.

An example of an issues management problem is as follows: BJC Occurrence Report ORO-BJC-K25ENVRES-2005-0006, *Failure of Operating Floor Panel – K-25 Building Operating Floor*, dated March 22, 2005, identified the following corrective actions, that when fully implemented, were to prevent recurrence of the incident:

1) Institute a process to ensure that fall protection or walk boards are required when working on the operating floor constructed from floor panels.

2) Conduct an evaluation of the Project's Structural Engineering Program (KC-8300 series procedures).

Table 3-1. Selected Results of Recent Investigations and Reviews of BJC and ORO

Investigation or Review	Judgment of Need or Pre-Start Finding
February 2003 Type B Accident Investigation of BJC Subcontractor PPE Ignition Incident (DOE/ORO-2151) The root cause identified for the accident was that BJC's and MACTEC's work control processes were inadequate.	JON – BJC and its subcontractors need to fully implement the Integrated Safety Management (ISM) program. Particular emphasis is needed in the identification of hazards, work controls, and feedback mechanisms.
	JON – BJC and its subcontractors need to develop and implement a system to facilitate sharing of work practices, issues, and solutions for effective lessons learned.
	JON – ORO needs to develop a risk-based policy for balancing assignment of facility representatives and subject matter experts on projects with contractor oversight responsibilities.
May 2004 Type B Accident Investigation of a BJC Subcontractor Release of Radioactively Contaminated Liquid During Transportation Activities (DOE/ORO-2183) Two root causes were identified for this accident: 1. Safety and Ecology Corporation D&D had inadequate work control. 2. BJC oversight was inadequate.	JON – Safety and Ecology Corporation D&D needs to improve its work control processes to ensure that: - Work Instructions are written with adequate detail ensure workers properly perform the tasks. Hold points that require specific knowledge or verification are included in Work Instructions. Reliance on "skill of the craft" should be used only where appropriate, based on the risks of the task and the qualifications of the workers.
	JON – BJC needs to improve its day-to-day oversight of subcontractors ensure work is performed in compliance with ISM.
	JON – BJC and Safety and Ecology Corporation D&D need to strengthen their lessons learned programs in the area of application of lessons learned.
	JON – ORO EM needs to ensure that oversight responsibilities are clearly defined and that transportation activities receive the appropriate priority.
September 2005 BJC Operational Readiness Review	Pre-Start Finding – Some Work Instructions and procedures are not clearly, concisely, and accurately written
	Pre-Start Finding – Effective application of disciplined operations and attention to detail in K-25/K-27 Project processes has not been achieved. Problems were identified in the following areas: 1. Use, quality, and control of work packages 2. Performance of safety system surveillances 3. Failure to follow procedures and Work Instructions 4. Completion of planned activity demonstrations
	Pre-Start Finding – Work packages/procedures are not always being followed in the proper sequence, and sometimes steps are not being performed as required.
October 2005 DOE Management Self-Assessment for the K-25/K-27 High-Risk Equipment Removal and Other Process Gas Equipment Removal	Pre-Start Finding – Procedure KD-1001 contains a process to perform Work Package changes which allows a "Change" to a Work Package in lieu of a "Revision" as required by BJC-FS-1001 for intent changes
	Pre-Start Finding – Work Packages for non-high-risk equipment component/item removal, handling, and disposition were not provided to the DOE Management Self-Assessment team, nor was a process to ensure adequate controls for handling non-high-risk equipment components/items presented.
October 2005 DOE Operational Readiness Review of the K-25/K-27 High-Risk Equipment Removal and Other Process Gas Equipment Removal Evidence indicated that all pre-start findings and corresponding corrective actions were completed and verified closed by DOE.	Pre-Start Finding – Work Packages are often not adequate in defining the Work Instructions needed for safe and efficient operations performance.
	Pre-Start Finding – Document control and records management processes are not adequately implemented in some areas.
	Pre-Start Finding – Numerous procedure deviations and inadequate practices were noted during the implementation of the Work Instructions.
	Pre-Start Finding – Prejob preparations were inadequate for some operations.

3) Institute a process to require the use of hold point signoffs of all prerequisites (e.g., special equipment and/or engineering evaluations).

4) Schedule self-assessments to verify that all listed material/equipment is available and that work steps are implemented.

The corrective actions were entered into the Issues/Corrective Action Tracking System under Issue No. I002510. BJC completed the corrective actions and documented closure evidence in Action Detail Reports 03296, 30297, 00298, 30299, 30300, and 30301. The required self-assessments were listed in the *K-25/K-27 Decontamination and Decommissioning Project Management Assessment and Subcontractor Oversight Plan, FY 2005 Integrated Assessment Schedule*, Revision 1**.** The Board reviewed the evidence provided for the self-assessments required by corrective action 4 above. The self-assessments were required to assess the documenting of material/equipment in work instructions, as well as verifying that the work steps had been implemented as required. BJC did not complete the corrective actions because the checklist used for this assessment only evaluated the equipment/material associated with the ongoing work and did not evaluate the adequacy of work step implementation.

Therefore, the Board concludes that the corrective actions have not been effective in eliminating or reducing work control issues.

Oversight

The ORO Assistant Manager for EM issued a memorandum entitled "Accelerated Cleanup Contract Safety and Operational Oversight," dated March 30, 2004. This memorandum provides a schedule for conducting operational awareness reviews of the Accelerated Closure Project. In addition, the memorandum identifies the oversight expectations for the DOE Facility Representatives and subject matter experts and for BJC Project management. From the evidence reviewed, the DOE Facility Representatives and subject matter experts have conducted walkthroughs of the K-25 Building operating floor activities. The oversight activities did not identify any failure to follow the fall protection requirements. In one instance, a Facility Representative observed one employee on the operating floor off the grating without fall protection. The Board found no evidence that oversight activities included observation of grating installation after the fall protection requirements were relaxed.

BJC's oversight activities of the Project are performed via independent assessments and management self-assessments, completion of weekly "ES&H Walkdown Questionnaire" forms, and daily walkdowns. Not all areas or job activities are walked down daily by the Project's Safety personnel. The Project developed and issued an integrated assessment schedule for fiscal year 2005. An Internal Project Review conducted in June 2005 evaluated the implementation of the Integrated Safety Management System (ISMS). This review covered several key areas, including training, AHAs, plan of the day meetings, and procedures. The review team did not identify any major findings. In addition, another Internal Project Review was conducted on May 11 and 16 and June 13, 2005. This Internal Project Review covered BJC's activities related to the high-risk equipment and process gas equipment removal on the cell floor of the K-25 Building. The team reviewed the weekly walkdowns by Safety personnel and the implementation of fall protection requirements. No major findings were identified.

The Board reviewed evidence related to feedback and improvement, such as the STARRT cards and the weekly "ES&H Walkdown Questionnaire" forms. The STARRT cards reviewed did not have any comments identified by workers for areas of concern. The Safety Representatives submit the weekly walkdown information (the

"ES&H Walkdown Questionnaire" forms) to their management, and some of these forms covered the grating installation activities observed on the K-25 Building operating floor. The Safety Representative checked the box on the forms which indicate that fall protection was being used. The Board interviewed several workers who installed grating under Work Request 005 (December 2005). All of them understood that fall protection was not required as long as they stayed on the grating.

The Board concludes that although ORO's and BJC's oversight initiatives have been implemented, each of these initiatives was less than adequate in observing grating installation work that required the use of fall protection.

Worker Feedback

With regard to concerns identified by the iron workers, the Board determined from interviews that the workers encountered problems with the rubber shoe covers continually tearing when they worked on the operating floor. Workers often brought extra shoe covers in with them and wore them because of this problem. Through interviews, the Board determined that some members of craft supervision were aware of the problem with the shoe covers. In addition, the workers interviewed expressed concern about inadequate lighting on the operating floor. BJC management identified STARRT cards and tailgate meetings as two of the main mechanisms used to address worker concerns on the Project. However, there is no documentation that these mechanisms were used to address the workers' concerns on lighting and the rubber shoe covers.

The Board concludes that BJC has feedback systems in place to capture workers' concerns, but the systems are not used effectively.

3.1.4 Training

The BJC Training Program is documented in BJC-HR-0702, *Training Program*, Revision 5, dated December 6, 2004. The program requires training to be documented and tracked in the BJC Training database. In addition, until the required training is satisfied, an employee's duties are appropriately restricted or supervised by a fully trained person. The Board reviewed the Training Matrix for supervisors and workers associated with the K-25 Building grating installation activities. The Training Matrix identifies the required training and the status of training for Project personnel. Personnel associated with the Project have completed all required training.

The worker that was injured completed fall protection training on December 7, 2005. The fall protection training module involves five hours of classroom instruction and harness application. The training emphasizes the weight restriction of 310 pounds for the fall arrest system. The injured worker passed fall protection training, yet BJC did not have a harness and fall arrest system which would have enabled him to work wearing fall protection. Specially-designed arresting systems are required for workers over 310 pounds to limit the force applied to the body to less than 900 pounds.

On December 19, the BJC Occupational Safety Manager sent a site-wide electronic mail message addressing the weight limit restriction for fall protection equipment. This message served as a general reminder; however, it did not establish policy or prevent workers over the weight limit from being assigned to work activities requiring the use of fall protection.

The Board concludes that BJC has not implemented a qualification process to identify personnel who exceed the weight limit for fall protection PPE in order to prevent them from being assigned work that requires using fall protection.

3.1.5 Lessons Learned

The Board reviewed and analyzed the application of lessons learned from similar accidents within DOE. The following accidents were reviewed:

(1) Type B Accident Investigation of the July 7, 1997, Industrial Accident at the Knolls Atomic Power Laboratory

Accident: A laborer fell through an unprotected roofing skylight that was not recognized as a hazard. The laborer wore fall protection that did not perform as required.

Root Causes:

a. Management failed to ensure that the fall protection requirements were understood and properly implemented in accordance with both contractual and applicable regulatory requirements.

b. The contractor failed to identify and resolve the reasons for recurring fall protection deficiencies noted from previous accidents.

(2) Type A Accident Investigation of the February 20, 1996, Fall Fatality at the Radioactive Waste Management Complex Transuranic Storage Area – Retrieval Enclosure at the Idaho National Laboratory

Accident: A project engineer fell 20 feet from a temporary, unguarded platform. He was not wearing fall protection.

Root Causes:

a. The failure of subcontractor to implement requirements and procedures that would have mitigated the hazards.

b. The failure by the subcontractor to effectively implement the Secretary's guiding principle mandating line management responsibility for safety performance.

Based on a review of these reports, the Board found similarities between these previous accidents and the K-25 Building fall injury. The Board's conclusion reached in Section 3.1.3 applies here as well.

3.2 Integrated Safety Management Analysis

Management systems were examined as potential contributing and root causes of the accident. The Board reviewed the roles of ORO, the DOE ETTP Closure Project Office, and BJC management in promoting and implementing ISM in this operation. The BJC ISMS provides a formal, organized process for planning, performing, assessing, and improving the safe conduct of work. Properly implemented, ISM is a standards-based approach to safety, requiring rigor and formality in the identification, analysis, and control of hazards. The system establishes a hierarchy of components to facilitate the orderly development and implementation of safety management throughout the DOE complex. The guiding principles and core functions of ISM are the primary focus for contractors in conducting work efficiently and in a manner that ensures the protection of workers, the public, and the environment. The Accident Investigation Program requires that accidents be evaluated in terms of ISM to foster continued improvement in safety and to prevent additional accidents.

ISM was implemented by DOE in the late 1990s. DOE has fully embraced ISM and has directed its contractors to fully implement the standard. BJC has an approved ISMS description, and in June 2003, the BJC ISMS was reverified. However, the Board has identified weaknesses in all the ISM core functions. Appendix B, Table B-1 summarizes the deficiencies in the application of the five core functions of ISM as they relate to this accident.

3.3 Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all tasks. For an accident to occur, there must be a hazard that comes into contact with a target because the barriers or controls were not in place, not used, or failed. A hazard is the potential for unwanted energy flow to result in an accident or other adverse consequence. A target is a person or object that a hazard may damage, injure, or fatally harm. A barrier is any means used to control, prevent, or impede the hazard from reaching the target, thereby reducing the severity of the resultant accident or the adverse consequence. The results of the barrier analysis are used to support the development of the causal factors. Appendix C, Table C-1, contains the barrier analysis.

3.4 Change Analysis

Change is anything that disturbs the "balance" of a system that is operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Change analysis examines the planned or unplanned changes that caused the undesired results or outcomes related to the accident. This process analyzes the difference between what is normal (or "ideal") and what actually occurred. The results of the change analysis are used to support the development of the causal factors. Appendix D, Table D-1, contains the change analysis.

3.5 Events and Causal Factors Analysis

An events and causal factors analysis was performed in accordance with the DOE Workbook *Conducting Accident Investigations*. The events and causal factors analysis requires deductive reasoning to determine which events and/or conditions contributed to the accident. Causal factors are the events or conditions that produced or contributed to the occurrence of the accident, and they consist of direct, contributing, and root causes.

The direct cause is the immediate events or conditions that caused the accident. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the accident but which did not cause the accident. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar accidents. A summary of the Board's causal factors analysis is presented in Appendix E, Table E-1, and it is followed by Figure E-1, Events and Causal Factors Chart.

3.6 Human Performance Improvement Analysis

Analysis of events in many different types of industry has shown that between 60 and 90% of major accidents have some type of human error as a contributing cause. Of these human errors, only about 30% are due to the active mistake or error of an individual and the remaining 70% are due to weaknesses that exist in the organization that supports or directs the work. Including an approach in this accident investigation to identify the precursor conditions that contributed to human error and the potential organizational weaknesses helped the Board to identify not only any systemic problems but also to point out where human fallibility may have contributed. Equally important is the opportunity to identify and anticipate the likelihood of human error in the future and to strengthen barriers to those failures. See Appendix F, Table F-1, for the Board's analysis of the human performance elements of the accident.

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4.0 CONCLUSIONS AND JUDGMENTS OF NEED

JONs are the managerial controls and safety measures determined by the Board to be necessary to prevent or minimize the probability or severity of a recurrence. These JONs are linked directly to the causal factors, which are derived from facts and analyses. They form the basis for corrective action plans which must be developed by line management. Table 4-1 contains the Board's conclusions and the JONs.

Table 4-1. Conclusions and Judgments of Need

Conclusions	Judgments of Need
• The Work Package was inadequate because the Project planning team did not work interactively to develop clear Work Instructions consistent with the controls in the AHA. The Project did not perform an adequate review of the Work Package, and conflicting requirements regarding fall protection use while installing the grating were issued to the field. • During the planning job walkdown, a work package checklist (BJCF-764) to identify the procedural hold points for inspections was not used. • No post-job review was conducted for the grating installation activities.	JON 1 – BJC needs to enforce and verify compliance with its work control process and: • Increase rigor to ensure the Work Instructions (including all warnings, cautions, and notes) and the AHA are compatible and appropriately integrated. • Identify and correct work packages for the Project that have not undergone a review for ambiguity and consistency. • Ensure consistent worker involvement during the work planning process. • Ensure adequate post-job reviews are conducted.
• When a request for resolution of the fall protection requirements was raised to Construction management, the formal work change control process was not followed. The informal process used resulted in a breakdown of communications and a poor decision to discontinue use of fall protection. • Communication between Construction management and Safety did not occur.	JON 2 – BJC needs to develop and implement a documented process whereby line management is required to coordinate any change in the use of safety controls with a representative of the functional safety organization prior to the change being implemented.
• As the work was performed after fall protection use was discontinued (approximately July 14 to August 9, 2005, and December 7, 2005, to January 3, 2006), several opportunities to identify the conflict were missed by the Project, BJC oversight, and ORO oversight. • Factors potentially leading to slips, trips, and falls are: (1) the workers not adhering to the Work Package requirements not to lift in excess of 50 pounds, (2) the catching and tearing of the rubber shoe covers on the grating, (3) poor lighting, (4) the operating floor was wet and slick, and (5) the workers standing on grating that had not been validated as spanning the structural steel. • Although ORO's and BJC's oversight initiatives have been implemented, each of these initiatives was less than adequate in observing grating installation work that required fall protection.	JON 3 – ORO and BJC need to improve Project oversight to ensure work is understood and performed in accordance with the Work Package requirements.

Table 4-1. Conclusions and Judgments of Need (continued)

Conclusions	Judgments of Need
• There were no engineered barriers that met Title 29, Code of Federal Regulations, Part 1926.502(b), to prevent personnel from stepping off the grating. • The decision to relax the fall protection requirements did not account for the likelihood of irrecoverable acts such as slips, trips, and falls that could cause a worker to come off the grating.	JON 4 – BJC needs to implement a strategy to identify and mitigate the consequences of human error in the design, planning, and execution of work.
• BJC has not implemented a qualification process to identify personnel who exceed the weight limit for fall protection equipment in order to prevent them from being assigned work that requires using such equipment.	JON 5 – BJC needs to develop and implement a screening process to ensure compliance with the fall protection weight restriction requirements.
• The corrective actions have not been effective in eliminating or reducing work control issues. • BJC has feedback systems in place to capture workers' concerns, but the systems are not used effectively.	JON 6 – ORO and BJC need to ensure that corrective actions related to work control in response to accident investigations, operational readiness reviews, self-assessments, and lessons learned are implemented and verified as effective.
• The failed panel had little or no load-carrying capacity due to deteriorating conditions caused by the infiltration of water and exposure to extreme environmental conditions. • The lack of roof maintenance in the K-25 Building is the major contributor to the operating floor panel deterioration. • The contractor's report recommendation that "General foot traffic access is acceptable for the entire operating floor within Bldg. K-25. Care should be taken to avoid the marked panels." provides a false sense of security relative to the structural integrity and load-carrying capacity of the floor panels.	JON 7 – BJC needs to evaluate the safety risk of continuing to access the K-25 Building operating floor versus the risk/benefit of implementing alternative D&D strategies.
• The emergency response, event notification, and event categorization were timely and appropriate.	None

5.0 BOARD SIGNATURES

Edward B. Blackwood
DOE Accident Investigation Board Chairperson
U.S. Department of Energy
Office of Regulatory Liaison, EH-21

J. T. Howell
DOE Accident Investigation Deputy Board Chairperson
U.S. Department of Energy
Oak Ridge Office

Douglas Paul
DOE Accident Investigation Trained Board Member
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Debra Dyer
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Robert A. Edlund
DOE Accident Investigation Board Member
National Nuclear Security Administration
Y-12 Site Office

Tyrone Harris
DOE Accident Investigation Board Member/Analyst
U.S. Department of Energy
Oak Ridge Office

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6.0 BOARD MEMBERS, ADVISORS, AND STAFF

Board Members

Chairperson	Edward B. Blackwood, Director, Office of Regulatory Liaison, Office of Environment, Safety, and Health, DOE
Deputy Chairperson	J. T. Howell, Deputy Assistant Manager, Nuclear Fuel Supply, DOE ORO
Trained Accident Investigator	Douglas Paul, Facility Representative, DOE ORO
Member	Debra Dyer, Emergency Management Specialist, DOE ORO
Member	Robert A. Edlund, General Engineer, National Nuclear Security Administration, Y-12 Site Office
Analyst	Tyrone Harris, Senior Quality Assurance Engineer, DOE ORO

Advisors

Advisor	J. Chris Cantwell, Safety Leadership Program Director, UT–Battelle, LLC
Advisor	Doran Christensen, Associate Director and Staff Physician, Radiation Emergency Assistance Center/Training Site, Oak Ridge Institute for Science & Education
Advisor	F. Lester Ginn, General Engineer, DOE ORO
Advisor	Robert E. James, Attorney, Office of Chief Counsel, DOE ORO
Advisor	Cathy Stachowiak, Industrial Hygienist, DOE ORO

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Court Reporter	Sharon Mahan

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Appendix A – Appointment of Type B Accident Investigation Board

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DOE F 1325.8
(4/93)

United States Government **Department of Energy**

Oak Ridge Office

memorandum

DATE: January 11, 2006

REPLY TO
ATTN OF: SE-30:Kelly

SUBJECT: **TYPE B INVESTIGATION OF EMPLOYEE FALL IN K-25 BUILDING, BECHTEL JACOBS COMPANY LLC, OAK RIDGE, TENNESSEE, JANUARY 3, 2006**

TO: Edward B. Blackwood, Director, Office of Regulatory Liaison, EH-21, GTN

You are hereby appointed Chairperson of the Investigation Board to investigate the subject incident that occurred on January 3, 2006, at the East Tennessee Technology Park. You are to perform a Type B investigation of this incident and to prepare an investigation report. The report shall conform to requirements detailed in the Department of Energy (DOE) Order 225.1A, *Accident Investigations*, and DOE G 225.1A-1, *Implementation Guide for Use with DOE 225.1A, Accident Investigations*. The Board will be comprised of the following members:

J.T. Howell, Deputy Assistant Manager for Nuclear Fuel Supply, Deputy Chair
Doug Paul, Technical Support and Assessment Division, Member, Trained AI
Debra Dyer, Emergency Management Team, Member
Robert A. Edlund, Y-12 Site Office, Member
Tyrone Harris, Environmental and Quality Management Division, Member, Analyst
Cathy Stachowiak, Technical Support and Assessment Division, Advisor
Jim Dougan, Pro-2-Serve, Structural Engineer, Advisor
Karen Brown, Parallax, Inc., Coordinator

Rob James, Office of Chief Counsel, will serve as the legal liaison for the Board. The scope of the Board's investigation is to include, but is not limited to, identifying all relevant facts; analyzing the facts to determine the direct, contributing, and root causes of the incident; developing conclusions; and determining judgments of need that, when implemented, should prevent the recurrence of the incident. The Board will focus on and specifically address the role of DOE and contractor organizations and Integrated Safety Management Systems, including oversight of subcontractors as they may have contributed to the overall accident. The scope will also include an analysis of the application of lessons learned from similar accidents within DOE.

If additional resources are required to assist you in completing this task, please let me know and it will be provided. You and members of the Board are relieved of your other duties until this assignment is completed.

The Board will provide my office with weekly reports on the status of the investigation but will not include any findings or arrive at any premature conclusions until an analysis of all the causal factors have been completed. Draft copies of the factual portion of the investigation report will be submitted to my office and to Bechtel Jacobs Company LLC for factual accuracy review prior to the report finalization.

The final investigation report should be provided to me by February 13, 2006. Any delay in this date shall be justified and forwarded to this office. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report. A copy of the Oak Ridge Accident Investigation Guidelines is attached for your use. If you have any questions, please contact me or Larry Kelly, of my staff, at 865-576-0891.

Gerald G. Boyd
Manager

Attachment:
ORO AI Guidelines

cc w/o attachment:
James Rispoli, EM-1, HQ/FORS
Charles Anderson, EM-2, HQ/FORS
Raymond Orbach, SC-1, HQ/FORS
Don Erbschloe, SC-3, HQ/FORS
John Shaw, EH-1, HQ/FORS
Raymond Hardwick, EH-2, HQ/FORS
Richard Stark, EH-24, HQ/GTN
Robert Brown, M-3, ORO
John Shewairy, M-4, ORO
Steve McCracken, EM-90, ORO
Larry Kelly, SE-30, ORO
Jack Howard, EM-93, ORO
Dale Jackson, EM-94, ORO

Appendix B – Integrated Safety Management System Analysis

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Table B-1. Integrated Safety Management System Analysis – Core Functions

Significant weaknesses in the implementation of the five core functions of ISM contributed to the occurrence of this accident. These weaknesses include the following:
Core Function 1 Define the Scope of Work
• The craft employees were not included in the work planning processes. • "Established grating" was not defined in the AHA and Work Instructions, which was significant to understanding when fall protection was no longer required.
Core Function 2 Analyze the Hazards
• Degradation of the operating floor panels has resulted from exposure to environmental elements due to deterioration of the K-25 Building roof. • The Planner did not recognize the degraded panels as open holes; therefore, the Work Instructions had a conflicting warning statement concerning the use of fall protection.
Core Function 3 Develop and Implement Hazard Controls
• The Work Instructions do not include fall protection in the "Safety Controls" section. • The AHA and Work Instructions were prepared separately, and there was limited interaction to ensure proper integration. The hazard controls were inconsistent between the work method and the AHA. • Personnel training/qualification does not adequately restrict workers over 310 pounds from wearing fall protection devices. Employees are not screened against the equipment limitations when assigned to a training matrix. • BJC did not account for human error and the potential for slips, trips, and falls in the final walkway design. Structural handrails were not incorporated into the design.
Core Function 4 Perform Work Within Controls
• The workers were not utilizing fall protection while installing the grating. • When fall protection use changed in the field, the AHA was not updated to reflect this new understanding. This same AHA continued to be used to brief new crew members even though the work controls utilized in the field were different. • The change in fall protection utilization was not communicated to the Safety organization. • There was a lack of rigor in implementation of the work controls: ➢ Engineering did not sign the Work Package section accepting installation of the grating. ➢ The workers were lifting in excess of 50 pounds. ➢ The ends of the grating sections (in the vicinity of the accident) were not aligned with the support steel. The grating sections were approximately 18 inches out of alignment. ➢ The requirement for a maximum load of four pieces of grating per cart in Work Request 003 was not included in Work Request 005 and was not being followed in the field.

Table B-1. Integrated Safety Management System Analysis – Core Functions (continued)

Core Function 5 Provide Feedback and Continuous Improvement
• Project oversight did not observe workers installing grating. The dates of active installation after the change in fall protection were July 14 through August 9, 2005, and December 6, 2005, through January 3, 2006. The change in fall protection use was not observed. • Independent verification was added to KD-1001, *Work Control Procedure*, Revision 6, dated September 16, 2005. The independent verification of work steps and warning statements was not conducted on previous standing work packages. • Feedback from the work crew regarding inadequate lighting and the rubber shoe covers tearing was not documented on the STARRT cards. The rubber shoe covers catching on the grating was a recurring condition. • The Work Package post-job review was not conducted.

Appendix C – Barrier Analysis

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Table C-1. Barrier Analysis

Barrier	Purpose	Analysis/Effect on Incident
Physical Barrier		
Fall protection system/PPE	Prevent injury from a fall	Fall protection was not utilized, and the iron worker fell through the operating floor.
Grating	Supplement the load-carrying capacity of the concrete floor panels	The iron worker caught his foot on the grating, slipped onto a degraded panel, and fell through the operating floor to the cell floor below.
Concrete floor panels	Serve as the floor for personnel on the operating floor	After tripping, the iron worker stepped/slipped onto a known defective floor panel that failed, and employee fell through the operating floor.
Management Barriers		
Work planning team	Identifies the scope of work and the hazards and controls. Defines the Work Instructions for the safe execution of the work.	Work planning resulted in conflicting safe Work Instructions and controls, which resulted in employees working without fall protection. The team also failed to involve craft workers in these meetings.
Work Package: 1. AHA 2. Work Instructions	1. Identify the hazards and controls 2. Define the steps for safe execution of the work	1. The fall protection controls were identified and required for installation of grating. The AHA change control process failed to recognize changed conditions. 2a. The AHA requirements relative to fall protection were not integrated with the Work Instructions. The warning statement in the Work Instructions conflicts with the AHA fall protection controls. Workers installed grating without fall protection. The Work Instructions do not anticipate slips, trips, or falls. 2b. No procedural hold points were identified.
Project Review Committee	Performs a Project-level review of the Work Package	The Project Review Committee process was not required for this Work Package because it did not directly impact the Documented Safety Analysis, the Technical Safety Requirements, or the Nuclear Criticality Safety Evaluations.
DOE oversight	Provides assurance that the work is being performed in a safe manner in accordance with the contract	The oversight system is implemented. However, the system failed to detect the conflict between the Work Instructions and the AHA with regard to the fall protection requirements. DOE oversight personnel did not observe grating installation.
BJC oversight: 1. Safety 2. Craft supervision 3. Operations	The oversight groups provide assurance that the work is being performed in a safe manner in accordance with the Work Package	1. The BJC oversight system is implemented. However, the system failed to detect the conflict between the Work Instructions and the AHA with regard to fall protection requirements. BJC oversight personnel did not observe grating installation. 2. The new Superintendent recognized the conflict in fall protection requirements, but he was told that it had been resolved during the summer timeframe, so he did not pursue the question further. (Therefore, he missed the opportunity to discuss the issue with the Safety Representatives.)

Table C-1. Barrier Analysis (continued)

Barrier	Purpose	Analysis/Effect on Incident
Management Barriers (continued)		
BJC oversight (continued)		3. As part of the completion of the corrective actions associated with the occurrence report for the cart punch-through incident, a self-assessment was performed by Operations. This self-assessment did not evaluate the steps in the Work Instructions for accuracy as required.
Prejob briefing	To inform workers of the hazards and controls in the Work Package (i.e., AHA and Work Instructions)	Three prejob briefings were conducted after the decision to relax the fall protection requirements. The potential existed for new craft personnel joining the Project (or ES&H personnel if they had chosen to attend) to have recognized and questioned the conflict between the AHA and the Work Instructions.
Daily tailgate meetings and STARRT meeting	Daily reinforcement of safe work practices and controls	These meetings did not capture employee feedback on concerns with inadequate lighting and the rubber shoe covers tearing.
Quality Assurance	Assures that work control documents (i.e., Work Instructions and the AHA) meet the requirements	The quality assurance process did not detect the conflict in the work control documents. Employees were allowed to install grating on the operating floor without using fall protection.

Appendix D – Change Analysis

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Table D-1. Change Analysis

Normal or Ideal Conditions	Actual Conditions	Analysis
WHAT		
100% fall protection during installation of grating	No fall protection was worn during installation of the grating.	The iron worker fell through the operating floor.
A work control change requires review and revision to the AHA, as applicable	The work control change was made without a revision to AHA.	The work control changed without Safety's review or acknowledgement.
The work control requirements between the Work Instructions and the AHA agree	A conflict existed between the Work Instructions and the AHA concerning fall protection requirements.	The conflict allowed interpretation of the fall protection requirements.
A Work Package review would identify the conflict : a. Work Package development/approval b. Prejob briefings	The conflict was not identified: a. The approvals were complete. b. The conflict was not raised during prejob briefings.	Work was allowed to commence under the conflicting Work Package.
WHO		
The workers are involved in Work Package development	The workers were not involved in development of the Work Package.	The benefit of the workers' input was not realized.
Project oversight: a. Project oversight should be knowledgeable of the work control change b. Project oversight should be knowledgeable that the grating installation is in accordance with the design	a. Project oversight personnel were not knowledgeable of the work control change. b. Project oversight personnel were not knowledgeable of whether the grating installation was in accordance with the design.	a. After the change in fall protection requirements for this work activity, Project oversight personnel did not observe the affected work activity. b. The installation did not meet the design expectations for a safe walkway. The steel grating was 18 inches out of alignment at the scene of the accident.
HOW		
Recognizing the deteriorating condition of the operating floor	Line management did recognize the changing condition.	The extent of the panel degradation was not recognized.
Line management and oversight display a questioning attitude: a. Fall protection b. Lighting c. Rubber shoe covers	A questioning attitude was present, but it was not effective.	a. Questions on interpretation of the warning note in the Work Instructions were addressed to Construction management and not the Safety organization. b. Craft supervision did not adequately raise these concerns. The STARRT cards were not used as a feedback mechanism for these concerns.

Table D-1. Change Analysis (continued)

Normal or Ideal Conditions	Actual Conditions	Analysis
WHY		
The Work Package review would identify the conflict	The conflict was not recognized.	The Work Package and AHA were developed separately. There was an urgency to get the Work Package issued. The AHA developer and the Work Package Planner had multiple jobs going on at that time.
Project management would recognize the degraded panels as open holes and develop the final design accordingly	The Project was taking some credit for the degraded panels not failing under worker slips, trips, or falls.	The grating walkway was inadequate.

Appendix E – Events and Causal Factors Analysis

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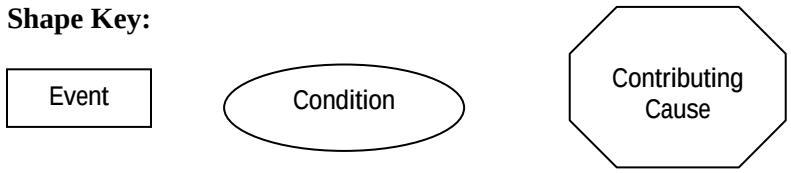
Table E-1. Events and Causal Factors Analysis Table

No.	Contributing Cause	Discussion	Related JON
CC-1	Inadequate Work Package	• The Work Package contains conflicting fall protection requirements between the AHA and the Work Instructions. The Work Instructions contain a statement within a "warning" stating that fall protection can be avoided if the worker stays on the grating during installation. The AHA requires 100% fall protection during installation or until the grating is "established." The Work Instruction steps are unclear in that "established grating" is not defined. • During the planning job walkdown, a work package checklist (BJCF-764) to identify the procedural hold points for inspections was not used. • These two documents (AHA and Work Instructions) were prepared separately and not integrated. • The AHA preparer had multiple jobs ongoing, and the Planner was about to leave for vacation. The craft employees were not included in the work planning process. An independent verification was not conducted, and "established grating" is referred to in the AHA but is not defined.	JON 1 JON 4
CC-2	The Project's change control process was not followed	• When fall protection use was discontinued, the change control process was not followed. This would have required a revision to the AHA. The conflict between the AHA and the Work Instructions continued unresolved. • There were opportunities to suspend the work and resolve the conflict: ➢ Prejob briefings ➢ Project oversight (field, management, Safety, and DOE) ➢ The new Superintendent who inquired about fall protection requirements in December 2005 and accepted a verbal explanation • The informal management approach to render a decision that affected the Work Package did not follow the formal work control process. Communication between Safety and Construction management did not occur.	JON 2 JON 3 JON 4
CC-3	Work was not performed within the hazard controls	• The AHA requires the use of fall protection for grating installation; however, fall protection use was discontinued. • The work being performed ignored the limitations on cart loading (Work Request 003), lifting in excess of 50 pounds (AHA), and standing on grating that did not fully span the structural steel (Work Instructions). These are indicators that the work requirements were selectively implemented.	JON 1 JON 3 JON 5

Table E-1. Events and Causal Factors Analysis Table (continued)

No.	Contributing Cause	Discussion	Related JON
CC-3 (cont.)	Work was not performed within the hazard controls	• Walkways were being utilized as "established," although approval of the installation was not documented as required in the Work Package. • Workers weighing over the limits for the fall protection PPE (310 pounds) completed fall protection training. This could have allowed situations where workers over the weight limit were utilized in jobs where fall protection was used.	
CC-4	Inadequate feedback and improvement	• The corrective actions associated with the occurrence report for the cart punch-through incident included a self-assessment of material/equipment and the work implementation steps of current work packages. The checklist used for this assessment only evaluated equipment/material associated with the ongoing work and did not evaluate work step implementation. • BJC procedure FS-1001 requires a post-job review. However, no post-job review was conducted for the grating installation activities. In addition, as part of the BJC operational readiness review, all high-risk equipment-related work packages were reviewed for ambiguous statements. However, the grating installation Work Package was not part of the scope of the operational readiness review. • The corrective actions related to work control in response to accident investigations, operational readiness reviews, self-assessments, and lessons learned have not been implemented and verified as effective.	JON 1 JON 6
CC-5	Failure to recognize floor integrity for final design	• The BJC design of the safe walkway consisted of grating paths with stanchions, plastic chains, and warning signs. This design did not account for human error due to slips, trips, and falls. The stanchions and plastic chains were administrative barriers only, not physical barriers. • The planning of the walkways did not recognize the degraded concrete panels as open holes.	JON 4 JON 7

Shape Key:



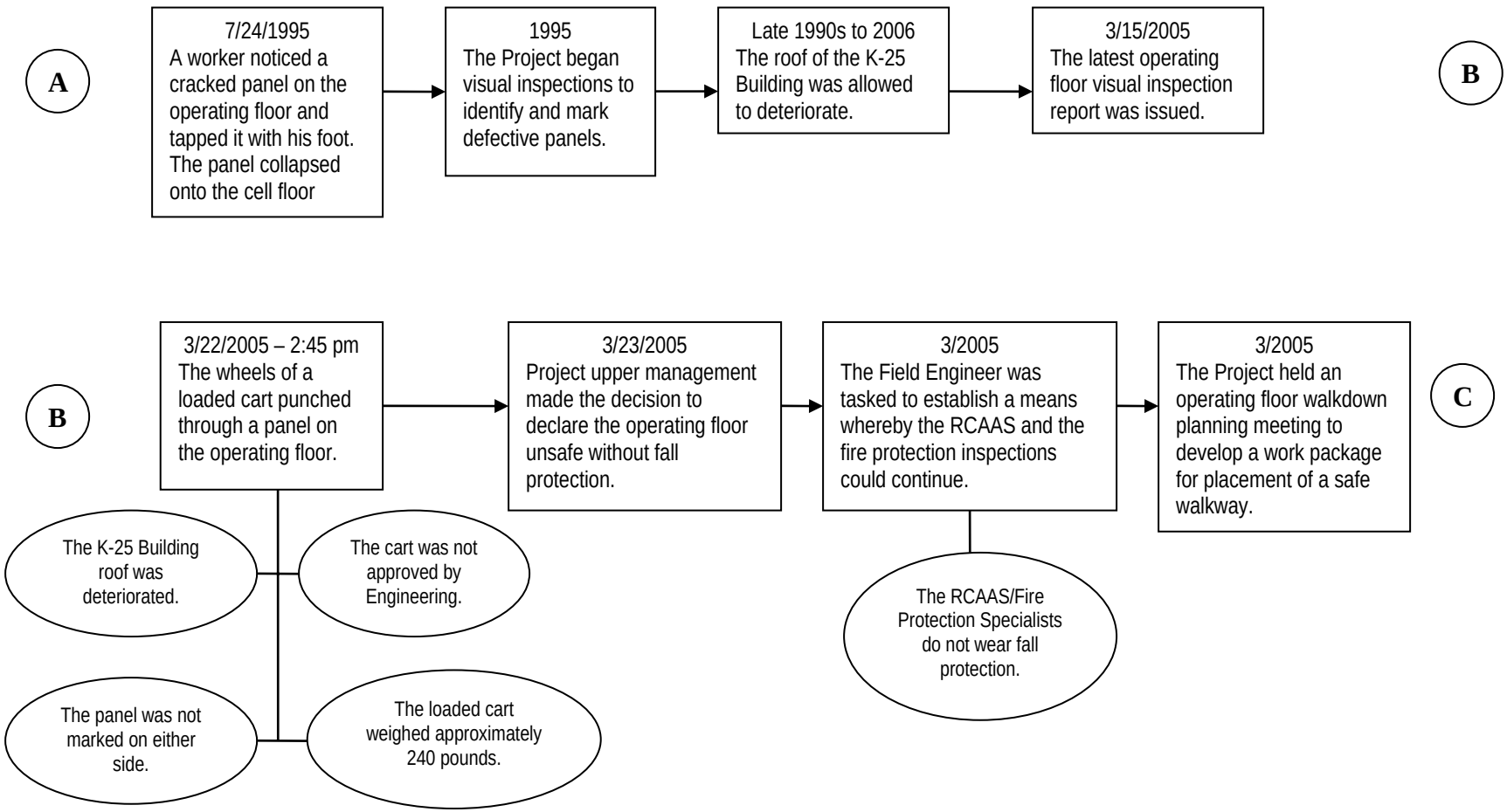
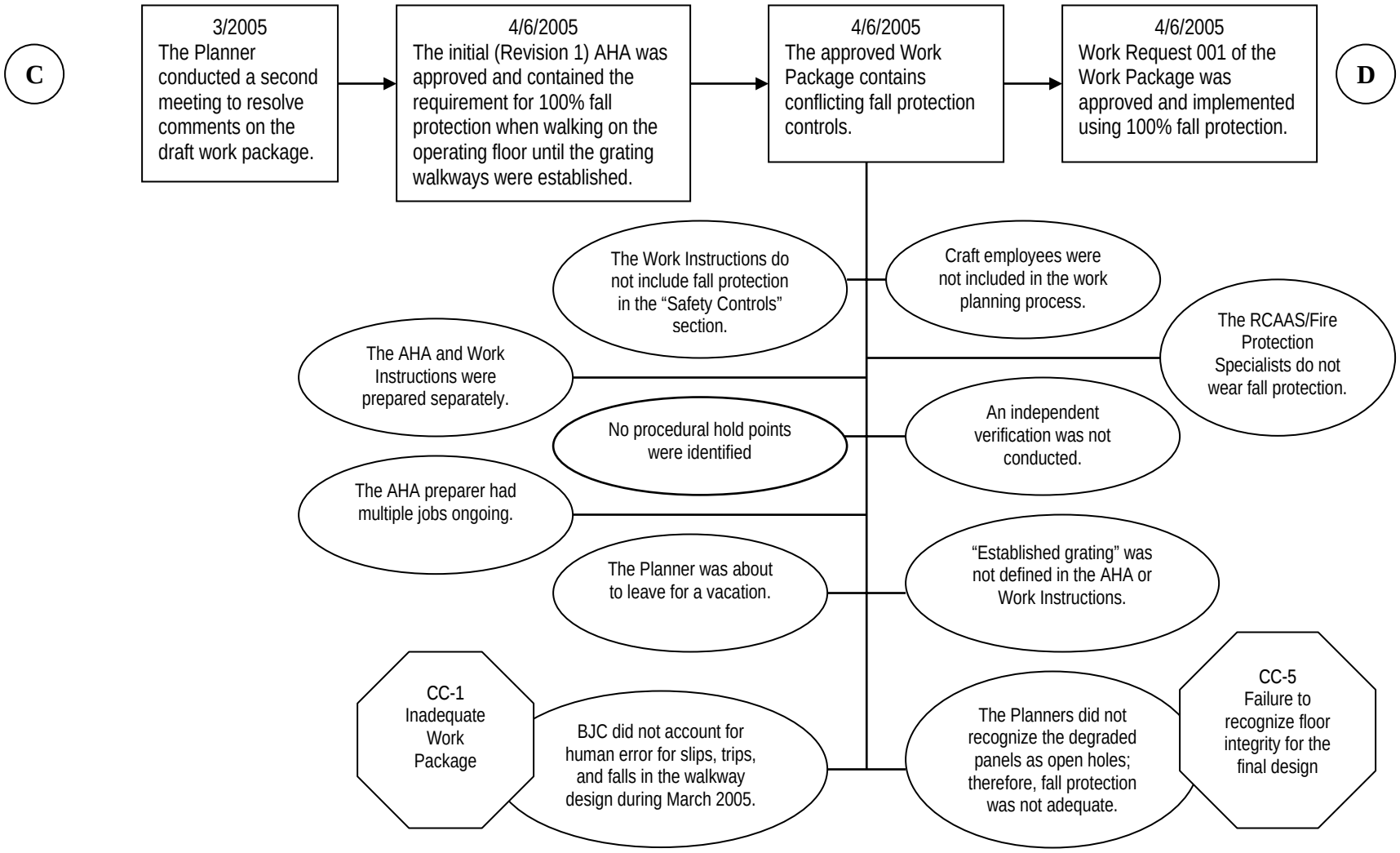
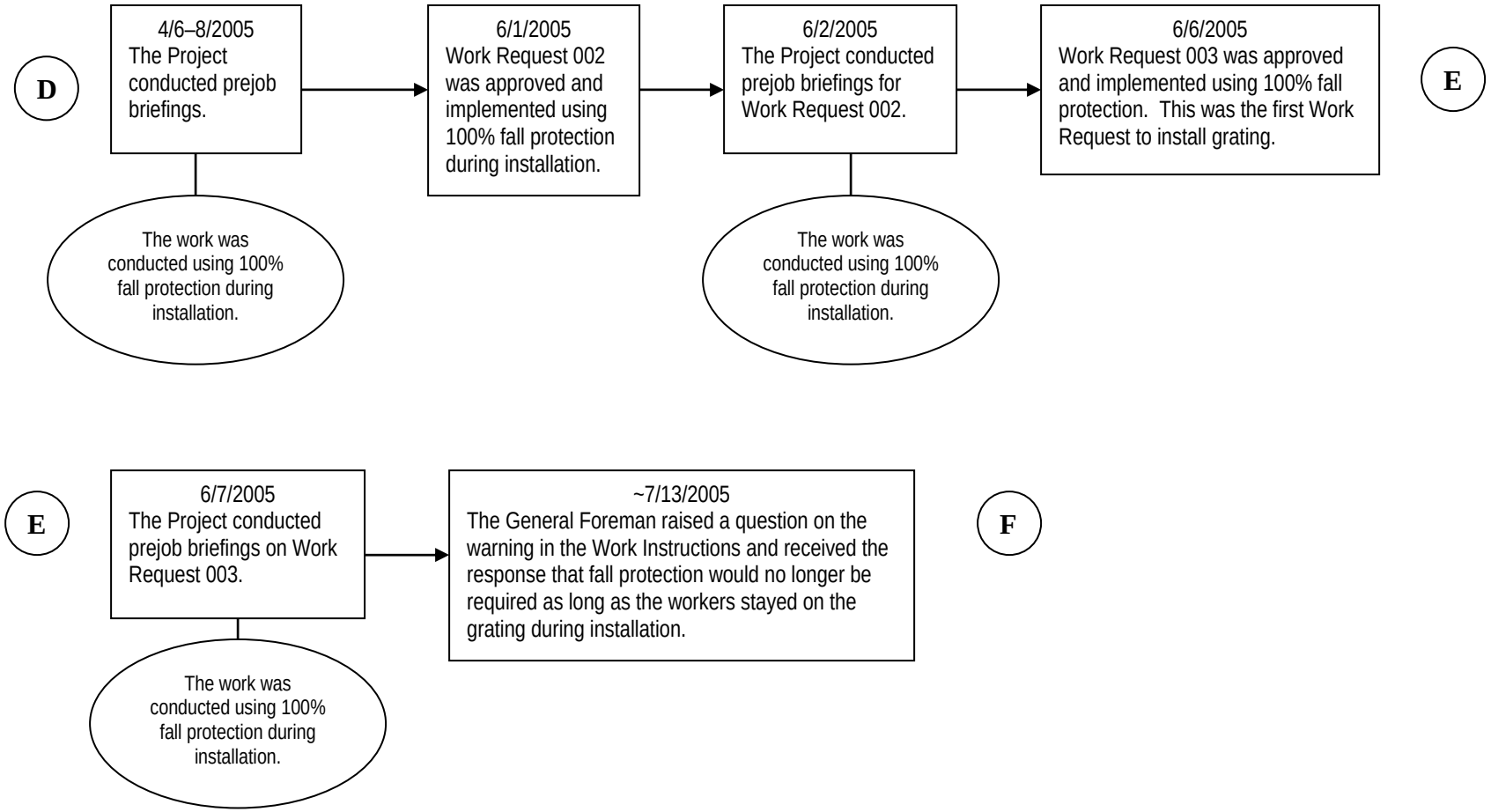
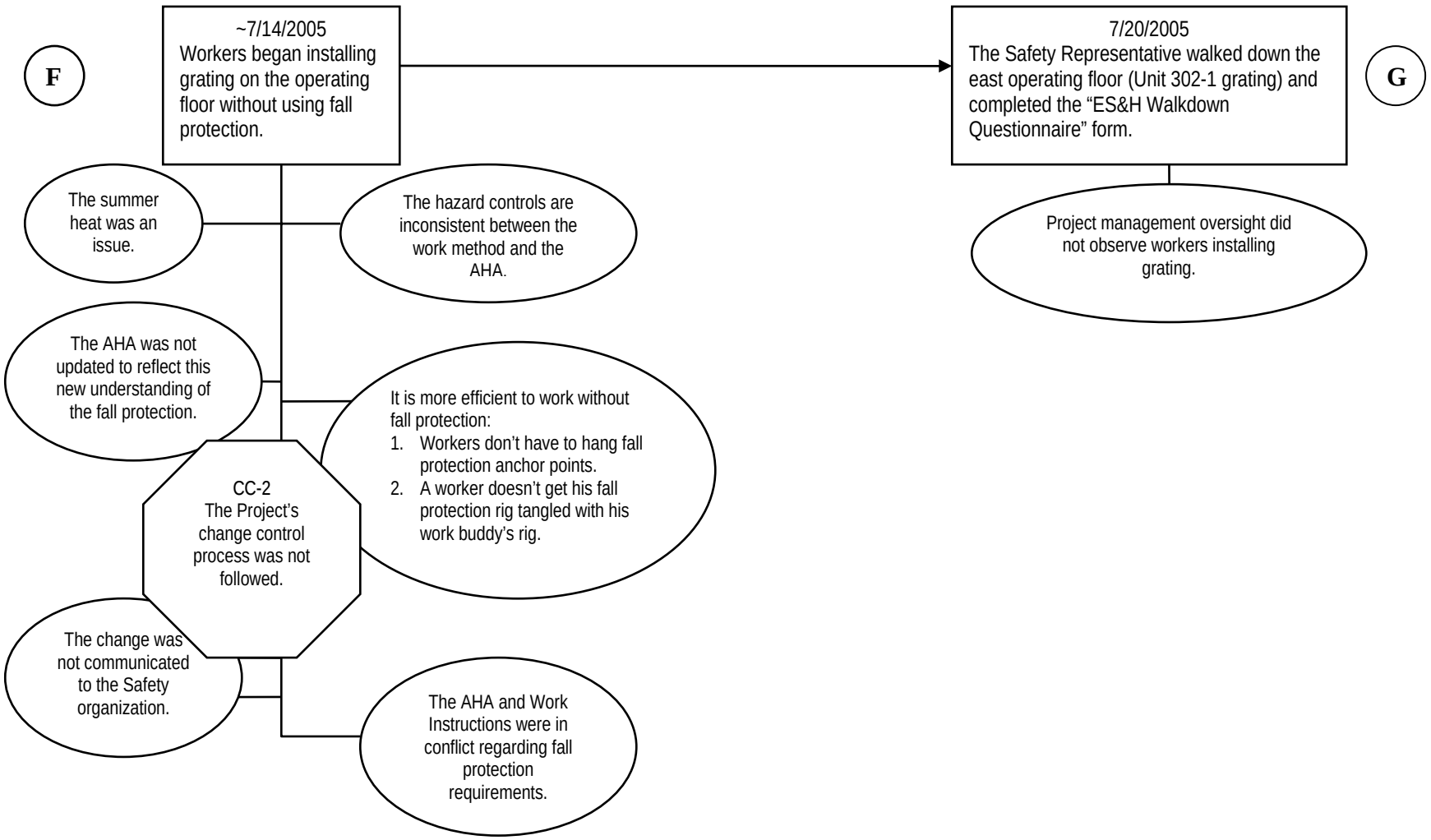
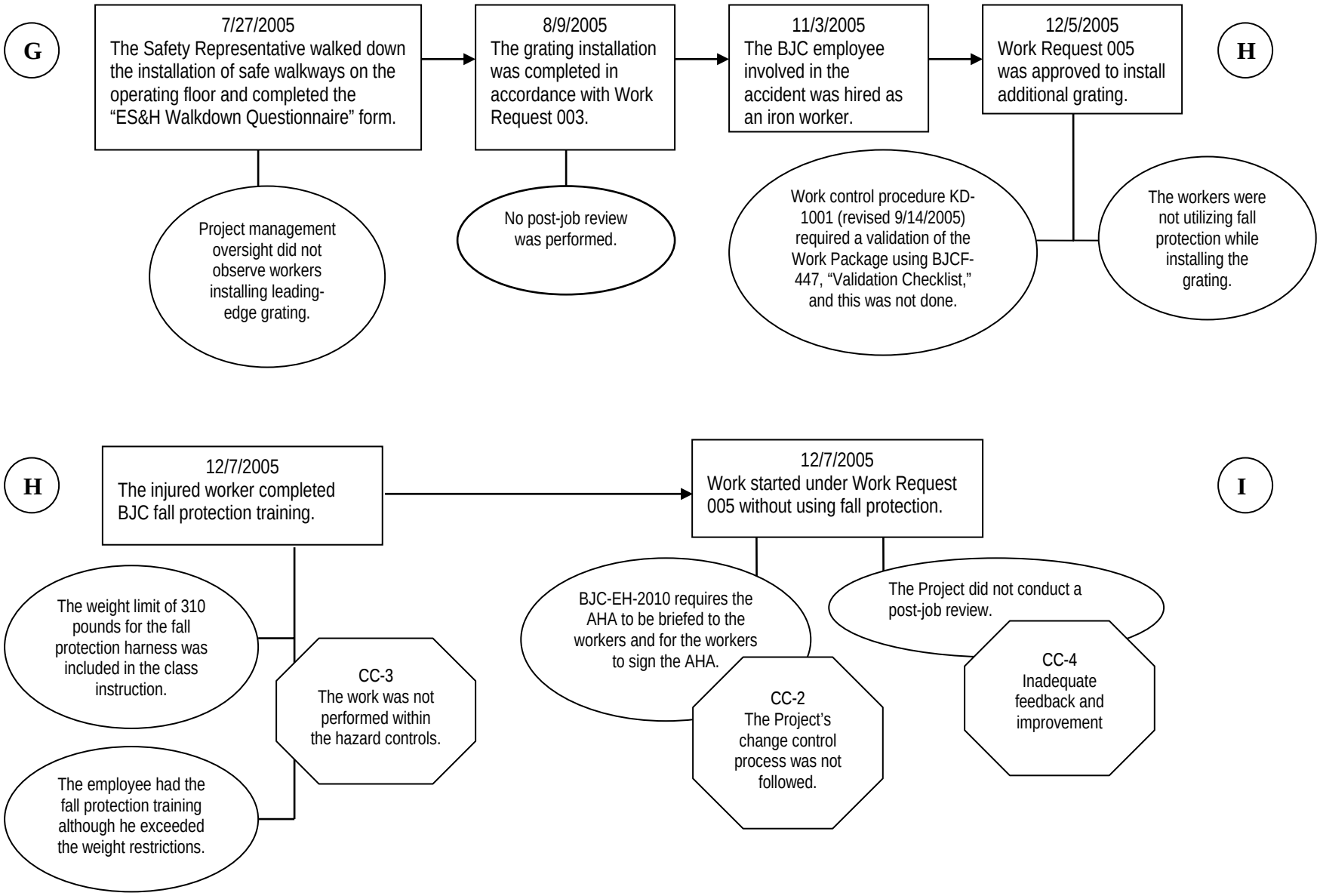


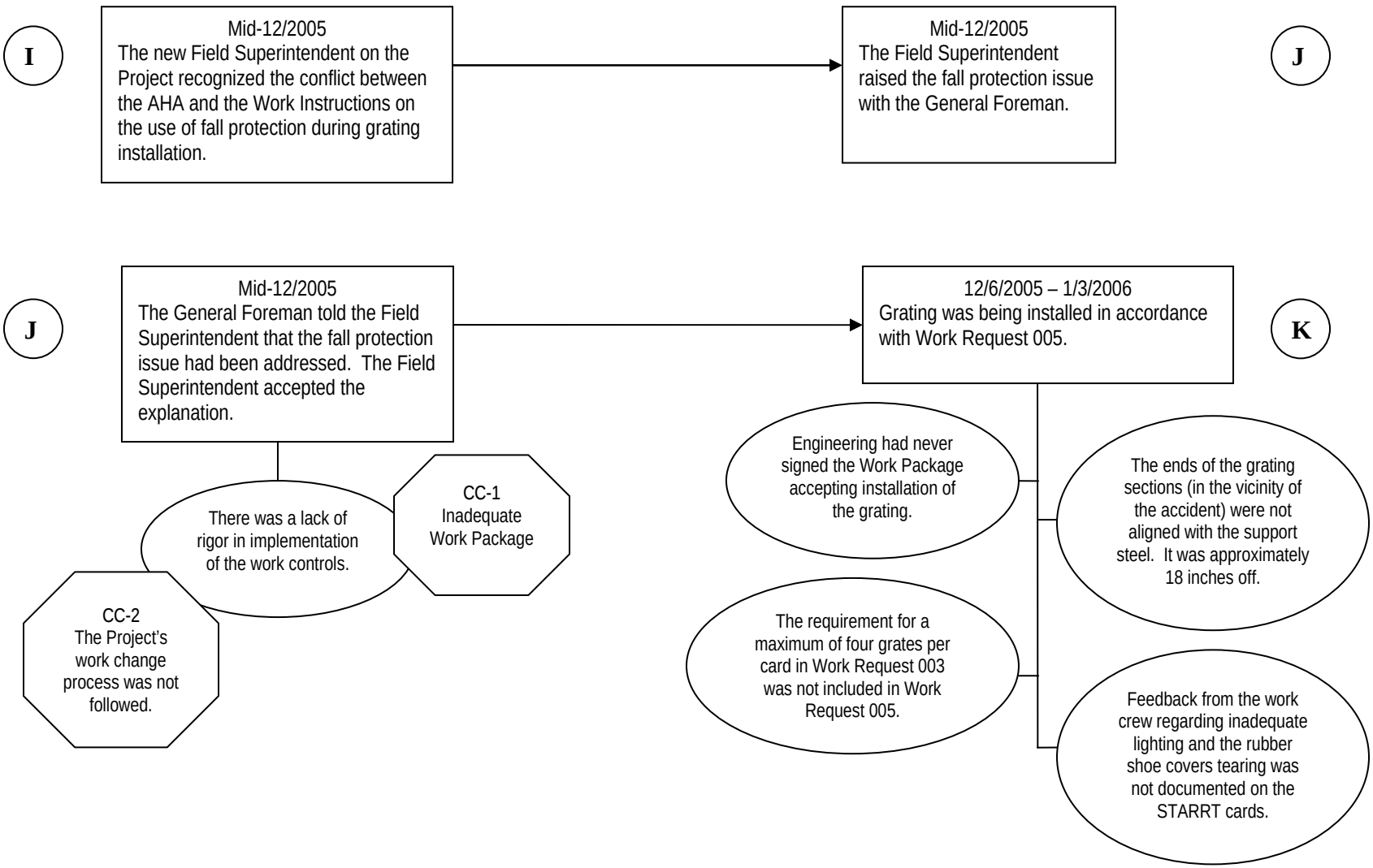
Figure E-1. Events and Causal Factors Chart

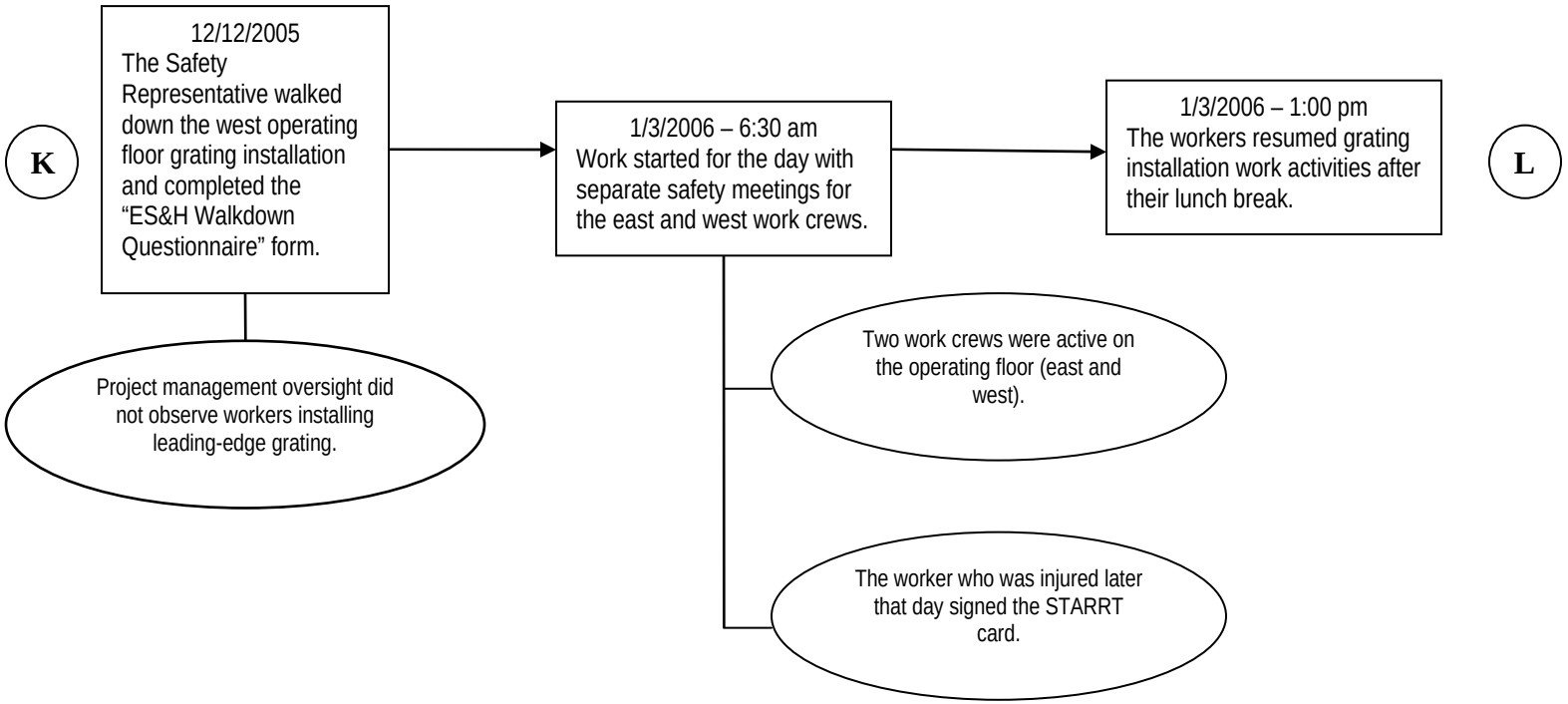

C
3/2005
The Planner conducted a second meeting to resolve comments on the draft work package.
4/6/2005
The initial (Revision 1) AHA was approved and contained the requirement for 100% fall protection when walking on the operating floor until the grating walkways were established.
4/6/2005
The approved Work Package contains conflicting fall protection controls.
4/6/2005
Work Request 001 of the Work Package was approved and implemented using 100% fall protection.
D
The Work Instructions do not include fall protection in the "Safety Controls" section.
Craft employees were not included in the work planning process.
The RCAAS/Fire Protection Specialists do not wear fall protection.
The AHA and Work Instructions were prepared separately.
No procedural hold points were identified
An independent verification was not conducted.
The AHA preparer had multiple jobs ongoing.
The Planner was about to leave for a vacation.
"Established grating" was not defined in the AHA or Work Instructions.
CC-1 Inadequate Work Package
BJC did not account for human error for slips, trips, and falls in the walkway design during March 2005.
The Planners did not recognize the degraded panels as open holes; therefore, fall protection was not adequate.
CC-5 Failure to recognize floor integrity for the final design

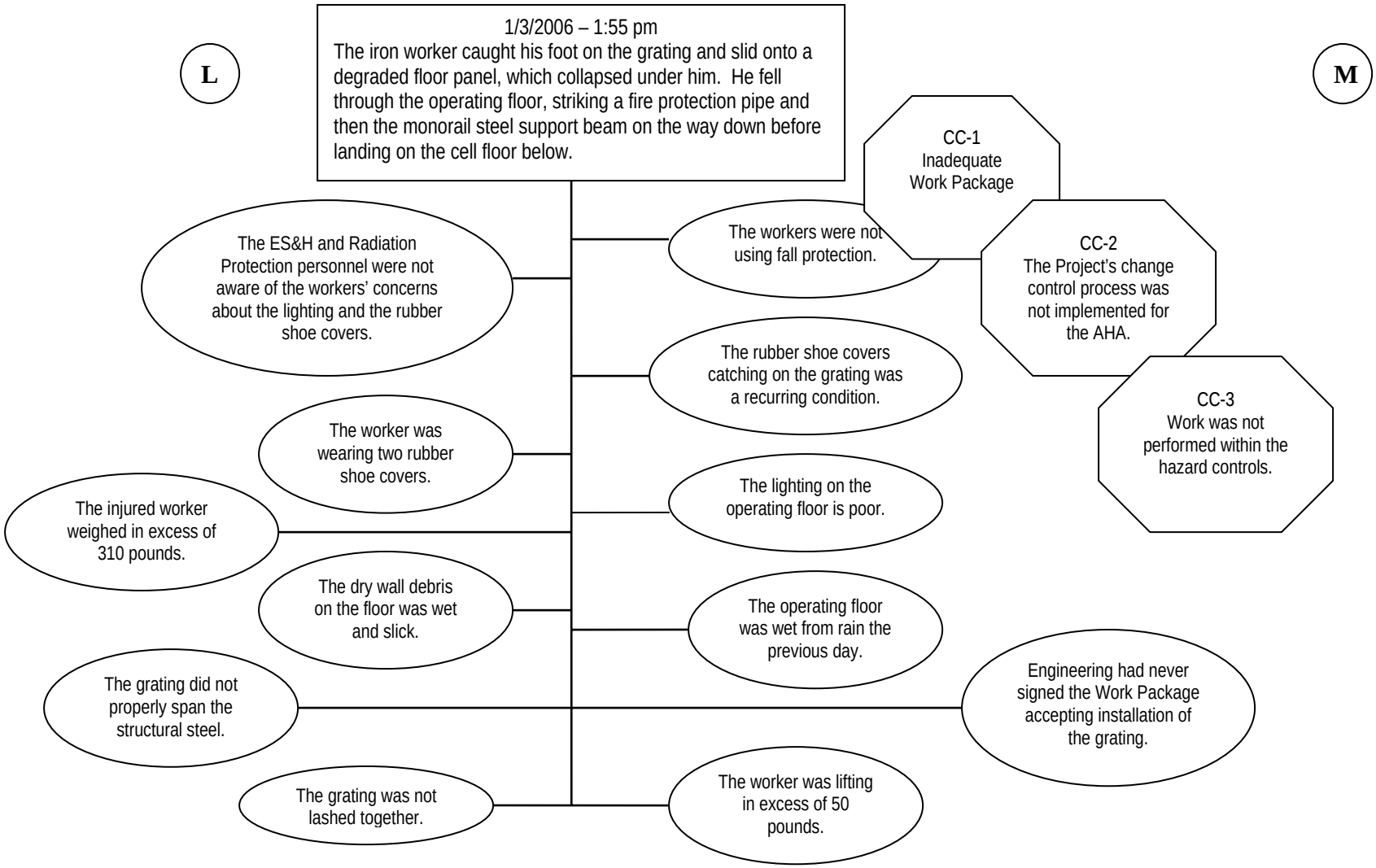

D
4/6–8/2005
The Project conducted prejob briefings.
The work was conducted using 100% fall protection during installation.
6/1/2005
Work Request 002 was approved and implemented using 100% fall protection during installation.
6/2/2005
The Project conducted prejob briefings for Work Request 002.
The work was conducted using 100% fall protection during installation.
6/6/2005
Work Request 003 was approved and implemented using 100% fall protection. This was the first Work Request to install grating.
E
E
6/7/2005
The Project conducted prejob briefings on Work Request 003.
The work was conducted using 100% fall protection during installation.
~7/13/2005
The General Foreman raised a question on the warning in the Work Instructions and received the response that fall protection would no longer be required as long as the workers stayed on the grating during installation.
F

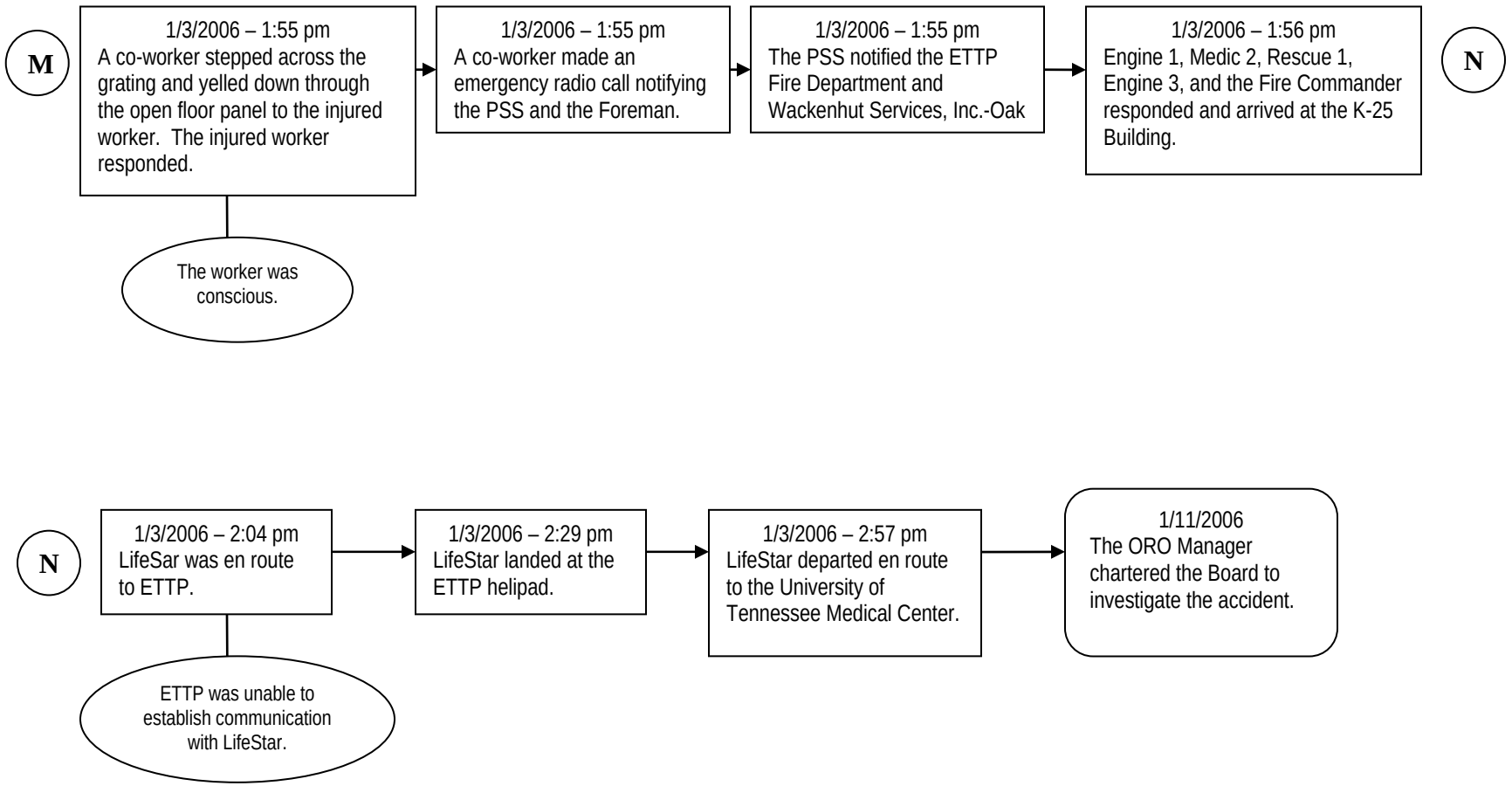

F
~7/14/2005
Workers began installing grating on the operating floor without using fall protection.
7/20/2005
The Safety Representative walked down the east operating floor (Unit 302-1 grating) and completed the "ES&H Walkdown Questionnaire" form.
G
The summer heat was an issue.
The hazard controls are inconsistent between the work method and the AHA.
Project management oversight did not observe workers installing grating.
The AHA was not updated to reflect this new understanding of the fall protection.
It is more efficient to work without fall protection:
1. Workers don't have to hang fall protection anchor points.
2. A worker doesn't get his fall protection rig tangled with his work buddy's rig.
CC-2
The Project's change control process was not followed.
The change was not communicated to the Safety organization.
The AHA and Work Instructions were in conflict regarding fall protection requirements.


G
7/27/2005
The Safety Representative walked down the installation of safe walkways on the operating floor and completed the "ES&H Walkdown Questionnaire" form.
Project management oversight did not observe workers installing leading-edge grating.
8/9/2005
The grating installation was completed in accordance with Work Request 003.
No post-job review was performed.
11/3/2005
The BJC employee involved in the accident was hired as an iron worker.
12/5/2005
Work Request 005 was approved to install additional grating.
Work control procedure KD-1001 (revised 9/14/2005) required a validation of the Work Package using BJCF-447, "Validation Checklist," and this was not done.
The workers were not utilizing fall protection while installing the grating.
H
H
12/7/2005
The injured worker completed BJC fall protection training.
The weight limit of 310 pounds for the fall protection harness was included in the class instruction.
The employee had the fall protection training although he exceeded the weight restrictions.
CC-3
The work was not performed within the hazard controls.
12/7/2005
Work started under Work Request 005 without using fall protection.
BJC-EH-2010 requires the AHA to be briefed to the workers and for the workers to sign the AHA.
CC-2
The Project's change control process was not followed.
The Project did not conduct a post-job review.
CC-4
Inadequate feedback and improvement
I


I
Mid-12/2005
The new Field Superintendent on the Project recognized the conflict between the AHA and the Work Instructions on the use of fall protection during grating installation.
Mid-12/2005
The Field Superintendent raised the fall protection issue with the General Foreman.
J
J
Mid-12/2005
The General Foreman told the Field Superintendent that the fall protection issue had been addressed. The Field Superintendent accepted the explanation.
There was a lack of rigor in implementation of the work controls.
CC-1
Inadequate Work Package
CC-2
The Project's work change process was not followed.
12/6/2005 – 1/3/2006
Grating was being installed in accordance with Work Request 005.
K
Engineering had never signed the Work Package accepting installation of the grating.
The ends of the grating sections (in the vicinity of the accident) were not aligned with the support steel. It was approximately 18 inches off.
The requirement for a maximum of four grates per card in Work Request 003 was not included in Work Request 005.
Feedback from the work crew regarding inadequate lighting and the rubber shoe covers tearing was not documented on the STARRT cards.


K
12/12/2005
The Safety Representative walked down the west operating floor grating installation and completed the "ES&H Walkdown Questionnaire" form.
Project management oversight did not observe workers installing leading-edge grating.
1/3/2006 – 6:30 am
Work started for the day with separate safety meetings for the east and west work crews.
Two work crews were active on the operating floor (east and west).
The worker who was injured later that day signed the STARRT card.
1/3/2006 – 1:00 pm
The workers resumed grating installation work activities after their lunch break.
L


L
1/3/2006 – 1:55 pm
The iron worker caught his foot on the grating and slid onto a degraded floor panel, which collapsed under him. He fell through the operating floor, striking a fire protection pipe and then the monorail steel support beam on the way down before landing on the cell floor below.
M
CC-1
Inadequate
Work Package
CC-2
The Project's change control process was not implemented for the AHA.
CC-3
Work was not performed within the hazard controls.
The ES&H and Radiation Protection personnel were not aware of the workers' concerns about the lighting and the rubber shoe covers.
The workers were not using fall protection.
The rubber shoe covers catching on the grating was a recurring condition.
The worker was wearing two rubber shoe covers.
The lighting on the operating floor is poor.
The injured worker weighed in excess of 310 pounds.
The dry wall debris on the floor was wet and slick.
The operating floor was wet from rain the previous day.
The grating did not properly span the structural steel.
Engineering had never signed the Work Package accepting installation of the grating.
The grating was not lashed together.
The worker was lifting in excess of 50 pounds.


M
1/3/2006 – 1:55 pm
A co-worker stepped across the grating and yelled down through the open floor panel to the injured worker. The injured worker responded.
The worker was conscious.
1/3/2006 – 1:55 pm
A co-worker made an emergency radio call notifying the PSS and the Foreman.
1/3/2006 – 1:55 pm
The PSS notified the ETTP Fire Department and Wackenhut Services, Inc.-Oak
1/3/2006 – 1:56 pm
Engine 1, Medic 2, Rescue 1, Engine 3, and the Fire Commander responded and arrived at the K-25 Building.
N
N
1/3/2006 – 2:04 pm
LifeSar was en route to ETTP.
ETTP was unable to establish communication with LifeStar.
1/3/2006 – 2:29 pm
LifeStar landed at the ETTP helipad.
1/3/2006 – 2:57 pm
LifeStar departed en route to the University of Tennessee Medical Center.
1/11/2006
The ORO Manager chartered the Board to investigate the accident.

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Appendix F – Human Performance Improvement Analysis

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Table F-1. Human Performance Improvement Analysis – Error Precursors

Task Demands
☒ Time pressure (in a hurry) • Some pressure for the Planner to complete the Work Package prior to leaving on vacation.
☐ High workload (memory requirements)
☐ Simultaneous, multiple tasks
☐ Repetitive actions, monotonous
☒ Irrecoverable act • Stepping on a degraded panel. No barrier was in place to prevent the fall.
☒ Interpretation of requirement • An in-field review of the Work Instructions warning allowed an interpretation that fall protection use could be relaxed.
☐ Unclear goals, roles, and responsibilities
☒ Lack of or unclear standards • There were different expectations and requirements in the Work Instructions and the AHA. At the work level, the employees and supervision were confident that they understood the Work Instructions.
Work Environment
☐ Distractions/interruptions
☐ Changes/departures from routine
☒ Confusing displays or controls • Information in the planning documents, the Work Instructions, and the signs on the operating floor did not provide clear or consistent guidance on the floor-loading capacity. • The definition of "established grating" is not clearly defined in the Work Instructions.
☐ Workarounds/out-of-service instruments
☐ Hidden system response
☐ Unexpected equipment conditions
☐ Lack of alternative indication
☐ Personality conflicts
Individual Capabilities
☒ Unfamiliarity with the task/first time • The installation of grating was new to the K-25 Building work crews, but the job had several month's worth of activity prior to the accident.
☒ Lack of knowledge (mental model) • There was an inconsistent understanding of the integrity of the operating floor.
☒ New technique not used before • The installation of grating was new to the K-25 Building work crews, but the job had several months' worth of activity prior to the accident.

Table F-1. Human Performance Improvement Analysis – Error Precursors (continued)

Individual Capabilities (continued)
☒ Imprecise communication habits • There was ineffective communication between the Planner and the AHA developer that allowed conflicting statements and expectations to be developed. • The review process did not catch the inconsistencies. • The ineffective communication between the General Foreman, the Superintendent, and management resulted in an inconsistent understanding of the decision to relax the fall protection requirements.
☐ Lack of proficiency/inexperience
☐ Indistinct problem-solving skills
☒ Unsafe attitude for critical task • The "iron worker legacy" possibly led to an acceptance of the risk of working without fall protection.
☐ Illness/fatigue
Human Nature
☐ Stress (limits attention)
☒ Habit patterns • There were some indications that people occasionally stepped off the grating with no adverse effects. • The previous experience of walking on the panels may have influenced the design not to include substantial railings and to put the warning in the Work Instructions allowing the relaxation of the fall protection requirements.
☒ Assumptions (inaccurate mental picture) • Assumptions were made by all parties that the instruction to stay on the grating was an adequate control to keep people from stepping off the grating and onto a degraded panel.
☐ Complacency/Overconfidence
☒ Mindset ("tuned" to see) • It is possible that the perception of the need to wear the rubber shoe covers for contamination control overrode concerns about the shoe covers snagging on the grating.
☒ Inaccurate risk perception (Pollyanna) • The workers were aware of the potential for a fall, but they accepted the risk of working without fall protection. • The workers, the Planner, and the AHA developer did not appreciate the potential for a person to trip or slip off the grating, leading to a fall through a degraded panel.
☒ Mental shortcuts (biases) • The Work Instructions planning and AHA development processes may have created a similarity bias between walking on the installed grating and walking on grating on a solid surface. They did not perceive the job as having an "open hole" risk. The AHA process was more conservative during installation but assumed the same level of risk once the grating was "established."
☐ Limited short-term memory