DOE/ORO-2175

Type B Accident Investigation Board Report

BNFL Inc. Employee Foot Injury on December 17, 2003, at the East Tennessee Technology Park, Building K-31

February 2004

Oak Ridge Operations Office
U.S. Department of Energy

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INDEPENDENT REPORT

This report is an independent product of the Type B Accident Investigation Board (Board) appointed by Gerald G. Boyd, Manager, Oak Ridge Operations Office, U.S. Department of Energy. The Board was appointed to perform a Type B investigation of the event and prepare an investigation report in accordance with DOE O 225.1A, *Accident Investigations,* and DOE G 225.1A-1, *Implementation Guide for Use with DOE 225.1A, Accident Investigations*.

The discussion of facts, as determined by the Board, and the views expressed in the report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, 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 15, 2004, I appointed a Type B Accident Investigation Board to investigate the December 17, 2003, employee foot injury in Building K-31, BNFL Inc. The responsibilities of the Accident Investigation Board have been satisfied with respect to this investigation. The analysis and the identification of contributing and root causes and 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 Operations Office

Date Accepted: 2/24/04

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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.

Many of the activities performed for the Oak Ridge Operations Office (ORO) involve the routine use of hand tools during demolition work. All work has the potential for injury. Appropriately analyzing the hazards and developing/implementing controls are critical to performing work safely. Therefore, it is imperative that the Guiding Principles and Core Functions of Integrated Safety Management (ISM) 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 all types of work activities represent a unique challenge to identify and negate their hazards. I encourage all federal and contractor employees to vigorously continue their efforts to fully implement ISM in their daily work activities.

Gerald G. Boyd
Manager
Oak Ridge Operations Office

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TABLES

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ACRONYMS

ANSI	American National Standards Institute
AMEM	Assistant Manager for Environmental Management
BCS	Boundary Control Station
BNFL	British Nuclear Fuels Limited Inc.
Board	Type B Accident Investigation Board
CFR	Code of Federal Regulations
Clinic	BNFL Medical Facility
COR	Contracting Officer's Representative
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
ER	Emergency Room
ETTP	East Tennessee Technology Park
EWP	Enhanced Work Plan
FCN	Field Change Notice
HA	Hazard Assessment
H&S	Health and Safety
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
JON	Judgment of Need
OJT	On-the-job training
OPS	Operations
ORO	Oak Ridge Operations Office
ORPS	Occurrence Reporting and Processing System
PAPR	Powered Air-Purifying Respirator
PCM	Personal Contamination Monitor
POD	Plan of the Day
PPE	Personal Protective Equipment
OAV	Operational Awareness Visit
RCAAS	Radiation/Criticality Accident Alarm System
RWP	Radiological Work Permit
SEB	Source Evaluation Board
SME	Subject Matter Expert
SRC	Senior Review Committee

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EXECUTIVE SUMMARY

On December 17, 2003, at approximately 7:15 a.m., an accident occurred at the U.S. Department of Energy (DOE) East Tennessee Technology Park, Building K-31. An employee (Pipefitter) of British Nuclear Fuels Limited Inc. (BNFL) was injured while attempting to remove concrete block from within a wide-flange, steel column during demolition of the K-31 Control Room (first floor, center of building). The Pipefitter was using a 4-pound, hand-held sledgehammer and a wrecking/pry bar when the top block fell approximately 10 feet 8 inches from inside the web of the column striking the Pipefitter on his left foot. To improve his visibility, the Pipefitter had his cutting shield in the up position (inner, clear shield was down) since he did not need it at the time. Under the hot work Radiological Work Permit, the workers were intermittently cutting steel along with performing block removal. The Pipefitter reported that he felt the concrete block brush against the raised shield as it fell before striking his foot.

The Pipefitter did not report to the BNFL Medical Facility (Clinic), and he remained at work until later in the afternoon. After leaving the workplace, the Pipefitter drove home and was transported by his spouse to the Methodist Medical Center of Oak Ridge Emergency Room. The Pipefitter was hospitalized initially for a period of four days (December 17 through 21) during which time he underwent surgery. The surgery included insertion of pins in the fourth and fifth toes and a fasciotomy (lancing of the bottom of the foot to relieve pressure). Complications arose over the Christmas and New Year holidays, and the Pipefitter was re-admitted to the hospital on January 7, 2004. Due to dry gangrene (necrosis), the Pipefitter underwent amputation of the fifth toe. In addition, removal of skin from the abdomen for full-thickness skin grafting to the top of the left foot was performed due to hematoma and necrosis. The Pipefitter remained in the hospital for eight days and returned to work on restricted duty on February 3, 2004 (continues on restricted work activity at this time).

On November 27, 2003, demolition of the K-31 Control Room was authorized in the Plan of the Day meeting. The operator was using a trackhoe with a standard bucket attachment to knock down the block walls. The block demolition debris was piled up as the work progressed. The operator of the trackhoe removed the block flush with the wide-flange column; however, the trackhoe was not used to remove the remainder of the blocks within the wide-flange columns due to accessibility problems. Several wide-flange columns were left with blocks remaining in the webs. Hand removal of blocks was not addressed in the Enhanced Work Plan (EWP) nor was it discussed during safety or crew meetings. Crewmembers independently decided how to best accomplish the work. One crewmember used a scissor lift near one wide-flange column to gain access to the top of the block stack and manually removed the blocks using hand tools. A scissor lift could not be used near some columns due to the large piles of debris. The Pipefitter used a 4-pound, hand-held sledgehammer to break the grout and a

wrecking/pry bar to loosen and remove the block at chest height. As the block was removed, the remaining upper blocks slid down onto the lower stack of blocks. The Pipefitter then repeated this method on the lowest block in the upper stack until all blocks in the top stack were removed. The lower stack of blocks was then removed by prying out a block at a time. The injured Pipefitter had performed hand removal of blocks for approximately 2½ days prior to the accident.

Direct Cause
The direct cause of the accident was a loosened concrete block, weighing approximately 49 pounds, falling 10 feet 8 inches from inside the web of a wide-flange, steel column, and striking the Pipefitter on his left foot.

The Type B Accident Investigation Board concluded that the direct cause of the accident was a loosened concrete block, weighing approximately 49 pounds, falling 10 feet 8 inches, and striking the Pipefitter on his left foot. Based on the distance of the fall and the weight of the concrete block, the impact would release approximately 500 foot-pounds of kinetic energy. The work boot worn by the Pipefitter was an American National Standards Institute rated, 75-pound, steel-toe, work boot (which would equate to protection of approximately 110 foot-pounds of kinetic energy). Neither this work boot nor the use of a metatarsal guard (rated 75, 50, and 30 foot-pounds) would have supported the 500 foot-pounds of energy generated by the falling concrete block.

The Board reviewed the work controls involving block room demolition, response to the accident, and corrective actions associated with previous DOE Oak Ridge Operations Office (ORO) Type B accident investigations of BNFL. The results of these reviews were factored into the five Core Functions of Integrated Safety Management (ISM). Judgments of Need (JONs) were developed that considered what actions were necessary to prevent recurrence of this accident and other similar events.

The JONs are focused on management systems and will accomplish the following:

- Increase management-worker communications and worker involvement in work planning to improve performance,
- Manage performance to ensure that managers and workers conduct work within controls,
- Ensure appropriate and consistent responses to accidents and changes to unanticipated conditions encountered during operations, and
- Ensure that DOE evaluates performance of work within controls and validates closure of corrective actions to ensure comprehensive solutions to prevent recurrence.

It is the conclusion of the Board that the work control planning process was not adequate to ensure worker safety. Associated with the work control process, BNFL did not adequately address revisions and Field Change Notice changes to ensure that work steps and identification and control hazards were applied to the new work scope.

Also, the Board concludes that BNFL continues to fall short of comprehensive application and programmatic correction to prevent recurrence of similar deficiencies in other areas of the project (based on this investigation and the two previous Type B investigations [see Table 3-1.]). DOE ORO line management has not ensured that Corrective Action Plans and validation of corrective action closures consider negative trends and provide comprehensive solutions to prevent recurrence and sustain higher performance. Although DOE ORO had increased the BNFL Facility Representative coverage, this was not sustained on the day of the accident (one Facility Representative on a Source Evaluation Board and one Facility Representative on vacation).

The Board identified one Root Cause and twelve JONs (details of the contributing causes are presented in Appendix D, Table D-1). See below:

Table ES-1. Judgments of Need

JON No.	Judgment of Need	Contributing and Root Causes
Conduct of Work		
JON 1	BNFL needs to ensure that the Stop Work process (informal and formal) is clear and understood by management and workers and fully institutionalized for all work activities.	CC-1, 3, 6, 8, 9, 10, 11, 12 RC-1
JON 2	The BNFL EWP process needs to ensure that all ISM Core Functions are addressed and implemented.	CC-1, 2, 3, 4, 5, 7, 8, 9, 10 RC-1
JON 3	BNFL needs to increase formality and rigor of daily operations' communications to ensure appropriate knowledge and direction are provided to management and workers to perform work safely.	CC-1, 3, 4, 8, 9, 10 RC-1

Table ES-1. Judgments of Need (continued)

JON No.	Judgment of Need	Contributing and Root Causes
JON 4	BNFL needs to revise EWP-CONV-056 so that all ISM Core Functions are incorporated at a level to ensure safe demolition.	CC-1, 2, 3, 4, 5, 7, 9 RC-1
Accident Response		
JON 5	BNFL needs to strengthen and implement their policy to ensure accident responses are appropriate, timely, and the staff trained.	CC-8, 9, 10, 11 RC-1
JON 6	BNFL needs to review their medical evaluation and treatment process and incorporate improvements.	CC-10, 11 RC-1
Feedback and Improvement		
JON 7	BNFL needs to ensure that Type B and other corrective actions are implemented and applied project wide to prevent recurrence.	CC-2, 4, 9 RC-1
JON 8	BNFL needs to ensure that lessons learned are continuously incorporated and applied in the EWP process.	CC-2, 3, 4, 8 RC-1
Management Oversight		
JON 9	BNFL needs to ensure that its management oversight systems are effectively implemented and reinforce all ISM Core Functions.	CC-1, 3, 5, 6, 7, 8 , 9, 10, 11 RC-1
JON 10	BNFL needs to ensure roles and responsibilities are clearly defined and communicated project wide.	CC-6, 8, 11 RC-1

Table ES-1. Judgments of Need (continued)

JON No.	Judgment of Need	Contributing and Root Causes
DOE Oversight		
JON 11	DOE ORO line management needs to strengthen the validation process to ensure the contractor is implementing appropriate corrective actions to prevent recurrence.	CC-1, 3, 4, 9, 10, 12 RC-1
JON 12	DOE ORO line management needs to ensure the contractor is performing effective trending and analysis of corrective actions.	CC-1, 3, 4, 9, 10, 12 RC-1

Table ES-2. Root Cause

RC No.	Root Cause	Discussion	Related JONs
RC-1	BNFL failed to implement an effective work planning process.	• Work plans for K-33 were assumed to be applicable to K-31 without walkdown or analysis. • Management and work crew failed to stop work when configuration was different from EWP (and had not been trained to the stop work policy). • EWP was unclear and open to different methods that could be used to perform work. • Hazards were not adequately addressed. • Failure to implement ISM Core Functions.	JONs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

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1.0 INTRODUCTION

1.1 Background

On December 17, 2003, at approximately 7:15 a.m., an employee (Pipefitter) of British Nuclear Fuels Limited Inc. (BNFL) was injured while prying concrete block from within a wide-flange, steel column during demolition of the Control Room in Building K-31 at the East Tennessee Technology Park (ETTP). At the time of the accident, the employee was attempting to remove concrete block from a wide-flange, Column N25, using a 4-pound, hand-held sledgehammer and a wrecking/pry bar when the top block fell 10 feet 8 inches from inside the web of the column striking the employee on his left foot.

The employee did not report to the BNFL Medical Facility (Clinic), and he remained at work until later in the afternoon. After leaving the workplace, the employee drove home and was transported by his spouse to the Methodist Medical Center of Oak Ridge Emergency Room (ER). The employee was hospitalized initially for a period of four days (December 17 through December 21), during which time he underwent surgery.

On December 18, 2003, BNFL management learned of the injured employee's hospitalization and planned a critique of the accident. Due to the employee's extended hospital stay, the critique was cancelled on December 19, 2003, when the decision was made to proceed with a Type C Investigation. BNFL initiated a Type C Investigation of the accident on December 22, 2003 (per Procedure PR-GM-002, *Incident Investigations)*.

On January 7, 2004, the Pipefitter was re-hospitalized for a period of eight days. On January 13, 2004, the U.S. Department of Energy (DOE) Oak Ridge Operations Office (ORO) categorized the incident as a Type B Accident Investigation due to the length of the hospital stay. This information was informally discussed with BNFL at that time. A meeting was held on January 14, 2004, between BNFL and DOE ORO to report the status of the Type C Investigation and the employee's condition.

Gerald G. Boyd, ORO Manager, formally appointed (by memo dated January 15, 2004) a Type B Accident Investigation Board (Board) to investigate the accident in accordance with DOE O 225.1A, *Accident Investigations* (see Appendix A). This report documents the facts of the accident and the analyses and conclusions of the Board.

1.2 Facility Description

ETTP is located approximately five miles west of Oak Ridge, Tennessee. ETTP, formerly known as the K-25 Site, was a gaseous diffusion plant for uranium enrichment during and after World War II. The site is now undergoing remediation and reindustrialization of its facilities.

In August 1997, BNFL was awarded a direct, fixed-price contract with ORO for the ETTP Three-Building Decontamination and Decommissioning (D&D) and Recycle Project. This project's mission is to dismantle, remove, and disposition the process equipment in the three buildings (K-29, K-31, and K-33) and to decontaminate the interior of the three buildings. BNFL currently employs approximately 1,200 workers, running two-shifts/day and working 24-hours/day, 7-days/week. The work performed at this site involves heavy construction-type dismantlement, disassembly, and removal operations of process equipment and support materials and waste removal and disposal. Building K-33 contained 632 converters, weighing 66,000 pounds each; Building K-31 contained 595 converters, weighing 29,400 pounds each; and Building K-29 contained 399 converters, weighing 24,800 pounds each. Another 1,534 compressors, weighing up to 36,000 pounds each, and 1,540 motors, weighing up to 16,000 pounds each, were also in the three buildings. A view of the K-31 Building is provided in Exhibit 1-1.

Exhibit 1-1. K-31 Building (Looking West)

By the date of the accident, BNFL had processed approximately 1,529 converters and 1,533 compressors, which represents nearly 100 percent completion of the removal operations phase of the project. So far, approximately 285 million cumulative pounds of material have been removed from the project site. The project completion is expected in August 2004.

1.3 Scope, Conduct, and Methodology

The Board began its activities on January 16, 2004, and submitted the final report to the DOE-ORO Manager on February 23, 2004. The scope of the Board's investigation was to review all relevant facts; analyze the facts to determine the direct, contributing, and root causes of the incident; develop conclusions; and determine Judgments of Need (JONs) that, when implemented, should prevent recurrence of similar incidents. The Board specifically addressed the role of DOE and contractor organizations and Integrated Safety Management Systems (ISMS). The scope also included an analysis of the application of lessons learned from previous BNFL Type B Accident Investigations.

The investigation was performed in accordance with DOE O 225.1A, *Accident Investigations*, using the following methodology:

- Facts relevant to the accident were gathered through interviews and reviews of documents and evidence.

- The event scene was inspected, and photographs were taken of the scene.

- Facts were analyzed to identify the causal factors using event and causal factors analysis, barrier analysis, root cause analysis, change analysis, and Integrated Safety Management (ISM) analysis.

- JONs for corrective actions to prevent recurrence were developed to address the causal factors of the event.

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**, 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. The causal factors related to weaknesses in the five Core Functions of **Integrated Safety Management (ISM)** are analyzed.

Event and causal factors analysis includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the event 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.

Root Cause Analysis is a technique that identifies the underlying deficiencies that, if corrected, would prevent the same or similar accidents from occurring.

Judgments of Need are managerial controls and safety measures necessary to prevent or minimize the probability or severity of a recurrence of an accident.

Requirements Verification Analysis is a forward/backward analysis process to ensure that all portions of the report are accurate and consistent in the flow of facts to analysis to conclusions to the Judgments of Need.

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2.0 FACTS

2.1 Accident Description and Chronology

2.1.1 Accident Description

On the morning of December 17, 2003, at approximately 7:15 a.m., a Pipefitter sustained a foot injury due to a falling concrete block (cinder block filled with concrete) striking his left foot. The Pipefitter had been in the process of removing concrete blocks from inside the web of the wide-flange, steel Column N25, during the K-31 Control Room demolition, using a wrecking/pry bar at chest height and a hand-held, 4-pound sledgehammer. The wrecking/pry bar and hand-held sledgehammer are shown in Exhibit 2-1.

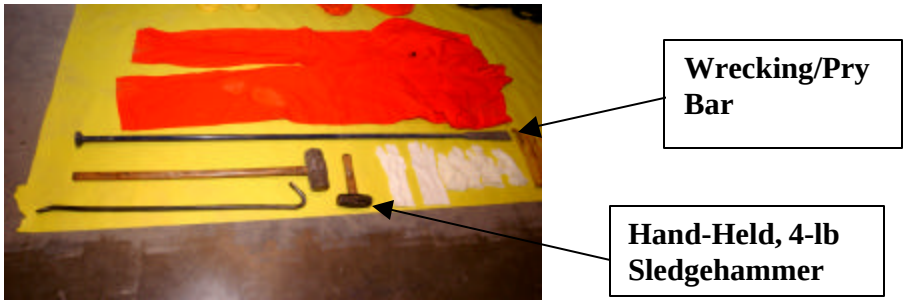


Exhibit 2-1. Tools Used for Hand Removal of Concrete Blocks from Wide-Flange Column

Column N25, shown in Exhibit 2-2 as it currently appears with all block removed, had been full of concrete blocks to a height of approximately 12 feet. An example of a column filled with concrete blocks is shown in Exhibit 2-3.

The Pipefitter found the concrete blocks in the wide-flange, steel Column N25 more difficult to remove than the previous columns he had worked on for the K-31 Control Room. The Pipefitter had given up and was turning to walk away when the accident occurred. When falling, the concrete block grazed the Pipefitter's cutting shield, which was in the raised position, before striking his foot. (*Note:* The Pipefitter's inner, clear shield in the Powered Air-Purifying Respirator (PAPR) was in the closed position.)

Exhibits 2-4, 2-5, and 2-6 show a view of a column with block remaining in the lower portion of the column, a view of a column with block remaining in the column after wall demolition, and a view of the remaining east wall of the Control Room, respectively. The schematic shown in Figure 2-1 provides a plan view of the K-31 Control Room demolition area on the day of the accident. Under the hot work Radiological Work Permit (RWP), the workers were intermittently cutting steel along with performing block removal.

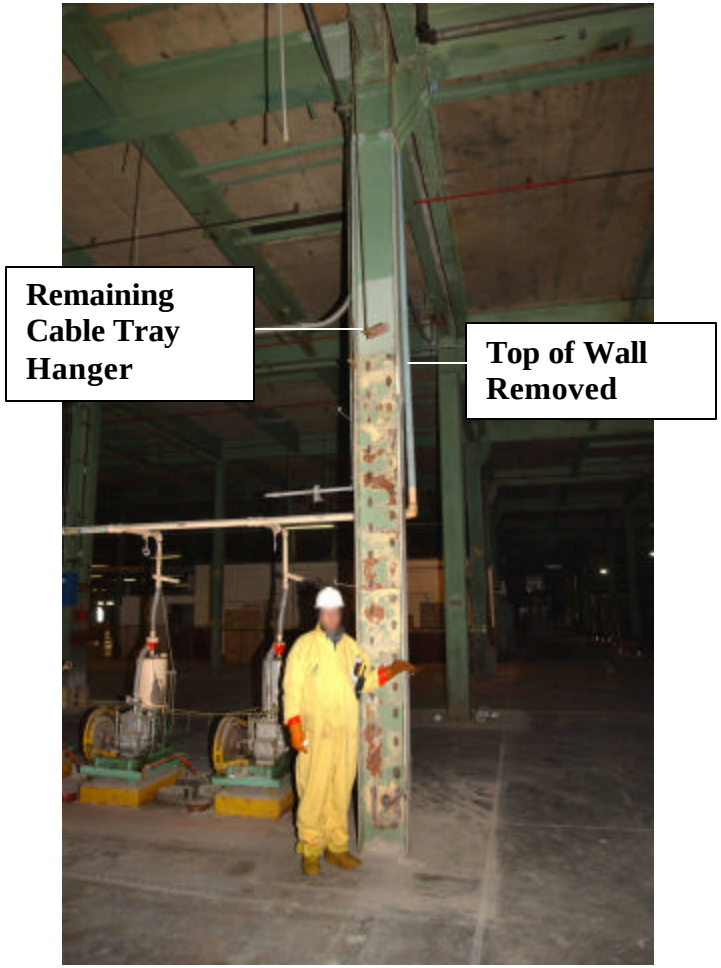


Exhibit 2-2. Column N25 (Looking North)

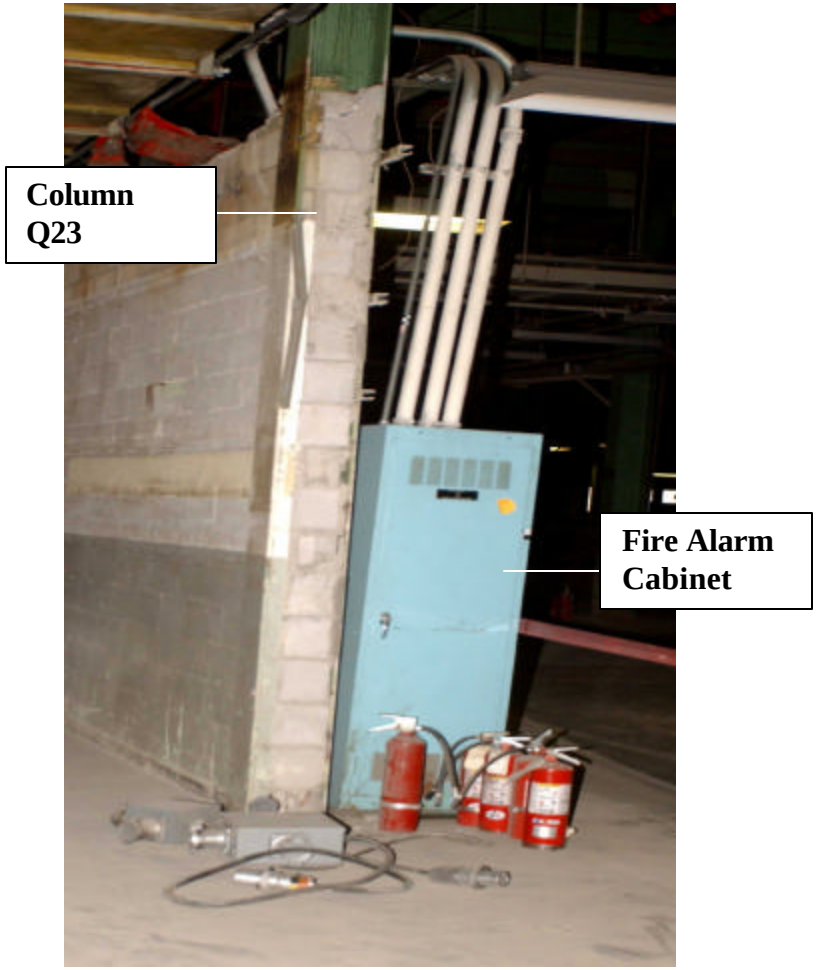


Exhibit 2-3. Example of Column Filled with Concrete Blocks (Looking South)

Exhibit 2-4. View of Column P25 with Lower Block in Column (Looking South)

Exhibit 2-5. View of Column P23 with Block Remaining in Column after Wall Demolition (Looking South)

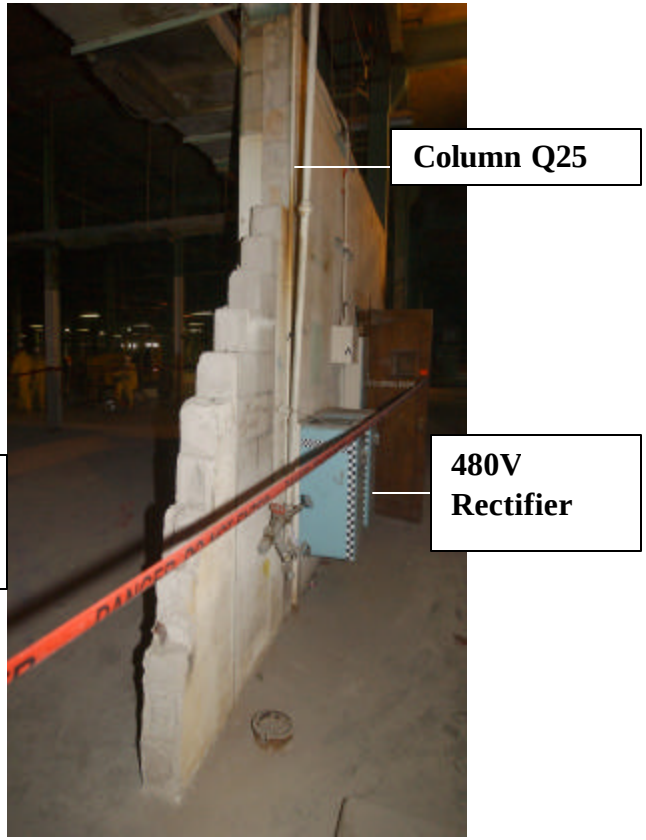
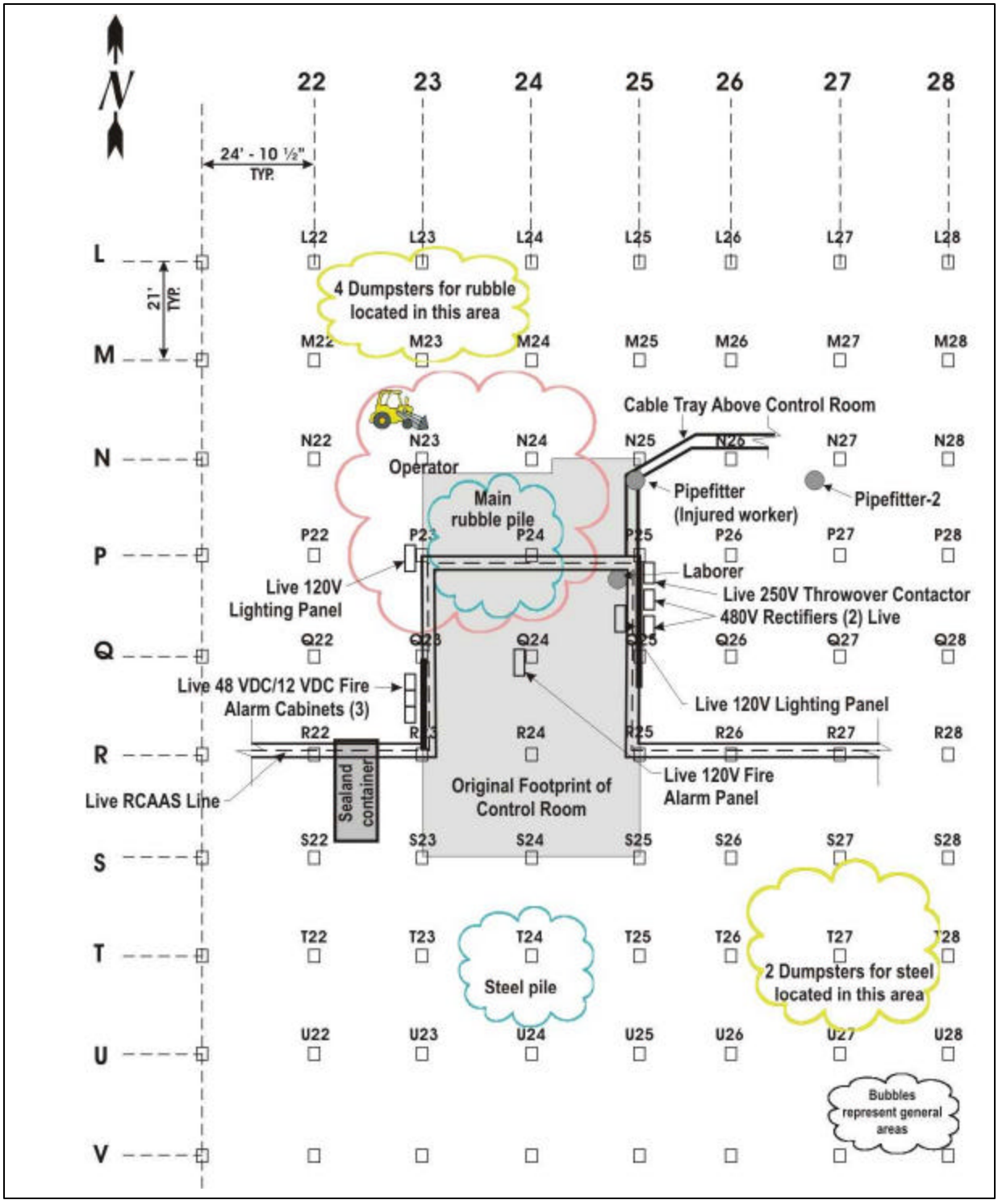


Exhibit 2-6. View of Remaining East Wall of Control Room (Looking North)



(NOTE: In Building K-31, columns are numbered 1 to 50 [west to east] and lettered A to EE [north to south]—the Control Room is located in the center of the building.)

Figure 2-1. Schematic of Control Room Area on Day of Accident (12/17/2003)

An elevation schematic of Column N25 depicting where the Pipefitter was standing is shown in Figure 2-2. Figure 2-3 provides elevation and plan schematics of Column N25 and pertinent dimensions. Figure 2-4 shows a section view of the wide-flange column and top view of the cable tray that ran in front of Column N25 at the time of the accident. (*Note*: The section of cable tray shown in the schematic had been removed before the Type B Investigation began.)

After the accident occurred (between 0715 and 0720) and before the arrival of the K-31 Building Manager (herein referred to as Building Manager per the individual [*Note:* the official organizational chart indicates the position is Area Manager]), the blocks between the top block and chest height fell out of the column. Reportedly, no one in the area observed this.

Approximately 5 minutes after the accident, the Building Manager observed the Pipefitter limping and asked what happened. The Pipefitter stated that the top concrete block had fallen on his left foot and had struck the steel toe of his work boot. The Building Manager asked the Pipefitter if he needed to go to the Clinic. The Pipefitter responded he did not need to go to the Clinic, that the block had hit his steel toe, and he would be all right if he walked it off. The Pipefitter demonstrated for the Building Manager the method he used for removing the blocks, this time using a crow bar to pry at the remaining blocks in the wide-flange steel, which were at approximately 5½ feet from floor level and below. During the demonstration, a couple of the remaining blocks fell out of the wide-flange column. After this demonstration, the Building Manager did not recognize the event (at this time) to be a near miss and did not issue a stop work on block removal using hand tools. The Building Manager told the Pipefitter that if his foot continued to hurt to go to the Clinic.

The Building Manager departed, and the employee remained in the work area. Other crewmembers (Pipefitter-2, operator, and laborer) noticed the Pipefitter hopping and limping and suggested that he go to the Clinic. The Pipefitter responded that he did not think he was hurt that bad.

The Foreman, General Foreman, and Health and Safety (H&S) Officer were not in the area at the time of the accident. The Foreman was in the K-33 Building with another crew, and the H&S Officer was assigned to oversee another job in the K-29 Building and was in K-29 on December 15-17, so he was unable to conduct his usual walkdowns in K-31. The backup H&S Officer was in the K-33 Building overseeing an activity.

The Foreman returned to the work area a few minutes before morning break, observed the Pipefitter limping, and suggested several times that he go to the Clinic. The employee responded that he did not want to go to the Clinic, left the immediate area, and rested in the PAPR and tools-storage area (cool-down area). At 10 a.m., the Pipefitter exited the Boundary Control Station (BCS) area through the Personal Contamination Monitor (PCM-2) for morning break. The Pipefitter returned at 10:21 a.m. to the BCS, logging into RWP Number 20030165.

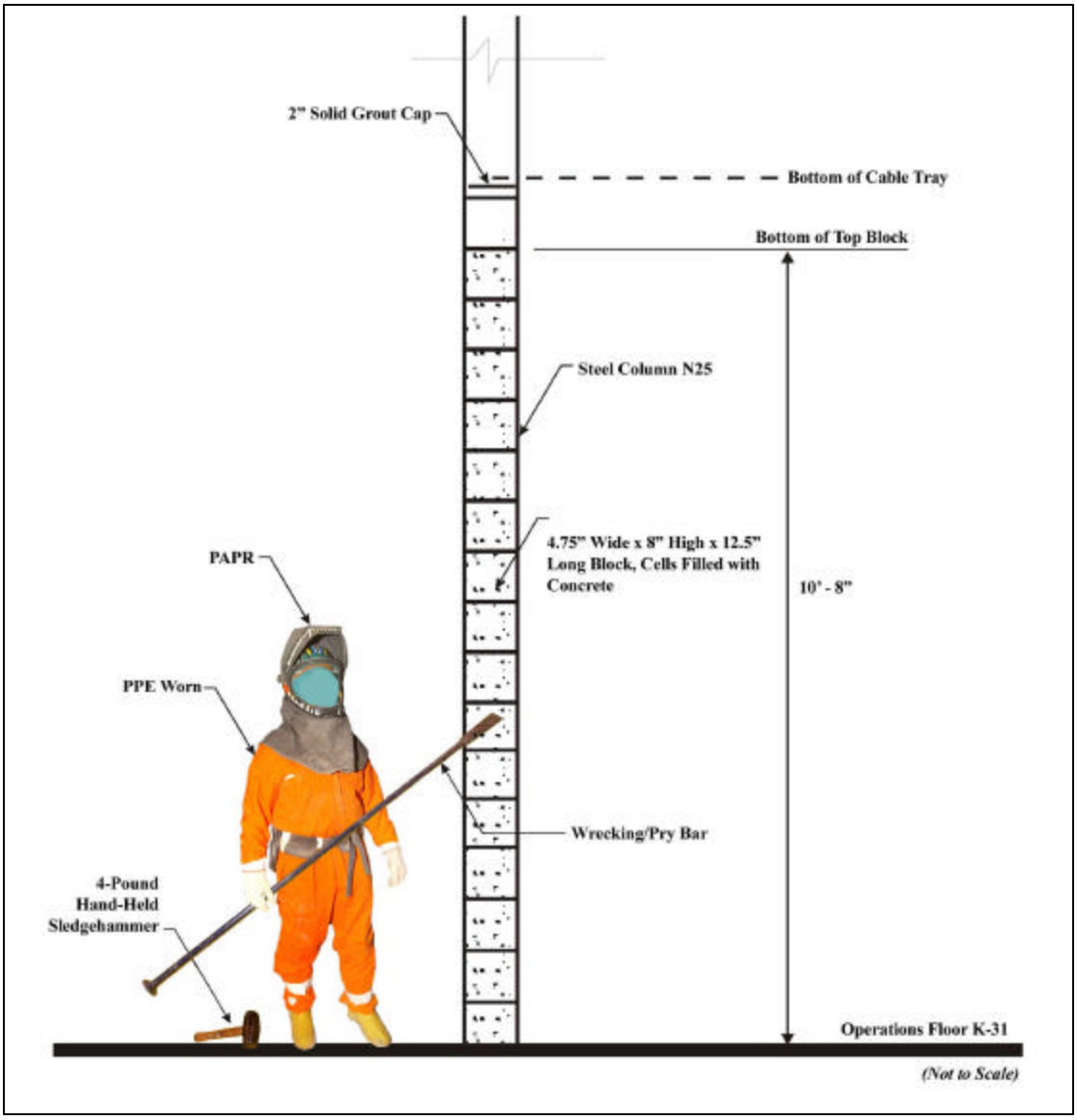


Figure 2-2. Elevation Schematic of Column N25 Depicting Where Pipefitter was Working

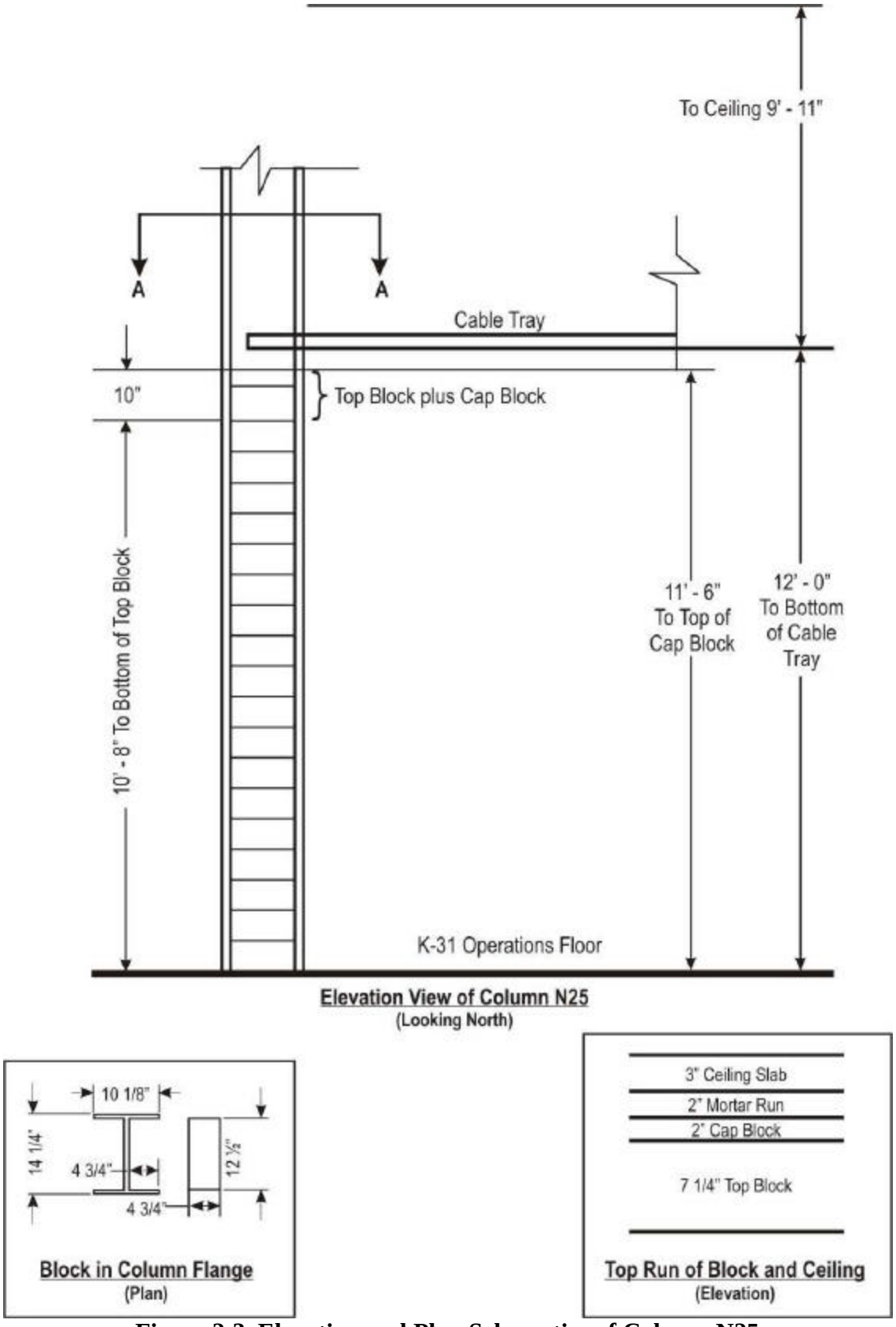


Figure 2-3. Elevation and Plan Schematics of Column N25

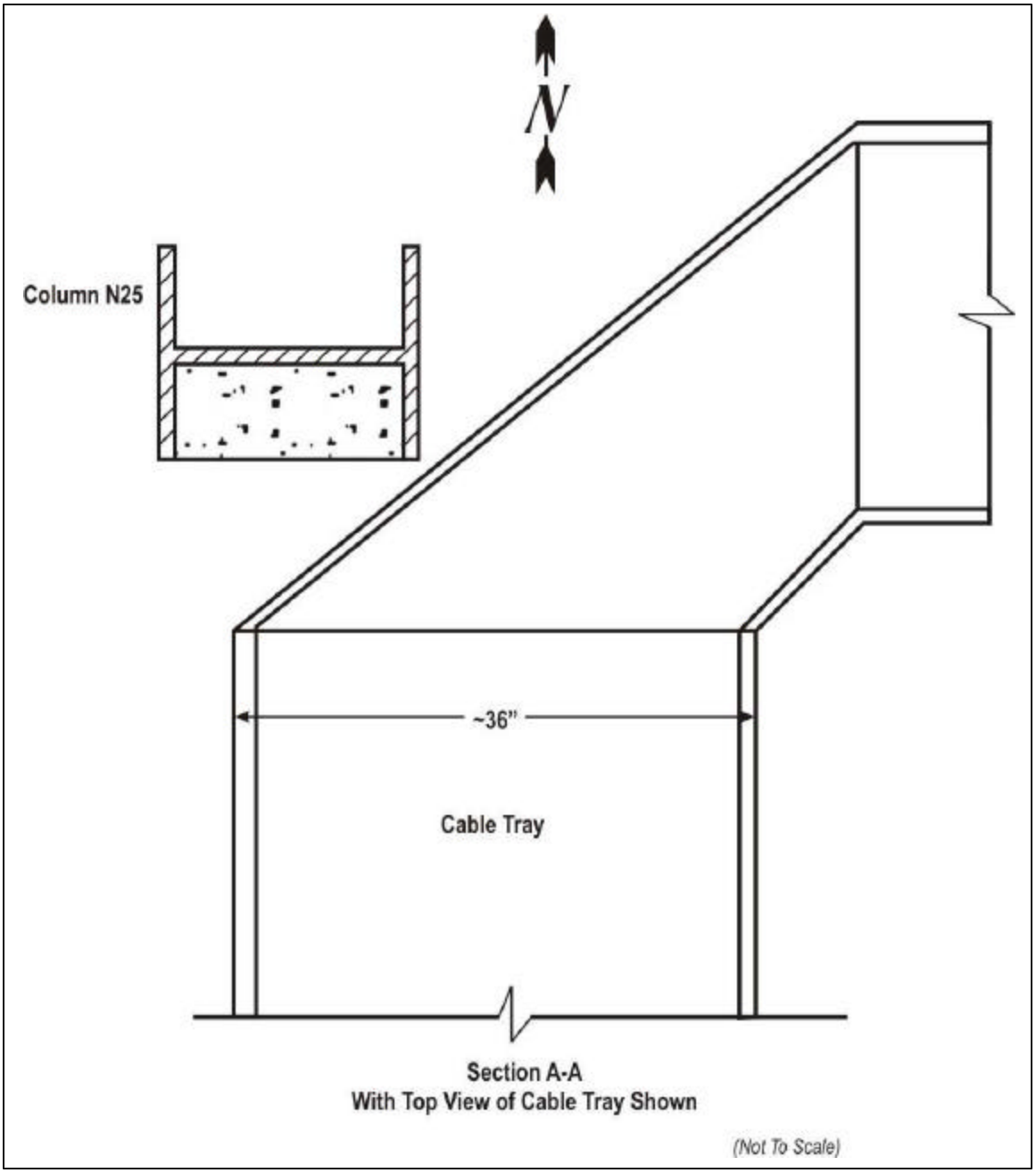


Figure 2-4. Section View of Wide-Flange Column N25 and Top View of Cable Tray

The Pipefitter returned to the Control Room work area where the Foreman and Pipefitter-2 noticed that he was still limping and suggested that he go to the Clinic. Pipefitter-2 drove the Pipefitter to the BCS in a cart and asked the Pipefitter if he needed to go to the Clinic (according to the Pipefitter). The Pipefitter allegedly responded that he would prefer to go to the ER (Pipefitter-2 does not recall this conversation). The Pipefitter remained in the BCS area and rested. The Pipefitter exited the BCS PCM-2 at 11:23 a.m. and was seen at lunch break by the Operator.

After lunch break, the Pipefitter walked to the change house across from the K-31 Building and propped up his foot. The Pipefitter left the BNFL site at approximately 2 p.m., walked approximately ¼-½ mile to his truck, and drove home (an approximate 45-min drive). The crew completed removal of the concrete blocks from the wide-flange, steel Column N25 and cleaned up demolition rubble around the column.

The Pipefitter arrived home, removed his left work boot, noticed blood in the work boot, and put ice on his foot. The bleeding from his foot worsened, and he contacted his spouse who returned home and transported the Pipefitter to the Methodist Medical Center of Oak Ridge ER, signing in at 5:30 p.m.

The Pipefitter was admitted to the hospital, and surgery was performed. Surgery included insertion of pins in the fourth and fifth toes and a fasciotomy of the left foot. (A fasciotomy is an intrusive procedure involving lancing of the bottom of the foot to relieve pressure under the skin and is subject to infection.) The Pipefitter remained in the hospital for four days and was discharged on December 21, 2003.

At approximately noon on December 18, 2003, the Pipefitter's spouse arrived at the BNFL site to pick up the Pipefitter's payroll check and contacted the Building Manager from the security portal. The Building Manager met the Pipefitter's spouse at the portal where she informed him that the Pipefitter was in the hospital.

The Building Manager attended the Senior Review Committee (SRC) meeting later that day (at approximately 12:15 p.m.) and informed BNFL management of the accident and the Pipefitter's condition. BNFL management planned to initiate a critique of the accident and to informally stop work on concrete block demolition of the Control Room. The Building Manager conducted the Plan of the Day (POD) at approximately 1:00 p.m. on December 18, 2003, and mentioned the accident and the informal stop work. The POD meeting is a management meeting held daily to authorize work and ensure coordination between various organizations. The H&S Officer attended the POD where he first heard about the accident. The verbal, informal stop work, however, was not documented in the POD. The Building Manager allegedly notified the General Foreman of the informal stop work for block removal (*Note:* The General Foreman denies knowledge of an informal stop work.).

After the POD meeting (December 18, 2003), the H&S Officer and General Foreman went to the work area, and the wide-flange Column N25 was clean with no block remaining. They talked with the Operator, Laborer, and Pipefitter-2 about what had

happened, and prepared a "pre-critique." This information was used as input to the planned critique and the Occurrence Reporting and Processing System (ORPS) report. Based on interviews with the General Foreman, Foreman, and crew, they were unaware of an informal stop work but had decided no more removal of concrete blocks from the remaining wide-flange, steel columns would be done without the use of a scissor lift. They continued to remove concrete blocks from some wide-flange, steel columns using a scissor lift using a top-down approach. The POD log indicated the last work authorized on the Control Room demolition was December 31, 2003.

The employee was re-hospitalized on January 7, 2004, for a period of eight days where he underwent amputation of the fifth toe due to dry gangrene (necrosis). In addition, removal of skin from the abdomen was performed for full-thickness skin grafting to the top of the left foot due to hematoma and necrosis.

2.1.2 Description of Events Preceding the Accident

The following describes the relevant events preceding the accident beginning with Building K-33 demolition work since that work plan was used for Building K-31 demolition.

Building K-33

Demolition of the interior buildings within the K-33 Building began with the approval of EWP-CONV-056, Revision 0, *K-33 Fifth Avenue Rooms Disassembly*, on November 13, 2002. Revision 0 to the Enhanced Work Plan (EWP) was ranked as a Category 2. According to BNFL Procedure PR-GM-003, Revision 3, *Enhanced Work Planning*, Section 4.4.1.6, Category 2 EWPs are required to be located in the work area, require a pre-job re-brief a minimum of once every six months (if no Field Change Notice [FCN] or EWP revision occurred), and cover activities having significant health, safety, or environmental risk to the employee or the public. Pre-job briefings for EWP-056 Revision 0 occurred on November 14, 2002, and December 30, 2002.

Revision 1 of this EWP was effective on June 16, 2003. Revision 1 changes included a format update, a step added to mark any live conduits, and recategorization of the EWP from a Category 2 to 3. A Category 3 EWP is required to be accessible for the employee to consult, as necessary; requires a pre-job re-brief a minimum of once every twelve months (if no FCN or EWP revision occurs); and covers activities where the risk to the employee or the public is sufficiently low (per PR-GM-003). A pre-job briefing occurred for Revision 1 on June 17, 2003.

Building K-31

EWP-CONV-056, FCN 1, issued July 23, 2003, changed the EWP to include demolition of the interior buildings in the K-31 Building. FCN 1 was designated as an intent change, and a pre-job briefing occurred on July 23, 2003. The Pipefitter and crew attended the pre-job briefing. As part of the pre-job brief, lessons learned are to be

discussed. EWP-CONV-056 includes the following Lessons Learned (NCR-98-055), which states "When a worker cannot follow an instruction, or identifies a hazard that is not address in the instruction, he or she must STOP WORK and contact his or her supervisor."

A previous corrective action closed by BNFL from the converter fire Type B investigation, Corrective Action 1.12 to JON 1, was to "Improve upon the method in which lessons learned that are identified during the actual use of the EWP are input into the EWP." BNFL Procedure PR-AD-007 was revised to address the JON. This procedure was replaced by PR-GM-004, Revision 0, *Lessons Learned Process*, on 12/31/02. The procedure in Section 4.3.1 requires that the task group hold a post-job briefing following the first use of a new or revised EWP. Also, BNFL Procedure PR-GM-003, *Enhanced Work Planning*, Section 4.4.5.1, requires a post-job briefing (1) after the first performance, (2) following an incident, or (3) if requested.

Meetings and briefings occurred (i.e., safety meetings, some Toolbox Training, crew briefings, etc.) in the K-31 Building between August 13 and December 17, 2003, at the beginning of the shift. Some of these meetings and/or training were documented (i.e., some formal Toolbox Training and safety meetings). Most were undocumented. Informal work location walkdowns on task-specific requirements were conducted prior to actual work being conducted in K-31. However, since these walkdowns were informal, the specific tasks, methods discussed, and workers and/or subject matter experts (SMEs) involved are not documented. According to BNFL personnel interviewed, it is BNFL's practice to only document Toolbox Training conducted as part of a corrective action or lesson learned. Demolition work in K-31 (battery rooms, etc.) was accomplished without encountering configuration changes until work began on the K-31 Control Room.

Training Module 10223, *Stop Work/Communications Training*, and the BNFL Procedure PR-GM-001, *Stop Work Authority*, upon which it is based, omits instructions to stop work ". . . if you encounter a configuration different than the one for which work steps were developed. . ." as described in BNFL Procedure PR-GM-003. The Building Manager, General Foreman, Foreman, and the crew had not received training on Module 10223. After the accident, the Building Manager did not complete appropriate notification and documentation of the informal stop work.

On November 27, 2003, demolition was authorized of the K-31 Control Room. Prior to beginning the K-31 Control Room demolition, the Foreman and crew walked down the area. The crew consisted of two pipefitters, the pipefitter apprentice, the operator, and the laborer. The Foreman and crew recognized that the block walls were built into the webs of the wide-flange columns and did not anticipate any problems with this configuration. The operator was using a trackhoe (Exhibit 2-7) having a standard bucket attachment to knock down the block walls. The block demolition debris was piled up as the work progressed. The operator of the trackhoe removed the block flush with the wide-flange column, and the trackhoe was not used to remove the remainder of the blocks within the webs due to accessibility problems.

The trackhoe used for demolition has a 30-inch wide bucket attachment and has four teeth spaced about 8 inches apart (Exhibit 2-8). The inside width of the wide-flange column containing the block is 12½ inches. Based on a telephone interview with BNFL Engineering personnel, the columns are load bearing and should not be "worked" (striking the steel column with equipment or hand tools). The appropriate method is to strike only the concrete block within the column.

Several wide-flange columns were left with blocks remaining in the webs. Hand removal of blocks was not addressed in the EWP. Some members of the crew described the manual removal of the blocks from within the wide-flange columns as "finishing up work" or "keeping busy work." Based on interviews, the methodology to be used for removal of the block from the wide-flange columns was not discussed during safety or crew meetings (e.g., hand tools for use when on elevated surfaces, hand tools for use when standing at floor level, top-down approach, use of scissor lift, etc.)

Another crewmember used a scissor lift near one wide-flange column to gain access to the top of the block stack and manually removed the blocks using tools from the top down. Based on interviews with the Foreman and crewmembers, a scissor lift could not be positioned near some columns due to rubble piles generated from block wall demolition debris, and the debris had to be pushed aside by the trackhoe so that it could maneuver in the work area. Some personnel interviewed stated that the skid loader (Bobcat) was not available at the start of the Control Room demolition job in Building K-31 but was available for debris cleanup during the time of the accident.

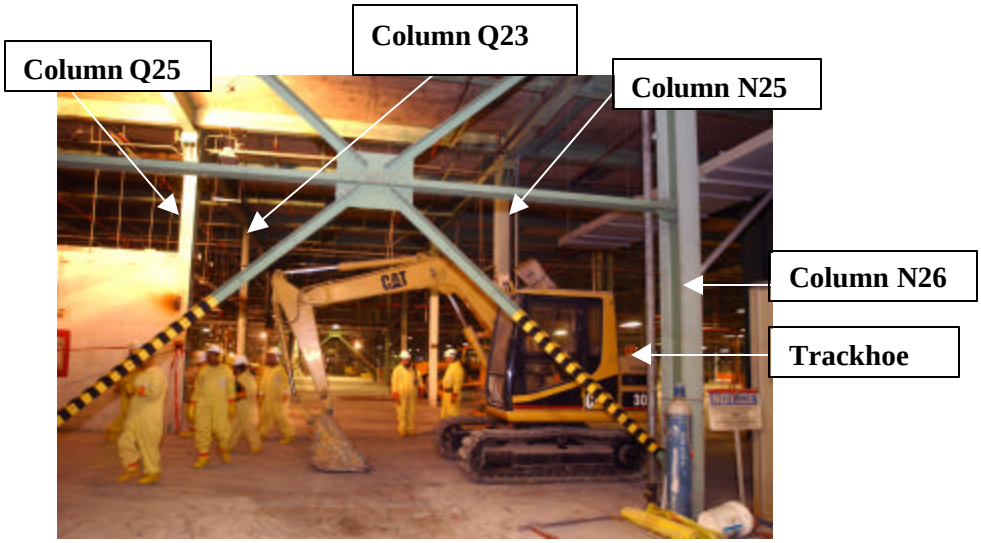


Exhibit 2-7. View of Trackhoe and Control Room Demolition Area (Looking West)

Exhibit 2-8. Trackhoe Bucket Attachment (30 Inches in Width, 4 Teeth Spaced Approximately 8 Inches Apart)

On December 16, 2003, the Pipefitter Apprentice was reassigned to work in Building K-33. He did not rejoin the crew until December 18, 2003. The Pipefitter reportedly stood on the floor adjacent to the wide-flange column and used a wrecking/pry bar and a 4-pound sledgehammer to break the grout and loosen block at chest height (Figures 2-1 and 2-2). The block was then pried out of the block stack. As the block was removed, the remaining upper blocks slid down onto the lower stack of blocks. The Pipefitter then repeated this method on the lowest block in the upper stack until all blocks in the top stack were removed. The lower stack of blocks was then removed by prying out a block at a time. This method was repeated by the Pipefitter to remove blocks from approximately six wide-flange columns prior to the accident. The Pipefitter had performed hand removal for approximately 2½ days prior to the accident. The Building Manager, Foreman, H&S Officer, and crewmembers stated they did not observe the Pipefitter's method of performing work. For some wide-flange columns, some of the blocks in the web had fallen out during wall demolition using the trackhoe. For Column N25, all of the blocks in the web were intact.

Some employees interviewed stated they intended to remove all the block so the area could be cleaned up at one time and have the debris put into the Sealand container before the container was moved to the next area. Also mentioned was the need to stay busy and that workers were being laid off as the project progressed toward completion.

Dates and times for each event and additional details are provided in Section 2.1.3.

2.1.3 Chronology of Events

Table 2-1 provides the events leading up to and immediately following the employee foot injury that occurred on December 17, 2003, in Building K-31, BNFL Inc.

Table 2-1. Event Chronology

Date	Time	Event
Events preceding accident		
6/16/2003		EWP-CONV-056 R1 (Changes EWP from Activity Category 2 to 3)
7/23/2003		EWP FCN 1 generated (FCN to include demolition in K-31) (Step 1.3).
		Pipefitter and crew attend pre-job briefing (FCN 1).
8/13/2003		K-31 internal building removal authorized (EWP-56) (POD 8/13/2003).
8/13/2003-12/2003		Documented and undocumented safety briefings, crew briefings, or Toolbox meetings are conducted, generally in work area, each morning.
11/27/2003		Control Room demolition authorized (POD).

Table 2-1. Event Chronology (continued)

Date	Time	Event
12/1/2003		Foreman, General Foreman, and crew walkdown K-31 Control Room job and encounter change in wide-flange column configuration.
		Control Room demolition authorized for K-31 (POD 12/1/2003).
12/1/2003-12/17/2003		Crew begins removal of block from wide-flange columns in Control Room.
12/15/2003-12/17/2003		H&S Officer reassigned to oversee work in K-29 Building.
12/16/2003-12/17/2003		Pipefitter Apprentice reassigned to perform work in K-33 Building.
Day of Accident		
12/17/2003	0551	Pipefitter enters BCS in K-31.
	0551-0715	Pipefitter begins hand removal of block from N25 wide-flange column.
	0600-0715	Pipefitter attempts to pry block (at chest height) loose from wide-flange column (N25) using wrecking/pry bar.
	0715	Pipefitter stops attempt to pry block and turns to walk away.
	0715	Top block (filled with concrete weighing ~49 pounds) falls 10 feet 8 inches and strikes Pipefitter's left foot.
		General Foreman, Foreman, and H&S Officer were not in Building K-31 at time of accident. Building Manager was not in the immediate area at time of accident.
		DOE ORO Facility Representative coverage was not provided (on holiday leave and Source Evaluation Board [SEB] assignment).
	0715-0720	Blocks between top block and chest height fell out of column (reportedly, no one observed this).
	0720	K-31 Building Manager arrives in area, notices Pipefitter limping, discusses accident, and talks to Pipefitter about going to the Clinic (Pipefitter declines visit to Clinic).
	0720-1000	Coworkers interact with Pipefitter and notice he is injured, suggest he go to Clinic. Pipefitter declines.
	0930	Foreman sees Pipefitter limping and suggests going to Clinic. Pipefitter declines.
	1000	Pipefitter exits BCS first time after accident (morning break).

Table 2-1. Event Chronology (continued)

Date	Time	Event
12/17/2003 (continued)	1021	Pipefitter reenters BCS.
	1021-1030	Pipefitter-2 and Foreman notice Pipefitter limping (in pain) and suggest he go to the Clinic. Pipefitter declines.
	1030-1123	Pipefitter-2 drives Pipefitter to BCS in cart and asks if he needs to go to the Clinic. The Pipefitter states he would prefer to go to the hospital ER (Pipefitter-2 does not recall this conversation.) Pipefitter rests in BCS area.
	1123	Pipefitter goes through the BCS and leaves K-31.
	~1130	Operator sees Pipefitter at dinner break.
	~1245	After lunch, Pipefitter remains in break area resting foot.
	~1400	Pipefitter leaves site and walks to truck (¼ mile) and drives home (truck has automatic transmission).
	~1445	Pipefitter arrives home.
	~1630	Pipefitter telephones spouse to drive to ER.
	0715-1630	Crew cleans up area around the wide-flange column (N25).
	1730	Pipefitter arrives at hospital ER, and he is admitted.
12/17/2003-12/21/2003		Pipefitter treated at hospital (fasciotomy, pins in the fourth and fifth toes, and infection).
Days following accident		
12/18/2003	~1200	Pipefitter's spouse arrives at site to pickup Pipefitter's check; informs K-31 Building Manager of hospital admittance.
	1215	K-31 Building Manager notifies SRC of accident and verbally initiates an (unofficial) informal stop work.
		Building Manager allegedly notifies General Foreman of informal stop work for block removal (General Foreman does not recall receiving verbal notification).
		The Shift Manager is not notified of the informal stop work; thus, it is not logged in the Shift Logbook.
	1215-end of day	Building Manager talks with General Foreman and learns that block removal from the column has already been completed on the remainder of the 12/17/03 day shift and the morning of 12/18/03.
		General Foreman and Foreman are not aware of informal stop work initiated by Building Manager, and crew continues working.

Table 2-1. Event Chronology (continued)

Date	Time	Event
12/18/2003 (continued)	1300	Building Manager conducts POD and informs attendees of accident and informal stop work; the POD record does not indicate informal stop work initiated.
		H&S Officer attends POD and first learns of accident and informal stop work.
	1350	H&S Officer and General Foreman go to work area and interview Operator, Pipefitter-2, and Laborer and prepare a "pre-critique," which is used as input to the ORPS report.
		General Foreman, Foreman, and crew are still unaware of the informal stop work on block removal from columns.
	1415	Notification to DOE Facility Representative of accident
	1508	Notification to DOE Project Manager of accident
	1508	Notification to DOE Assistant Manager for Environmental Management (AMEM) of accident
	1747	BNFL submits Occurrence Notification Report ORO-BNFL-K31-2003-0003.
		K-31 Building Manager plans a critique of accident.
		The Building Manager's draft critique stated that metatarsal guards be used for any future work removing concrete block. (This recommendation did not actually get implemented.)
		DOE Project Manager visits site (sees column with all blocks removed).
12/18/2003-12/31/2003		Another crew removes overhead cable tray in front of N25 column.
12/18/2003-1/01/2004		DOE Project Manager informed by BNFL management that informal stop work is in place.
12/19/2003		DOE Project Manager decides and recommends to AMEM that no briefing is needed by BNFL until after holidays.
		AMEM concurs with waiting on briefing.
		Building Manager stops critique process due to management decision (Deputy General Manager) to elevate investigation to Type C.
12/21/2003		Pipefitter discharged from hospital.
12/22/2003		AMEM issues letter to BNFL General Manager stressing safety expectations as the project comes to closure and expressing concern over the recent occurrences in December.
		BNFL Type C Accident Investigation convenes.

Table 2-1. Event Chronology (continued)

Date	Time	Event
12/24/2003-12/28/2003		BNFL Holidays
01/07/2004		Pipefitter readmitted to hospital.
01/7/2004-01/15/2004		Pipefitter's left, fifth toe amputated, skin grafted to top of foot (8-day hospital stay).
01/13/2004		Deputy General Manager initiates and signs formal Stop Work #2004-002 Rev 0.
		DOE informally notifies BNFL that a Type B Investigation will be performed based on worker's hospital stay exceeding 5 days.
		BNFL conducts illumination survey of K-31 Control Room area and concludes lighting was probably inadequate at the time of the accident.
01/14/2004		BNFL ropes off accident area at Control Room wide-flange column.
		Formal stop work is documented in POD.
	1500	BNFL briefs DOE (AMEM, Type-B Team, and Project Manager) on accident.
1/15/2004		Pipefitter discharged from hospital (second time).
		DOE Type B Investigation formally initiated by ORO Manager.
1/19/2004		Occurrence Notification Report ORO-BNFL-K31-2003-003 updated to Significance Category 2.
1/20/2004		Type B In-brief (BNFL turnover meeting)
1/28/2004		BNFL issues Type C DRAFT Final Report.
2/3/2004		Pipefitter returns to work on restrictions.

2.1.4 Building Conditions

Based on interviews with workers, the control room area was very dark. Conflicting information was provided on whether there was portable lighting in the area at the time of the accident. One worker stated that the only lighting in the immediate vicinity was that of the trackhoe or Bobcat equipment. Other workers stated there were stand lights furnished at the beginning of the Control Room demolition job but they were blinding. The portable lights were turned away from the work area due to their brightness. Workers and safety personnel stated that, depending on the placement angle of the light, it could result in a blinding glare to workers and heavy equipment operators. (One worker compared it to looking into a flashcube.)

Workers stated that due to the aforementioned lighting inadequacies and dust generated during demolition efforts, overall visibility was somewhat limited. Based on interviews with the workers and the H&S Officer, large quantities of dust were only generated when stirred up by mechanical equipment moving through the area. At the time of the accident, a cable tray abutted Column N25 at an angle just above the top of the block wall, providing a canopy over the edge of the beam.

The EWP Hazard Assessment (HA) identifies inadequate lighting as a hazard and specifies a minimum of 5 footcandles for construction activities. No documented illumination surveys were performed for the K-31 Operations floor demolition until January 13, 2004. When this survey was performed, it was determined that the light levels immediately surrounding Column N25 where the injury occurred were approximately 1 to 2 footcandles. This survey was conducted after the demolition work was completed (with the exception of remaining blocks in columns) and after removal of overhead obstacles (cable trays). Refer to Exhibit 2-9 for an example of Control Room cable trays and columns.

2.1.5 Personal Protective Equipment

The Pipefitter and other crewmembers were wearing personal protective equipment (PPE) consisting of flame-retardant, orange coveralls and a PAPR, as required in RWP Number 20030165. Additional PPE included steel-toe shoes and anti-Cs. Exhibits 2-10a and 2-10b depict the type of anti-Cs worn during the accident. During the accident, the Pipefitter's cutting shield was positioned up as shown in Exhibit 2-10b, and the inner, clear shield was down. The RWP was written for general demolition use and included the use of flame-retardant coveralls and a cutting shield on the PAPR for use when cutting metal during Control Room demolition.

Personal Protective Equipment required per Radiological Work Permit 20030165 (Contamination and High Contamination Areas)
1-Cloth Coveralls (flame retardant) **1-Anti-C gloves** (Leather work gloves may be worn in place of outer Anti-C gloves by personnel performing hot work) **1-Surgeons' gloves** **1-Booties** **1-Rubber shoe covers** **Powered Air-Purifying Respirator**

Based on the distance of the fall (10 feet 8 inches) and the weight of the concrete block (approximately 49 pounds), the block struck the worker's foot with approximately 500 foot-pounds of kinetic energy. The work boot worn by the Pipefitter was an American National Standards Institute (ANSI)-rated, 75-pound, steel-toe, work boot (which would equate to protection of approximately 110 foot-pounds of kinetic energy).

Exhibit 2-9. Standing Inside Control Room Footprint
(Looking Southeast at Remaining East Wall and Overhead Cable Tray)

Exhibit 2-10-a. Worker Wearing Flame Retardant Anti-C PPE (with Cutting Shield Down)

Exhibit 2-10b. Worker Wearing Flame Retardant Anti-C PPE with Cutting Shield Up and Inner, Clear Shield Down (Clear Shield Shaded to Obscure Face)

Metatarsal guards, which were identified for use in the draft critique planned by the Building Manager, are sometimes worn for hand demolition work. The guards were not part of the crew's PPE. Metatarsal guards (see an example of a metatarsal guard in Exhibit 2-11) are tested in the same manner as a steel-toe, work boot and classed accordingly (75, 50, and 30 pounds) (ANSI Standard Z41-1991, Personal Protective Footwear). A metatarsal guard would also equate to protection of approximately 110 foot-pounds of kinetic energy. Based on the class ratings of work boots and metatarsal guards, neither of these types of PPE would have supported the 500 foot-pounds of energy released by the impact of the free-falling concrete block.

Exhibit 2-11. Example of a Metatarsal Guard (Not Part of Required PPE)

2.1.6 Medical Summary

Exhibit 2-12. Work Boots Worn by Pipefitter

The Pipefitter had an approximate 49-pound concrete block fall onto his left, steel-toe work boot. The Pipefitter noted immediate pain and swelling. Exhibit 2-12 is a photograph of the actual work boots worn by the Pipefitter at the time of the accident. Exhibit 2-13 is a cutaway view of the Pipefitter's left work boot. The Pipefitter was admitted to the hospital for compartment syndrome to the left foot; dislocation of the joint on the left, fourth toe; and open dislocation of the left, fifth toe with fracture.

Pins were placed in the fourth and fifth toes, and a fasciotomy was performed on the bottom of his left foot. His toe was also treated for infection. (A fasciotomy is an intrusive procedure involving lancing of the bottom of the foot to relieve pressure under the skin and is subject to infection.) The employee was released from the hospital on December 21, 2003. The Pipefitter had an office visit two days following hospital discharge and necrosis (dead tissue) to the left fifth toe was diagnosed.

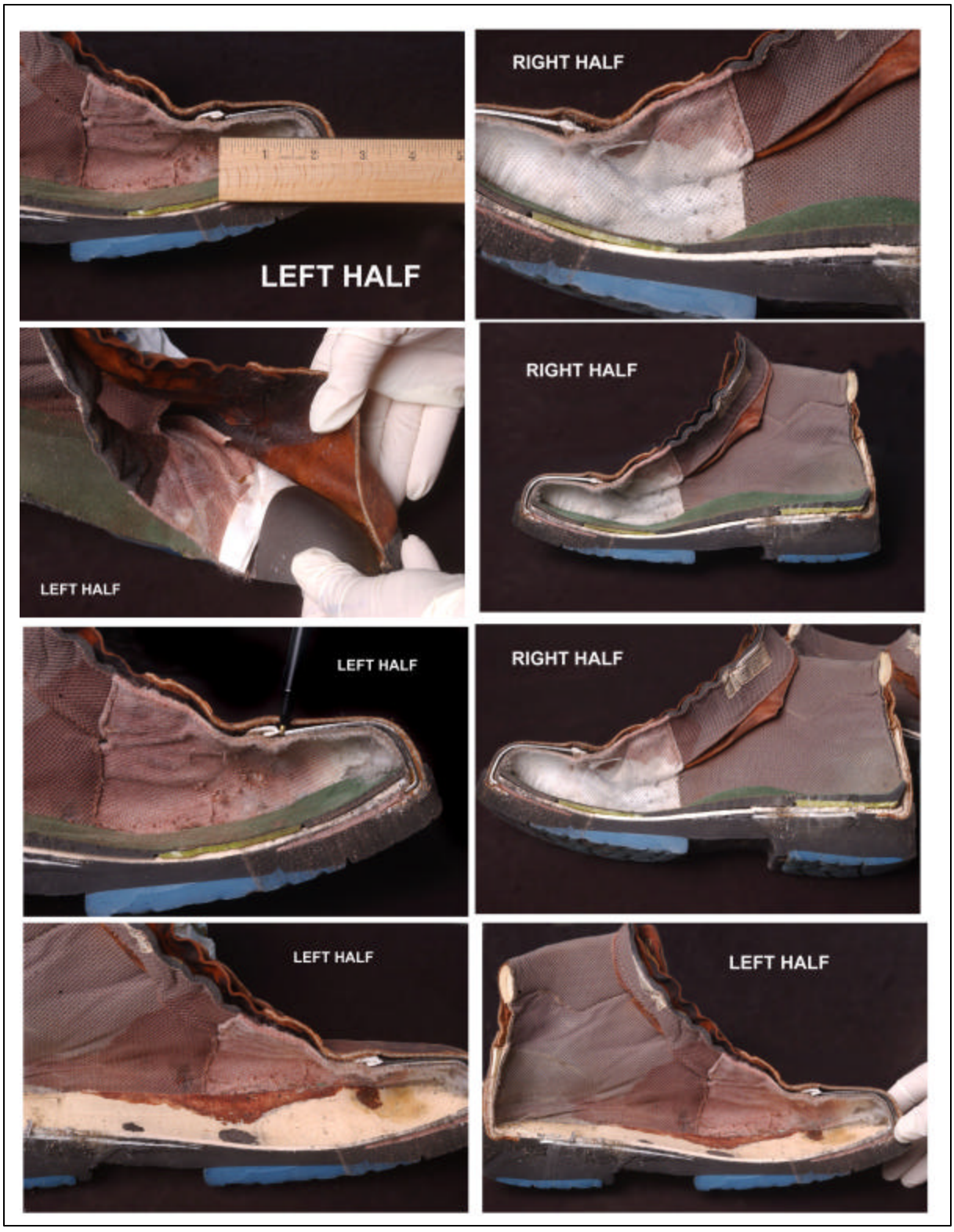


Exhibit 2-13. Cutaway View of Pipefitter's Left Work Boot

The employee was re-hospitalized on January 7, 2004, for a period of eight days where he underwent amputation of the fifth toe due to dry gangrene (necrosis). In addition, removal of skin from the abdomen was performed for full-thickness skin grafting to the top of the left foot due to hematoma and necrosis.

The Pipefitter was sent home on January 15, 2004, with antibiotics and pain medication. On February 3, 2004, the Pipefitter returned to work on restricted duty in the Clinic until his physician releases him for full duty.

The Pipefitter and some workers interviewed expressed concerns with going to the Clinic, and others did not. Some BNFL managers and supervisors interviewed were aware that there were some concerns surrounding going to the Clinic. This concern was partially based on the experience of an injured laborer who broke his arm in K-31 on December 3, 2003, two weeks prior to the Pipefitter's accident (Occurrence Report Number: ORO-BNFL-K31-2003-0002, *Worker Breaks Arm in K-31*). Based on an interview with the injured laborer, he was initially sent to the Clinic where his arm was packed in ice, and then he was transported to the BNFL Occupational Physician's Office for further evaluation and x-rays. He expressed satisfaction with his treatment at the BNFL Clinic; however, he expressed dissatisfaction with being required to go to the BNFL Occupational Physician's Office rather than being transported directly to the hospital since he knew his arm was broken. The BNFL Occupational Physician's Office x-rayed his arm and confirmed multiple fractures. The injured laborer was then driven to an orthopedist office for evaluation of the fractures. He received additional x-rays, and his surgery was scheduled for the following day. He believed that reporting to the BNFL Occupational Physician's Office delayed his treatment and surgery until the following day (December 4, 2003) and increased his pain and suffering. In addition, the injured laborer had complications at the hospital that resulted in a second surgery on his elbow on December 5, 2003. He returned to work on restrictions on December 8, 2003.

2.1.7 DOE Oversight

DOE oversight of BNFL consists of a multi-discipline approach. Two facility representatives are assigned full time to the BNFL oversight effort. In addition to the facility representatives, the following disciplines perform oversight of BNFL on a scheduled basis: radiation protection, industrial safety, industrial hygiene, fire protection, emergency management, facility safety/authorization basis, criticality safety, and quality assurance. Historically, industrial safety oversight consists of a scheduled monthly Operational Awareness Visit (OAV), in addition to quarterly unannounced OAVs by a professional safety engineer who is a Certified Safety Professional. In calendar year 2004, management increased the number of industrial safety OAVs to three each month through March when the workload should drop significantly. Additional industrial safety and other discipline oversight are planned.

On December 22, 2003, the AMEM issued a letter to BNFL which transmitted an OAV schedule for calendar year 2004. The letter indicated that more frequent walkthroughs

and attendance at project safety and operations type meetings would occur by the ORO staff. Concern was expressed over three serious accidents occurring within a three-week period the first half of December 2003. These accidents were: (1) December 3 – Laborer fell off a ladder breaking his arm (ORPS Occurrence Report ORO-BNFL-K31-2003-0002), (2) December 8 – Near miss when a cable that pulled a gantry (i.e., a cart on a rail system with a winch mechanism for movement) was severed and the recoil missed an employee by five feet (ORPS Occurrence Report ORO-BNFL-K32-2003-0004), and (3) December 17 – The Pipefitter's foot injury covered by this investigation (ORPS Occurrence Report ORO-BNFL-K31-2003-0003). The importance of safety in every facet of the work activities was expressed as well as the increased number of OAVs scheduled for 2004.

2.1.8 Definition of Roles and Responsibilities

No accurate organization chart was provided by BNFL. BNFL Policy PO-RO-101, *Removal Operations Functional Organization*, contains an out-of-date organizational chart. Job descriptions (or anything similar) were not available for the Foreman or any of the crew.

3.0 ANALYSIS

The Board used several analytical techniques to determine the causal factors of the event. Events and causal factors were charted using the ISM Core Functions. The Board used change and barrier analysis techniques to analyze the facts and identify the causes of the event. The causal factors related to weaknesses in implementation of the ISM Core Functions and collectively contributed to the event. JONs are presented in Tables ES-1 and 4-1.

3.1 Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all accidents/events. Barriers are developed into a system or work process to protect personnel and equipment from hazards. For an accident/event to occur, there must be a hazard that comes into contact with a target (worker) 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 adverse consequence. The results of the barrier analysis are used to support the development of the causal factors. Appendix B, Table B-1, contains the barrier analysis.

3.2 Change Analysis

Change is anything that disturbs the "balance" of a system which 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 planned or unplanned changes that caused undesired results or outcomes related to the event. 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 C, Table C-1, contains the change analysis.

3.3 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/event. Causal factors are the events or conditions that produced or contributed to the occurrence of the accident/event, and they consist of direct, contributing, and root causes.

The direct cause is the immediate events or conditions that caused the accident/event. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the event but which did not cause this event. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar events. The Board concluded that *the direct cause of the accident was a loosened concrete block, weighing approximately 49 pounds, falling 10 feet 8 inches, striking the Pipefitter on his left foot.* A summary of the Board's causal factors analysis is presented in Appendix D, Table D-1. A chart depicting the Events and Causal Factors is provided in Appendix E.

3.4 Root Cause Analysis

Root cause analysis is a systematic process that uses the facts and results of the core analytic techniques to determine the most important reasons for the accident. The intent of the analysis is to address only those root causes that can be controlled within the system being investigated, excluding events or conclusions that cannot be reasonably anticipated or controlled, such as some natural disasters. Root causes analysis is primarily performed to resolve the question, "Why?"

As a result of this investigation, the Board determined there was one Root Cause. This Root Cause is: BNFL failed to implement an effective work planning process (see Table ES-2).

3.5 Requirements Verification Analysis

Requirements verification analysis is conducted after all the analytical techniques are completed and a draft of the report has been prepared. The analysis ensures that all portions of the report are accurate and consistent and verifies that the conclusions are consistent with the facts and judgments of need. The verifications analysis determines whether the flow from facts to analysis, conclusions, and judgments of need is logical. The conclusions and judgments of need are traced back to locate the facts to support the conclusions. The goal is to eliminate conclusions that are not based on facts. One approach is to compare the facts, analysis, conclusions, causes, and judgments of need on a wall chart, and then validate the continuity of facts through the analysis and conclusions to the judgments of need. This method also identifies any misplaced facts, insufficient analyses, and unsupported conclusions or judgments of need. This analysis tool used by the Board is not included as part of the report.

3.6 Integrated Safety Management

The Board examined management systems as potential contributing and root causes of the event. The DOE Accident Investigation Program requires that accidents be evaluated in terms of ISM to foster continued improvements in safety and to prevent or minimize future accidents. The Core Functions and Guiding Principles 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. Properly

implemented, ISM is a standards-based approach to safety, requiring rigor and formality in the identification, analysis, and control of hazards. Weakness in implementation of the ISM Core Functions is shown in Table 3-2.

3.6.1 Define the Work

Missions are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated.

3.6.1.1 Definition of Roles and Responsibilities

Part of defining the work involves clear definition of roles and responsibilities for conducting work and setting priorities. BNFL Policy PO-RO-101, *Removal Operations Functional Organization*, contains an out-of-date organizational chart. During this investigation, BNFL provided multiple versions of the organizational chart, none of which were correct. Job descriptions (or anything similar) were not available for the Foreman or any of the crew. The Board concluded that roles, responsibilities, and expectations were not clearly defined and communicated at the functional management level, group level, or crew level, as required by ISM Principle 2.

3.6.1.2 The EWP Process Implementation

The EWP is BNFL's primary mechanism for implementing the Core Functions of its ISMS. The EWP process is divided into five phases: Development, Review, Approval, Implementation, and Evaluation. The EWP is the work control/planning document to which all hands-on work is performed on site. Management authorizes work to proceed on the EWPs in the POD meeting, which is conducted daily and documented. The POD is a high-level management meeting that authorizes work and ensures coordination between various organizations. The EWP document establishes the approved work steps, hazards, and hazard controls for performing a work activity on the D&D project site. It includes the EWP Field Task Plan and the Support Plan. The EWP remains active until cancelled by the Building Manager or for the duration of the task for which it was developed. Changes to the EWP are made through a Revision or an FCN.

The FCN is an attached change to the EWP, and after three FCNs, a revision must be issued on the EWP. FCNs may be intent changes (i.e., modification[s] that alter the work steps, hazards, hazard controls or bounding conditions) or non-intent changes (i.e., modification[s] that correct minor typographical errors, reference changes, or add clarifying statements that do not alter work steps, hazards, hazard controls or bounding conditions). Intent FCNs and new or revised EWPs require a pre-job briefing. A re-briefing of the EWP is conducted by the Building Manager using the pre-job briefing checklist when the following conditions apply: (1) prior to implementing an intent FCN, (2) prior to implementing a revised EWP, (3) if requested, or (4) if the worker or workers have not performed the work for one month.

The EWP in use during the accident was *K-33 Fifth Avenue Rooms Disassembly*, EWP-CONV-056. This EWP was approved for use in the K-33 Building on November 13, 2002. Revision 0 to the EWP was ranked as a Category 2. According to PR-GM-003, Section 4.4.1.6, Category 2 EWPs are required to be located in the work area, require a pre-job re-brief a minimum of once every six months (if no FCN or EWP revision occurs), and cover activities having significant health, safety, or environmental risk to the employee or the public. The scope was: "Scope of Work: This scope of this EWP is to disassemble the rooms located on 5th Avenue in Building K-33. Work activities include using forklifts, mechanical equipment and tools, including but not limited to plasma arc and acetylene/oxygen torches to: demolish block walls, take down roof panels, take down support steel, remove steel grid ceiling frames and demolish filter housing." Pre-job briefings for EWP-056 Revision 0 occurred on November 14, 2002, and December 30, 2002.

Revision 1 of this EWP was effective on June 16, 2003. Revision 1 changes included a format update, a step added to mark any live conduits, and recategorization of the EWP from a Category 2 to 3. A Category 3 EWP is required to be accessible for the employee to consult, as necessary; requires a pre-job re-brief a minimum of once every twelve months (if no FCN or EWP revision occurs), and covers activities where the risk to the employee or the public is sufficiently low (per PR-GM-003). The following words were removed from the EWP scope: ". . . include using forklifts, mechanical equipment and tools, including but not limited to plasma arc and acetylene/oxygen torches to. . ." A pre-job briefing occurred for Revision 1 on June 17, 2003.

FCN 1, to Revision 1, issued July 23, 2003, changed the use of the EWP to include the K-31 Building and demolition of the interior buildings. The scope was modified: "Scope of Work added: To include demolition on the Operations (OPS) floor in Building K-31. The additional work to be covered under this EWP only includes the demolition of block walls and pre-cast concrete and metal roofs that make up the OPS floor rooms. All other associated work such as utilities will be covered under other EWPs." FCN 1 was designated as an intent change, and a pre-job briefing occurred on July 23, 2003. The Pipefitter and crew attended the pre-job briefing. No validation walkdown was conducted in K-31 during development of the EWP, Rev 1, FCN 1. Demolition work in K-31 (battery rooms, etc.) was accomplished without encountering configuration changes until work began on the K-31 Control Room. As noted in the POD, the K-31 Control Room demolition was authorized on November 27, 2003. There was a significant time lag between when the pre-job briefing occurred and initiation of Control Room demolition.

The only work step addressing block wall demolition throughout the revisions and FCN was Step 1.3, which states: "For block walls, use mechanical equipment to demolish wall and mechanical equipment with a bucket to load block into intermodals/sealands for disposition." The EWP was written at a high level such that the crew informally depended on themselves to develop adequate work details. The pre-job brief used as a means to train workers on work steps, hazards, and controls was deficient because it

was based on an insufficient EWP and did not cover how the Control Room walls would be safely demolished.

Although the Pipefitter was in a crew, he was working without interaction with other workers on how the block removal should be performed. The crew and others interviewed stated they did not see the Pipefitter removing the block from the column, and he had been performing this task for at least 2½ days prior to the accident.

After the accident, the Pipefitter demonstrated for the Building Manager the method he used for removing the blocks, this time using a crow bar to pry at the remaining blocks in the wide-flange steel, which were at approximately 5½ feet from floor level and below. During the demonstration, a couple of the remaining blocks fell out of the wide-flange column. However, during the interview, the Building Manager's process expectation and interpretation was that the block wall demolition would be accomplished using only mechanical equipment (i.e., trackhoe). The trackhoe in use had a 30-inch wide bucket attachment. The wide-flange column containing the blocks has an inside width of 12½ inches. A telephone conversation was held between the trackhoe manufacturer's sales representative and the Board's Safety Advisor concerning the use of the trackhoe (Caterpillar® Model 307 Hydraulic Excavator with a standard 30-inch bucket attachment) in removal of concrete block from a wide-flange column. The representative indicated that there is a 12- or 18-inch bucket attachment available that could possibly work in the scenario discussed (block removal from within a wide-flange column). However, the manufacturer's representative suggested that if the wide-flange columns were to remain intact, he would recommend the work be performed by hand, which would prevent possible damage to the steel column by the trackhoe. Based on interviews with BNFL Engineering personnel, the columns are load bearing and should not be "worked" (striking the steel column with equipment or hand tools). The appropriate method is to strike only the concrete block within the column.

The EWP did not define the work process clearly enough to ensure that management expectations were understood. The EWP was written at such a high level that it relied too heavily on "skill of the craft" of the crew to determine the details of the work. As a result, the Foreman and crew believed they were following the EWP when they interpreted "hand tools," mentioned in the hazard analysis, as allowing any use of hand tools needed to get the job done. The Building Manager and safety representatives, on the other hand, interpreted "hand tools" to mean brooms, shovels, etc., for cleanup.

Documented and undocumented meetings and briefings occurred (i.e., safety meetings, some Toolbox Training, crew briefings, etc.) in the K-31 Building between July 23 and December 17, 2003, at the beginning of the shift. Some of these meetings and/or training were documented (i.e., some formal Toolbox Training and safety meetings). Informal work location walkdowns on task-specific requirements were conducted prior to actual work being conducted in K-31. However, since these walkdowns were informal, the specific tasks, methods discussed, and workers and/or SMEs involved are not documented. Communications among the crew (lateral) and between management

and the crew (vertical) during these meetings and briefings were ineffective in planning the safe conduct of work.

In conclusion, the Board determined that BNFL's implementation of the EWP process was not effective, it violated their own procedures, and did not ensure worker safety. The numerous failures noted throughout the EWP process for the K-31 demolition work brings into question the integrity of the process on a project-wide basis. Communications and briefings were insufficient to ensure work process expectations were understood. The pre-job briefing was documented; however, daily communications and briefings are primarily informal. The consistency and rigor of these essential daily shift communications and briefings cannot be ensured without more formality.

3.6.1.3 Worker Participation in Work Planning

Worker involvement should be integrated into work planning activities to ensure planners receive input from workers on proposed work methods, hazards, and controls. While BNFL's EWP Procedure PR-GM-003, *Enhanced Work Planning*, ISM Program Description, and Quality Assurance Program Plan Description describe the worker involvement in the EWP process, this involvement is informal and not documented on the EWP or FCN sign-off sheet.

It is not known which workers, if any, were involved in the work planning or preparation of the EWP because it does not identify the "work team" representatives. No validation walkdown was conducted in K-31 during development of the EWP, Revision 1, FCN 1. Training on the EWP process is not provided to the Foremen and crew who are supposed to be participating in the development phase of the EWP per BNFL Procedure PR-GM-003. Thus, the Foreman and crew were not indoctrinated as to their roles and responsibilities in the development phase of the EWP. The Board concludes that worker participation was less than adequate in the EWP development and revision process. Interviews confirmed that the Foreman and crew did not participate in development of FCN 1.

3.6.2 Analyze the Hazards

Hazards associated with the work are identified, analyzed, and categorized.

The hazard analysis associated with this demolition work was contained within EWP-CONV-056. The hazard analysis of the hazards associated with demolition of rooms located in Building K-31 was assumed to be identical to the hazards in K-33 due to similar building configuration, and, therefore, a separate hazard analysis and walkdown for Building K-31 was not conducted by BNFL SMEs. The hazard analysis did not identify the hazards associated with hand tool removal of block (whether standing on floor or utilizing scissor lift) and did not provide adequate controls. Access to all of the necessary equipment (i.e., skid loader) was not provided on a continuous basis resulting in an accumulation of debris/rubble which prevented access of the trackhoe for possible

mechanical removal of block from columns and prevented access of the scissor lift for hand removal. A management perception existed that the Operations Floor (and Control Room) block room demolition was a lower relative risk.

BNFL Procedure PR-GM-003, *Enhanced Work Planning*, Paragraph 4.1.3.8, states that the Group (Building) Manager, during the EWP development phase, "Adds, as applicable, the following note at the beginning of the task steps: If you encounter a configuration different than the one for which work steps were developed, or identify that a bounding condition has been violated, stop work in accordance with PR-GM-001, Stop Work Authority." This requirement was not included in the EWP. Prior to beginning the K-31 Control Room demolition, the Foreman and crew walked down the area. The Foreman and crew did recognize the changed configuration (i.e., the block walls within the wide-flange columns). However, they did not recognize any potential problems or hazards. No one initiated stop work, even though the work steps to accomplish demolition were not provided, nor had a hazard analysis been done.

Step 1.1 in the EWP contains a note which states: "Note: Prior to demolition, contact Engineering to establish specific requirements associated with Room Construction." No documentation exists substantiating that this was followed for the interior building demolition in the K-33 or the K-31 Building.

Based on interviews with workers, the control room area was very dark. Conflicting information was provided on whether there was portable lighting in the area at the time of the accident. One worker stated that the only lighting in the immediate vicinity was that of the trackhoe or Bobcat equipment. Other workers stated there were stand lights furnished at the beginning of the Control Room demolition job but they were blinding. The portable lights were turned away from the work area due to their brightness. Workers and safety personnel stated that, depending on the placement angle of the light, it could result in a blinding glare to workers and heavy equipment operators. (One worker compared it to looking into a flashcube.)

Workers stated that due to the aforementioned lighting inadequacies and dust generated during demolition efforts, overall visibility was somewhat limited. Based on interviews with the workers and the H&S Officer, large quantities of dust were only generated when stirred up by mechanical equipment moving through the area. At the time of the accident, a cable tray abutted Column N25 at an angle just above the top of the block wall, providing a canopy over the edge of the beam.

The EWP hazard analysis recognizes inadequate lighting as a hazard and specified 5 footcandles minimum for demolition. No illumination study was conducted prior to the Control Room demolition. An illumination survey conducted on January 13, 2004, revealed lighting conditions around Column N25 were 1-2 footcandles. Although the survey could only provide an approximation of illumination levels, it concluded, ". . . it is probable that the illumination levels in the immediate area of the block that fell were less than adequate." This survey was conducted after the demolition work was

completed (with the exception of remaining blocks in columns) and after removal of the overhead obstacles (cable trays).

The Board determined that the hazards associated with the K-31 Control Room demolition were not effectively identified, analyzed, and controlled by BNFL. The BNFL management decision to apply the K-33 EWP to the demolition work in K-31 without further analysis was flawed. It was the perception by BNFL management that the interior buildings were similar enough for the work controls and hazards to be identical during demolition activities. However, the configuration of the Control Room walls was different and thus, the hazard analysis did not identify the hazards associated with hand removal of block (whether standing on the floor or utilizing a scissor lift). Workers are a valuable resource in identifying hazards at the task/activity level due to their knowledge of the process and its hazards. However, the work planning process was not sufficient in ensuring that workers were appropriately involved because the FCN for the K-31 demolition work was not as rigorously processed as an original EWP. All types and levels of hazard analysis should provide for worker input to the process. Prior to the demolition activities of the K-31 Control Room, the Foreman and crewmembers conducted a walkdown of the Control Room and did identify that the blocks in the columns were different than what they had previously encountered. At that point, they depended upon the skill of the craft and work experience to perform the work.

3.6.3 Develop and Implement Controls

Applicable standards and requirements are identified and agreed-upon, controls to prevent/mitigate hazards are identified, the safety envelope is established, and controls are implemented.

FCN 1, to Revision 1, changed the use of the EWP to include the K-31 Building and demolition of the interior buildings. The only work step addressing block wall demolition throughout the revisions and FCN was Step 1.3, which states: "For block walls, use mechanical equipment to demolish wall and mechanical equipment with a bucket to load block into intermodals/sealands for disposition."

Since the EWP work steps did not specify detailed work requirements to be used in the K-31 Building (i.e., hand removal of block was not addressed), the unique configuration of the Control Room was not recognized or addressed. The block room demolition for the K-31 task was considered by management to be a routine task. The Foreman and crew relied upon the skill of the craft and experience to perform the work. As a result, the crew operated as a self-directed team. The EWP was written at a high level such that the crew informally depended on themselves to develop adequate work details. The EWP was also unclear and open to different interpretations of the methods (hand tools vs. mechanical equipment) that could be used to perform the work. The EWP work steps specified the use of mechanical equipment but did not define the term. According to the Building Manager and the H&S Officer, hand removal of the blocks was outside the scope of the EWP. Further, the Board concludes that hand removal of blocks using

a scissor lift was also outside the scope of the EWP. The changed condition (i.e., blocks in wide flange of column) was outside the scope of the EWP.

The Building Manager, General Foreman, and the H&S Officer did not recognize the changed condition or observe the hand demolition method used by the Pipefitter. Neither the Foreman nor the crew declared a formal or informal stop work once the change in configuration (blocks within columns) was recognized after the work had begun. BNFL procedure, PR-GM-003, Paragraph 4.1.3.8, states that the Group (Building) Manager, during the EWP Development phase, "Adds, as applicable, the following note at the beginning of the task steps: If you encounter a configuration different than the one for which work steps were developed, or identify that a bounding condition has been violated, stop work in accordance with PR-GM-001, Stop Work Authority." This note was not added into the EWP. The Building Manager is responsible for the overall EWP development, and he had received EWP training.

Training Module 10223, *Stop Work/Communications Training*, and the BNFL Procedure PR-GM-001, *Stop Work Authority*, upon which it is based, omits instructions to stop work ". . . if you encounter a configuration different than the one for which work steps were developed. . ." as described in BNFL Procedure, PR-GM-003. The Building Manager, General Foreman, Foreman, and the crew had not received training on Module 10223. After the accident, the Building Manager did not complete appropriate notification and documentation of the informal stop work, thus the work continued. In addition, once the Building Manager observed the Pipefitter's demonstration of his hand-removal method, the Building Manager became aware that hand-removal methods were being used which were outside the EWP work steps; however, he failed to issue a formal stop work, as required by BNFL procedures.

In addition, BNFL personnel are instructed in the BNFL Training Module 0011, *Quality Assurance,* that they are responsible for "Stopping work when you can't follow the documents or an unsafe condition exists." Employees are required to take this training one time. The Building Manager, General Foreman, Foreman, and the Pipefitter all completed this training. However, after the second converter fire, BNFL determined that the converter crew did not fully understand their stop work authority. As a result, BNFL developed a new Training Module 10223 focused solely on stop work authority (NTS-K31-2001-0001, Item 4). The only employees required to have training on Module 10223 are workers and management involved in converter work. BNFL did not recognize that the lack of understanding on when to stop work by the converter crews was an indicator that additional training was needed to ensure that all BNFL personnel understood their stop work authority.

The injured worker (Pipefitter), crew, and management chain were unaware of the BNFL requirement to report to the Clinic for medical evaluation as required by BNFL Policy PO-SS-301, *Accessing the Medical Clinic and Services*, which states "Workers with occupational injuries and illnesses shall come to the Clinic for treatment." Although the Building Manager, Foremen, and crew encouraged the Pipefitter to go to the Clinic, he was reluctant to go; and his supervision did not require him to go as they

should have in accordance with BNFL policy. The injured Pipefitter remained in the work area. The Board determined that BNFL was not acting within policy controls by allowing the injured Pipefitter to remain in the work area. It is not a safe work practice to allow someone who has been injured, limping, and showing obvious signs of pain to continue to work without medical evaluation.

It is the conclusion of the Board that BNFL did not adequately develop and implement controls for the planned work. Without appropriately analyzing the hazards of the work that is to be performed, implementing controls to ensure worker safety cannot be effectively accomplished. The changed condition (between K-33 and K-31) had not been recognized, hazards were not identified, and detailed job tasks/work steps were not addressed. Additionally, the EWP was written at such a high level that the process to perform the work was unclear and misinterpreted by the Foreman, each crewmember, H&S Officer, General Foreman, and the Building Manager. The Building Manager, General Foreman, and H&S Officer did not recognize the changed condition and did not observe any hand demolition work being performed.

3.6.4 Perform Work Safely

Readiness is confirmed and work is performed safely.

BNFL's craft personnel have experience and knowledge in demolition work. The foremen and crew each have several years of experience in performing industrial work. The Pipefitter is a journeyman with over 20 years experience. In the K-31 demolition work, the EWP was deficient in identifying hazards and delineating specific job tasks/work steps. The work crew relied on on-the-job training (OJT), skill of the craft, and craft cross training to perform the work.

The Pipefitter used an unsafe method by attempting removal of block using hand tools while prying from the center of a 12-foot column of blocks while standing on the floor (in harms way of a potential overhead falling hazard). Analyzing the process as described by the Pipefitter (i.e., top stack sliding down within web), it is unclear to the Board what positive barrier would keep the top stack of blocks within the web of the column after the stack is broken loose from the web (when the stack fell onto the lower stack).

After the accident, the Pipefitter demonstrated for the Building Manager the method he used for removing the blocks, this time using a crow bar to pry at the remaining blocks in the wide-flange steel, which were at approximately 5½ feet from floor level and below. During the demonstration, a couple of the remaining blocks fell out of the wide-flange column. After this demonstration, the Building Manager did not recognize the event (at this time) to be a near miss and did not issue a stop work on block removal using hand tools.

The supervisor position was vacant (duties were being covered by Building Manager and General Foreman). The Removal Operations Manager, Building Manager, General

Foreman, Foreman, H&S Officer, and coworker (Pipefitter Apprentice) were not in the area at the time of the accident. In addition, the Building Manager, Foreman, H&S Officer, and the crewmembers stated they did not observe the Pipefitter's method of performing work. The reduced oversight and work coverage resulted in reducing an important safety barrier and increasing the risk for the workers.

The Board determined that the lack of an effective work control process led to failures in performing the work safely. The proper job tasks/work steps and hazard identification had not been performed to ensure worker safety. The planned K-31 task was considered by BNFL management to be a routine task that could rely upon the skill of the craft. As a result, the BNFL FCN and EWP creation and revision processes did not identify the changed condition; therefore, the unique configuration of the Control Room and specific detailed work requirements were not addressed nor were hazards identified. Additionally, the EWP was written at such a high level that it was unclear and left the determination of exactly how to get the work done to the crew. The crew believed they were working within the scope of the EWP.

3.6.5 Feedback and Improvement

Feedback information on the adequacy of controls is gathered, opportunities for improving the definition and planning of work are identified and implemented, line and independent oversight is conducted, and, if necessary, regulatory enforcement actions occur.

3.6.5.1 BNFL

BNFL's feedback and improvement requirements are included in the *Integrated Safety Management Program Description* (PO-GM-006), which was approved by the DOE Project Manager (also the Contracting Officer's Representative [COR]) on January 14, 2003. Corrective actions are required as part of the Title 10 Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management*, Subpart A, "Quality Assurance Requirements." Specific requirements are described in Paragraph 830.122, Criterion 3, "Management/Quality Improvement." BNFL has a Quality Assurance Program Plan based on the International Standard for Quality Assurance, ISO 9000. BNFL implements Subpart A of 10 CFR 830 through the *East Tennessee Technology Park Three-Building Decontamination and Decommissioning and Recycle Project Quality Assurance Program Plan (QAPP) for 10 CFR 830 Subpart A* (PO-CS-004, Revision 5, dated September 3, 2003).

Requirements for quality improvement and corrective actions include the following:

- Establish and implement processes to detect and prevent quality problems.
- Identify, control, and correct items, services, and processes that do not meet the established requirements.

- Identify the causes of problems and work to prevent recurrence as a part of correcting the problem.

- Review item characteristics, process implementation, and other quality-related information to identify items, services, and processes needing improvement.

The Corrective Action 1.12 to JON 1, closed by BNFL from the converter fire Type B investigation, was to "Improve upon the method in which lessons learned that are identified during the actual use of the EWP are input into the EWP." A review of EWP-CONV-056 reveals that there have been no lessons learned from implementation of this EWP that have been incorporated back into the EWP when it was updated for Revision 1 and the FCNs. The EWP has been in effect since November 2002.

A post-job briefing is not required until all work associated with the EWP is completed. The life cycle of the EWP, which was written for K-33, continues to be extended by adding new scope with each revision and FCN change; thus, the benefit of feedback that could be gained from the post-job brief is further delayed. No post-job briefing was documented for initiation of Revision 0 or Revision 1 work. In addition, no post-job briefing is documented for the EWP 056, R1, FCN 1 initiation (beginning of work in K-31).

The Board determined that the BNFL feedback and improvement process, though well defined, is not effectively implemented. BNFL failed to adequately implement corrective actions to prevent recurrence of the deficiencies identified in the two previous Type B Investigations (1999 Worker Injury and 2002 Converter Fire). Four recurring issues from these Type B reports (EWP implementation, communications, stop work, and training) were identified. Further analyses of these issues are included in Section 3.6.5.3.

3.6.5.2 DOE ORO Line Management

DOE oversight of BNFL consists of a multi-discipline approach. Two facility representatives are assigned full time to the BNFL oversight effort. In addition to the facility representatives, the following disciplines perform oversight of BNFL on a scheduled basis: radiation protection, industrial safety, industrial hygiene, fire protection, emergency management, facility safety/authorization basis, criticality safety, and quality assurance. Historically, industrial safety oversight consists of a scheduled monthly OAV, in addition to quarterly unannounced OAVs by a professional safety engineer who is a Certified Safety Professional. In calendar year 2004, management increased the number of industrial safety OAVs to three each month through March when the workload should drop significantly. Additional industrial safety and other discipline oversight are planned. Reports are generated as a result of the OAVs and forwarded to the COR. The COR enters the data into the ORION2 (Oak Ridge Issues Open Items and Nonconformances) database and forwards the report to the contractor. The contractor's responses are shared with the SMEs who raise any concerns with the corrective actions proposed to the COR or facility representatives for resolution.

As a result of problems identified in safety performance during December, the AMEM issued a letter (December 22, 2003) to BNFL which transmitted an increased OAV schedule for calendar year 2004. The letter indicated that more frequent walkthroughs and attendance at project safety and operations type meetings would occur by the ORO staff. Concern was expressed over three serious accidents occurring within a three-week period the first half of December 2003. These accidents were: (1) December 3 – Laborer fell off a ladder breaking his arm (ORPS Occurrence Report ORO-BNFL-K31-2003-0002), (2) December 8 – Near miss when a cable that pulled a gantry (i.e., a cart on a rail system with a winch mechanism for movement) was severed and the recoil missed an employee by five feet (ORPS Occurrence Report ORO-BNFL-K32-2003-0004), and (3) December 17 – The Pipefitter's foot injury covered by this investigation (ORPS Occurrence Report ORO-BNFL-K31-2003-0003). The importance of safety in every facet of the work activities was expressed as well as the increased number of OAVs scheduled for 2004.

The level of oversight for demolition activities appears to be adequate for the work being performed. However, facility representative coverage was not adequate on the day of the accident because one Facility Representative was assigned to an SEB and one Facility Representative was on vacation.

3.6.5.3 Analysis of Recurring Issues

The Board performed an analysis of issues from two previous ORO Type B Accident Investigations of BNFL (DOE/ORO-2083, *Type B Accident Investigation Board Report on the Worker Injury at the BNFL ETTP Three-Building Decontamination and Decommissioning and Recycle Project Site*, May 1999, and DOE/ORO-2132, *Type B Accident Investigation Exothermic Metal Reaction Event During Converter Disassembly in Building K-33 at the East Tennessee Technology Park on June 27, 2002*, July 2002) and compared them to the employee foot injury Type B Accident Investigation. The analysis revealed the following:

- The Corrective Action 1.12 to JON 1, closed by BNFL from the converter fire Type B investigation, was to "Improve upon the method in which lessons learned that are identified during the actual use of the EWP are input into the EWP." A review of EWP-CONV-056 reveals that there have been no lessons learned from implementation of this EWP that have been incorporated back into the EWP when it was updated for Revision 1 and the FCNs. The EWP has been in effect since November 2002.

- As a corrective action from the second K-31 tube bundle fire (NTS-K31-2001-0001, Item 4), BNFL developed *Stop Work/ Communications Training*, Module 10223, and added a training requirement for personnel doing converter work but not for other BNFL personnel. The corrective action to prevent recurrence should have been more comprehensive than for those performing converter work. The Board

concludes that the training requirement should have been added to the training needs assessment checklist and training provided for all workers and management.

Table 3-1 summarizes four recurring issues and the corresponding JONs from each investigation.

Table 3-1. Comparison of Similar Issues from Previous BNFL Accident Investigation Judgments of Need

Issue	JUDGMENTS OF NEED		
	Employee Foot Injury Type B	**Converter Fire Type B**	**Worker Injury Type B**
1. EWP Implementation	JONs 2 and 4	JONs 2 and 7	BNFL JON 2 *IDM JONs 1 and 5
2. Communications	JONs 1, 3, 5, and 6	JONs 1 and 5	BNFL JON 3 IDM JON 4
3. Stop Work	JON 1		IDM JONs 3 and 5
4. Training	JONs 3, 4, and 5	JONs 2 and 5	IDM JONs 1 and 2

*BNFL Subcontractor—IDM Environmental Corporation

The work control process at BNFL is the Enhanced Work Planning Process; however, problems with implementation of this process have been identified since the 1999 Worker Injury Type B Accident Investigation. Overhauls of the process have been performed over the years, but problems encountered with the EWP-CONV-056 implementation indicate that the process is still not at the mature level necessary to ensure worker safety. It appears the rigor of implementation has reduced over the past year possibly due to the forthcoming completion of work activities. Several interviewees indicated that worker and foremen involvement in the EWP process has not been occurring. As a result, knowledge of the work control process has been affected. Also, BNFL has taken an EWP for one job and made it "fit" work in a similar building without analyzing the changes in building configuration and work controls.

Communications across all levels of staff have been less than adequate over the past several years. Lack of worker involvement, feedback, and continuous improvement is highlighted as a result of this Type B investigation. Communications across shifts and among workers on the same job continue to be less than adequate.

In the 1999 Type B, subcontractor employees did not understand the use of stop work authority. This investigation has revealed inconsistencies in communicating informal and formal stop work to the shift manager and the working level. Also, workers are not aware that stop work must be initiated when conditions on the job site are different than that identified in the EWP. For example, the EWP for the K-31 work required use of mechanical equipment while, in fact, the employees were performing the work by use of hand tools because of the building configuration.

Training needs range from the subcontractor employees (in 1999) requiring training on the EWP process and its implementation to training on the EWP for BNFL employees has been less than adequate (in 2002). During this investigation, several training needs were identified. BNFL needs to increase formality and rigor of daily operations' communication mechanisms and training to ensure appropriate knowledge and direction are provided to management and workers.

The Board concludes that BNFL and DOE ORO have not taken effective corrective actions to prevent recurrence of similar type events. While these four issues were not the root causes, they were contributing factors in the accidents. BNFL has not ensured that corrective actions are comprehensive, and DOE ORO line management has not been able to ensure during validation efforts that closure of these actions would effectively resolve the issue and prevent recurrence.

Table 3-2. Weaknesses in Implementation of the ISM Core Functions

There are weaknesses in BNFL's implementation of the five Core Functions of ISM that contributed to this event. These weaknesses include the following:
Core Function 1 **Define the Work** • Supervision relied too heavily on OJT and "skill of the craft" to implement work steps not covered in the EWP. • Foreman and crew interpreted "hand tools," as listed in the hazard analysis, as covering any use of hand tools needed to get the job done. Management and safety representatives interpreted "hand tools" to mean brooms, shovels, etc., for cleanup. • It is not known which workers, if any, were involved in the planning and preparation of the EWP because it does not identify the "Work Team" representatives. • No validation walkdown was conducted in K-31 during development of the EWP, Rev 1, FCN 1. • Training on the EWP process is not provided to General Foremen, Foremen, and crew who are supposed to be participating in the development, review, implementation, and evaluation phases of the EWP. • Roles and responsibilities were not clearly defined and documented. **Contributing Causes:** 1, 2, 3, 8, and 9
Core Function 2 **Analyze the hazards** • The hazard analysis used was developed on the conditions within the K-33 Building, not the K-31 Building. • Assumption was made that the K-31 and K-33 Control Room construction were the same configuration. • The hazard analysis did not identify the hazards associated with hand removal of block (whether standing on floor or utilizing scissor lift) and did not provide adequate controls. • BNFL Engineering was not contacted to establish specific requirements associated with the room construction as required by the EWP. • Personnel conducting walkdowns failed to recognize hazards associated with the different Control Room configuration. • Management perception existed that the Operations Floor (and Control Room) block room demolition was a lower relative risk. • An illumination survey conducted on January 13, 2004, revealed lighting conditions around Column N25 were 1-2 footcandles. Although the survey could only provide an approximation of illumination levels, it concluded "it is probable

that the illumination levels in the immediate area of the block that fell were less than adequate." The EWP hazard controls specified 5 footcandles minimum.

Contributing Causes: 2, 3, and 7

Core Function 3

Develop and Implement Controls

- The FCN and EWP creation and revision process did not address the unique configuration of the Control Room and did not specify detailed work requirements (i.e., hand removal of block was not addressed).
- The FCN and EWP creation and revision processes did not identify the change in configuration of the blocks within the wide-flange columns.
- The FCN and EWP creation and revision processes did not prompt the consideration of alternative methods to remove the blocks from the wide-flange columns.
- The block room demolition for the K-31 task was considered by management to be a routine task that relied upon the skill of the craft.
- Crew operated as a self-directed team.
- The EWP was unclear and open to different interpretations of methods that could be used to perform the work.
- BNFL Procedure PR-GM-003, Section 4.1.3.8, states to "Adds, as applicable, to the EWP: If you encounter a configuration different than the one for which work steps were developed, or identify that a bounding condition has been violated, stop work in accordance with PR-GM-001, Stop Work Authority." This statement was not included in EWP 056.
- The *Stop Work/Communications Training* (Module 10223), and the BNFL Procedure PR-GM-001, *Stop Work Authority*, upon which it is based, omits instructions to stop work ". . . if you encounter a configuration different than the one for which work steps were developed. . ." as described in BNFL Procedure, PR-GM-003.
- The Building Manager had not received training Module 10223 on stop work/communications.
- The Building Manager did not declare a formal stop work.
- The Building Manager did not complete appropriate notifications and documentation of the informal stop work.
- The General Foreman had not been given, nor is required to take, training Module 10223 on stop work/communications.
- Neither the Foreman nor the crew declared a formal or informal stop work.
- Neither the Foreman nor the crew had been given, nor are they required to take, training Module 10223 on stop work/communications.
- Injured worker and management chain were unaware of the BNFL requirement to report to the Clinic for medical evaluation.

Contributing Causes: 1, 2, 3, 8, 9, and 10

Core Function 4

Perform Work Safely

- The Pipefitter used an unsafe method by attempting removal of block using hand tools while prying from the center of a 12-foot column of blocks while standing on the floor (in harms way of a potential overhead falling hazard).
- Analyzing the process as described by the Pipefitter (i.e., top stack sliding down within web), it is unclear to the Board what positive barrier would keep the top stack of blocks within the web of the column after the stack is broken loose from the web (when the stack fell onto the lower stack).
- The use of a scissor lift and top-down approach to remove block from the wide flange was a safer method of block demolition; however, it was a hand method of demolition not addressed in the EWP. A stop work and contacting the supervisor would have been the appropriate actions to take when the new condition was encountered and mechanical means could not be used to perform the work.
- BNFL did not issue a formal stop work until nearly a month after the accident.
- The Building Manager failed to issue a formal stop work on 12/17/2003 upon learning of the hand removal method after the accident, as required by BNFL Procedure PR-GM-001, *Stop Work Authority,* Section 3.3.
- The informal stop work was not communicated to the Foreman and crew, and appropriate notifications and required documentation in the shift log and POD were not performed.
- BNFL management failed to follow the EWP, Step 1.1, requirement to contact Engineering prior to demolition.
- One crewmember was reassigned the day preceding and the day of the accident (Pipefitter Apprentice), and the remaining crewmembers stated they did not see the Pipefitter performing the work or how he had been doing the block removal which had been going on for at least 2½ days.
- The supervisor position was vacant (duties were being covered by Building Manager and General Foreman). The Removal Operations Manager, Building Manager, General Foreman, Foreman, H&S Officer, and coworker (Pipefitter Apprentice) were not in the area at the time of the accident. The reduced oversight and work coverage resulted in reducing an important safety barrier and increasing the risk for the workers.
- The EWP hazard controls specified 5 footcandles minimum. Workers reported that while they were doing the work there was very poor lighting in the area, and they had complained. Overhead lighting was not relamped prior to doing the work. Florescent lights were not in the immediate work area. Stand lights were furnished but did not provide an effective solution because of the glare. It was generally known that lighting conditions were poor. No illumination survey was requested or performed prior to conducting the Control Room demolition.
- Adequate resources to perform the work were not continuously available (i.e., rubble was in work area because equipment [i.e., skid loader] needed to remove rubble was unavailable at the start of the job; the shovel on the trackhoe was not the appropriate attachment to use for mechanical removal of the block from the

wide flange).

- The only "mechanical equipment" being used for block wall demolition was the trackhoe with a 30-inch wide bucket. The wide-flange column containing the blocks has an inside width of 12½ inches. According to the manufacturer of the trackhoe, the use of this equipment is not recommended if the desire is to leave the wide-flange column intact.
- Based on interviews with the crew, mental attitude and haste may have factored into the decision to proceed with removal of the blocks remaining in the wide-flange columns instead of waiting until after the debris from the wall and roof demolition had been cleaned up. Some interviewed stated they intended to remove all the block so the area could be cleaned up at one time and have the debris put into the Sealand container before the container was moved to the next area. Also mentioned was the need to stay busy and that workers were being laid off as the project progressed toward completion.

Contributing Causes: 1, 3, 4, 5, 6, 7, 8, 9, 10, and 11

Core Function 5

Feedback and Improvement

- The Corrective Action 1.12 to JON 1, closed by BNFL from the converter fire Type B investigation, was to "Improve upon the method in which lessons learned that are identified during the actual use of the EWP are input into the EWP." A review of EWP-CONV-056 revealed that there have been no lessons learned from implementation of this EWP that have been incorporated back into the EWP when it was updated for Revision 1 and the FCNs. The EWP has been in effect since November 2002.
- A post-job briefing is not required until all work associated with the EWP is completed. The life cycle of the EWP, which was written for K-33, continues to be extended by adding new scope with each revision and FCN change; thus, the benefit of feedback that could be gained from the post-job brief is further delayed. No post-job briefing was documented for initiation of Revision 0 or Revision 1 work. In addition, no post-job is documented for the EWP 056, R1, FCN 1 initiation (beginning of work in K-31).
- Based on interviews with the foremen, crew, and some managers, none had participated in a post-job briefing from prior EWP work.
- As a corrective action from the second K-31 tube bundle fire (NTS-K31-2001-0001), BNFL developed *Stop Work/Communications Training*, Module 10223, and added a training requirement for personnel doing converter work but not for other BNFL personnel. The corrective action to prevent recurrence should have been more comprehensive than just those performing converter work.
- The Board concludes that the training requirement should have been added to the training needs assessment checklist and training provided for all workers and management.
- BNFL Procedure PR-AD-007 was revised to address the JON. This procedure was

replaced by PR-GM-004, Revision 0, *Lessons Learned Process*, on 12/31/02. The procedure in Section 4.3.1 requires that the task group hold a post-job briefing following the first use of a new or revised EWP. Also, BNFL Procedure PR-GM-003, *Enhanced Work Planning*, Section 4.4.5.1, requires a post-job briefing (1) after the first performance, (2) following an incident, or (3) if requested. The two procedures are inconsistent in the requirements for when post-job briefings must be conducted.

Contributing Causes: 4, 8, and 11

Conclusion:
The above weaknesses in the implementation of the ISM Core Functions were determined to have contributed to the event. The lack of an effective work planning process was further determined to be the Root Cause of this accident.

4.0 CONCLUSIONS AND JUDGMENTS OF NEED

Conclusions are a synopsis of the facts and analyses that the Board considers significant. JONs (Table 4-1) 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 causal factors, which are derived from facts and analyses and form the basis for corrective action plans, which are the responsibility of line management.

The Board reviewed the work controls involving block room demolition, response to the accident, and corrective actions associated with previous DOE ORO Type B accident investigations of BNFL. The results of these reviews were factored into the analysis of the five Core Functions of ISM.

The JONs are focused on management systems and will accomplish the following:

- Increase management-worker communications and worker involvement in work planning to improve performance,
- Manage performance to ensure that managers and workers conduct work within controls,
- Ensure appropriate and consistent responses to accidents and changes to unanticipated conditions encountered during operations, and
- Ensure that DOE evaluates performance of work within controls and validates closure of corrective actions to ensure comprehensive solutions to prevent recurrence.

It is the conclusion of the Board that the work control process was not adequate to ensure worker safety or meet the requirements of the ISM Core Functions. Processes associated with work control (i.e., stop work, rigor of daily operations, communications, timely response to incidents, an ineffective corrective action program, oversight, and application of lessons learned) were also determined to have contributed to the event. BNFL did not adequately address revisions and FCN changes to ensure that work steps and identification and control of hazards were applied to the new work scope.

Also, the Board concludes that BNFL continues to fall short of comprehensive application and programmatic correction to prevent recurrence of similar deficiencies in other areas of the project (based on this investigation and the two previous Type B investigations [see Table 3-1.]). DOE ORO line management has not ensured that Corrective Action Plans and validation of corrective action closures consider negative trends and provide comprehensive solutions to prevent recurrence and sustain higher performance. Although DOE ORO had increased the BNFL Facility Representative coverage, this was not sustained on the day of the accident (one Facility Representative on SEB and one Facility Representative on vacation).

Table 4-1. Judgments of Need

JON No.	Judgment of Need	Contributing and Root Causes
Conduct of Work		
JON 1	BNFL needs to ensure that the Stop Work process (informal and formal) is clear and understood by management and workers and fully institutionalized for all work activities.	CC-1: Unapproved and improper work methods were used to remove blocks from wide-flange columns. CC-3: Implementation of the EWP was less than adequate. CC-6: Oversight of the job task was less than adequate. CC-8: Communications were less than adequate in ensuring safe conduct of work, in obtaining prompt medical attention for the injured worker, and in ensuring that appropriate personnel were cognizant of the informal stop work. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident. CC-10: BNFL personnel failed to follow company policy, procedure, and EWP requirements. CC-11: BNFL's response to the accident was less than adequate. CC-12: DOE ORO's response to the accident was less than adequate. RC-1: BNFL failed to implement an effective work planning process.

Table 4-1. Judgments of Need (continued)

JON No.	Judgment of Need	Contributing and Root Causes
JON 2	The BNFL EWP process needs to ensure that all ISM Core Functions are addressed and implemented.	CC-1: Unapproved and improper work methods were used to remove blocks from wide-flange columns. CC-2: The EWP and FCN preparation and planning process was less than adequate in providing the job steps needed to safely perform Control Room demolition. CC-3: Implementation of the EWP was less than adequate. CC-4: Application of lessons learned was less than adequate. CC-5: Identification, analysis, and control of the hazards associated with hand removal of concrete block from the column were less than adequate. CC-7: Working conditions did not meet the EWP specified hazard controls or were less than adequate during job task performance. CC-8: Communications were less than adequate in ensuring safe conduct of work, in obtaining prompt medical attention for the injured worker, and in ensuring that appropriate personnel were cognizant of the informal stop work. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident. CC-10: BNFL personnel failed to follow company policy, procedure, and EWP requirements. RC-1: BNFL failed to implement an effective work planning process.
JON 3	BNFL needs to increase formality and rigor of daily operations' communications to ensure appropriate knowledge and direction are provided to management and workers to perform work safely.	CC-1: Unapproved and improper work methods were used to remove blocks from wide-flange columns. CC-3: Implementation of the EWP was less than adequate. CC-4: Application of lessons learned was less than adequate. CC-8: Communications were less than adequate in ensuring safe conduct of work, in obtaining prompt medical attention for the

Table 4-1. Judgments of Need (continued)

JON No.	Judgment of Need	Contributing and Root Causes
		injured worker, and in ensuring that appropriate personnel were cognizant of the informal stop work. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident. CC-10: BNFL personnel failed to follow company policy, procedure, and EWP requirements. RC-1: BNFL failed to implement an effective work planning process.
JON 4	BNFL needs to revise EWP-CONV-056 so that all ISM Core Functions are incorporated at a level to ensure safe demolition.	CC-1: Unapproved and improper work methods were used to remove blocks from wide-flange columns. CC-2: The EWP and FCN preparation and planning process was less than adequate in providing the job steps needed to safely perform Control Room demolition. CC-3: Implementation of the EWP was less than adequate. CC-4: Application of lessons learned was less than adequate. CC-5: Identification, analysis, and control of the hazards associated with hand removal of concrete block from the column were less than adequate. CC-7: Working conditions did not meet the EWP specified hazard controls or were less than adequate during job task performance. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident. RC-1: BNFL failed to implement an effective work planning process.

Table 4-1. Judgments of Need (continued)

Accident Response		
JON 5	BNFL needs to strengthen and implement their policy to ensure accident responses are appropriate, timely, and the staff trained.	CC-8: Communications were less than adequate in ensuring safe conduct of work, in obtaining prompt medical attention for the injured worker, and in ensuring that appropriate personnel were cognizant of the informal stop work. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident. CC-10: BNFL personnel failed to follow company policy, procedure, and EWP requirements. CC-11: BNFL's response to the accident was less than adequate. RC-1: BNFL failed to implement an effective work planning process.
JON 6	BNFL needs to review their medical evaluation and treatment process and incorporate improvements.	CC-10: BNFL personnel failed to follow company policy, procedure, and EWP requirements. CC-11: BNFL's response to the accident was less than adequate. RC-1: BNFL failed to implement an effective work planning process.
Feedback and Improvement		
JON 7	BNFL needs to ensure that Type B and other corrective actions are implemented and applied project wide to prevent recurrence.	CC-2: The EWP and FCN preparation and planning process was less than adequate in providing the job steps needed to safely perform Control Room demolition. CC-4: Application of lessons learned was less than adequate. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident. RC-1: BNFL failed to implement an effective work planning process.

Table 4-1. Judgments of Need (continued)

JON 8	BNFL needs to ensure that lessons learned are continuously incorporated and applied in the EWP process.	CC-2: The EWP and FCN preparation and planning process was less than adequate in providing the job steps needed to safely perform Control Room demolition. CC-3: Implementation of the EWP was less than adequate. CC-4: Application of lessons learned was less than adequate. CC-8: Communications were less than adequate in ensuring safe conduct of work, in obtaining prompt medical attention for the injured worker, and in ensuring that appropriate personnel were cognizant of the informal stop work. RC-1: BNFL failed to implement an effective work planning process.
Management Oversight		
JON 9	BNFL needs to ensure that its management oversight systems are effectively implemented and reinforce all ISM Core Functions.	CC-1: Unapproved and improper work methods were used to remove blocks from wide-flange columns. CC-3: Implementation of the EWP was less than adequate. CC-5: Identification, analysis, and control of the hazards associated with hand removal of concrete block from the column were less than adequate. CC-6: Oversight of the job task was less than adequate. CC-7: Working conditions did not meet the EWP specified hazard controls or were less than adequate during job task performance. CC-8: Communications were less than adequate in ensuring safe conduct of work, in obtaining prompt medical attention for the injured worker, and in ensuring that appropriate personnel were cognizant of the informal stop work. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident. CC-10: BNFL personnel failed to follow company policy, procedure, and EWP requirements. CC-11: BNFL's response to the accident was

Table 4-1. Judgments of Need (continued)

		less than adequate. RC-1: BNFL failed to implement an effective work planning process.
JON 10	BNFL needs to ensure roles and responsibilities are clearly defined and communicated project wide.	CC-6: Oversight of the job task was less than adequate. CC-8: Communications were less than adequate in ensuring safe conduct of work, in obtaining prompt medical attention for the injured worker, and in ensuring that appropriate personnel were cognizant of the informal stop work. CC-11: BNFL's response to the accident was less than adequate. RC-1: BNFL failed to implement an effective work planning process.
DOE Oversight		
JON 11	DOE ORO line management needs to strengthen the validation process to ensure the contractor is implementing appropriate corrective actions to prevent recurrence.	CC-1: Unapproved and improper work methods were used to remove blocks from wide-flange columns. CC-3: Implementation of the EWP was less than adequate. CC-4: Application of lessons learned was less than adequate. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident. CC-10: BNFL personnel failed to follow company policy, procedure, and EWP requirements. CC-12: DOE ORO's response to the accident was less than adequate. RC-1: BNFL failed to implement an effective work planning process.
JON 12	DOE ORO line management needs to ensure the contractor is performing effective trending and analysis of corrective actions.	CC-1: Unapproved and improper work methods were used to remove blocks from wide-flange columns. CC-3: Implementation of the EWP was less than adequate. CC-4: Application of lessons learned was less than adequate. CC-9: Training of management and workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the

Table 4-1. Judgments of Need (continued)

		accident. CC-10: BNFL personnel failed to follow company policy, procedure, and EWP requirements. CC-12: DOE ORO's response to the accident was less than adequate. RC-1: BNFL failed to implement an effective work planning process.

5.0 BOARD SIGNATURES

Teresa C. Perry, Chairperson
DOE Accident Investigation Board
U.S. Department of Energy
Oak Ridge Operations Office

Jenny Mullins, Accident Investigator*
DOE Accident Investigation Board
U.S. Department of Energy
Oak Ridge Operations Office

Charles R. Eberle, Facility Representative
DOE Accident Investigation Board
U.S. Department of Energy
Oak Ridge Operations Office

*The original Accident Investigator (Jacqueline Noble-Dial) assigned to the Board was unable to complete the investigation and was replaced during the analysis phase of the investigation.

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6.0 BOARD MEMBERS, ADVISORS, AND STAFF

Chairperson	Teresa Perry, DOE ORO
Member	Charles R. Eberle, DOE ORO
Member (Trained Accident Investigator*)	Jenny Mullins, DOE ORO
Safety Advisor	Dean Sheridan, DOE ORO
Legal Advisor	Terri Slack, DOE ORO
Technical Support	Sheila Thornton, Parallax, Inc.

*The original Accident Investigator (Jacqueline Noble-Dial) assigned to the Board was unable to complete the investigation and was replaced during the analysis phase of the investigation.

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Appendix A – Appointment of Type B Accident Investigation Board

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DOE F 1325.8
(3/96)

United States Government **Department of Energy**
Oak Ridge Operations Office

memorandum

DATE: January 15, 2004

REPLY TO
ATTN OF: SE-32:Mullins

SUBJECT: **TYPE B INVESTIGATION – EMPLOYEE FOOT INJURY ON DECEMBER 17, 2003, BUILDING K-31, BNFL INC. – OAK RIDGE, TENNESSEE**

TO: Teresa C. Perry, Quality Assurance Team Lead, Assessment and Emergency Management Division, SE-32

You are hereby appointed Chairperson of the Investigation Board to investigate the subject incident that occurred at Building K-31, BNFL Inc., located 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 Investigation,* 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:

Jacqueline Noble-Dial, Environmental Technology Group, Accident Investigator
Chuck Eberle, Facility Representative, Member
Dean Sheridan, Industrial Safety Subject Matter Expert, Advisor
Terri Slack, Office of Chief Counsel, Legal Advisor

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. The scope will also include an analysis of the application of lessons learned from similar accidents within the Department.

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 the contractor for factual accuracy review prior to the report finalization.

The final investigation report should be provided to me by February 17, 2004. Any delay to 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 Robert Poe at 576-0891.

for Gerald G. Boyd
Manager

Attachment:
ORO AI Guidelines

cc w/attachment:
Jacqueline Noble-Dial, EM-90, ORO
Dean Sheridan, SE-31, ORO
Chuck Eberle, EM-94, ORO
Terri Slack, CC-10, ORO

cc w/o attachment:
Beverly A. Cook, EH-1, HQ/FORS
Jessie H. Roberson, EM-1, HQ/FORS
Paul M. Golan, EM-1, HQ/FORS
Patrice M. Bubar, EM-20, HQ/FORS
Milt D. Johnson, SC-3, HQ/FORS
Raymond J. Hardwick, EH-2, HQ/FORS
Robert A. Crowley, EH-2, HQ/FORS
Robert J. Brown, M-2, ORO
Steven L. Wyatt, M-4, ORO
Robert W. Poe, SE-30, ORO
Jack L. Howard, EM-90, ORO
Stephen H. McCracken, EM-90, ORO
Randall C. Smyth, EM-90, ORO
Tim Noe, EM-94, ORO
Jennifer Fowler, CC-10, ORO
Harold Monroe, SE-31, ORO

DOE F 1325.8
(3/96)

United States Government **Department of Energy**
Oak Ridge Operations Office

memorandum

DATE: February 20, 2004

REPLY TO
ATTN OF: SE-32:Perry

SUBJECT: **BOARD MEMBER SUBSTITUTION – TYPE B INVESTIGATION OF THE EMPLOYEE FOOT INJURY – BNFL INC.**

TO: Gerald G. Boyd, Manager, M-1

Due to personal circumstances, the trained accident investigator, Jacquie Noble-Dial, was unable to complete the investigation. To ensure a seamless transition, Jenny Mullins began assuming those responsibilities on February 13, 2004. Ms. Mullins serves as the ORO Accident Investigation Point-of-Contact, has extensive training and investigation experience, and is highly qualified to continue the investigation to its completion. This action has been coordinated with EM and ES&H management. Please indicate by your signature below your concurrence with this action.

If you have any questions, please contact me at 576-8473 or Bob Poe at 576-0891.

Teresa C. Perry
Chairperson

Approved

Date 2/18/04

cc:
J. Mullins, SE-32
J. Noble-Dial, EM-90
S. McCracken, EM-90
R. Poe, SE-30
R. Smyth, EM-90
R. Sleeman, EM-90
D. Allen, SE-32
B. Hawks, SE-32

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Appendix B – Barrier Analysis

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Table B-1. Barrier Analysis

Barrier	Purpose	Analysis/Effect on Accident
Management Barriers		
EWP CONV-056 R1 FCN-1	To provide detailed planning of work by all persons involved, analyze hazards expected to be encountered by workers, and provide controls to mitigate hazards so that work can be accomplished safely	Barrier failed because: Vague description of job task. Assumptions that work and hazards were the same as K-33. Hazard analysis of wall demolition task in Building K-31 was not performed. "Mechanical equipment" not defined and was interpreted differently by personnel.
SME involvement/ evaluation	To establish specific requirements associated with the room construction, prior to demolition	Barrier failed because Engineering was not contacted prior to room demolition in K-31, as specified in EWP CONV-056 R1 FCN-1 (Step 1.1). Unique block-wall configuration may have been noticed and work appropriately planned. H&S Officer was not involved in walkdown with Foreman and crew prior to Control Room demolition.
Hazard Analysis	To identify the hazards expected to be encountered, provide controls to mitigate hazards, and revise hazard analysis to conform to changing conditions	Barrier failed because the HA was inadequate of the K-31 block wall demolition (especially for new configuration of Control Room Building). Adequate hazard controls were not put in place due to inadequate hazard analysis. Worker safety was jeopardized.

Table B-1. Barrier Analysis (continued)

Barrier	Purpose	Analysis/Effect on Accident
Pre-Job Briefs	To provide and clarify directions to workers regarding task assignments, hazards present, and hazard controls to be used	The pre-job brief (EWP CONV-056 R1 FCN-1) failed as the first step in implementing the EWP for the K-31 Control Room demolition. As a result of having a vague description in the EWP, the pre-job briefing did not provide adequate details to the workers on performing the job task.
Toolbox Meetings/Training	To discuss with and train employees on how to perform job assignments safely, efficiently, and properly	Barrier failed because unique configuration in Building K-31 was not assessed. Methods for safe removal of block from wide-flange column were not discussed.
Stop Work	To stop work and seek corrective actions when in the presence of a previously unidentified and unmitigated hazard	Stop work not initiated when conditions changed (i.e., block-wall configuration). Stop work not initiated when unsafe block removal method was used. However, after the accident, the Foreman and crew determined that future hand removal of block from columns would not be done without the use of a scissor lift. Stop work not initiated after Pipefitter demonstrated hand tool block removal (not in EWP) to Building Manager. Stop work not initiated when worker was injured. No evidence was found to substantiate an informal stop work as stated by BNFL management. Formal stop work for hand removal of block was not put in place until 1/13/04, and the accident occurred on 12/17/03. Lessons learned documented in the EWP concerning stop work was not applied.

Table B-1. Barrier Analysis (continued)

Barrier	Purpose	Analysis/Effect on Accident
Supervision	To assist in work planning, conduct safety meetings, make work assignments, ensure roles and responsibilities are clearly defined, provide directions to workers regarding task performance and hazard mitigation, and make corrections, as required	Barrier failed because detailed planning was not provided for this job task; job hazards were not adequately identified; and hazards present were not controlled. No supervisory oversight in the area at time of accident (i.e., Foreman, General Foreman, Supervisor [vacant position], Building Manager, Removal Operations Manager, General Manager). No up-to-date organizational chart for Removal Operations and no position descriptions on file for Foreman and crewmembers.
Independent Surveillance/ Assessment	To assist in identifying and correcting unsafe working conditions	Barrier failed because surveillance personnel (Safety, Radiation Protection, and Quality Assurance) were not in the area when the accident occurred and did not observe hand removal previously being performed. ORO Facility Representative coverage was not adequate due to holiday leave.
On-site Medical Services	To ensure prompt and efficient assessment/treatment of injuries and illnesses	Barrier failed because worker did not report to the Clinic and continued to work. Building Manager, Supervisor, General Foreman, and Foreman did not require the Pipefitter to go to the Clinic for evaluation or treatment.
Walkdown of Job Site	To familiarize supervision and crew with the specific scope and hazards of the task and consider alternate methods to accomplish the work safely and efficiently	Barrier failed because no consideration was given to the potential hazards of the demolition after observing the different configuration of the block-wall construction during informal walkdown; therefore, no instructions were provided to the crew on how to perform the task safely and efficiently.
Communications Between Workers	Exchange lessons learned and techniques to facilitate safe job task performance and	Barrier was not effective because frequent reassigning of workers familiar with the job task and crew to other tasks impaired communications and utilization of lessons learned.

Table B-1. Barrier Analysis (continued)

Barrier	Purpose	Analysis/Effect on Accident
	completion	Worker was placed at greater risk while operating outside of analyzed parameters in an unsafe manner.
Physical Barriers		
Worker PPE	Personnel safety	Barrier failed to mitigate injury because the hazard was well beyond the limitation of the PPE (steel-toe boot). Improper PPE for wall block removal (i.e., PAPR with cutting shield raised) limited worker's ability to see above his head.
Working Condition (i.e., lighting)	To provide adequate visibility to perform job tasks	Barrier failed to provide adequate illumination per EWP. Restricted visibility thereby placing personnel at greater risk.
Mechanical Equipment (skid loader, trackhoe)	Safe and efficient removal operations	Barrier failed because mechanical means were not used to remove block from wide-flange column. EWP did not specify the type of mechanical equipment to use, and the available equipment did not provide a practical means to perform block removal from the columns.

Appendix C – Change Analysis

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Table C-1. Change Analysis

Normal "Ideal"	Actual	Analysis
Workers in composite crew receive formal documented cross-training for various tasks	Supervisors reassign workers to perform cross-craft tasks as needed (i.e., pipefitters performing laborer tasks, laborers performing pipefitter tasks).	No formal OJT documentation suggests that workers may not have been consistently or adequately trained to new work assignment.
Use of proper worker PPE	Proper PPE was used for methods and hazards specified in EWP.	Hazards were not analyzed in EWP for hand removal of block from wide-flange column. There is no standard PPE that would have protected worker from overhead block falling.
Training provides detailed task specific direction to workers and is given real-time	Training was not task specific and was provided well in advance of performance of work.	Lack of documentation (i.e., Toolbox meetings/training) suggests that workers were not sufficiently trained on work assignments and associated hazards. Lack of documentation (i.e., EWP, Toolbox, walkdown) suggests that workers did not identify hazards associated with the task.
Workers/supervisors can stop work when in the presence of an unidentified and unmitigated hazard	Crew continued task in an unsafe manner.	Workers/supervisors did not recognize hazards involved in continuing work; therefore, stop work was not initiated. Workers were not provided adequate information to allow them to determine unsafe conditions. Lessons learned documented in the EWP concerning stop work was not applied. The Building Manager did not ensure stop work was issued in a timely manner and understood.

Table C-1. Change Analysis (continued)

Normal "Ideal"	Actual	Analysis
Communications between workers is continuous and effective	Workers frequently reassigned to other tasks and other crews.	Frequent reassignment of workers familiar with the crew and task to other tasks impaired communications and utilization of lessons learned.
EWP provides for detailed work planning, hazard analysis and mitigation, job-specific training, and detailed task direction	The EWP did not provide instructions on the level of detail required for each step to complete the task; detailed planning was not provided for the new task; and a formal hazard analysis was not performed.	EWP was deficient in analyzing changes to the K-31 Building configuration (i.e., Control Room block wall) and associated hazards. Instructions were not created with the level of detail required for each step to complete the task to ensure consistent safe demolition.
The FCN-1 and EWP-CONV-056 revision process identifies the hazards in Building K-31	The FCN-1 and EWP-CONV-056 revision process did not identify the hazards associated with the unique configuration of the Control Room and did not prompt consideration of alternative methods to remove the block wall from the wide-flange column.	Identification of new hazards before operations commence ensures worker safety by using proper removal methods for block wall demolition in wide-flange column.
Safety personnel interject themselves into all aspects of the project that may affect safety	Safety personnel were not cognizant of the unsafe block wall demolition methods.	Safety personnel were reassigned to a higher priority task during this phase of wall removal.
Management/ Supervision ensures roles and responsibilities are clearly defined, provides task direction for workers, identifies hazards associated with the work, controls activities	Management/ Supervision did not clearly define roles and responsibilities, identify hazards associated with the unique wall configuration, did not provide corrections to methods used to remove the block from	Inadequate level of Management/Supervision allowed work to be performed using methods that placed workers at risk. Roles and responsibilities are not clearly defined. The BNFL organizational chart has not been kept up to date and some personnel do not have position descriptions.

Table C-1. Change Analysis (continued)

Normal "Ideal"	Actual	Analysis
associated with work, and provides corrections where required	the wide-flange column, and did not stop work immediately.	
Injured workers receive prompt medical evaluation/treatment for injury or illness	Worker did not receive medical evaluation/treatment for 10+ hours.	Worker indicated the injury was minor; and management, supervisors, and coworkers did not challenge the worker's assessment. The delay in evaluation/treatment may have worsened the injury.
Working conditions provide adequate lighting and are conducive to safe and efficient work environment	Lighting conditions were less than adequate.	Lighting (i.e., facility lighting, supplemental light stands, haze from dust, interference of cable tray) provided less than adequate illumination as required by the EWP (5 footcandles); restricted visibility thereby placed workers at greater risk.
Mechanical equipment (i.e., trackhoe, skid loader) is used appropriately to ensure safe and efficient demolition	Mechanical equipment was not configured or available to perform all demolition, resulting in hand removal of block remaining in wide-flange column.	No evaluation was performed on use of mechanical equipment/attachments to accomplish task safely and efficiently.
Mechanical lift devices (i.e., scissor lifts) are used effectively and safely to position workers for demolition efforts	Demolition rubble prevented use of lifts next to wide-flange column. Access to top blocks may have also been restricted by overhead cable tray.	Removal of rubble pile prior to attempting block removal from wide-flange column would have provided access for lifts to be utilized as in other columns. However, since hand removal was not allowed by the EWP work steps, a stop work would have been the appropriate action.
Workers perform work safely within controls	Workers were outside the scope of the EWP regarding hand removal methods	Workers did not stop when outside EWP work steps.
Independent surveillance/ assessment	Deficiencies are identified, corrected, comprehensive, and timely	BNFL and DOE had less than optimal coverage and validation processes were not effective in ensuring comprehensive corrective actions.

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Appendix D – Events and Causal Factors Analysis

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Table D-1. Events and Causal Factors Analysis

CC No.	Contributing Causes	Discussion	Related JONs
CC-1	Unapproved and improper work methods were used to remove blocks from wide-flange columns.	• The Pipefitter used an unsafe method by attempting removal of block using hand tools while prying from the center of a 12-foot column of blocks while standing on the floor (in harms way of potential overhead falling hazard). • Foreman and Crew failed to follow the EWP work steps and use the equipment specified when they opted for using hand tools for demolition instead of mechanical equipment as specified by Step 1.3 in the EWP. The use of a scissor lift and top-down approach to remove block from the wide flange was a safer method of block demolition; however, it was not addressed in the EWP. A stop work and contacting the supervisor would have been the appropriate actions to take when the new condition was encountered and mechanical means could not be used to perform the work. • The only "mechanical equipment" being used for block wall demolition was the trackhoe with a 30-inch wide bucket. The wide-flange column containing the blocks has an inside width of 12½ inches. According to the manufacturer of the trackhoe, this use of the equipment is not recommended if the desire is to leave the wide-flange column intact. • The General Foreman, Foreman, and Crew misinterpreted the EWP hazard control that called for use of a dust mask when using hand tools to mean that hand tools could be used to perform demolition work and considered the option of using hand tools to perform demolition to be within the "skill of the craft."	JONs 1, 2, 3, 4, 9, 11, 12

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

CC No.	Contributing Causes	Discussion	Related JONs
		• Based on interviews with the crew, mental attitude and unnecessary haste may have factored into the decision to proceed with removal of the blocks remaining in the wide-flange columns instead of waiting until after the debris from the wall and roof demolition had been cleaned up. Some interviewed stated they intended to remove all the block so the area could be cleaned up at one time and have the debris put in the Sealand container before the container was moved to the next area. Also mentioned was the need to stay busy and that workers were being laid off as the project progressed toward completion.	
CC-2	The EWP and FCN preparation and planning process was less than adequate in providing the job steps needed to safely perform Control Room demolition.	• Building Manager, SMEs, and the SRC chairperson signed the FCN 1. Assumption was made that the K-31 and K-33 Control Room construction were the same configuration. No validation walkdown of this assumption was conducted in K-31 during development of the EWP, Rev 1, FCN 1. • BNFL Procedure PR-GM-003, *Enhanced Work Planning*, Section 4.1.3.8, requires the following note be added, as applicable, to the EWP: "If you encounter a configuration different than the one for which work steps were developed, or identify that a bounding condition has been violated, stop work in accordance with PR-GM-001, Stop Work Authority." This statement was not included in EWP-056. The Building Manager was responsible for the EWP process, and he had been trained on this process. • The block room demolition for the K-31 task was considered to be a routine task. The Foreman and crew relied upon skill of the craft and experience to perform the work. • The EWP work steps did not address the unique configuration of the Control Room and did not specify detailed work	JONs 2, 4, 7, 8

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

CC No.	Contributing Causes	Discussion	Related JONs
		requirements (i.e., hand removal of block was not addressed). • The EWP was unclear and open to different interpretations of methods that could be used to perform the work. • Foreman and crew interpreted "hand tools" as listed in the hazard analysis as covering any use of hand tools needed to get the job done including hand removal of block, even though the EWP job Step 1.3 specified the use of "mechanical equipment." • Management and safety representatives took a strict interpretation of the term "hand tools" (i.e., broom, shovel, etc., for cleanup) which did not include hand removal of block and included hand tools needed to cleanup area. • It is not known which workers, if any, were involved in the planning and preparation of the EWP because it does not identify the "Work Team" representatives specified in BNFL's EWP Procedure, PR-GM-003, *Enhanced Work Planning*. The Group Manager, the SMEs, the SRC, and Chairman sign the EWP but not the work team representatives. Based on interviews with the Foreman and crew, they were not involved in preparation of the EWP FCN for the K-31 demolition work. The Board concludes that the EWP could be strengthened by identifying the work team members and containing their signatures.	
CC-3	Implementation of the EWP was less than adequate.	• The pre-job briefing was at a high level such that the crew informally depended on themselves to develop adequate work details. • There was a significant time lag between when the pre-job briefing occurred and initiation of Control Room demolition (pre-job briefing was conducted on July 23, 2003, and even though the K-31 demolition began in August, the Control Room demolition did not begin until December).	JONs 1, 2, 3, 4, 8 9, 11, 12

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

CC No.	Contributing Causes	Discussion	Related JONs
		• Personnel conducting walkdowns failed to recognize hazards associated with the different Control Room configuration. • Lighting levels and engineering involvement were not adequately addressed as required in the EWP. • Crew was working outside of hazard controls as presented in the EWP (i.e., hand demolition, lighting). • Adequate resources to perform the work were not continuously available (i.e., excessive rubble accumulation was in the work area because equipment needed to remove rubble was unavailable at the start of the job). The Board concludes that this bucket on the trackhoe was not the appropriate attachment to use for mechanical removal of the block from the wide-flange.	
CC-4	Application of lessons learned was less than adequate.	• A post-job briefing is not required until all work associated with the EWP is completed. • Based on a previous corrective action closed by BNFL from the converter fire Type B investigation, Corrective Action 1.12 to JON 1 was to "Improve upon the method in which lessons learned that are identified during the actual use of the EWP are input into the EWP." BNFL Procedure PR-AD-007 was revised to address the JON. This procedure was replaced by PR-GM-004, Revision 0, *Lessons Learned Process*, on 12/31/02. The procedure in Section 4.3.1 requires that the task group hold a post-job briefing following the first use of a new or revised EWP. Also, BNFL Procedure PR-GM-003, *Enhanced Work Planning*, Section 4.4.5.1, requires a post-job briefing (1) after the first performance, (2) following an incident, or (3) if requested. The two procedures are inconsistent in the requirements for when post-job briefings must be conducted. • A review of EWP-CONV-056 reveals that there have been no lessons learned from this	JONs 2, 3, 4, 7, 8, 11, 12

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

CC No.	Contributing Causes	Discussion	Related JONs
		EWP identified and incorporated into the same EWP, and no post-job briefing was documented for initiation of Revision 0 or Revision 1 work. In addition, no post-job is documented for the EWP 056, R1, FCN 1 initiation (beginning of work in K-31). • Based on interviews with the foremen, crew, and some managers, none had participated in a post-job briefing from prior EWP work. • The similarity of previous BNFL Type B corrective actions has not been trended by DOE ORO. A comprehensive trending analysis would strengthen line management's validation process for closure of completed corrective actions.	
CC-5	Identification, analysis, and control of the hazards associated with hand removal of concrete block from the column were less than adequate.	• The hazard analysis was developed on the basis of an incomplete understanding of the K-31 Control Room configuration. • The hazard analysis did not identify the hazards associated with hand removal of block (whether standing on floor or utilizing scissor lift) and did not provide adequate controls. • Hazards were not recognized by the Pipefitter, crew, management, or safety as the work was being performed.	JONs 2, 4, 9
CC-6	Oversight of the job task was less than adequate.	• Crew operated as a self-directed team. • Individual removing block was working alone. • Ineffective management and lack of safety oversight existed during removal of block from the column on the day of the accident. • Management perception was that Operations Floor (and Control Room) block room demolition was a lower relative risk. • Supervisor position was vacant (duties being covered by Building Manager and General Foreman). Removal Operations Manager, Building Manager, General Foreman, Foreman, H&S Officer, and Pipefitter Apprentice were not in the area at the time of the accident. • The Building Manager, Foreman, H&S Officer, and crewmembers stated they did	JONs 1, 9, 10

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

CC No.	Contributing Causes	Discussion	Related JONs
		not observe the Pipefitter's method of performing work. • Roles and responsibilities were not clearly defined and documented as required by ISM Principle 2. Several versions of the BNFL organizational chart for Removal Operations were provided to the Board, and none were accurate. BNFL Policy PO-RO-101, *Removal Operations Functional Organization*, also contains an out-of-date organizational chart. • Foreman and crew did not have position descriptions (or anything similar). • Because of holidays and vacations, there was reduced work coverage by BNFL and DOE ORO at the time of the accident.	
CC-7	Working conditions did not meet the EWP specified hazard controls or were less than adequate during job task performance.	• The EWP hazard controls specified 5 footcandles minimum. Workers reported that while they were doing the work there was very poor lighting in the area, and they had complained. Overhead lighting was not relamped prior to doing the work. Florescent lights were not in the immediate work area. Stand lights were furnished but did not provide an effective solution because of the glare. It was generally known that lighting conditions were poor. No illumination survey was requested or performed prior to conducting the Control Room demolition. • At the time of the accident, a cable tray was located at the top of Column N25 and further contributed to low illumination levels in the immediate work area. • An illumination survey conducted on January 13, 2004, revealed lighting conditions around Column N25 were 1-2 footcandles. Although the survey could only provide an approximation of illumination levels, it concluded "it is probable that the illumination levels in the immediate area of the block that fell were less than adequate." The cable tray and portable lighting had been removed prior to the time of the	JONs 2, 4, 9

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

CC No.	Contributing Causes	Discussion	Related JONs
		survey. • Access to all of the necessary equipment (i.e., skid loader) was not provided on a continuous basis resulting in an accumulation of debris/rubble which prevented access of the trackhoe for possible mechanical removal of block from columns and prevented access of the scissor lift for hand removal.	
CC-8	Communications were less than adequate in ensuring safe conduct of work, in obtaining prompt medical attention for the injured worker, and in ensuring that appropriate personnel were cognizant of the informal stop work.	• Informal stop work notifications were not made in an appropriate manner, and workers were unaware of an informal stop work on block removal. • Communications among the crew (lateral) and between management and the crew (vertical) during Toolbox briefings, crew briefings, safety meetings, walkdowns, and during performance of wall demolition were ineffective in ensuring safe conduct of work. These channels of communication provide a mechanism to discuss specific work steps that may not be covered in a pre-job brief; however, these means of information exchange are informal and undocumented and, as such, the rigor, consistency, and effectiveness can not be evaluated or ensured. • Although the Pipefitter was in a crew, he was working without interaction with other workers on how the block removal should be performed. The crew and others interviewed stated they did not see the Pipefitter removing the block from the column, and he had been performing this task for at least 2½ days prior to the accident. • Roles and responsibilities are not clearly defined and communicated. Several of those interviewed gave inconsistent information on identifying the Supervisor of the crew and Foreman. No accurate organization chart was provided by BNFL.	JONs 1, 2, 3, 5, 8, 9, 10
CC-9	Training of management and	• Supervision relied too heavily on OJT and "skill of the craft" to implement work steps	JONs 1, 2, 3, 4,

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

CC No.	Contributing Causes	Discussion	Related JONs
	workers involved in job planning and implementation was ineffective in ensuring safe conduct of work and appropriate response following the accident.	not covered in the EWP. • The pre-job brief used as a means to train workers on safe implementation of the EWP was deficient because it was based on an insufficient EWP. • The pre-job briefing was at a high level such that the crew informally depended on themselves to develop adequate work details. • There was a significant time lag between when the pre-job briefing occurred and initiation of Control Room demolition (pre-job briefing was conducted on July 23, 2003, and even though the K-31 demolition began in August, the Control Room demolition did not begin until December). • Training on the EWP process (e.g., *Operations EWP Training*, Module 10100) is required and provided for those managers, supervisors, and SMEs who participate in development of an EWP but is not provided to General Foreman, Foreman, and crew who are supposed to be participating in the development, review, implementation, and evaluation phases of the EWP. • Management and workers allegedly received Toolbox Training that covered a requirement to report to the Clinic to have an evaluation following an injury; however, the Toolbox Training was not documented, and line managers and workers interviewed were not aware of this requirement. • The Building Manager (also the Supervisor of the injured worker) had not received *Stop Work /Communications Training* (Module 10223). He did not complete appropriate notifications and documentation of the informal stop work as required by BNFL Procedure PR-GM-001, *Stop Work Authority.* As Acting Supervisor, the General Foreman had not been given the stop work training, and it is not required in his Training Needs Assessment Checklist. • The Foreman and crew also have not been	5, 7, 9, 11, 12

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

CC No.	Contributing Causes	Discussion	Related JONs
		given the 30-minute training Module 10223 on stop work/communications. • As a corrective action from the second K-31 tube bundle fire (NTS-K31-2001-0001), BNFL developed *Stop Work/ Communications Training*, Module 10223, and added a training requirement for personnel doing converter work but not for other BNFL personnel. The corrective action to prevent recurrence should have been more comprehensive than for those performing converter work. • The Board concludes that the corrective action to prevent recurrence could have been more comprehensive than just limiting it to those performing converter work. The training requirement could have been added to the training needs assessment checklist and training provided for all workers and management. • The *Stop Work/Communication Training*, Module 10223, and the BNFL Procedure PR-GM-001, *Stop Work Authority*, upon which it is based, omits instructions to stop work "if you encounter a configuration different than the one for which work steps were developed." The requirement to stop work when a different configuration is encountered is specified in the BNFL Procedure PR-GM-003, *Enhanced Work Planning*, Section 4.1.3.8.	
CC-10	BNFL personnel failed to follow company policy, procedure, and EWP requirements.	• Requirement to report to the Clinic per BNFL Policy PO-SS-301, *Accessing the Medical Clinic and Services*, Sections 3.2 and 3.3, was not followed by injured worker or his management chain. • Building Manager failed to notify the H&S staff of the personnel injury as soon as possible following the incident, as required by BNFL Procedure PR-SS-068, *Health and Safety Plan*, Section 4.2. • Building Manager failed to issue a formal stop work upon learning of the hand	JONs 1, 2, 3, 5, 6, 9, 11, 12

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

CC No.	Contributing Causes	Discussion	Related JONs
		removal method after the accident and failed to perform all required notifications of the informal stop work as required by BNFL Procedure PR-GM-001, *Stop Work Authority*, Section 3.3. • The K-31 Group Manager (Building Manager) also did not follow BNFL Procedure PR-GM-003, *Enhanced Work Planning*, Section 4.1.3.8, when he did not stop work upon encountering a configuration different than the one for which work steps were developed. • BNFL management failed to follow the EWP, Step 1.1, requirement to contact Engineering prior to demolition. • BNFL workers failed to follow the EWP, Step 1.3, requirement to use mechanical equipment to demolish wall when they diverted to hand-removal methods. • BNFL workers were working outside the EWP hazard controls which required 5 footcandles of lighting for demolition work. • Accident scene was not preserved as required by BNFL Procedure PR-GM-002, *Incident Investigations*, Sections 3.0 and 4.4.	
CC-11	BNFL's response to the accident was less than adequate.	• Injured worker and management chain were unaware of the BNFL requirement to report to the Clinic for medical evaluation. • Reluctance of the injured worker to report to the Clinic caused delay in the injured worker receiving medical evaluation and most likely treatment. Reluctance was partially based on experience of other worker with broken arm two weeks earlier. • Management, workers, and the injured worker perceived that the foot injury was not a serious condition. This resulted in delaying medical evaluation and treatment. • Accident scene was not preserved as required by DOE Order 225.1, *Accident Investigation*, which is included in the BNFL Work Smart Standards. • Formal stop work not declared until nearly a	JONs 1, 5, 6, 9, 10

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

CC No.	Contributing Causes	Discussion	Related JONs
		month after the accident. • Informal stop work not communicated to crew, and appropriate notifications were not made. • BNFL's lack of urgency in doing investigation.	
CC-12	DOE ORO's oversight was less than adequate.	• The response to the accident was less than adequate: 1. Lack of timely management attention on DOE ORO's part in evaluating accident and getting briefings. 2. DOE Project Manager and AMEM elected not to have a briefing after the accident (on December 19, 2003). • Facility Representative coverage the day of the accident was insufficient. As a result of the last Type B, Facility Representative coverage had been increased. However, this level was not sustained (extra Facility Representative was on SEB duty and one was on vacation). • DOE's validation of previous corrective actions was not fully effective in ensuring that BNFL's corrective actions were comprehensive.	JONs 1, 11, 12

Root Causes

RC No.	Root Causes	Discussion	Related JONs
RC-1	BNFL failed to implement an effective work planning process.	• Work plans for K-33 were assumed to be applicable to K-31 without walkdown or analysis. • Management and work crew failed to stop work when configuration was different from EWP (and had not been trained to the stop work policy). • EWP was unclear and open to different methods that could be used to perform work. • Hazards were not adequately addressed. • Failure to implement ISM Core Functions.	JONs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Appendix E – Events and Causal Factors Chart

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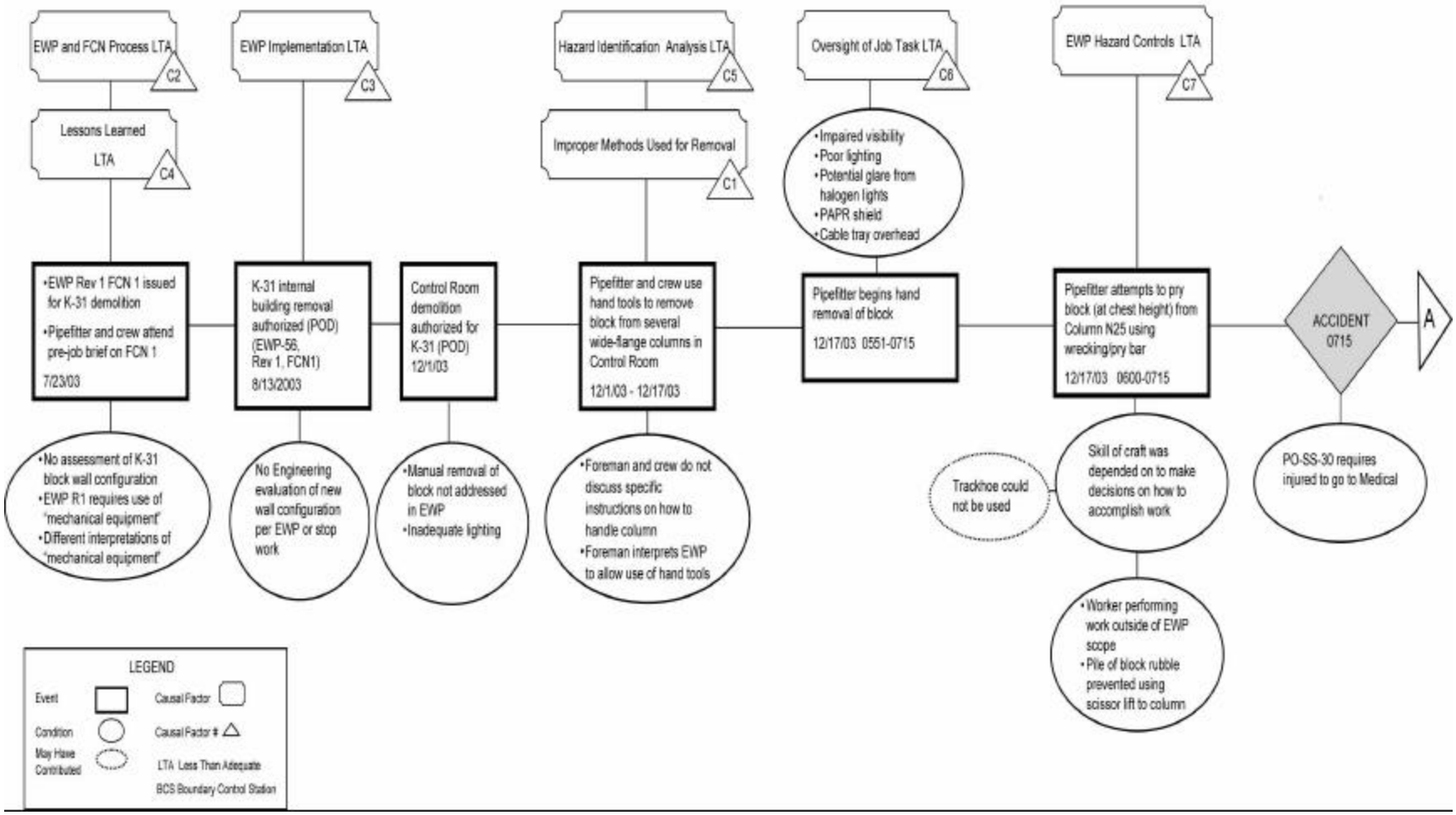
Event and Causal Factors Chart
Employee Foot Injury on December 17, 2003, BNFL Inc.



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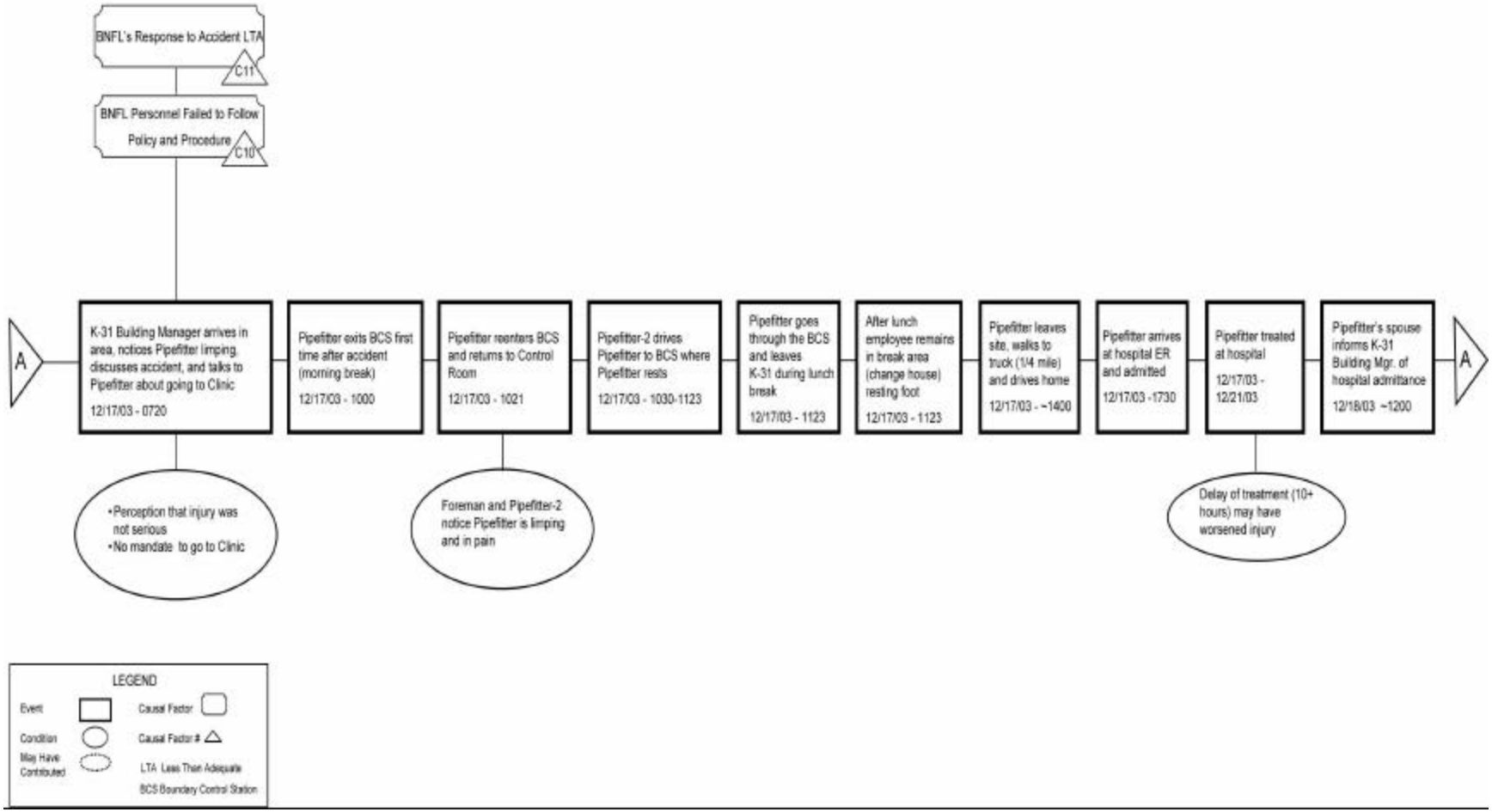
Event and Causal Factors Chart (continued)



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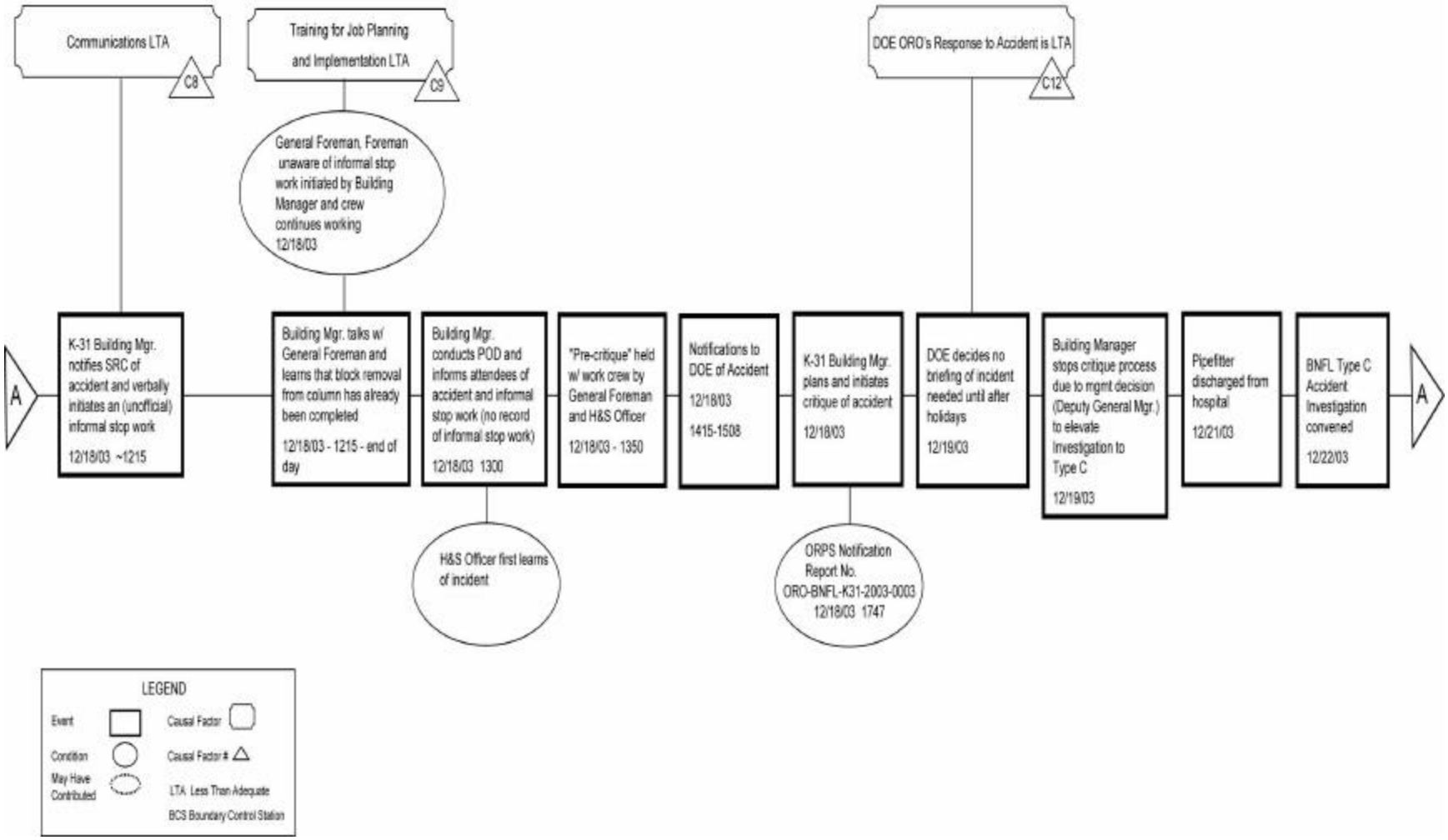
Event and Causal Factors Chart (continued)



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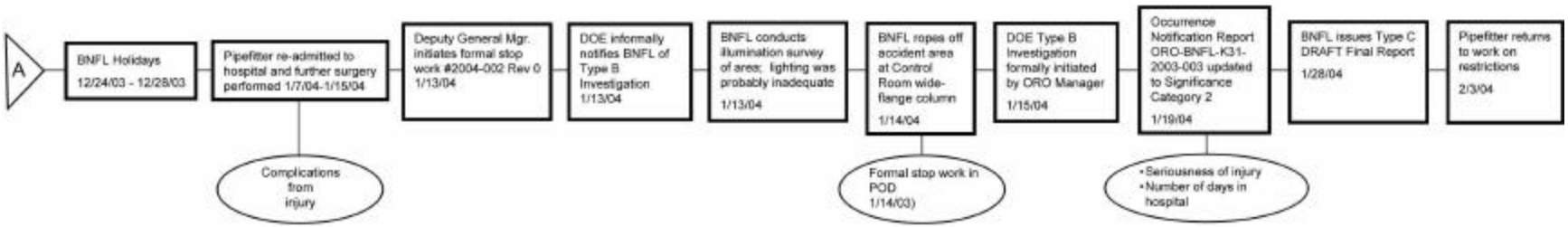
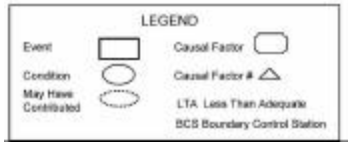
Event and Causal Factors Chart (continued)





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