Type B Accident Investigation Board Report on the October 22, 1997, Electrical Arc Blast at Building F-Zero Fermi National Accelerator Laboratory Batavia, Illinois

November 1997

Chicago Operations Office
U.S. Department of Energy

This report is an independent product of the Type B Accident Investigation Board appointed by Cherri J. Langenfeld, Manager, Chicago Operations Office, U.S. Department of Energy.

The Board was appointed to perform a Type B investigation of this accident and to prepare an investigation report in accordance with DOE Order 225.1, *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.

On October 30, 1997, the Manager, Chicago Operations Office, appointed a Type B Accident Investigation Board to investigate the October 22, 1997, Electrical Arc Blast at Fermi National Accelerator Laboratory, located in Batavia, Illinois. The responsibilities of the Board have been satisfied with respect to this investigation. The analysis, identification of contributing and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1, *Accident Investigations.*

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

John P. Kennedy
Acting Manager
Chicago Operations Office

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EXHIBITS, FIGURES, AND TABLES

ACRONYMS AND INITIALISMS

A	Ampere
CFR	Code of Federal Regulations
CH	U.S. Department of Energy, Chicago Operations Office
DOE	U.S. Department of Energy
EMT	Emergency Medical Technician
ES&H	Environment, Safety and Health
Fermilab	Fermi National Accelerator Laboratory
FESS	Facilities Engineering Services Section
FMI	Fermilab Main Injector
GeV	Giga-electron Volt
kV	Kilovolt
MCC	Motor Control Center
MI	Main Injector
OSHA	U.S. Occupational Safety and Health Administration
URA	University Research Association, Inc.
VAC	Volts Alternating Current

EXECUTIVE SUMMARY

INTRODUCTION

An accident at the Fermi National Accelerator Laboratory (Fermilab) was investigated in which two electricians received serious flash burns as a result of an electrical fault and subsequent electrical arc blast while working on a 480 VAC motor control center. In conducting its investigation, the Accident Investigation Board (the Board) used various analytical techniques including accident analysis, barrier analysis, and event and causal factor analysis. The Board inspected and photographed the accident scene, reviewed events relating to the accident, conducted interviews, and reviewed documents to determine the factors that contributed to the accident. Relevant management systems that could have contributed to the accident were evaluated within the framework of the Department of Energy's integrated safety management system.

ACCIDENT DESCRIPTION

At approximately 12:10 p.m. on October 22, 1997, two subcontractor electricians were attempting to provide temporary power for lighting and heat from the Motor Control Center (MCC) Cabinet #4 to an electrical panel in the RF Gallery F-Zero Compressor Room. The two subcontractor electricians were removing the upper bus bar cover that shields the line side connections in the panel. The cover was being removed to connect the neutral line associated with the temporary power connection. While attempting to remove the cover, it contacted the "C" phase of the bus bar causing a short to ground and a subsequent arc blast.

CAUSAL FACTORS

The Board identified two root causes for the accident, the elimination of either would have prevented the accident:

- The subcontractor electricians did not understand that there were energized components behind the bus bar cover.
- DOE-CH and Fermilab management did not ensure that an adequate integrated safety management system was implemented for electrical work.

The Board also identified five contributing causes that may have increased the likelihood of the accident, without individually causing the accident:

- Fermilab procedures were not adequately defined or implemented.
- Job planning and hazards analysis were performed informally, inadequately documented, and poorly communicated to the workers.
- Fermilab did not provide training or ensure that workers had adequate knowledge to safely perform the work.
- Fermilab managers and supervisors did not have a clear understanding of their roles, responsibilities, and authorities for electrical safety.

- Due to inadequate oversight by DOE and Fermilab, the opportunity to identify electrical safety program deficiencies was missed.

CONCLUSIONS AND JUDGMENT OF NEED

Table ES-1 presents the conclusions and judgments of need determined by the Board. The conclusions are those the Board considered significant and are based upon facts and pertinent analytical results. Judgments of need are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the probability or severity of a recurrence of this type of accident. Judgments of need are derived from the conclusions and causal factors and are intended to assist managers in developing follow-up actions.

Table ES-1. Conclusions and Judgments of Need

Conclusions	Judgments of Need
Fermilab does not have a comprehensive program in place to ensure electrical workers are qualified prior to commencing field work.	There is a need for Fermilab to ensure that personnel engaged in their primary skill are knowledgeable and trained in the construction, operation, and hazards involved in the work they perform.
Fermilab lockout/tagout and energy verification practices for the site are inadequate to ensure protection from hazardous electrical energy.	There is a need for Fermilab to strengthen, communicate, and enforce the requirements for lockout/tagout, including energy verifications.
Work planning and hazards analysis were inadequate.	There is a need for Fermilab to ensure that potentially exposed workers are informed of, and clearly understand, the hazards. There is a need for Fermilab to clarify policies and procedures for planning and executing projects.
Fermilab's Lessons Learned program is ineffective in disseminating work planning information for potentially affected electrical activities. This appears to be a systemic problem throughout all site activities.	There is a need for Fermilab to implement a Lessons Learned program that disseminates the information effectively throughout the workforce.
DOE and Fermilab have not performed an adequate review of the electrical safety program.	There is a need for DOE-CH to conduct a comprehensive review of the Fermilab electrical safety program. There is a need for Fermilab to comprehensively review, and revise as necessary, their electrical safety program.

Fermilab and Contractor personnel did not have a clear understanding of their roles, responsibilities, and authorities for safety.	There is a need for Fermilab to ensure that roles, responsibilities, and authorities for management and safety are clearly defined, understood, and implemented at all levels by personnel involved in the work.
Fermilab's controls, documentation, and communications associated with the electrical work were inadequate to satisfy the five core functions of DOE's integrated safety management system.	There is a need for DOE-CH to conduct a comprehensive review of the definition, communication, and implementation of Fermilab's integrated safety management system.

Type B Accident
Investigation Board Report
on the October 22, 1997,
Electrical Arc Blast
at
Building F-Zero
Fermi National Accelerator Laboratory
Batavia, Illinois

1.0 INTRODUCTION

1.1 BACKGROUND

On October 22, 1997 at approximately 12:10 p.m., two electricians were injured as a result of an electrical arc blast while working on a 480 VAC motor control center in the F-Zero Compressor Room at Fermi National Accelerator Laboratory (Fermilab).

On October 22, 1997, two electricians were injured as a result of an electrical arc blast while working on a 480 VAC motor control center.

On October 30, 1997, Cherri Langenfeld, Manager, Chicago Operations Office (CH), U.S. Department of Energy (DOE), appointed a Type B Accident Investigation Board (referred to as "the Board") to investigate this accident in accordance with DOE Order 225.1, *Accident Investigations* (See Appendix A).

1.2 FACILITY DESCRIPTION

The primary mission of Fermilab is to advance the understanding of the fundamental nature of matter and energy. Fermilab provides high-energy physics research facilities for 2,300 scientists from 36 states and 21 countries. The majority of active U.S. particle physicists use Fermilab for their research. The laboratory is situated on 6,800 acres approximately 30 miles west of Chicago.

Fermilab's core competence is supported by the following primary capabilities: operation of the world's highest-energy physics user facility; accelerator research, design, construction and operation; superconducting magnet research, design and development; detector development and operation; high-performance computing and networking; international scientific collaboration; construction and management of large scientific and technical projects; and scientific training.

Contractor activities at Fermilab are managed by the DOE Fermi Group (FRMI) which reports to and receives support services from the Chicago Operations Office. The cognizant DOE secretarial office is the Office of Energy Research. University Research Association, Inc. (URA) which has operated Fermilab since 1967, had their contract renewed January 1, 1997 through December 31, 2001. URA is a corporation of 86 major research-oriented universities.

The Fermilab Main Injector (FMI) Project provides for the construction of a new accelerator, designated the FMI, to provide particles (both protons and antiprotons) for injection into the existing Fermilab superconducting accelerator, for delivery of protons onto the antiproton production target, and for direct delivery of protons to the existing fixed target experimental areas. The accelerator is 3.3km in circumference and is capable of accelerating protons and antiprotons to 150 GeV. It is constructed using conventional copper/iron core magnets. Also provided are five new beamlines required to tie the FMI into the existing accelerator complex and to provide slow extracted beam to the A0 Transfer Hall, from where it can be directed toward the fixed target experimental areas. The FMI Project involves construction of 15,000 ft of tunnel enclosure, 11 service buildings, and a new 345 kV substation. Construction was initiated in June, 1992 and is expected to be completed in 1999. The electrical work being performed by Arbor Electric, Inc. (hereafter referred to as “the Contractor”) at the time of the accident was encompassed under the FMI Project.

Work being performed when the accident occurred was in support of the demolition of the RF-1, 2 and 3 transformer pads at the north end of Building F-Zero. In order to accomplish this work it was necessary to schedule an outage of 13.8 kV Feeder 45 supplying power to these transformers and the conventional power in Building F-Zero. This would cause Building F-Zero to be without lights and heat during the time of the scheduled temporary power outage. The installation of temporary power for Building F-Zero RF Gallery during the outage is the reason for work in which the Contractor was engaged.

1.3 SCOPE, PURPOSE, AND METHODOLOGY

The Board began its investigation on October 29, 1997, completed the investigation on November 7, 1997, and submitted its final report to the CH Manager on November 10, 1997.

The Type B accident investigation began on October 29, 1997.

The **scope** of the Board's investigation was to review and analyze the circumstances of the accident to determine its cause. The Board also evaluated the adequacy of safety management systems and work control practices of DOE, Fermilab and the Contractor, as they relate to the accident.

The **purposes** of this investigation were to determine the cause of the accident including deficiencies, if any, in the safety management systems, and to assist DOE in understanding lessons learned to improve safety and reduce the potential for similar accidents.

The investigation determined the cause of the accident and developed judgments of need to prevent recurrence.

The Board conducted its investigation using the following **methodology**:

- Facts relevant to the accident were gathered through interviews, document and evidence reviews, and examination of physical evidence.
- Event and causal factors charting[1], along with barrier analysis,[2] and change analysis[3] techniques were used to analyze facts and identify the accident's cause.

Based on analysis of the information gathered, judgments of need for corrective actions to prevent recurrence were developed.

[1] Charting depicts the logical sequence of events and conditions (casual factors) that allowed the event to occur.
[2] Barrier analysis reviews hazards, the targets (people or objects) of the hazards, and the controls or barriers that management control systems put in place to separate the hazards from the targets. Barriers may be administrative, physical, or supervisory/management.
[3] Change analysis is a systematic approach that examines barrier/control failures resulting from planned or unplanned changes in a system.

2.0 FACTS AND ANALYSIS

2.1 ACCIDENT DESCRIPTION AND CHRONOLOGY

2.1.1 Background and Accident Description

To support the FMI Project and other construction projects at the facility, general and subcontract labor is used. In this particular job the Contractor was considered a general contractor. The injured electricians (hereafter referred to as Electrician A and Electrician B) are both employees of the Contractor.

Initial discussion for installation of temporary power in Building F-Zero occurred on September 25, 1997 with an e-mail message from the Main Injector (MI) "interface" to the Building Manager's Representative for Building F-Zero. This work was planned to be completed by October 22, 1997. The work consisted of running a temporary circuit from the F-Zero Compressor Room to the middle of the RF Gallery. The power for the temporary circuit was to come from a 225 A breaker which would feed from the existing 480 volt, 3 phase, 800 A breaker in MCC Cabinet #4. The 800 A breaker was on Feeder 46 B. This arrangement was necessary since power from Feeder 46 B would not be affected by other work going on in the area.

On October 22, 1997, at 6:00 a.m., power to service Buildings F-Zero (see Figure 2-1), F-One, F-Two and F-Three were turned off by switches located at F4 and E4. The switches were locked out by the Fermilab FESS Operations/Electrical Engineer. This isolated power from Feeder 45. In addition, the cable from RF-1 transformer which feeds Building F-Zero was isolated. At approximately 7:30 a.m., Electrician A placed his lock on Feeder 45 and Transformer F-1. The MI "interface", Electrician A, and the FESS Operations/Electrical Engineer visually checked the lockouts on E4 and F-1. Electrician A then attended the weekly construction management meeting.

On October 22, 1997, at 10:00 a.m. Electricians A and B arrived at the RF Room of Building F-Zero to connect four cables in DHP-RF1-4. They completed hooking up the cables at DHP-RF1-4 (see Figure 2-1) shortly before 12:00 noon. At about 12:00 noon, Electricians A and B proceeded to the compressor room of Building F-Zero to finish a job that was started the day before by Electrician B and another Contractor electrician. The previous day a 225 A breaker was installed and connected to the 800 A breaker in MCC Cabinet #4. In addition, the cables from the 225 A breaker to panel DHP-RF1-4 had been run and connected in the MCC cabinet. Electricians A and B brought tools, a fiberglass ladder, portable generator and a temporary work light into the work area at MCC Cabinet #4. The only remaining task was to connect the neutral in MCC Cabinet #4.

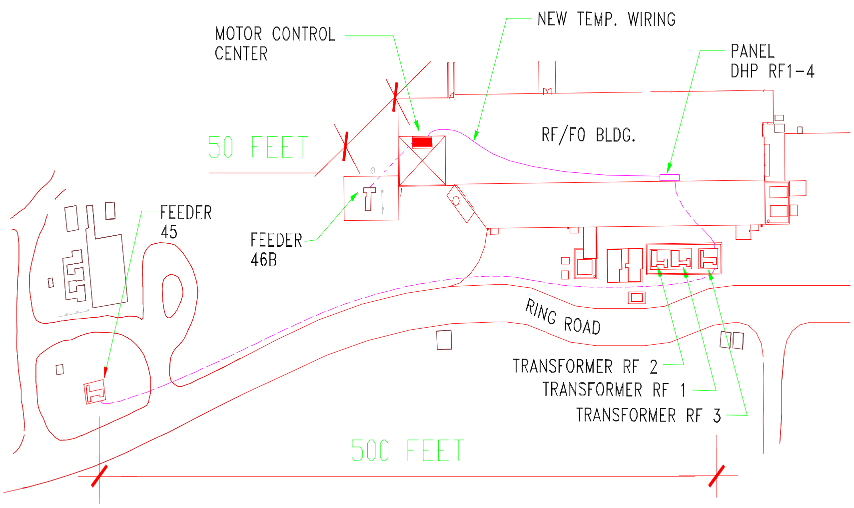

Figure 2-1. Layout of F-Zero Building and Electrical Systems

The two electricians set up temporary lighting fed from a portable generator located outside the building. Electrician A placed a step ladder in front of MCC Cabinet #4 as depicted in Exhibit 2-1. He was standing on the second step while Electrician B was standing on the floor next to the ladder and adjacent to MCC Cabinet #4. (See Figure 2-2).

Exhibit 2-1. View of Accident Location

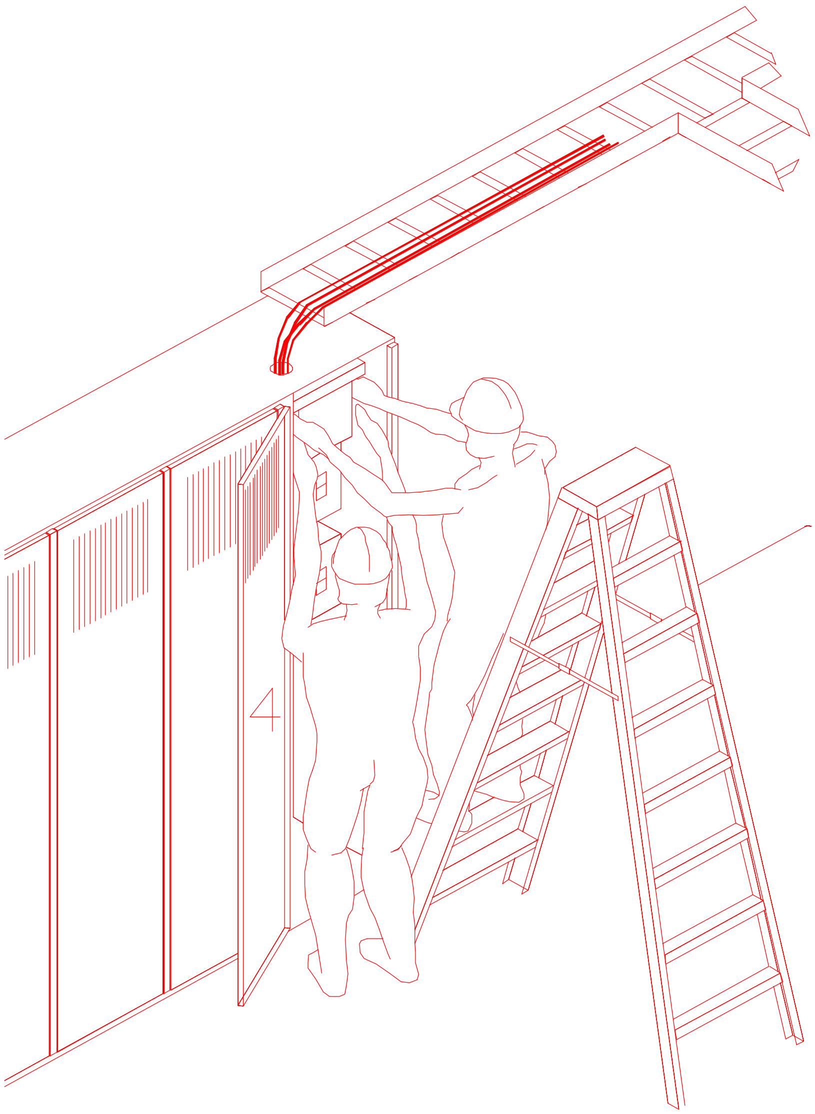

Figure 2-2. Artist Drawing of Work Activity Prior to Accident

Electrician A stated he saw no lights in the compressor room and assumed the power was off to the building. He also stated that he had been looking for a place to connect the neutral and that no one from Fermilab had instructed him on where to connect the neutral. After failing to find a neutral connection, Electricians A and B removed several screws from the upper bus bar cover and tried to remove the cover from the cabinet. Since Electricians A and B were working without any system diagrams or drawings, Electrician A intended to remove the bus bar cover to decide where to tie the neutral. Electrician A positioned his hands around the sides of the bus bar cover and proceeded to maneuver the cover to get it clear of the cabinet

Electrician A stated he saw no lights in the compressor room and assumed the power was off to the building.

case while Electrician B helped him (see Figure 2-2). During this maneuvering the cover contacted the “C” phase of the bus bar causing a short to ground and a subsequent arc blast.

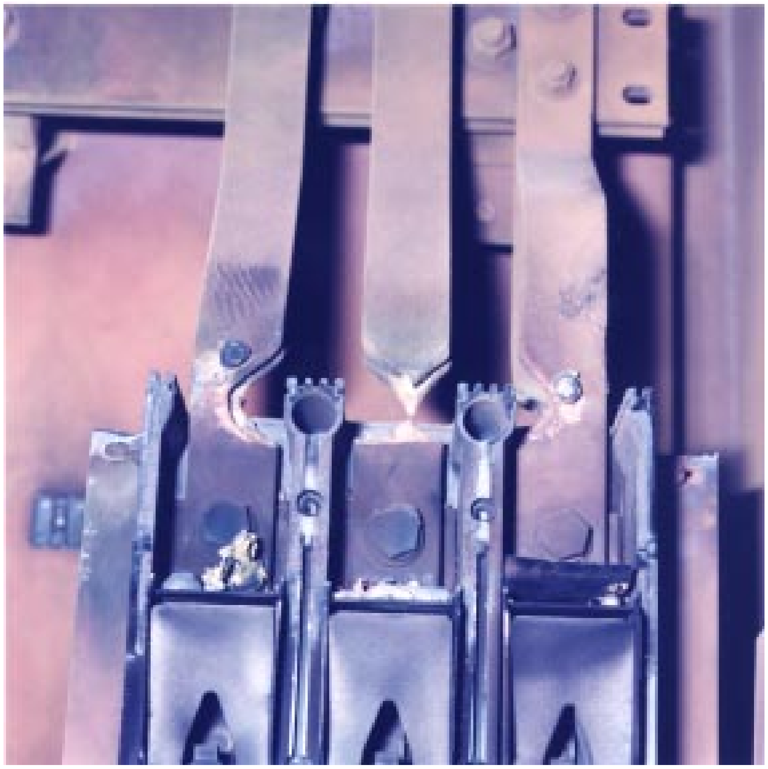

Exhibit 2-2. View of Bus Bar after Electrical Blast

The resulting arc blast vaporized the copper connection (see Exhibit 2-2) and, being deflected by the bus bar cover, was directed downward toward the head and face of Electrician B (see Exhibit 2-3). Electrician B received 2nd and 3rd degree burns to his face and hands while Electrician A, being on the ladder and partially protected by the bus bar cover, received 2nd degree burns to both hands. With the exception of a hard hat (see Exhibit 2-4), no other personal protective equipment was worn by either electrician. Electrician A was knocked off the ladder and both Electrician A and B were temporarily blinded by the arc blast. Electrician B’s coat was smoldering when Electrician A’s sight returned from the bright arc blast.

The resulting arc blast vaporized the copper connection and, being deflected by the bus bar cover, was directed downward toward the head and face of Electrician B. Electrician B received 2nd and 3rd degree burns to his face and hands while Electrician A, being on the ladder and partially protected by the bus bar cover, received 2nd degree burns to both hands.

The Damaged Bus Bar Cover

Similar Intact Bus Bar Cover

Exhibit 2-3. Comparison of an Intact and the Damaged Bus Bar Cover

Exhibit 2-4. Electrician B's Hard Hat After Electrical Arc Blast

2.1.2 Chronology of Events

Figure 2-3 summarizes the chronology of significant events.

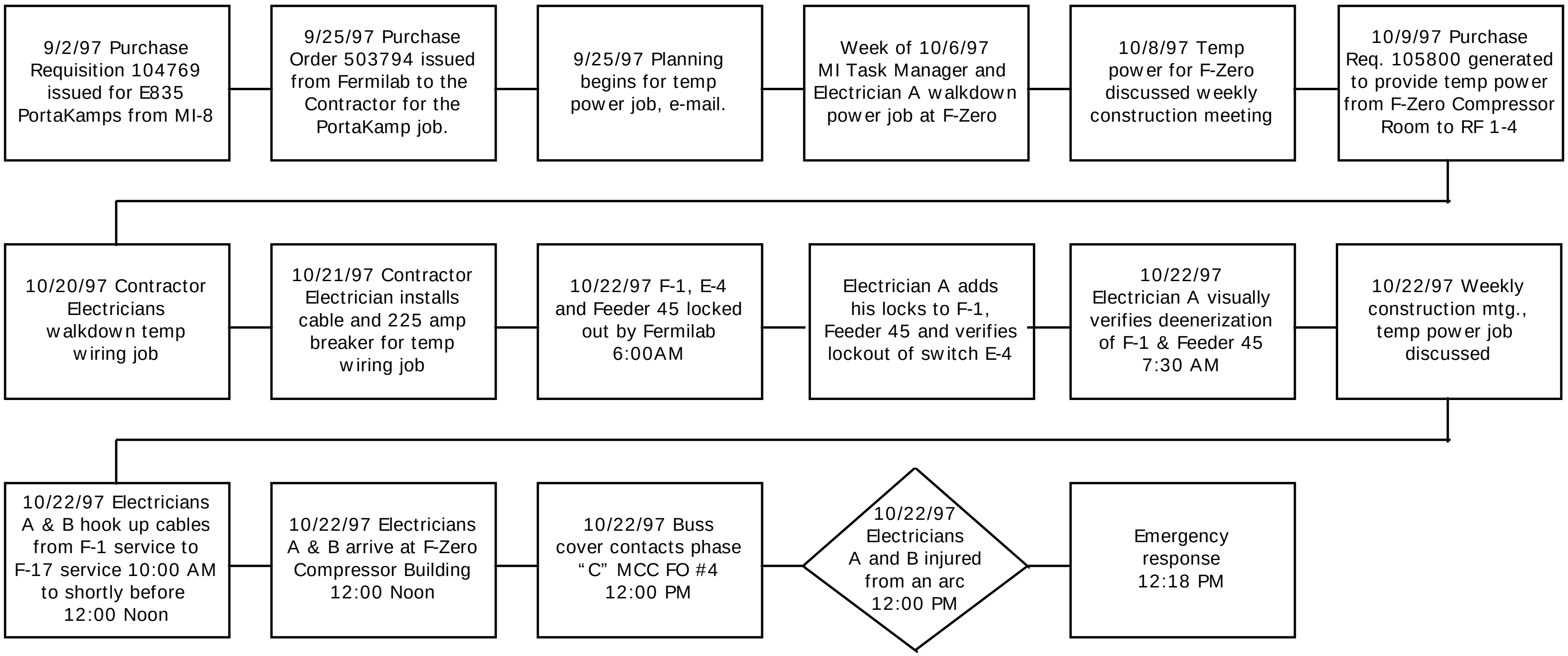

Figure 2-3 Summary Events and Accident Chronology

2.1.3 Emergency Response and Investigative Readiness

Electricians A and B recovered their sight and exited Building F-Zero on their own. Three construction workers outside Building F-Zero provided assistance while one worker went across the road to Building MI-60 and requested personnel there to call an ambulance. Electrician A re-entered Building F-Zero to see what had happened.

Electricians A and B recovered their sight and exited Building on their own. Three construction workers outside Building provided assistance while one worker went across the road to Building MI-60 and requested personnel there to call an ambulance.

The emergency call was logged in at 12:16 p.m. The first unit to arrive was 701 Heavy Rescue which arrived at 12:19 p.m., followed by Ambulance 751 at 12:21 p.m. Dispatch informed Ambulance 751 while en route to the accident that the injured personnel were moved to Building MI-60. Two additional ambulances were requested from the surrounding community: Ambulance 51 from Batavia arrived at 12:23 p.m. and Ambulance 251 from Geneva arrived at 12:36 p.m.

The emergency call was logged in at 12:16 p.m. The first unit to arrive was 701 Heavy Rescue which arrived at 12:19 p.m., followed by Ambulance 751 at 12:21 p.m.

Electricians A and B were transferred from the Building MI-60 area in Ambulance 751 to Building AP-50 for further medical treatment to be provided by Ambulance 51 which had advanced life support capabilities. Ambulance 751 notified Ambulance 51 while en route as to the extent of the injuries and requested a helicopter evacuation for Electrician B. Ambulance 51 arrived at Building AP-50 at 12:23 p.m., assumed care for the patients in Ambulance 751, and requested a helicopter through Delnor Hospital for transport of Electrician B to the Burn Center at Loyola Medical Center.

Necessary patient information was exchanged with Delnor Hospital and the use of helicopter transport was approved by Delnor Hospital. Electrician B was transported to Frelo Flying Field to await arrival of the Loyola Lifestar Helicopter which arrived at 12:53 p.m. Electrician B was evacuated by helicopter to Loyola Medical Center, arriving at 1:35 p.m. Electrician A was evacuated to Delnor Hospital, arriving at 12:55 p.m. and subsequently transferred to the Burn Center at Loyola Medical Center.

Electrician A was evacuated to Delnor Hospital, arriving at 12:55 p.m. and subsequently transferred to the Burn Center at Loyola Medical Center. Electrician B was evacuated by helicopter to Loyola Medical Center, arriving at 1:35 p.m.

At 12:55 p.m., one of the firefighters went to Building F-Zero to observe the accident scene. The firefighter heard an audible alarm but could not obtain any additional information from individuals at the scene. The firefighter noticed a haze in the building and called for assistance. Fire Department personnel using self-contained breathing apparatus surveyed the accident scene for hazards. The Fire Chief took charge of the accident scene, secured the building, and placed the building in the custody of FESS safety personnel.

The Board found no significant issues with the emergency response and investigative readiness.

The Board found no significant issues with the emergency response and investigative readiness.

2.1.4 Medical Report

Electrician A was treated for 2nd degree burns to the dorsum of the left hand and right thumb, and released at 4:50 p.m., October 22, 1997. Electrician B was treated for 2nd and 3rd degree burns to the face and both hands. He was discharged on October 27, 1997.

An alcohol test on Electrician B was negative. No additional tests for drugs or alcohol were performed.

2.2 HAZARDS, CONTROLS, AND MANAGEMENT SYSTEMS

2.2.1 Industrial and Worker Safety

With the national average for deaths in the workplace on a slow decline but the national average for electrical deaths on an increase, DOE continues to place emphasis on electrical safety. This is noted by the recent Electrical Safety meeting held in September, 1997 which emphasized the hazards of electrical arc blasts (see Exhibit 2-5), such as electrical burns and injuries. In addition, several documents have been issued by DOE over the past few years on electrical safety. Both the report of the Task Group on Electrical Safety of the Department of Energy Facilities, DOE/EH-0298, January, 1993 and the DOE Electrical Safety Guidelines, DOE/ID-10600, September, 1993 provide for the development of a comprehensive electrical safety program at each DOE contractor site. The DOE has identified and provided a Model Electrical Safety Program and delivered seminars to further assist contractors in developing their own programs over the past few years.

With the national average for deaths in the workplace on a slow decline but the national average for electrical deaths on an increase, DOE continues to place emphasis on electrical safety.

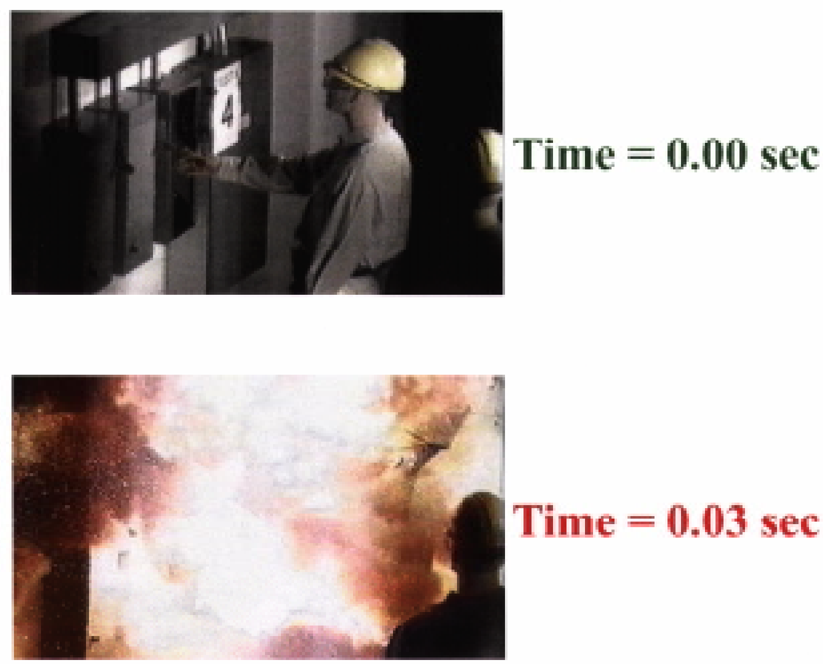

Exhibit 2-5. Electrical Arc Demonstration

These photographs with the elapsed time sequence are a staged electrical arc test of a 480 VAC, 20,000 A event with a mannequin worker. Courtesy of Electrical Trauma Research Program directed by Dr. Raphael C. Lee. For more information, please contact Dr. Lee at (773) 702-1633.

The job at the F-Zero Compressor Room was to establish temporary electrical power (for approximately two weeks) to panel DHP-RF1-4 which is a 277/480 VAC electrical distribution panel. This temporary power was for the purpose of providing lighting and heating for Building F-Zero, while the transformer pad was modified. The temporary wiring was to be removed once the transformer was back in-service. The master substation supplies 13.8 kV power to Feeder 46B, which converts the 13.8 kV Delta system to a wye system at 480 VAC to supply power to the F-Zero Compressor Room (See Exhibit 2-6).

The Board reviewed both 29 CFR 1910 and 29 CFR 1926. The Board determined that the applicable standards to cover this job are contained in 29 CFR 1910, due to the limited duration of the wiring and the fact that it would be removed immediately upon completion of the purpose for which the wiring was installed.

Exhibit 2-6. Feeder 46B and Building F-Zero Compressor Room

On October 21, 1997, two Contractor electricians pulled four cables from the F-Zero Compressor Room to the F-Zero RF Room. This involved installing a 225 A circuit breaker in MCC Cabinet #4. The three load phases were installed in the motor control center, with the neutral remaining to be installed the next day. It took approximately eight hours to complete this part of the job. The Electricians believed that Building F-Zero was deenergized and, hence, they did not use lockout/tagout or voltage verification to install the new 225 A breaker, as required by 29 CFR 1910.333(b)(2),

> "While any employee is exposed to contact with parts of fixed electric equipment or circuits which have been deenergized, the circuits energizing the parts shall be locked out or tagged or both..."

Engineering drawings of the electrical system for Feeder 46 B

Engineering drawings of the electrical system for Feeder 46 B and Building F-Zero Compressor Room were not reviewed by the Contractor or Fermilab nor could this be provided to the Board upon and Building F-Zero Compressor Room were not reviewed by the Contractor or Fermilab, nor could they be provided to the Board upon request. The Contractor stated electrical drawings were seldom provided by Fermilab or used by the Contractor. The Contractor stated they usually, but not always, place their lock and tag over the Fermilab lock and tag as required by 29 CFR 1910.333(b)(2). The Contractor also stated that they do not perform energized work and, hence, have no equipment to do energized work, such as gloves or blankets.

request.

Electricians A and B were not using proper electrical safety related work practices as required by 29 CFR 1910.333 (a),

> "Safety-related work practices shall be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts, when work is performed near or on equipment or circuits which are or may be energized. The specific safety-related work practices shall be consistent with the nature and extent of the associated electrical hazards."

The bus bar, from which Electricians A and B were removing the cover, was not deenergized and verified, as required by 29 CFR 1910.333 (b)(2), (b)(2)(iv), and (b)(2)(iv)(B):

- "While any employee is exposed to contact with parts of fixed electric equipment or circuits which have been deenergized, the circuits energizing the parts shall be locked out or tagged or both..."
- "...The requirements of this paragraph shall be met before any circuits or equipment can be considered and worked as deenergized."
- "A qualified person shall use test equipment to test the circuit elements and electrical parts of equipment to which employees will be exposed and shall verify that the circuit elements and equipment parts are deenergized..."

National Fire Protection Association (NFPA) 70 E, "Electrical Safety Requirement for Employee Workplaces", contains similar requirements to all the OSHA requirements referenced above.

The Board concluded that Fermilab lacks a formal, comprehensive electrical safety program as described in the DOE Model Electrical Safety Program.

The Board concluded that Fermilab lacks a formal, comprehensive electrical safety program as described in the DOE Model Electrical Safety Program. This was based on the facts that there was no work documentation and no engineering drawings of the electrical system for the job, and therefore the electrical hazards could not be adequately assessed or addressed. The power source was not identified and Electricians A and B did not perform lockout/tagout, did not verify that the circuit was deenergized, and did not use the appropriate electrical personal protective equipment for the job they were performing. Recognition of the electrical hazards should begin with the use of the appropriate work documentation and engineering drawings in the pre-planning phase of the job.

The lack of a formal, comprehensive electrical safety program to direct and plan electrical safety at Fermilab results in a "reactive" approach to solving electrical safety problems. A proactive approach would develop and utilize a thorough programmatic planning document which includes the purpose; scope; ownership; authorities; interfaces; accountabilities; training; order, standard, and regulation implementation; and specific procedural documents to further guide the electrical safety process.

2.2.2 Work Planning and Control

The DOE Implementation Plan for Integrated Safety Management, dated April 18, 1996, states that safety management activities can be grouped into five core safety management functions:

- Define the scope of work
- Identify and analyze the hazards associated with the work
- Develop and implement hazard controls
- Perform work within controls
- Provide feedback on adequacy of controls and continuous improvement in defining and planning work.

These five safety management functions provide the necessary structure for any work activity that could potentially affect the public, the worker, and the environment. The degree of rigor needed to address these functions varies with the type of work activity and the hazards involved. An analysis of the FMI work planning and controls applicable to the Building F-Zero Compressor Room in relation to the five core safety management functions follows.

Define the Scope of Work

The Board found that line management's responsibility and accountability for safety had not been satisfied, since the scope of work to be performed in the Building F-Zero Compressor Room was not adequately defined. No documented work package was developed that translated the job mission into work and set safety expectations. The only scope of work and information that the Contractor had was verbally communicated by Fermilab. This type of informal exchange leads to inadequate job planning.

Identify and Analyze the Hazards Associated With the Work

The identification of electrical hazards, use of lockout/tagout, and the use of appropriate personal protective equipment to mitigate known or unknown hazards have been addressed in 29 CFR 1910.132 and 331-335. These requirements are very specific in their meaning and intent. For example, 29 CFR 1910.333(b)(2)(i) states,

> "The employer shall maintain a written copy of the procedures outlined in paragraph (b)(2) and shall make it available for inspection by employees...."

Furthermore, 29 CFR 1910.333(b)(2)(ii)(B) states,

> "The circuits and equipment to be worked on shall be disconnected from all electric energy sources...."

OSHA [29 CFR 1910.132(d)(1) and (2)] also requires the employer to assess the workplace to determine if hazards are present, or are likely to be present. These regulations also require that,

> "The employer shall verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated; the person certifying that the evaluation has been performed; the date(s) of the hazard assessment; and, which identifies the document as a certification of

hazard assessment."

Examples of hazards associated with electrical work are electrical shock and burns. The Board found no documented evidence of any form of a hazard assessment being performed.

Develop and Implement Hazard Controls

Since there was no documented evidence of a hazard analysis being performed for this work, no controls were developed or implemented.

Perform Work Within Controls

The Board could find no evidence that adequate controls had been established for the work in the Building F-Zero Compressor Room.

Provide Feedback on Adequacy of Controls and Continuous Improvement in Defining and Planning Work

The feedback of lessons learned from accidents similar to this electrical work has not been communicated to employees. An accident occurred in March, 1997 that involved an electrician installing an electrical receptacle. Prior to performing work on the circuit, the electrician failed to verify that the energy source had been properly deenergized. The electrician locked out a circuit breaker, but it was not the correct one for the circuit he was working on. As a result, the electrician received an electrical shock. Corrective actions for this accident were to reinforce the existing lockout/tagout procedures and limitations of circuit tracing equipment. The Board concluded that corrective actions from this earlier accident were inadequate and the feedback of lessons learned from accidents similar to this electrical work have not been effectively communicated to employees.

Prior to performing work on the circuit, the electrician failed to verify that the energy source had been properly deenergized

Analysis

Based on an analysis of the facts, the Board concluded that work planning and controls for the Building F-Zero Compressor Room work did not ensure that an adequate hazards analysis or any other form of analysis was completed before the work began. The absence of clearly defined line management responsibilities and accountability for safety caused failures in translating the job mission into safe work practices, setting safety expectations, and allocating trained and experience personnel. Since line management did not

The Board concluded that work planning and controls for the Building F-Zero Compressor Room work did not ensure that an adequate hazards analysis or any other form of analysis was completed before the work began ensure that an adequate hazards analysis was completed prior to the work starting, measures and controls to mitigate the hazards for the work were not developed or implemented. In turn, this caused the work to be performed without appropriate controls. Lessons learned from previous work and reviews were not adequately evaluated, documented, or incorporated into the planning of work within the Building F-Zero Compressor Room. The Board concluded that the weekly construction meeting did not include the level of detail necessary for this job, to properly identify the hazards and controls necessary for this activity.

2.2.3 Policies and Procedures

In response to DOE policy and expectations for integrated safety management, Fermilab has promulgated an "Integrated Safety Management Plan", dated March 28, 1997, which clearly states expectations and general approaches for safety and health integration into all aspects of the work at the Laboratory. This document references subordinate or companion policies, programs, and procedures specified in Fermilab's Environment, Safety and Health (ES&H) Manual and implemented, in part, through the line organization's Specific Quality Implementation Plans. These documents, collectively, specify line management's roles and responsibilities for safety.

Recently, Fermilab sponsored an evaluation of their implementation of integrated safety management. Results were reported in an August 20, 1997 report entitled "Assessment Report - Fermilab Triennial Assessment of Integrated Safety Management." This report describes a variety of "commendable practices" in contract management, training, and management assessment. It also identifies deficiencies in the areas of "informality of operations" and "unclear roles, responsibilities and authorities." The Board identified similar inadequacies in the planning, control and execution of the electrical work in the Building F-Zero Compressor Room.

Fermilab's ES&H Manual addresses protocols for policy and administration, planning, training and discipline-specific safety procedures. Procedure 1010 (Rev. 3/96) provides a "corporate" level ES&H policy, including requirements that individuals are responsible for the ES&H concerns under their supervision. This policy further states that employees are responsible to recognize “those activities for which they are not qualified because of lack of training or otherwise.”

Fermilab’s ES&H Procedure 1030, “ES&H Organization and Responsibilities” (Rev. 4/94) and it’s Technical Appendix, also describes safety roles and responsibilities for individuals, supervisors, section heads and the Senior Laboratory Safety Officer. This individual is also the head of the ES&H Section which reports to the Laboratory Directorate and is responsible for, among other things, coordinating or initiating oversight activities and matrixing/coordinating safety and health expertise to other Laboratory organizations.

Fermilab’s ES&H Procedure 4010, “ES&H Training” (Rev. 10/95), addresses training requirements for employees, supervisors and management, but no specific minimum or core ES&H training is required.

The FESS issued Procedure 3001.0, Revision May 21, 1992, entitled “Environment, Safety and Health Procedures for Construction Covered by the Davis-Bacon Act.” This procedure describes the relationships, roles, responsibilities and interfaces required for construction activities. The most pertinent sections are the following:

- Section 1 specifies various organizational responsibilities. Based on the apparent obsolescence of the procedure with regard to the current organization, the absence of job related documentation, and conflicting interviewee responses, the Board was unable to determine the applicability of Section 1 responsibilities for the Building F-Zero work.

- Section 2 specifies that the portions of the Fermilab ES&H documents with direct application to the work shall be included into Exhibit A of the solicitation document. The Board found no evidence that this provision was implemented for Purchase Order 503794 or Purchase Requisition 105800.

- Section 3 requires submittal and approval of an ES&H Program or plan. No such plan was prepared for this work, nor could the Board find any evidence that the Contractor was included in Fermilab's ES&H Program.

- Section 5 specifies provisions for lockout and tagout, including requirements to comply with OSHA regulations 29 CFR 1910, Subpart S (electrical) and 29 CFR 1926, Subpart K (electrical), National Electric Code ANSI/NFPA 70, and Chapter 5120 of Fermilab's ES&H Manual. The Board found no evidence that these provisions were properly followed for the electrical work in the Building F-Zero Compressor Room.

The Board was provided with a February, 1993 procedure entitled "Environment, Safety and Health Procedures for Construction as Implemented for the Fermilab Main Injector (FMI) Project." The relevance of this procedure or link to FESS Procedure 3001.0 could not be determined by the Board. Many interviewees stated that construction projects covered by the Davis-Bacon Act have dollar thresholds that dictate safety provisions; e.g., jobs less than $25,000 do not require submittal of contractor safety plans and field changes can be initiated for modifications of $5,000 or less. The Board was unable to identify procedural specifications corroborating this information and interviewees could not provide definitive references.

Failure to provide adequate procedural controls, effective communication/training for all personnel required to implement them, and inadequate implementation of those provisions which existed prevented a clear understanding of expectations, job sequencing, and specific requirements applicable to the work. Because an inadequate hazards analysis was performed, failure to effectively document or communicate necessary controls and system configurations contributed to a dangerous situation.

2.2.4 Training and Qualifications

Training

Fermilab has a two-tiered training program: one for Fermilab employees, another for contractors. Fermilab employees can be provided training programs as their functions change. These training programs cover work practices and procedures and hazards incidental to the work. Responsibility for

Not all contractor employees receive training in specific Fermilab procedures, such as lock/tagout.

requesting such training rests primarily with the supervisor, although the employee also has a responsibility for requesting such training.

In the case of contractors, Fermilab provides training for a limited number of hazards, such as Oxygen Deficiency Hazards, Radiation Hazards, Confined Spaces, etc., which these employees may encounter in their work. Thus, not all contractor employees receive training in specific Fermilab procedures, such as lock/tagout.

According to training records maintained by Fermilab's ES&H Office, neither Electrician A nor Electrician B were trained in Fermilab's lockout/tagout procedures. In fact, there is no evidence that Electrician A received any Fermilab-specific training in over 15 years of working at Fermilab, with the exception of Radiation Worker II training. Electricians A and B have worked as electricians for over 20 years, respectively.

Qualifications

Although Fermilab requires electrical contractors to furnish journeyman electricians or greater, this does not ensure that they are qualified to perform the work in accordance with 29 CFR 1910.399, Note 1, definition of "qualified person", which states in part,

> "Whether an employee is considered to be a "qualified person" will depend upon various circumstances in the workplace. It is possible and, in fact, likely for an individual to be considered "qualified" with regard to certain equipment in the workplace, but "unqualified" as to other equipment."

Additional requirements for qualified persons are described in 29 CFR 1910.332(b)(3) (i)-(iii).

Electricians A and B stated that they had never removed a cover like this one and were not familiar with this type of motor control center. Neither Electrician A nor Electrician B were familiar with this type of electrical equipment/system, evidenced by the fact that they were looking for a neutral in a system that had no neutral. This is required by NFPA 70E Chapter 2-2 and 29 CFR 1910.399 which defines a qualified person to be one familiar with the construction and operation of the equipment and the hazards involved.

Based on the inability of Fermilab employees to accurately describe the electrical distribution system supplying power to the motor control center, the Board has concerns with regard to their qualifications to plan and oversee this work at the time of the accident.

2.2.5 Management Systems

Contractual Background

The temporary power supply work in Building F-Zero was conducted under the general operating contract (DE-AC02-76CH0300, Modification No. M219) between DOE and URA. This work was part of the Fermilab Main Injector Project. On September 25, 1997, Purchase Order No. 503794 ($16.6K) was issued by URA to the Contractor to provide power to E835 Portakamps from service building MI-8. The period of performance was through October 31, 1997. On October 9, 1997, Purchase Requisition No. 105800 ($4.5K) was prepared under Purchase Order 503794 for the Contractor to provide a "temporary power circuit from the F-Zero compressor room (FR 46) to switchboard in F-Zero S.B. (FR 45)." This task was to provide backup power for Building F-Zero when Feeder 45 was taken out of service. The Purchase Requisition specified that the work was to be completed by October 22, 1997.

This activity was considered a "field change" based on the estimated cost of the work. Although the procurement documents indicate that the Contractor was to perform the work directly for URA, Electrician A stated that he thought the work by his company was as a subcontractor to another firm. He also stated that the estimated cost of the work had not been discussed. Post accident interviews disclosed that no firm schedules had been established for the work and no additional documentation beyond the Purchase Requisition was identified. Project details were generally handled informally as one of a number of activities discussed at various weekly construction meetings. Interviews with Fermilab and Contractor employees disclosed that at least two job walkdowns occurred as part of the job planning, the last occurring on October 20, 1997, two days prior to the accident.

Because of conflicting testimony as well as the absence of pertinent job related documentation, however, the Board was unable to determine exactly what information was conveyed and understood regarding the job hazards.

Under the terms of their contract with DOE-CH, URA is responsible to implement (among other contractual provisions) “Laws, Regulations and DOE Directives”, specified in Appendix I and “Necessary & Sufficient ES&H Standards Set”, specified in Appendix J. These requirements are translated by URA into operating procedures for execution of work activities. Purchase Order 503794, Section 10, “Environment, Safety & Health Program”, invoked the “Vendor Approved Safety Plan” and “Fermilab ES&H Manual”. A Contractor safety plan approved by Fermilab could not be provided to the Board and no evidence was available that demonstrated that Contractor personnel had received training in appropriate portions of Fermilab’s ES&H Manual.

The overall Main Injector project organization and responsibilities (both DOE’s and URA’s), schedules, resources and task plans are described in the Fermilab Main Injector Project Management Plan, revised February 10, 1995. Originally promulgated on December 17, 1992, the Board could find no evidence that the 1995 revisions have been approved by organizations endorsing the original issue. Some areas of obsolescence were identified by the Board in the 1995 version.

DOE-CH/Fermi Group Office Roles and Responsibilities

DOE-CH and the Fermi Group organizational functions are described in Mission and Functions statements. Line management responsibility for the FMI Project flows from the DOE Office of Energy Research, High Energy & Nuclear Physics Program to the Manager, DOE Chicago Operations Office, to the Manager, DOE Fermi Group, to the DOE Project Manager, residing in Programs, Projects, and Facilities.

No safety and health support or oversight has been requested or provided to the FMI Project during the last year.

Although aware of the general “macro-scopic” level project activities, neither Fermi Group staff nor the DOE Project Manager were involved in the planning, identification of safety requirements, or safety and health monitoring of the

Building F-Zero Compressor Room work. The DOE Project Manager stated that he is responsible for safety and relies upon Fermilab personnel to properly implement safety requirements, in accordance with the contract and their own procedures. He also stated that he frequently visits the areas where work is actually performed and randomly selects activities and safety practices for monitoring. These walkthroughs typically include a safety representative from Fermilab's FESS. Results of these management walkthroughs are documented in weekly memoranda. None of the weekly memoranda for the last eleven months identified adverse electrical safety issues. However, the Board could not determine whether any work performed by the Contractor had been included in these walkthroughs.

The DOE-CH Technical and Administrative Services Group has a Safety and Technical Services organization which provides safety and health support to line organizations in a "matrix" arrangement. Safety expertise and oversight is provided at the request of either the line organization or senior management. Interviews disclosed that, with the exception of limited support in readiness assessments for major project initiatives, no safety and health support or oversight has been requested or provided to the FMI Project during the last year.

The Board could find no evidence that the Fermi Group, or any other organization from DOE, has comprehensively evaluated the FMI work from an integrated safety management perspective. Thus, the Board concluded that oversight activities are not adequate to assure that safety programs and policies are being implemented.

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Fermilab Roles and Responsibilities

Interviews with various levels of Fermilab personnel revealed that line management responsibility flowed from the Laboratory Directorate to the Head, Beams Division to the Associate Head, Fermilab III (the FMI Project Manager), to the Main Injector (MI) Department, represented by an "interface". The MI Department solicits construction support from FESS and contractual support from Fermilab's Business Services Section. The Fermilab ES&H Section provides assistance, as requested; it was not used for the Building F-Zero work. FESS provided project safety personnel plus a

Construction Coordinator who became the first line supervisor directing the work performed by the Contractor. The work specified in Purchase Order 503794 and supplemental Purchase Requisition 105800 was to follow the line management chain described above.

The definition and communication of work scope, schedule, and project details were generally informal for the work being done at the time of the accident. Existing Fermilab policies and procedures are ambiguous in terms of specific details required on smaller scale work. Failure to clearly and unambiguously communicate roles, responsibilities and lines of authority to interface with other necessary disciplines and crafts were indicative of the general informality in the design and execution of the work at the Building F-Zero Compressor Room.

The definition and communication of work scope, schedule, and project details were generally informal for the work being done at the time of the accident.

Since line management's understandings of safety oversight roles and responsibilities were unclear, crafts employees were exposed to undue risk. For example, inspection and evaluation of the actual work site by responsible supervision, safety, and crafts personnel was less than adequate for the electrical work in the Building F-Zero Compressor Room. The Associate Head of Fermilab III, the MI "interface", the FESS Construction Coordinator as well as a FESS safety representative, all assumed that the work was routine and could be handled by "skill of the craft."

Line management's understandings of safety oversight roles and responsibilities were unclear, crafts employees were exposed to undue risk.

Management controls, planning activities, and execution of the electrical work relied upon a base level of skill, referred to as "skill of the craft," to perform work safely. However, there was no common understanding at Fermilab as to the specific knowledge and skills represented by "skill of the craft." Furthermore, there is no commonly accepted distinction between "skill of the craft" and specific or "not routine" work. Prior experience with other similar electrical equipment was not sufficient to overcome the risks created by inadequate safety management controls.

Fermilab's organizational interrelationships have resulted in unclear line, administrative, and project reporting responsibilities and authorities. The Board concluded that there was general confusion with regard to specific responsibilities for this work. Since no one person took responsibility for overall project control, the workers were all

Fermilab's organizational interrelationships have resulted in unclear line, administrative, and project reporting responsibilities and authorities.

operating under a different set of assumptions.

The facts surrounding this accident include a variety of safety management system breakdowns: inadequate work planning, inadequate hazard evaluation, ineffective communications, inadequate work controls, and lack of implementation of work controls. For example, poor procedural implementation began with inadequate pre-job planning and continued through the failure to assign clear requirements or adequately communicate job hazards on the day of the accident. The Board concluded that management did not follow through on their commitment to safety for the electrical work in the Building F-Zero Compressor Room.

Integrated Safety Management - Analysis

Every organizational unit within line management must assume ownership and clearly communicate responsibility for the protection of workers, the public, and the environment. *Mission and Functions* statements for CH and the Fermi Group as well as URA's Safety and Health Policy Statement (ES-EH-100) and Occupational Safety and Health Program Description (SH-152PD) , indicate that line managers are responsible for safety and health. Organizational and individual management responsibilities for the safety of this work were not sufficiently documented, communicated or understood, clearly demonstrating that the Fermi Group, URA, and contractors such as the Contractor have not effectively implemented an integrated safety management process commensurate with the policies and expectations of the Department.

The Board concluded that controls, documentation and communications associated with the electrical work in the Building F-Zero Compressor Room were inadequate to satisfy the five core safety management functions identified in Section 2.2.2.

The Board concluded that controls, documentation and communications associated with the electrical work in the Building F-Zero Compressor Room were inadequate to satisfy the five core safety management functions.

2.3 BARRIER ANALYSIS

The safety barriers between Electricians A and B and the 480 VAC hazard within the MCC Cabinet #4 enclosure included physical barriers, administrative barriers, and management barriers. A description of why these barriers failed is contained in Table 2-1.

Table 2-1 Barriers That Failed

Injured Parties	Electricians A and B
Phys. Barrier	**MCC Cabinet #4 Bus Bar Cover** The physical barrier between the Electricians and the 480 VAC energy source in MCC Cabinet #4 enclosure was the bus bar cover. Electricians A and B attempted to remove the bus bar cover to locate a connection for the neutral conductor. This barrier failed because the metal bus bar cover contacted the “C” phase of the 480 VAC service.
Admin. Barriers	**Hazards Analysis** The hazards identification for the Electricians was not adequate, was not documented, and was not sufficiently comprehensive to identify hazards and appropriate controls associated with work in MCC Cabinet #4, thereby causing this barrier to fail.
	Electrical Engineering Drawings The Electricians did not request nor were they furnished electrical engineering drawings for the system. These drawings could have correctly identified the difference in configuration of electrical systems fed by Feeder 46B in the F-Zero Compressor Room and Feeder 45 in the F-Zero RF Room.
	Work Qualifications The use of qualified workers implies that personnel engaged in their primary skill area are knowledgeable and trained in the construction, operation and hazards associated with in the work they perform. Failure by the Electricians to verify Feeder 46B as being deenergized caused the failure of this barrier.
	Work Planning Effective work planning would have resulted in the use of electrical engineering drawings for assistance in defining and executing the work, specific procedures to be followed, and the identification of potential hazards. Any one of these items would have prevented the failure of this barrier.
	Lockout/Tagout Lockout/tagout is an effective barrier to electrical hazards. The MCC in Building F-Zero was fed from Feeder 46B which was not locked out. A routine check made at the 800 A breaker feed or the MCC incoming bus bar would have been an effective barrier; but since none was made, this barrier failed.
Mgmt. Barriers	**Clear Roles and Responsibilities** Roles and responsibilities for safety were not clearly communicated or understood by personnel which resulted in inadequate work planning, hazards analysis, documentation, application of controls, and selection of personnel to perform the work. As a result this barrier failed.
	Specification of Requirements No requirements were specified for electrical engineering drawings, a proper hazards analysis with appropriate safety controls, a written scope of work for use by the Electricians, or an adequate prejob briefing. Any one of these requirements could have prevented this barrier from failing.
	Line Management Line management failed to define and effectively enforce requirements for job planning and hazards analysis causing this barrier to fail.
Energy Source	**480 VAC Energized Bus Bar**

2.4 CAUSAL FACTORS

The **direct cause** of the accident was the contact of the bus bar cover to phase “C” of MCC Cabinet #4. However, there are also root causes and contributing causes. **Root causes** are the fundamental causes that, if corrected would prevent recurrence of this and similar accidents. **Contributing causes** are other causes that, would not, by themselves, have prevented the accident but are important enough to be recognized as needing corrective action. An Events and Causal Factors Analysis was used to evaluate the causal factors of this accident. A summary of this analysis is contained in Table 2-2.

Table 2-2. Causal Factors Analysis

Root Causes	Discussion
The Electricians did not understand that there were energized components behind the bus bar cover.	Had the Electricians understood that the bus bar was energized, they likely would not have removed the bus car cover and been exposed to the hazard. Fermilab did not take positive steps to assure that the contractors understood the potential hazards of the job. The Electricians did not do an energy check on the line side of the cabinet and assumed that the equipment was deenergized.
DOE-CH and Fermilab management did not ensure that an adequate integrated safety management system was implemented for electrical work.	Had DOE-CH ensured that Fermilab instituted a comprehensive ISM system which applied to all activities, adequate job planning would have been initiated. Once properly defined, the hazards could have been controlled and work procedures developed to assure that work was performed within these controls.
Contributing Causes	**Discussion**
Fermilab procedures were not adequately defined or implemented.	Procedures did not require the use of electrical engineering drawings. The requirements for lockout/tagout and voltage verification were not properly implemented.
Job planning and hazards analysis were performed informally, inadequately documented, and poorly communicated to the workers.	Due to the size of this job, work was considered to be routine and treated informally by all personnel involved. For example, no electrical engineering drawings were referenced or used to understand and execute the work; procedures applicable to the work were not specified; and the informality of the hazards analysis failed to adequately identify hazards associated with the work.
Fermilab did not provide training or ensure that workers had adequate knowledge to safely perform the work.	There was no evidence that the Electricians performing the work had received job specific training in the Fermilab ES&H manual provisions applicable to the work; nor did the Electricians or Fermilab personnel have a working knowledge of the system. The Board was not supplied with any safety criteria for contractor selection which may have ensured that personnel were knowledgeable and trained in the construction operation, and hazards involved in the work they perform.
Fermilab managers and supervisors did not have a clear understanding of their roles, responsibilities, and authorities for electrical safety.	Management’s reliance on delegation of authorities to clearly define and execute roles and responsibilities resulted in a lack of clarity and understanding to effectively control the safety aspects of the work.
Due to inadequate oversight by DOE and Fermilab, the opportunity to identify electrical safety program deficiencies was missed.	Neither DOE-CH nor Fermilab line management have performed an adequate review of the electrical safety program.

3.0 CONCLUSIONS AND JUDGMENTS OF NEED

Conclusions are a synopsis of those facts and analytical results that the Board considers especially significant. **Judgments of need** are managerial controls and safety measures believed necessary to prevent or minimize the probability or severity of a recurrence. They flow from the conclusions and are directed at guiding managers in developing corrective actions. Table 3-1 summarizes the Board's conclusions and judgments of need.

Table 3-1. Conclusions and Judgments of Need

Conclusions	Judgments of Need
Fermilab does not have a comprehensive program in place to ensure electrical workers are qualified prior to commencing field work.	There is a need for Fermilab to ensure that personnel engaged in their primary skill are knowledgeable and trained in the construction, operation, and hazards involved in the work they perform.
Fermilab lockout/tagout and energy verification practices for the site are inadequate to ensure protection from hazardous electrical energy.	There is a need for Fermilab to strengthen, communicate, and enforce the requirements for lockout/tagout, including energy verifications.
Work planning and hazards analysis were inadequate.	There is a need for Fermilab to ensure that potentially exposed workers are informed of, and clearly understand, the hazards. There is a need for Fermilab to clarify policies and procedures for planning and executing projects.
Fermilab's Lessons Learned program is ineffective in disseminating work planning information for potentially affected electrical activities. This appears to be a systemic problem throughout all site activities.	There is a need for Fermilab to implement a Lessons Learned program that disseminates the information effectively throughout the workforce.
DOE and Fermilab have not performed an adequate review of the electrical safety program.	There is a need for DOE-CH to conduct a comprehensive review of the Fermilab electrical safety program. There is a need for Fermilab to comprehensively review, and revise as necessary, their electrical safety program.
Fermilab and Contractor personnel did not have a clear understanding of their roles, responsibilities, and authorities for safety.	There is a need for Fermilab to ensure that roles, responsibilities, and authorities for management and safety are clearly defined, understood, and implemented at all levels by personnel involved in the work.
Fermilab's controls, documentation, and communications associated with the electrical work were inadequate to satisfy the five core functions of DOE's integrated safety management system.	There is a need for DOE-CH to conduct a comprehensive review of the definition, communication, and implementation of Fermilab's integrated safety management system.

4.0 BOARD SIGNATURES

_________________________________ Date: ____________________

Michael Saar, Chairperson
DOE Accident Investigation Board
U.S. Department of Energy
Chicago Operations Office

_________________________________ Date: ____________________

Dennis Vernon, Deputy Chairperson
DOE Accident Investigation Board
U.S. Department of Energy
Office of Environment, Safety and Health

_________________________________ Date: ____________________

Craig Schumann, Member
DOE Accident Investigation Board
U.S. Department of Energy
Argonne Group Office

_________________________________ Date: ____________________

Randall Smyth, Member
DOE Accident Investigation Board
U.S. Department of Energy
Office of Environmental Management

_________________________________ Date: ____________________

Thaddeus Tomczak, Member
DOE Accident Investigation Board
U.S. Department of Energy
Office of Energy Research

5.0 BOARD MEMBERS, ADVISORS, AND STAFF

Chairperson	Michael Saar, DOE-CH
Deputy Chairperson	Dennis Vernon, DOE-HQ, EH-21
Member	Craig Schumann, DOE-ARG
Member	Randall Smyth, DOE-HQ, EM
Member	Thaddeus Tomczak, DOE-HQ, ER
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APPENDIX A

APPOINTMENT MEMORANDUM FOR TYPE B ACCIDENT INVESTIGATION