Type B Accident Investigation Board Report on the September 4, 1998, Flammable Liquid Fire/Explosion at Fermi National Accelerator Laboratory Batavia, Illinois

October 16, 1998

Chicago Operations Office
U.S. Department of Energy

Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

October 21, 1998

SUBJECT: TYPE B ACCIDENT INVESTIGATION BOARD REPORT OF THE SEPTEMBER 4, 1998, FLAMMABLE LIQUID FIRE/EXPLOSION AT FERMI NATIONAL ACCELERATOR LABORATORY (FERMILAB)

On September 11, 1998, I appointed a Type B Accident Investigation Board to investigate the September 4, 1998, Flammable Liquid Fire/Explosion at Fermilab, located in Batavia, Illinois, that resulted in burns to three subcontractor employees. 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 Department of Energy Order 225.1A, "Accident Investigations."

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

John P. Kennedy
Acting Manager

This report is an independent product of the Type B Accident Investigation Board appointed by John P. Kennedy, Acting 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 225.1A, *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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ACRONYMS AND INITIALISMS

CFR	Code of Federal Regulations
CH	U.S. Department of Energy, Chicago Operations Office
DOE	U.S. Department of Energy
ES&H	Environment, Safety, and Health
Fermilab	Fermi National Accelerator Laboratory
FRMI	U.S. Department of Energy, Chicago Operations Office, Fermi Group
IDLH	Immediately Dangerous to Life or Health
JSA	Job Safety Analysis
LBR	LBR Consolidated Services
MEK	Methyl Ethyl Ketone
MSDS	Material Safety Data Sheet
OSHA	U.S. Occupational Safety and Health Administration
NIOSH	National Institute for Occupational Safety and Health
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
ppm	parts per million in air by volume
TLV	American Conference of Governmental Industrial Hygienists Threshold Limit Value

EXECUTIVE SUMMARY

INTRODUCTION

An accident at the Fermi National Accelerator Laboratory (Fermilab) was investigated in which three painters received burns as a result of a flammable liquid fire/explosion while preparing the floor of a storage room for painting. The Accident Investigation Board (the Board) used various analytical techniques, including accident analysis, barrier analysis, and event and causal factor analysis. The Board inspected the room where the accident occurred; conducted interviews; and reviewed photographs of the accident scene, events relating to the accident, and 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 (DOE) Integrated Safety Management System.

ACCIDENT DESCRIPTION

On September 4, 1998, shortly after 7:00 p.m., two painters and their foreman, all employees of a painting contractor (the Contractor) to Fermilab, were preparing the concrete floor of a dry storage room for painting. The dry storage room is adjacent to the kitchen on the ground floor of Wilson Hall, Fermilab's main office building. Preparation of the floor included removing all grease and other foreign material with a cleaning agent and then etching or abrading (sanding) the floor to improve paint adhesion. To prepare the floor, the painters used acetone in gallon quantities and an electric floor buffer. The Board concluded that while the painters were using acetone in the room, an ignition source, most likely the floor buffer, ignited the acetone vapors, causing a fire/explosion that injured the painters. The injuries were first-degree burns on the foreman, second-degree burns on one painter, and third-degree burns on the second painter. The second painter required hospitalization and skin graft surgery and was released on September 19, 1998.

CAUSAL FACTORS

The direct cause of the accident was the ignition of a flammable mixture of acetone vapor and air. The Board identified two root causes for the accident; the elimination of either would have prevented the accident:

- Root cause: The painting Contractor failed to recognize the hazards of using acetone to clean the dry storage room floor.

- Systemic root cause: Management failed to ensure adequate implementation of the Integrated Safety Management core functions relating to definition of work scope, hazard analysis, and development and implementation of controls.

The Board also identified seven contributing causes that collectively increased the likelihood of the accident, but that individually did not cause the accident:

- Work planning was inadequate for the work the painters were engaged in at the time of the accident.
- Work controls were not adequately defined and communicated to the Contractor employees.
- Fermilab failed to implement a fully integrated process to ensure adequate ES&H considerations are given to jobs that involve the use of hazardous substances.
- The Contractor Project Manager and Foreman were not informed of work controls contained in the contract or applicable Fermilab ES&H procedures.
- Fermilab did not provide training for the Contractor employees or ensure that they had adequate knowledge to perform the work safely.
- Fermilab did not provide adequate oversight of Contractor work activities.
- Fermilab did not utilize information from previous accident investigations and assessment reports to ensure continuous improvement in defining and planning contractor work.

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

Conclusion	Judgment of Need
Fermilab's work planning was incomplete, which resulted in poor understanding of the tasks, hazards, and control measures.	Fermilab needs to ensure that a job safety analysis, or project hazard analysis, is completed for contract services and construction that defines the job tasks; known and anticipated hazards; control measures to be used; and required approvals should there be a need to change the work plan, equipment, or chemicals used. Fermilab needs to ensure that the job hazard analysis is reviewed by ES&H and is communicated to its employees, as well as contractor employees.
Fermilab does not have an adequate system in place to ensure that all contractor employees are properly trained in the hazards associated with their work.	Fermilab needs to develop and implement a system to ensure that all outside contractor employees are properly trained in the hazards associated with their work. FRMI needs to oversee the development and implementation of Fermilab's system to ensure that contractor employees are properly trained.
Fermilab does not have an adequate system in place to ensure that all contractor employees are aware of site-specific procedures and ES&H requirements.	Fermilab needs to develop and implement a standard orientation training program that provides contractors with site-specific procedures and ES&H requirements. FRMI needs to evaluate the effectiveness of the Fermilab orientation training program to ensure that it provides adequate site-specific procedures and requirements.
Fermilab did not review the existing contract to ensure compliance with the current contractor Construction Safety Program procedure.	Fermilab needs to review existing contracts involving hazardous work and require contractors to prepare a job hazard analysis and submit it to the Fermilab ES&H Section for review. FRMI needs to assess the effectiveness of Fermilab's program for reviewing existing contracts involving hazardous work.
Fermilab does not have an adequate feedback process to ensure continuous improvements in its process for defining and performing contractor work.	Fermilab needs to develop and implement a feedback process that ensures deficiencies and corrective actions from precursor accidents and assessments are utilized for continuously improving operations.
FRMI has not adequately assessed the effectiveness of Fermilab's system for procuring and executing contract services and construction.	FRMI needs to assess the effectiveness of the systems that Fermilab uses to communicate and implement ES&H requirements applicable to contractors.
DOE-CH has not assessed Fermilab's Integrated Safety Management system to ensure adequate implementation of the five core functions.	DOE-CH needs to conduct a comprehensive review of Fermilab's Integrated Safety Management system.

TABLE ES-1 (Cont.)

Conclusion	Judgment of Need
The requirements for site accident readiness of DOE Order 225.1A were not met.	FRMI needs to ensure that the requirements of DOE Order 225.1A are met. Fermilab needs to develop and implement a procedure for preserving and securing the scene until arrival of, and transfer to, the Accident Investigation Board; and obtain timely initial statements from all individuals involved in the accident.
All emergency management personnel could not be immediately reached.	Fermilab needs to develop and implement a paging protocol for emergency management personnel so that they can be reached in a timely manner.

TYPE B ACCIDENT INVESTIGATION BOARD REPORT ON THE SEPTEMBER 4, 1998, FLAMMABLE LIQUID FIRE/EXPLOSION AT FERMI NATIONAL ACCELERATOR LABORATORY BATAVIA, ILLINOIS

1.0 INTRODUCTION

1.1 BACKGROUND

On September 4, 1998, shortly after 7 p.m., a contractor foreman and two painters were burned as a result of a flammable liquid fire/explosion while they were preparing a concrete floor for painting. The fire/explosion occurred in and immediately outside a dry storage room on the ground floor of Wilson Hall at Fermi National Accelerator Laboratory (Fermilab).

The dry storage room is in the cafeteria kitchen in Fermilab's main office building. The work was being performed by LBR Consolidated Services (LBR), a contractor to Fermilab (hereafter, LBR is referred to as the Contractor). An organization chart showing the reporting relationships of Contractor employees discussed in this report is provided in Figure 1.

On September 11, 1998, John P. Kennedy, Acting Manager, Chicago Operations Office (CH), U.S. Department of Energy (DOE), appointed a Type B Accident Investigation Board (hereafter referred to as "the Board") to investigate this accident in accordance with DOE Order 225.1AA, *Accident Investigations* (see Appendix A).

Activities at Fermilab are managed by the DOE Fermi Group (FRMI), which reports to and receives support services from CH (see Figure 2). The DOE program office with cognizance over Fermilab is the Office of Energy Research. Universities Research Association, Inc. (URA), has operated Fermilab since 1967; its contract with DOE was renewed from January 1, 1997, through December 31, 2001. URA is a corporation of 87 major research-oriented universities.

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 approximately 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 located about 30 miles west of Chicago on 6,800 acres.

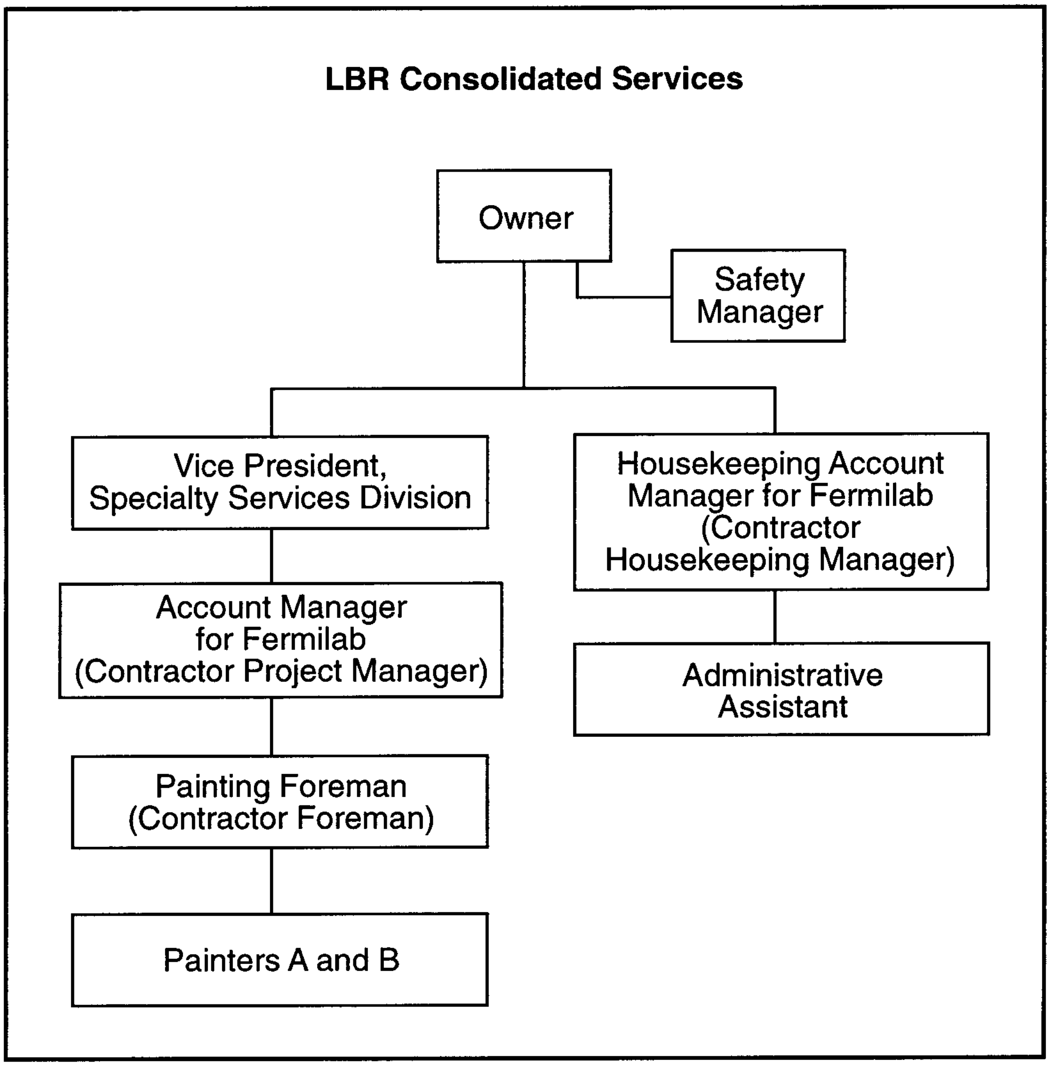

FIGURE 1 LBR Organization Chart

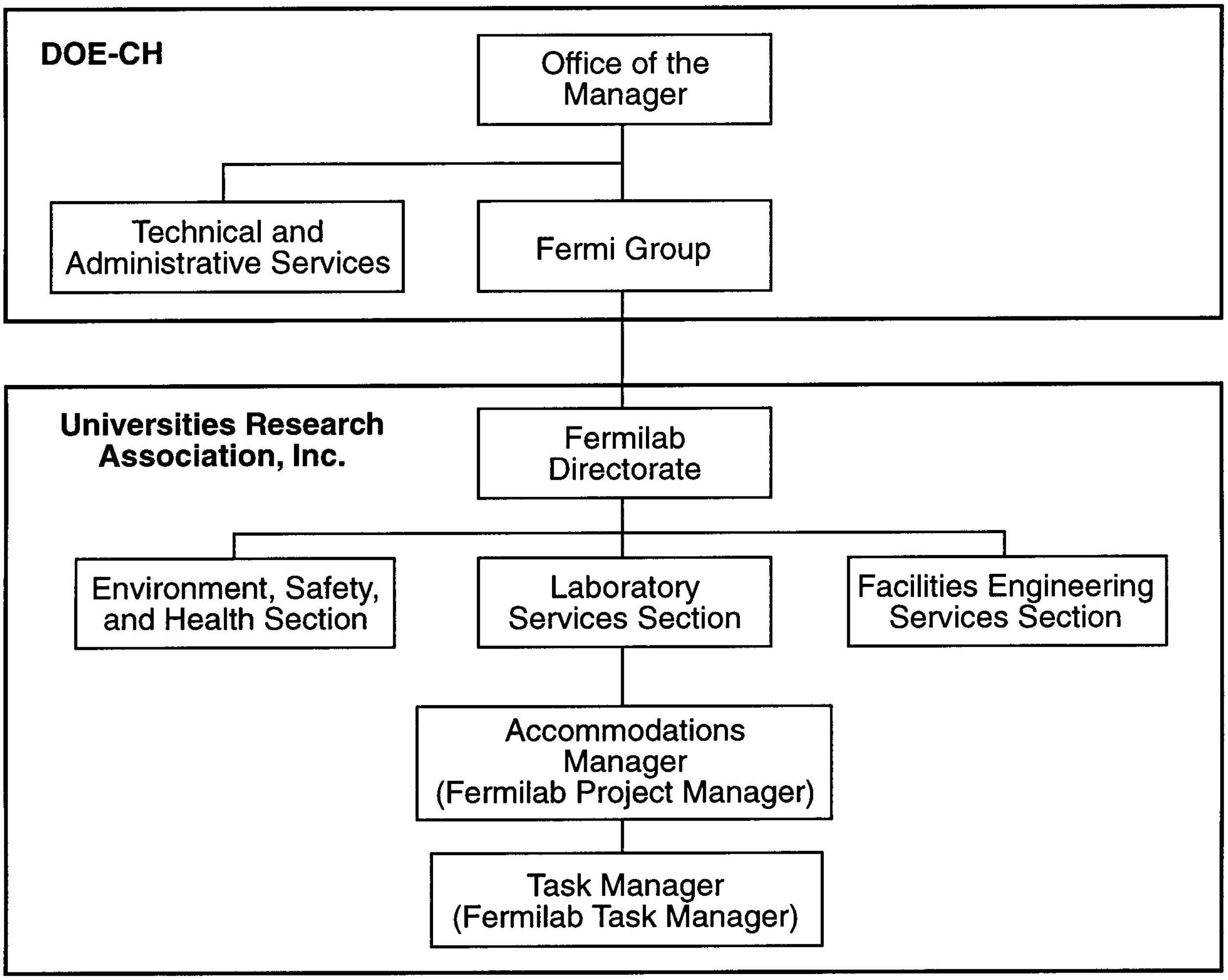

FIGURE 2 Simplified DOE-CH and Fermilab Organization Chart

Fermilab's mission 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.

1.3 PURPOSE, SCOPE, AND METHODOLOGY

The Board began its investigation on September 14, 1998; completed the investigation on September 25, 1998; and submitted its final report to the CH Manager on October 16, 1998. The report preparation was coordinated with the Accident Investigation Program Manager, Office of the Deputy Assistant Secretary for Oversight, for review and comment, in accordance with DOE Order 225.1A.

The purposes of this investigation were to determine the causes 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 scope of the Board's investigation was to review and analyze the facts and circumstances surrounding the accident and to gather accident-related information on the safety management systems and work control practices of DOE, Fermilab, and the Contractor, using the principles and core functions of Integrated Safety Management (DOE Policy P450.4). Using these facts, the Board determined the direct, contributing, and root causes; developed conclusions; and determined the judgments of need that, when implemented, should reduce the probability of similar occurrences.

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] and barrier analysis[2] techniques were used to analyze facts and identify the causes of the accident.
- Judgments of need for corrective actions to prevent recurrence were developed.

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[1] Charting depicts the logical sequence of events and conditions (causal 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.

2.0 FACTS AND ANALYSIS

2.1 ACCIDENT DESCRIPTION AND CHRONOLOGY

2.1.1 Background and Accident Description

Fermilab has two contracts with the Contractor, one with the Contractor's Housekeeping Division to provide janitorial services, the second with its Specialty Services Division for painting. A purchase order was prepared and approved for the Contractor to paint various Fermilab locations. Figure 1 shows the reporting relationships of the Contractor employees involved in the accident.

One of the painting tasks performed under the purchase order on September 4, 1998, consisted of repainting the concrete floors of two restrooms and a dry storage room in the kitchen on the ground floor of Wilson Hall (Figure 3). The dry storage room was used for storage of dry goods by the kitchen staff and as office space by the chief cook. The room had no ventilation. According to the LBR Specialty Services Division Account Manager for Fermilab (hereafter referred to as the Contractor Project Manager), preparation of the concrete floors for painting included removing all grease and other foreign material with a cleaning agent. After cleaning, the floor surface was to be etched with acid or abraded (sanded) to improve paint adhesion.

> The task was to paint a storage room that had no ventilation.

The following description of the accident is based on information provided during interviews with the responding firefighters, Fermilab personnel, and Contractor managers and on documentation provided to the Board. The Board attempted to interview the LBR Painting Foreman (hereafter referred to as Contractor Foreman) and Painters A and B, but they refused to be interviewed. Contractor management provided the Board written statements prepared from notes taken during two interviews of the Contractor Foreman and one interview of Painter A by Contractor personnel.[3] Using the best evidence available, the Board developed the most likely events and sequence of events. These were neither confirmed nor denied by the Contractor Foreman or Painters A and B. All times are approximate.

> The Contractor Foreman and Painters A and B refused to be interviewed.

On August 3, 1998, Fermilab selected the Contractor's Specialty Services Division to perform the painting tasks. On August 5, the Fermilab Task Manager gave a toolbox safety meeting to the Contractor Foreman and Painter B. Planning for this specific task occurred on August 31, 1998, in a conversation between the Contractor Project Manager and the Contractor Foreman. The Contractor

[3] The Contractor Office Manager talked to the Contractor Foreman on September 5, 1998, and Painter A on September 9, 1998; the Contractor Safety Manager talked to the Contractor Foreman on September 11, 1998.

Project Manager stated that he instructed the Contractor Foreman to order muriatic acid and some paint. Based on interviews and statements reviewed, the Board concluded that the Contractor Foreman misunderstood the Contractor Project Manager and ordered, by telephone, five gallons of "muriatic acetone" from the Contractor's supplier on September 1, 1998. The supplier filled the order as acetone. In his statement to the Contractor Safety Manager, the Contractor Foreman recalled that he picked up the order with other supplies on September 4, 1998, between 9:30 and 10:30 a.m. and that he was in a hurry and did not verify the contents of the order when he picked it up.

At 2:00 p.m. on September 4, the Fermilab Task Manager asked the Contractor Foreman when the task would begin and was informed that it would begin at 4 p.m. At 2:30 p.m., the Contractor Project Manager, who was en route to Fermilab from another project in Green Bay, Wisconsin, called the Contractor Foreman by cellular telephone. The Contractor Project Manager advised the Contractor Foreman that he would arrive at Fermilab between 7:00 and 8:00 p.m. and instructed him to obtain methyl ethyl ketone (MEK) and paint. He was also to obtain a grease remover from the Contractor Housekeeping Manager and to have the dry storage room floor ready for painting by 8:00 p.m.

The Contractor Foreman and Painter A arrived at the cafeteria at 3:00 p.m. and met with the LBR Housekeeping Division Account Manager (hereafter referred to as the Contractor Housekeeping Manager), who has an office on the Fermilab site to oversee day-to-day housekeeping activities. The Contractor Housekeeping Manager stated that he and the Contractor Foreman discussed the job and "walked down" the work site, and the Contractor Housekeeping Manager provided Powerhouse™ (a non-flammable industrial cleaner), some mops, and 10 warning signs to post at the work site. The Contractor Foreman was further instructed to contact the Contractor Housekeeping Administrative Assistant to obtain a stronger non-flammable cleaner/stripper and pad (for the floor buffer) if the Powerhouse™ was ineffective.

At 3:50 p.m., the Contractor Foreman obtained silica sand from the Fermilab Task Manager. At 4:15 p.m., the Contractor Foreman and Painter A began cleaning the dry storage room floor. About that same time, the Contractor Housekeeping Manager checked on the painters. According to the Contractor Foreman, at about 4:10 p.m., the Fermilab Task Manager visited the work area. The Fermilab Task Manager stated that he observed the Contractor Foreman and Painter A on their hands and knees scraping what looked like yellow tape from the floor. Painter B arrived at the work site at about 4:30 p.m., and the three began cleaning the floor with Powerhouse™ until about 5:15 p.m. The Contractor Foreman and Painter A applied and mopped with the Powerhouse™ while Painter B used the floor buffer.

At 5:15 p.m., after finishing the cleanup with Powerhouse™, the Contractor Foreman determined that a gritty film remained on the floor and that further cleaning was necessary. The Contractor Foreman sent Painter A to retrieve "muriatic acid" from the Foreman's van, and Painter A returned with a case containing four one-gallon containers of acetone. The Contractor Foreman opened the case, examined one of the containers, and read the label, including the warning statements. In his statement to the Contractor Safety Manager, the Contractor Foreman reported that he realized it was acetone and told the painters he had never used acetone. He further reported that he was uncertain whether to proceed and decided to call the Contractor Project Manager for direction. He placed the call via cellular telephone but the connection was poor, the conversation was short, and he did not ask for or receive any instructions about the acetone.

The Contractor Foreman determined that a gritty film remained on the floor and that further cleaning was necessary.

After the phone conversation, the Contractor Foreman returned to the work site and told the two painters that they were going to use the acetone. The Board was given two conflicting scenarios of how the acetone was used. The first scenario was provided by firefighters, who were told by the Contractor Foreman on September 4, 1998, that he and the two painters were cleaning the dry storage room floor using one gallon of acetone diluted in four gallons of water and a floor buffer when the fire/explosion occurred.

The Board was given two conflicting scenarios of how the acetone was used.

The second scenario was provided by Contractor Management, who were told by the Contractor Foreman on September 5 and again on September 11, 1998, that he poured acetone on the floor in small quantities while Painter A worked it into the floor surface with a mop. Painter B brought in the floor buffer and put a pad on the buffer. The Contractor Foreman recalled that at this time, a container of acetone was knocked over and spilled. The Contractor Foreman began to clean up the spill with a mop and bucket of water. During the spill cleanup, a second one-gallon container of acetone was knocked over and spilled. The Contractor Foreman instructed Painter A to remove the now-empty containers and get another bucket of water. Both the Contractor Foreman and Painter A continued mopping up the spill while Painter B used the floor buffer in areas they had finished mopping.

The Contractor Foreman reported that he had just exited the dry storage room with a mop bucket full of an acetone/water mix from the spill cleanup when he heard an explosion. According to the Fermilab Fire Department log, the explosion occurred at 7:07 p.m. See Figure 3 for the approximate locations of the Contractor Foreman and two painters at this time. The Contractor Foreman reported that the explosion slammed the door to the dry storage room shut, pushed him to the side, and ignited the bucket he was carrying. The Contractor Foreman dropped the bucket, turned back toward the dry storage room, and pushed open the door.

The Contractor Foreman reported that he had just exited the dry storage room when he heard an explosion.

Painter B, who was operating the floor buffer and closest to the door when the explosion occurred, ran out of the room first with the back of his shirt on fire. Painter A, who was 10-12 feet away from

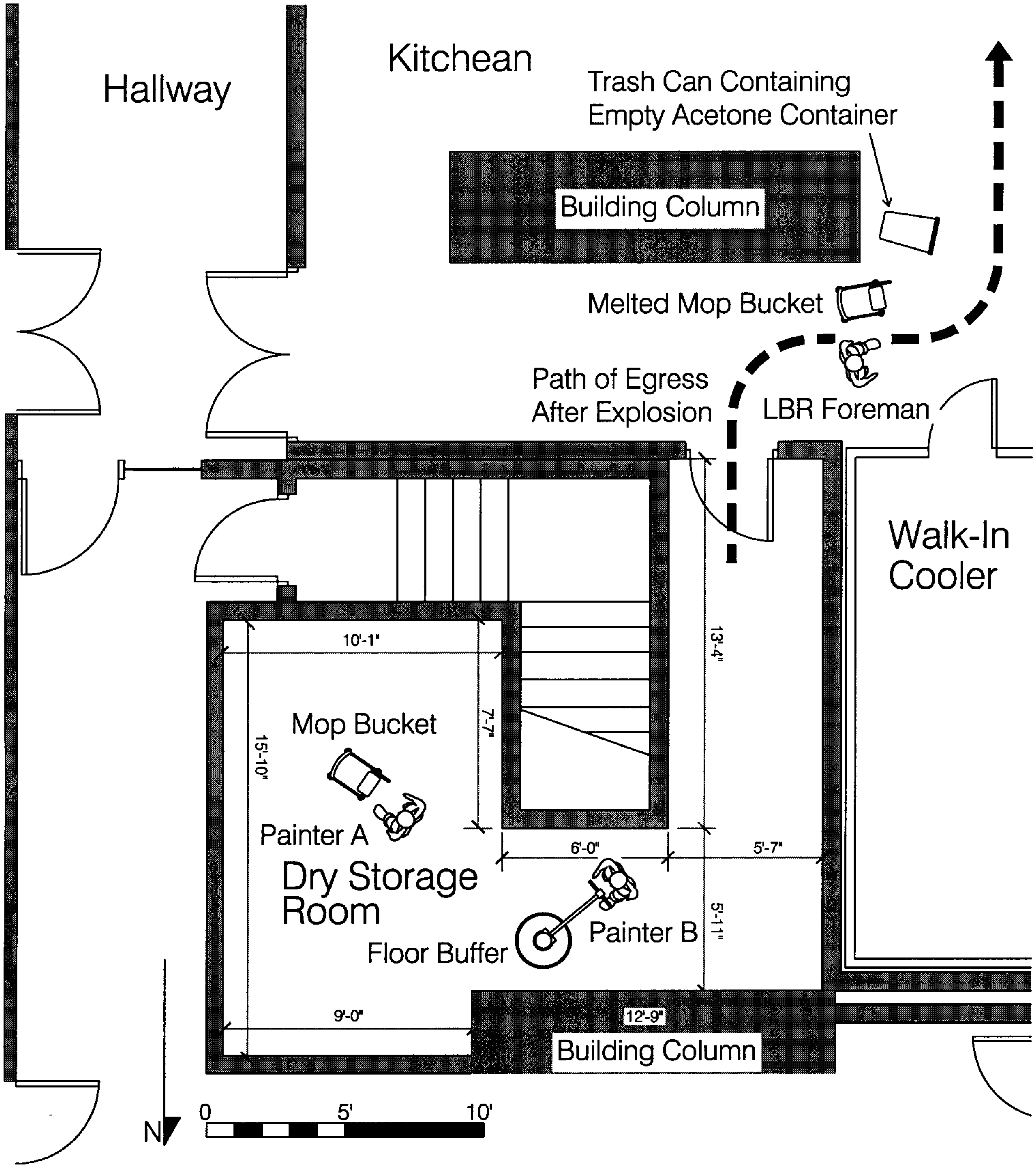

FIGURE 3 Layout of the Dry Storage Room Showing the Approximate Locations of the Contractor Foreman and Painters when the Flammable Liquid Fire/Explosion Occurred

FIGURE 4 Photograph of the Dry Storage Room after the Accident. When the fire/explosion occurred, Painter A was standing near the yellow mop bucket in the foreground and Painter B was using the floor buffer in the background.

the floor buffer, reported that the floor surrounding him became engulfed in flames, he had to jump over the floor buffer to escape, and he exited the room with flames on his face. Both the Contractor Foreman and Painter A helped extinguish the flames on Painter B. Once the flames were extinguished, all three exited the kitchen area and building.

Based on the best evidence available, the Board concluded that a spark from the electric floor buffer was the most likely source of ignition of the acetone vapors. Other potential sources of ignition could have been equipment in the kitchen, a dropped tool creating a spark, or an open flame.

The exact concentration and distribution of acetone vapors in the room could not be determined. It is known that approximately two gallons of acetone was used and/or spilled in the dry storage room. A calculation using the volume of the dry storage room and no dilution ventilation indicated that approximately one pint of acetone fully evaporated would result in a uniform vapor concentration equal to the permissible exposure limit (PEL). The fact that the accident was a flammable vapor fire/explosion establishes that at some point the acetone vapor concentration was greater than the lower explosive limit and less than the upper explosive limit (see Section 2.2.1.5).

The Board concluded that two hazards existed in the course of this accident. The first was a health hazard when the workers were potentially exposed to acetone vapors above the permissible exposure limit. The second was a physical hazard when the acetone vapor concentration exceeded the lower explosive limit and the vapors were ignited.

The severity of the explosion was indicated by visible structural damage to the north cinder block wall of the dry storage room. The wall was moved laterally at its top approximately one inch, damaging the suspended ceiling in the corridor outside the north wall. The ceiling tiles in the kitchen immediately to the south of the dry storage room were also dislodged and damaged.

2.1.2 Chronology of Events

Figure 5 summarizes the chronology of events leading up to the fire and explosion.

2.1.3 Emergency Response

Emergency response to the accident was evaluated in two parts: (1) the initial emergency response to the scene and (2) the emergency management response and activation of the Emergency Operations Center (EOC).

> The Board concluded that the initial response was timely and well coordinated.

The initial emergency response involved the Fermilab Fire and Security departments and four other mutual aid companies as shown in Figure 6. The Board concluded that the initial

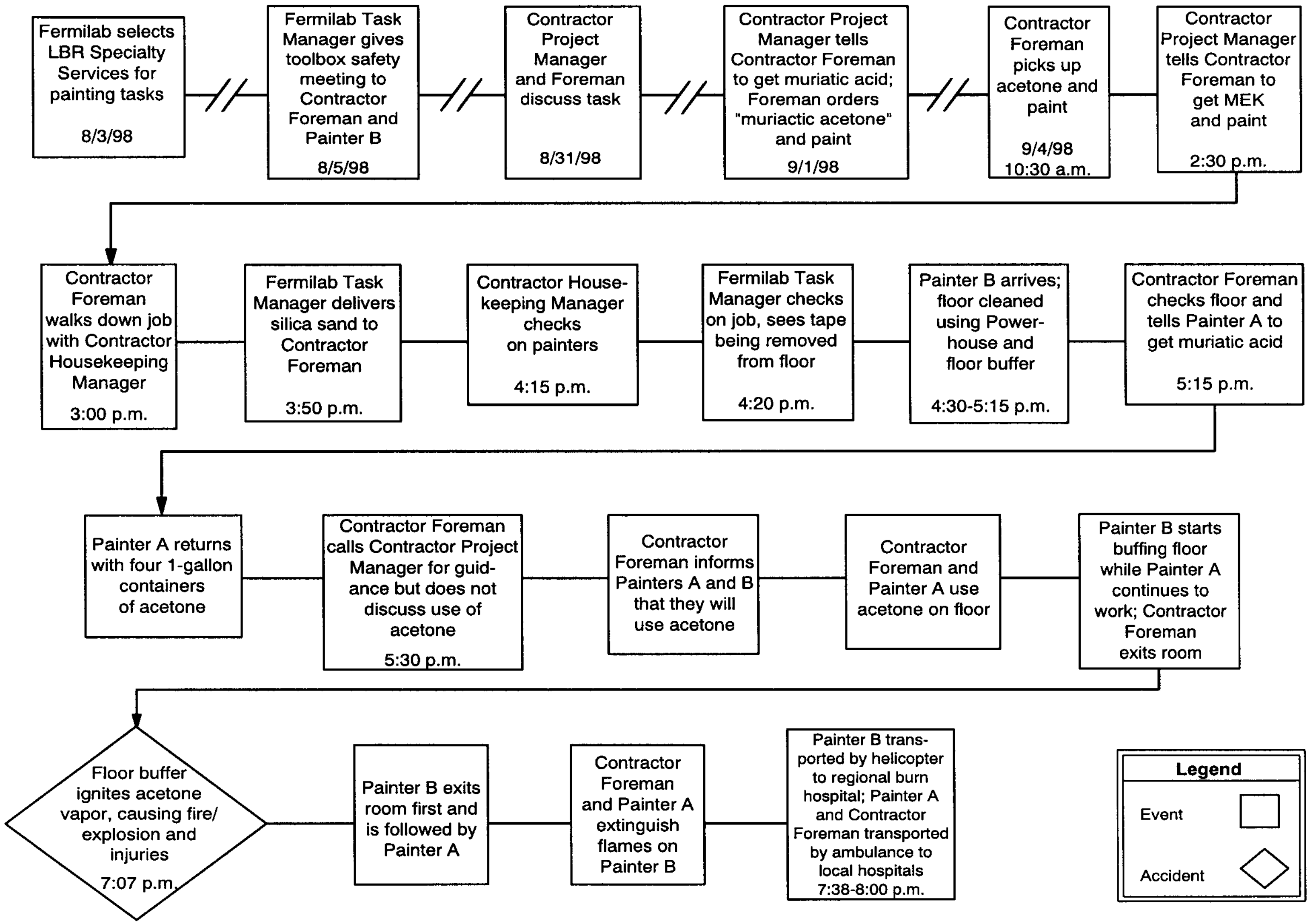

FIGURE 5 Summary of Significant Events and Accident Chronology (all times are approximate)

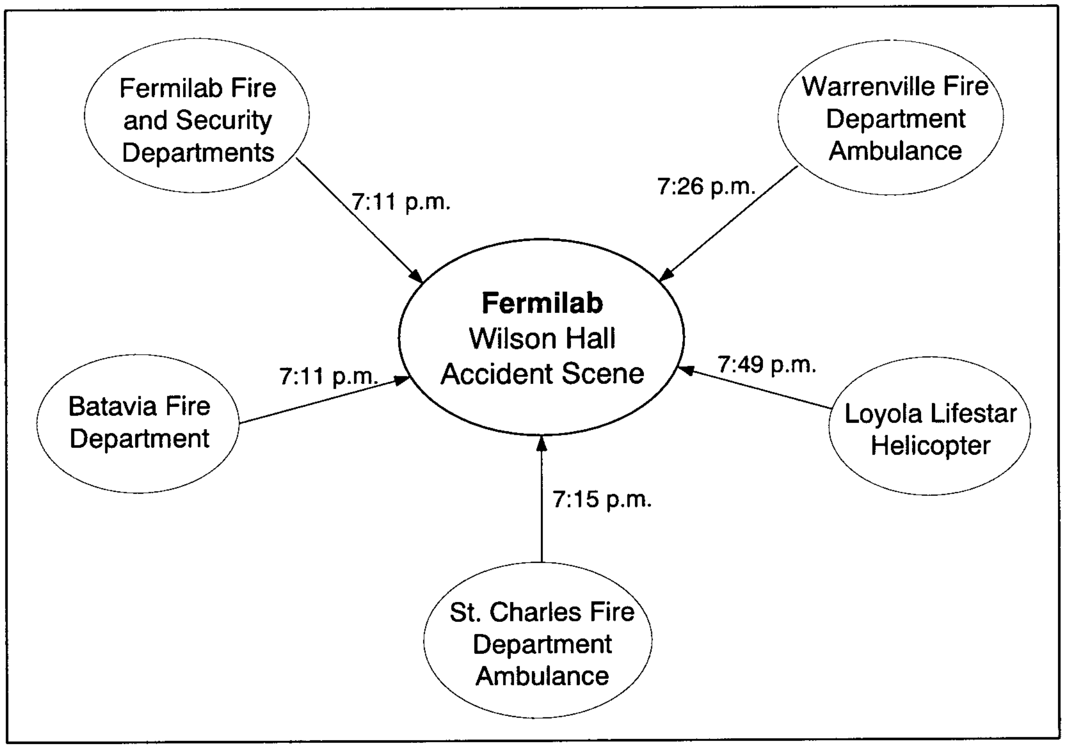

FIGURE 6 Emergency Responders and Arrival Times

response for fire-fighting activities, medical treatment of injured, and bringing the scene to a safe condition was timely and well coordinated. See Appendix B for a detailed sequence of events.

The emergency management response involved the Fermilab Emergency Coordinator, Emergency Director, Public Information Officer, and Com Center and the DOE On-Scene Commander. The Board concluded that emergency management response and activation of the EOC were also timely and well coordinated (Appendix B).

Although the emergency response to this accident was timely and well coordinated, the Com Center experienced some difficulty reaching Fermilab management personnel by telephone and Contractor management personnel because of an incomplete call list. The Board concluded that Fermilab needs to institutionalize a paging protocol for emergency management personnel so they can be reached in a timely manner (without depending on unreliable telephone contact and subsequent call back). Fermilab should also ensure that all call lists, including contractors, are complete and updated.

2.1.4 Medical

The Contractor Foreman was taken by ambulance to Delnor Community Hospital, where he was treated for a slight burn to the lower left forearm and later released. Painter A was taken by ambulance to Central DuPage Hospital, where he was treated for first- and second-degree burns to 20% of his body, mainly his hands, arms, face, ears, and neck. Painter A was released on Saturday, September 5, 1998.

Painter B received second- and third-degree burns to 33% of his body.

Due to the severity of his injuries (degloving of the skin on his hands, forearms, and ears), Painter B was airlifted to Loyola University Medical Center, where he was diagnosed with second- and third-degree burns to 33% of his body, mainly his hands, forearms, back of legs, face, ears, neck, and back. Painter B underwent surgery for skin grafting and was released on September 19, 1998.

No alcohol or drug tests were requested or performed after the accident. The Board concluded that, based on interviews with individuals who were in contact with the Contractor Foreman and two painters before and after the accident, fitness for duty was not an issue.

2.1.5 Investigative Readiness

The Board reviewed the investigative readiness of Fermilab for this accident in accordance with DOE Order 225.1A. The Order requires that Fermilab be prepared to quickly establish a team to mitigate accident consequences and assist with an investigation. The Order also requires that the integrity of the accident scene and evidence be preserved, data collection activities initiated, initial witness statements obtained, and the accident scene documented through photographs. The accident scene and evidence collected should remain secured or preserved until the Type A or Type B Accident Investigation Board arrives and takes control.

Immediately following the accident, Fermilab restricted access to the accident scene and photographed the area. The accident was categorized as an off-normal occurrence in accordance with DOE Order 232.1A, *Occurrence Reporting and Processing of Operations Information,* at 10:00 p.m., and the scene was released for cleanup. Cleanup included replacing the light fixtures, electrical receptacles, and sprinkler heads in the dry storage room. The accident was categorized as a Type B Accident the next workday, Tuesday, September 8, 1998. The Accident Investigation Board was officially appointed three days later, on Friday, September 11, 1998, in accordance with timeframes specified by DOE Order 225.1A.

The Board concluded that some of the requirements of DOE Order 225.1A were not met, as evidenced by the following:

The Board concluded that some of the requirements of DOE Order 225.1A were not met.

1. Initial statements from all individuals involved in the accident, both directly and indirectly (e.g., responders), were not obtained. For example, the Contractor Foreman returned to the scene on the same night of the accident as well as the following day, but Fermilab did not obtain an initial witness statement from him.

2. The scene was released for cleanup, and light fixtures, electrical receptacles, and sprinkler heads were replaced prior to the arrival of the Board. The Board concluded that the area where the accident occurred, the dry storage room, was not a critical area for site operations and should have been secured and preserved until the Board arrived.

3. A proper chain of custody was not established for the physical evidence. Evidence included personal protective equipment (PPE), the floor buffer, and chemicals that were present at the time of the accident. The floor buffer used by the Contractor was not examined by the Board due to the fact that it could not be ascertained without a doubt that this was the same floor buffer used at the time of the accident. Following the accident, the floor buffer was released and returned to the Contractor Foreman prior to the arrival of the Board. The Contractor Foreman reportedly gave it to a private attorney who later returned it to the Contractor.

2.1.6 Post-Accident Actions

On September 8, 1998, Fermilab management communicated preliminary lessons learned from the accident to all employees, users, and contractors in a memorandum. Three points were addressed: (1) avoid substituting approved materials with non-approved materials, (2) use Fermilab's emergency reporting system to report spills of hazardous materials, and (3) use flammable liquids in accordance with manufacturer guidelines and away from potential ignition sources.

On September 8, 1998, Fermilab management communicated preliminary lessons learned from the accident.

On September 8, 1998, Contractor Management issued a memorandum to the Contractor's suppliers stating that, effective immediately, under no circumstances is anyone from the Contractor authorized to purchase acetone or MEK. This memorandum was copied to Contractor Account Managers.

2.2 HAZARDS, CONTROLS, AND MANAGEMENT SYSTEMS

2.2.1 Industrial and Worker Safety

The job to paint the floor of the dry storage room exposed employees to various hazards. The painters should have been adequately trained in the proper handling of hazardous chemicals, proper use and selection of personal protective equipment including respiratory protection, and electrical safety-related work practices.

> The job potentially exposed employees to various chemical and electrical hazards.

Fermilab had included this task as one of several different painting tasks defined in Purchase Order 505986. The floor had previously been painted and was being painted again due to the poor condition of the existing paint. The painting was performed in a routine, scheduled, or anticipated fashion. Since this is a recurring maintenance activity, the Board determined that the relevant standards for this job are contained in Part 1910 of Title 29 of the Code of Federal Regulations (CFR).

By contract, the Contractor had the responsibility for complying with all applicable safety regulations. The Fermilab Task Manager assigned to this task had the responsibility for assuring that the contractor met all safety provisions and requirements of the contract. A hazard analysis was required for all tasks, and the Fermilab Project Manager or Fermilab Task Manager was responsible for determining how extensive the hazard analysis needed to be.

2.2.1.1 Hazardous Chemicals

The painting tasks involved the use of several hazardous chemicals. Under 29 CFR 1910.1200, employers must provide information to their employees by means of labels on containers, material safety data sheets (MSDSs), and training.

The intent of the OSHA standard is to ensure that all employees who are exposed to hazardous chemicals receive information about them through a comprehensive hazardous chemical communication program. Effective hazardous chemical communication reduces the risks to workers handling hazardous chemicals by providing them with information they have a need and right to know. One element of the hazardous chemical communication program requires that employers maintain a complete list of the hazardous chemicals that employees may be exposed to. The Contractor's written hazard communication program was reviewed, and it did not contain a list as required by 29 CFR 1910.1200(e)(1)(I). The Board was provided no evidence that Fermilab had ever requested such a list.

The Fermilab Project Manager reviewed some MSDSs for chemicals intended for use by the Contractor during the floor preparation and painting. Appendix C lists the MSDSs reviewed, summarizes handling information required by the MSDS, and includes the Fermilab Project Manager's notations. On each MSDS, the Fermilab Project Manager wrote the words, "OK to use," on the MSDS to indicate his approval for use of the chemical at Fermilab.

The Board was not provided any evidence that the Fermilab Project Manager reviewed the MEK MSDS. The Contractor Project Manager told the Board that he had intended the painters to use MEK to clean tools and equipment after the two-part epoxy paint application.

Any chemical must be used in a knowledgeable and reasonable fashion. The Contractor Project Manager planned to use muriatic acid and MEK for this job. Although neither were used, adequate control measures for their use were not developed. MSDSs for muriatic acid and MEK both state that ventilation is to be used at the source. In addition, for muriatic acid there was no nearby eyewash or other suitable facility for flushing of the eyes, as required by 29 CFR 1910.151(c).

2.2.1.2 Ventilation

Ventilation is an engineering control that is commonly used to control employee exposures to hazardous chemicals. General ventilation is not as satisfactory for health hazard control as is local exhaust ventilation. Local exhaust ventilation is used to control worker exposure in situations in which the chemicals are toxic, the quantity of vapors generated is large, workers are working in close proximity to where the vapors are generated, and/or the vapor generation is not uniform.

All of the MSDSs reviewed by the Fermilab Project Manager indicated that ventilation (local exhaust and/or good general ventilation) was necessary during the use of the chemicals to control airborne concentrations to less than the OSHA permissible exposure limits (PELs) and threshold limit values (TLVs). Airborne concentrations above these limits require the use of appropriate respiratory protection.

The Fermilab Project Manager's hazard analysis and instructions written on the MSDSs did not indicate that the use of ventilation would be required as a control measure. Additionally, there was no evidence that the Contractor Foreman intended to use ventilation as a control measure during the floor preparation and painting activities.

> No evidence indicated that ventilation was intended as a control measure for the job.

One of the primary objectives when working with hazardous chemicals is to prevent atmospheric contamination. This should be accomplished as far as feasible by accepted engineering control measures. Proper ventilation is a

> Ventilation in the dry storage room was inadequate.

prerequisite to working in a confined area such as the dry storage room. This room had no means for supplying clean air and exhausting room air to adequately control emissions, exposures, and chemical hazards.

The Board concluded that adequate ventilation was not provided to use hazardous chemicals in the room.

2.2.1.3 Respiratory Protection

In the absence of adequate ventilation or engineering controls, appropriate respirators may be used to prevent or reduce worker exposure. OSHA requires that respirators be selected on the basis of hazards to which the worker is exposed. Generally accepted industrial hygiene practices for respirator selection are as follows:

1. Selection and provision of an appropriate respirator must be based on the respiratory hazard to which the worker is exposed and workplace and user factors that affect respirator performance and reliability.

2. Respirators must be NIOSH-certified and used in compliance with the conditions of its certification.

3. The person selecting the respirator must identify and evaluate the respiratory hazard in the workplace; this evaluation includes a reasonable estimate of employee exposures to the respiratory hazard and an identification of the contaminant's chemical state and physical form. Where the person selecting the respirator cannot identify or reasonably estimate the employee exposure, the respirator selector will consider the atmosphere to be immediately dangerous to life or health (IDLH).

4. Respirators selected for IDLH atmospheres include a full-mask pressure-demand self-contained breathing apparatus certified by NIOSH for a minimum service life of 30 minutes, or a combination full-mask pressure-demand supplied-air respirator with auxiliary self-contained air supply.

5. The level of respiratory protection may be reduced when industrial hygiene sampling data indicate that acceptable airborne concentrations are being maintained.

As stated in the preamble to the new OSHA standard regarding respirators, painters are an example of one of the trades that often involve overexposure to toxic substances and require respirators for control. For this reason, the Contractor has a written respiratory protection program.

The Board was shown two half-mask organic vapor cartridge respirators, with dust pre-filters, that were found at the scene of the accident. The Board concluded that, without exposure monitoring data from chemical use in a similar situation, these respirators were inappropriate for controlling employee exposure to muriatic acid, MEK, silica sand dust, Powerhouse™, and the two-part epoxy paint. Furthermore, the Board concluded that the Contractor's respiratory protection program was inadequate.

> The Contractor used respirators that were inappropriate for controlling employee exposure.

2.2.1.4 Personal Protective Equipment

The OSHA standard in 29 CFR 1910.132(d)(1) requires employers to assess the workplace to determine if hazards are present or likely to be present that necessitate the use of personal protective equipment (PPE). The standard also requires employees to be trained in the use of PPE needed to protect them from hazards.

The Board was provided no evidence that the Contractor or Fermilab conducted an adequate hazard assessment for use of PPE. Use of the Fermilab-approved hazardous chemicals such as the Powerhouse™ cleaner, muriatic acid, and the two-part epoxy paint would require this assessment to be conducted. In addition, the Board was provided no evidence that the Contractor painters had been properly trained in the use of PPE. The Board concluded that, although the absence of any particular PPE was not directly involved in this accident, it is indicative of the lack of job planning by both Fermilab and the Contractor. It should be noted that two respirators and two pair of safety glasses were found at the scene, but no protective gloves were found at the scene.

> Neither the Contractor nor Fermilab conducted an adequate hazard assessment for use of PPE.

2.2.1.5 Electrical Safety

The Board concluded that an electric floor buffer present at the accident scene was the most likely ignition source for the fire and explosion. Statements provided by Contractor Management indicated that the floor buffer was being operated when the fire and explosion occurred. The relevant standard for use of the floor buffer is found in 29 CFR 1910.334(d):

> "Where flammable materials are present only occasionally, electric equipment capable of igniting them shall not be used, unless measures are taken to prevent hazardous conditions from developing. Such materials include, but are not limited to: flammable gases, vapors, or liquids; combustible dust; and ignitable fibers or flyings."

While storage, manufacture, and other on-going presence of flammables are covered under the installation requirements for hazardous locations, temporary uses are not. The electrical standard prohibits energizing electric equipment where it might ignite flammable or ignitable materials, unless suitable protective measures, such as providing ventilation, are taken. Electrical equipment must be recognized as a serious source of ignition. This is reiterated in the MSDS for acetone, which states that “excessive heat and all sources of ignition” are conditions to avoid. Also, the container label states, “Keep away from heat, open flame or sparks ...”

> An electric floor buffer present at the accident scene was the most likely ignition source for the fire and explosion.

Two weeks after the accident, the Contractor Safety Manager checked the floor buffer, believed to be involved in the accident, and found no warning label. Other floor buffers similar to the one used at the time of the accident reportedly had a label that stated, “Warning, risk of fire – do not use with flammable or combustible liquid to clean floor – risk of explosion, floor sanding can result in an explosive mixture of fine dust and air. Use floor sanding machine in a well ventilated area.” The relevant standard is 29 CFR 1910.303(b)(2):

> “Listed or labeled equipment shall be used or installed in accordance with any instructions included in the listing or labeling.”

Use of this floor buffer in an unventilated area or an area with flammable vapors would not be in accordance with the listing or labeling of the floor buffer. The Board concluded that the floor buffer was not designed for use in an area where flammable vapors or dusts are present. During an interview, one firefighter stated that he had observed a gap between the motor cord and handle cord of the floor buffer and thought this may have been the source of ignition.

OSHA promulgated a standard on electrical safety-related work practices in 1990 that covered the safe use of electric equipment. The training section (29 CFR 1910.332), which became effective in 1991, requires employees to be trained in electrical safety-related work practices. The painters not only were working with flammable vapors but were also mopping the floor in preparation for the paint, thus becoming exposed to electric shock. The cleaning liquids had the potential to enter electric equipment designed for dry locations. The risk of electric shock was not reduced to a safe level, as required by the electrical safety requirements found in 29 CFR Part 1910. As the hazard of using electricity under wet conditions is widely recognized, OSHA requires such employees to be trained in electrical safety practices. Table S-4 of 29 CFR 1910.332 specifically lists painters as an occupation typically facing a higher-than-normal risk of electrical accident.

The Board was provided no evidence that Contractor employees involved in the accident had received proper training in or were aware of electrical safety-related work practices.

2.2.1.6 Acetone

The Board could find no evidence that the Contractor had a copy of the MSDS for acetone or that the Contractor Foreman or two painters involved in this accident had ever been properly trained on the use of acetone. Familiarity with the properties and characteristics of flammable liquids is important to the proper handling of such material. The warning label on the acetone stated: "Keep away from heat, open flame or sparks. Do not smoke while using. Use only under well ventilated conditions." The Board concluded that the Contractor's use of acetone without having the MSDS and proper training is another indication of an ineffective Contractor hazardous chemical communication program.

> Use of the acetone without an MSDS and proper training indicates an ineffective Contractor hazardous chemical communication program.

The relevant standards that were not adhered to for this particular job are found in 29 CFR 1910.1200(g) and 29 CFR 1910.1200(h),

> "Employers shall have a material safety data sheet in the workplace for each hazardous chemical which they use," and

> "Employers shall provide employees with effective information and training on hazardous chemicals in their work area at the time of their initial assignment, and whenever a new physical or health hazard the employees have not previously been trained about is introduced into their work area."

The fire/explosion would not have occurred if adequate ventilation had been provided to ensure that airborne concentrations of acetone did not exceed the TLV (750 ppm) or the PEL (1,000 ppm), since the lower explosive limit is 25,000 ppm and the upper explosive limit is 128,000 ppm. In addition, since the IDLH limit is 2,500 ppm, the employees were in imminent danger before the flammable liquid fire/explosion occurred. See Figure 7 for the relevant physical characteristics and regulatory limits of acetone.

> The employees were in imminent danger before the flammable liquid fire/explosion occurred.

The Board heard conflicting testimony regarding chemicals "prohibited" by Fermilab. The Board concluded that the Contractor was never told that acetone or MEK was prohibited. The Board was provided documentation that indicated that acetone is used onsite, thus indicating that Fermilab does not generally prohibit the use of acetone.

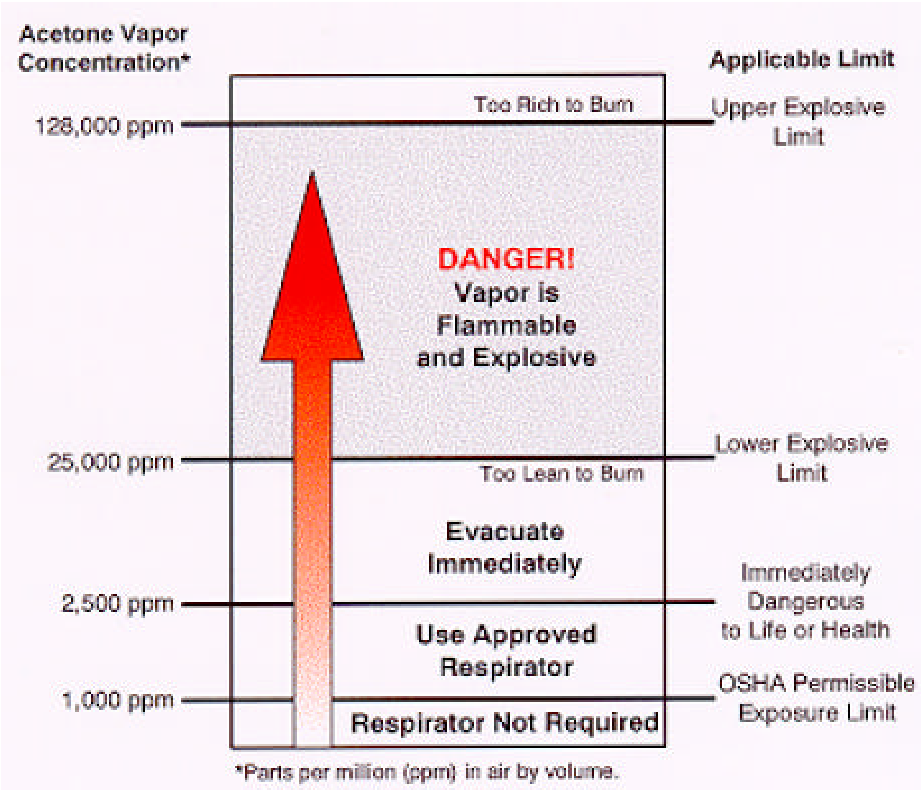

FIGURE 7 Hazards of Acetone Vapors in Air

2.2.2 Safety Management Core Functions

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. The following

following sections present an analysis of the work planning and controls process for the painting of the dry storage room floor in relation to the five core safety functions.

2.2.2.1 Define the Scope of Work

The Board concluded that the scope of work for painting in the dry storage room was not adequately defined. A written work package was not developed to translate the job mission into work requirements, materials to be used, and adequate safety expectations. The only scope of work and information received by the Contractor from Fermilab was communicated verbally. In addition, the Board discovered during interviews that there were different understandings on the part of Fermilab and the Contractor of how the job was to be completed, indicating that the scope of work was not well defined.

> A written work package was not developed. The scope of work was not well defined.

2.2.2.2 Identify and Analyze the Hazards Associated with the Work

The Board was provided no evidence that the Contractor conducted a hazard analysis for the painting task. The Board was provided evidence that the Fermilab Project Manager conducted a project hazard analysis in the form of handwritten notes in the margin of the MSDSs and notes on a manilla folder. MSDSs for chemicals that were intended to be used identified the need for adequate ventilation, respiratory protection, gloves, and other appropriate PPE.

The Board concluded that the hazard analysis for this job was inadequate because it failed to recognize all potential hazards for painting the dry storage room.

> Hazard analysis for this job was inadequate and failed to recognize all potential hazards.

2.2.2.3 Develop and Implement Hazard Controls

The Board concluded that, since there was an inadequate hazard analysis performed for this job, proper controls were not developed or implemented. Controls were not in place to ensure that chemicals were used safely, for example, with adequate ventilation and appropriate PPE.

> Proper controls were not developed or implemented.

The contract between Fermilab and the Contractor required Fermilab to approve all chemicals to be used by the Contractor. The Contractor did not submit the acetone MSDS to Fermilab for review and approval.

Fermilab issues a work permit before contractors start work. Some of the work permit sections include the job location, description, conditions or requirements, required precautions, and checklist for organizations needing notification. The work permit for the task to paint the dry storage room floor stated the following information:

> Location of Job: Fermilab Village – LSS Buildings
>
> Brief Description: Prepare surface and paint per directions from task manager.
>
> Precautions Required: Standard OSHA Construction Standards and Fermilab ES&H regulations. All work to be scheduled through Fermilab Housing Office in advance.

The Board concluded that the work permit issued for the project, which included about 17 tasks, was not specific for the preparation and painting of the dry storage room. The work permit did not identify the use of a corrosive (muriatic acid) nor did the permit indicate the PPE to be used. The "required precautions" section of the permit should have been more specific concerning required work controls.

2.2.2.4 Perform Work Within Controls

The Board could find no evidence that adequate controls had been established for the work in the dry storage room. Fermilab requires completion of a work permit before work begins, and this was completed and signed. The permit did not specify any special conditions to be met, such as the chemicals to be used or ventilation requirements.

A review of the permit indicated that the Fermi Project Manager had approved the permit in three different approval blocks — project leader, department head, and safety officer. The Fermilab Task Manager also signed in the project leader block. There was only one other signature that appeared on the permit, and it was the division/section head.

To effectively control work, a work permit system should require approvals by separate individuals. The Fermilab Project Manager should not be able to approve a permit in three different roles. Also, Fermilab does not require a baseline review for a particular task before a work permit is issued. The Board concluded that the existing work permit system at Fermilab is not an effective work control.

> The existing work permit system at Fermilab was not an effective work control for the tasks.

Sections of the Contractor's Health and Safety Manual that are applicable to this accident include Job Safety Analysis Program, Hazard Communication, and Respiratory Protection Program. Assigned responsibilities are as follows:

1. Supervisor Job Safety Analysis (JSA) Responsibilities: Identify jobs for which a JSA should be conducted, including new jobs created by changes in process; assign personnel to conduct the JSA; approve the JSA; and implement job procedures that result from the JSA.

   The Board was provided no evidence that the Contractor had conducted a JSA for painting the dry storage room.

   > The Contractor did not conduct a JSA for painting the dry storage room.

2. Supervisor Hazard Communication Responsibilities: Review chemicals prior to their introduction into the workplace and conduct employee training as necessary; update a list of chemicals and MSDSs as required; request MSDSs for any new chemical purchased from suppliers and forward the MSDSs to the Contractor hazard communication coordinator; and inform the hazard communication coordinator of the identity, amount, and use locations of any new chemicals.

   The Board was provided no evidence that the Contractor Foreman had fulfilled these responsibilities regarding hazardous chemical communication.

3. Respirator Program Coordinator Responsibilities: Select proper respiratory protective equipment based on OSHA standards and discussions with responsible people expected to wear or supervise users of the equipment.

   The Board was provided no evidence that the proper respirators were selected, as evidenced by the two respirators that were found at the scene.

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

The Board conducted a DOE-wide search of the Occurrence Reporting and Processing System and Computerized Accident/Incident Reporting System to determine whether any similar incidents have occurred. The search found no similar incidents involving the use of flammable liquids and electrical equipment.

Investigations of past incidents at Fermilab have identified similar inadequate work planning and hazard analysis of contractor work. The Board reviewed the Type B investigation report for the October 1997 electrical arc blast accident at Fermilab and a preliminary report of a July 1998 contractor employee concern.

Past incidents at Fermilab have identified inadequate work planning and hazard analysis deficiencies.

Both reports identified inadequate work planning and hazard analysis involving contractor operations as a deficiency.

In 1997, Fermilab conducted an evaluation of its implementation of integrated safety management. The results were reported in an August 20, 1997, report titled "Assessment Report – Fermilab's Triennial Assessment of Integrated Safety Management." This report identifies deficiencies in "formality of operations."

During August 1998, Fermilab instituted a system to evaluate past safety performance of contractors. However, existing contractors are not evaluated under this system until contract renewal. The Board concluded that Fermilab should reconsider its policy and evaluate the safety performance of existing contractors.

The Board concluded that Fermilab is not adequately using previous accident information in a timely manner to improve its contractor safety program.

Fermilab has not adequately used previous accident information to improve its contractor safety program in a timely manner

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 integrating safety and health into all aspects of work at Fermilab. This document references subordinate or companion policies, programs, and procedures specified in Fermilab's Environment Safety and Health (ES&H) Manual. These documents specify line management's roles and responsibilities for safety.

Fermilab's ES&H Procedures do not specifically address use of flammable liquids or restrict their use in any way. The Fermilab Work Smart Standards include relevant sections of the National Fire Protection Association Fire Codes, which recommend appropriate storage and handling methods for flammable liquids.

Fermilab's ES&H Procedure 5051, "Hazard Communication" (revised 3/97), provides direction for hazard communication to contractors. This procedure states

> "Because the Laboratory uses and stores hazardous chemicals onsite in a way that the employees of other employer(s) may be exposed (for example, employees of a construction subcontractor working onsite), the Business Services Section Contracts Department shall enclose a summary of this Hazard Communication Program in subcontracts involving work onsite. Alternatively, this summary may be provided to subcontractors in pre-construction meetings."

The original contract to LBR was awarded in August 1996 prior to the issuance of this procedure; however, the specific job task was originated in August 1998. The Board concluded that, as a good business practice, Fermilab should have provided this hazard communication procedure to the Contractor with the assignment of the new task order. The Board was given no indication that a copy of the site hazardous chemical communication program was provided to the Contractor.

> The Fermilab hazardous chemical communication program was not provided to the Contractor.

2.2.4 Training and Experience

The Contractor had worked at Fermilab since 1996 without any reported safety problems. The painters involved in the accident had various years of experience: Painter A had one (1) year, Painter B had two (2) years, and the Contractor Foreman had eight (8) years.

> The Contractor had no previously reported safety problems.

Prior to the beginning of work, the Fermilab Task Manager is required to conduct a "toolbox" talk with outside contractors. Toolbox talks given to workers prior to beginning the job is an excellent method of communicating safety information. The standard Fermilab toolbox talk covered eight basic areas regarding safety. However, only two of three individuals involved in this accident attended the toolbox talk given by the Fermilab Task Manager. Painter A was not present for the toolbox talk by Fermilab, and the Board did not receive any evidence indicating that Painter A was ever briefed by the Contractor Foreman about the topics discussed. The Board concluded that Painter A should have received a toolbox talk.

Toolbox talks should not be a substitute for initial briefing or orientation to Fermilab. Currently, Fermilab gives contractors a handbook but does not conduct an initial training or general orientation for contractors working onsite. An example of contractor training Fermilab provides is radiation protection training to workers working in radiological control areas. Safety training given before work begins can help eliminate many accidents. The Contractor Project Manager told the Board that most of the Contractor's other large industrial accounts require the Contractor's employees to undergo a site-specific safety briefing or orientation. Fermilab does not have an adequate system in place to ensure that all contractor employees are aware of site-specific rules and procedures.

Fermilab's contractor management system does not ensure that all contractors are aware of site-specific rules.

Contracts awarded by Fermilab require that all contractor employees be properly trained to perform their job in a safe manner. Neither the Fermilab Project Manager nor Fermilab Task Manager adequately verified whether the Contractor employees had been properly trained in hazard communication; the proper use and limitations of PPE, including proper respiratory protection; and electrical safety-related work practices.

The Board concluded that, based on the evidence reviewed, the Contractor Foreman and painters were not properly trained in the hazards associated with their work and that they were not familiar with the solvent they were using. During interviews, several people told the Board that the Contractor Foreman spoke and read English and that Painters A and B spoke limited English. The Board was given no evidence that a language barrier contributed significantly to the accident. However, the Board concluded that, if the painters were unable to read English, this could have limited their ability to be aware of the hazards of the materials they were working with.

The Contractor Foreman and painters were not properly trained in the hazards associated with their work.

2.2.5 Management Systems

2.2.5.1 Contract Between Fermilab and the Contractor

The Fermilab Facilities Engineering Services Section administers a "blanket" contract with the Contractor, dated 1996, wherein Fermilab divisions desiring painting work can contact the Contractor for a cost estimate. The requesting division will then send a task order and work description to the Fermilab Facilities Engineering Services Section, which then assigns the work to the Contractor.

At the time of contract award in 1996, the Facilities Engineering Services Section reviewed the Contractor's safety plan, which consisted of the sections of the Company's safety manual that dealt with painting. The Contractor has a Fermilab-approved safety and health program, but the program does not address the specific hazards and control measures related to Fermilab painting tasks. The Contractor did not prepare a site-specific safety plan for painting at Fermilab.

The Contractor did not prepare a site-specific plan for painting at Fermilab.

At the time the blanket contract with the Contractor was signed, Fermilab did not evaluate the Contractor's previous ES&H performance before awarding the contract. For Purchase Order 505986, the Fermilab Project Manager had obtained a cost estimate from two painting contractors. The Fermilab Project Manager said in an interview, however, that he considered his knowledge of previous Contractor work, including his knowledge of their safe performance, in his choice of the Contractor over another time-and-materials contractor.

If a company wants to contract with Fermilab, Fermilab reviews the company's safety record as well as the company's safety and health program (Fermilab ES&H Procedure 7010, Revised 8/98). Once Fermilab awards a contract, and before work can begin, contractors must submit a job hazard analysis for Fermilab review and acceptance. Fermilab is not currently examining its existing contracts to implement these contractor requirements. The Board concluded that Fermilab should review all existing contracts to bring contractors into compliance with requirements for new contractors.

Fermilab should bring all existing contractors into compliance with the new requirements for contractors.

The Board reviewed the safety provisions in the contract with the Contractor for the work to be performed. The provisions and Contractor deficiencies relevant to the accident are:

- Approval of hazardous materials, including submission of MSDSs, before bringing the chemicals onsite. The Contractor failed to submit MSDSs and obtain Fermilab approval for the MEK, acetone, and Powerhouse™ brought onsite.

- Fire safety requirements, including safe handling of flammable liquids. The Contractor failed to identify the need to provide ventilation in a confined area while using a flammable liquid.

- Wearing of appropriate personal protective equipment. The Contractor did not require employees to wear the appropriate PPE to prevent exposure to hazardous conditions.

- Reporting of spills of hazardous materials. The Contractor failed to recognize the hazardous material spill and take the appropriate action of notifying Fermilab Emergency Dispatch (extension 3131 at Fermilab).

The Board concluded that the Contractor did not comply with the safety provisions of the contract.

2.2.5.2 Fermilab Responsibilities

The contract between DOE and Universities Research Association, Inc., for the operation of Fermilab states that

1. "[Fermilab] is responsible for compliance with the ES&H requirements applicable to this contract regardless of the performer of the work." and

2. "Line management is responsible for the protection of employees [including contractor employees], the public, and the environment. Line management includes those [Fermilab and contractor] employees managing or supervising employees performing work."

In general, Fermilab responsibilities include defining the work, selecting a qualified contractor, and administering the executed contract, ensuring the performance of the contractor.

Active participation between Fermilab and the Contractor is necessary to adequately conduct work, planning and control. At a minimum, work planning should have included an open exchange of information between Fermilab and the Contractor during the definition of the scope of work, tasks to be conducted, chemicals to be used, hazards associated with the work, and hazard controls to be used. Fermilab and the Contractor should have jointly performed adequate job planning to ensure hazards were analyzed and procedures developed to control the work.

> Fermilab and the Contractor should have jointly planned the job.

2.2.5.3 CH and FRMI Responsibilities

The DOE line management responsibility for Fermilab lies with FRMI. FRMI reports to CH, which reports to the DOE Headquarters Office of Field Management. The Office of Energy Research at DOE Headquarters funds the work at Fermilab, is responsible for Fermilab's overall performance, and is responsible for evaluation of scientific research performance. The Office of Energy Research also evaluates the budget requests from Fermilab, including requests for funding for safety improvement and infrastructure projects at Fermilab.

An interview with the CH Safety and Technical Services Group revealed that they had conducted an Integrated Safety Management Assessment of FRMI in February 1998. The Board reviewed this report and FRMI's response and draft Action Plan. This report was critical of FRMI management regarding the ES&H oversight of Fermilab, in general, with some focus on a lack of review of program elements. This integrated safety management review was also critical of the effectiveness of FRMI's oversight of contractor activities at Fermilab. Although FRMI disagreed with much of the content of the report, FRMI's draft Action Plan addresses the significant issues in the CH report. The Board interviewed the FMRI Manager and ES&H Team Leader and reviewed records to assess the level of involvement and effectiveness of the DOE presence at Fermilab. FRMI's oversight activities include unannounced walk-throughs of Fermilab facilities, activities given in the draft Fermi Group Operational Awareness Program, evaluation of performance according to the Fermilab contract performance measures, and participation in the tripartite assessment program with Fermilab ES&H/Operating divisions. The tripartite assessment program consists of assessments of facility and program areas by the Fermilab organization that is responsible for operations in that area, the Fermilab ES&H Section, and FRMI. No tripartite assessments have yet been made regarding work planning at Fermilab, although future assessments are planned.

At the time of the accident, FRMI staff members were not aware of the specific work activity that led to this accident. They were also not involved in the planning for this work, including the identification of safety requirements. The Board concluded that FRMI's lack of direct involvement in the work planning for this particular painting task was appropriate.

The Board concluded, however, that FRMI should ensure the effectiveness of Fermilab systems for procuring and administering contract services and construction. Interviews with the FRMI ES&H Team Leader revealed that FRMI had previously recognized a need to evaluate the effectiveness of the contracting systems at Fermilab. The 1998 tripartite assessment schedule includes some assessments in this area, and the schedule may be modified to more closely examine this area for 1999.

The Type B accident investigation report of the October 1997 arc-blast accident at Fermilab also pointed out the need for better work planning and FRMI involvement. The Board concluded that FRMI needs to assess and verify the effectiveness of Fermilab requirements for work planning, hazard analysis, and pre-start meetings to address ES&H requirements in its contracted activities. In addition, CH needs to conduct a comprehensive review of Fermilab's Integrated Safety Management System and implementation.

> FRMI needs to assess Fermilab requirements for contracted activities. CH needs to review Fermilab's Integrated Safety Management System.

As discussed in Section 2.1.5, the accident scene was not preserved and secured. The Board concluded that FRMI needs to ensure accident scenes are secured until the CH Manager determines that further investigation is not warranted.

2.3 BARRIER ANALYSIS

For an accident to occur, there must be a hazard that comes into contact with a target because barriers or controls were unused or failed. In this accident, the hazard was the airborne acetone vapor concentration, which increased over time: (1) first, exceeding the OSHA PEL of 1,000 ppm;

(2) second, exceeding the IDLH level of 2,500 ppm; and (3) finally, exceeding the lower explosive limit of 25,000 ppm. The use of acetone in the dry storage room exposed the Contractor employees to chemical health and physical hazards that increased in severity over time.

A barrier is defined as anything that is used to control, prevent, or impede process or physical energy flows to protect a person or object from hazards. The safety barriers between the target (Contractor Foreman and the two painters) and the hazard (high concentration of acetone vapors) were physical barriers, administrative barriers, and management barriers. Figure 8 describes why these barriers failed.

2.4 CAUSAL FACTORS ANALYSIS

The direct cause of the flammable liquid fire/explosion accident was the ignition of a flammable mixture of acetone vapor and air. The direct cause resulted from two root causes and several contributing causes. Root causes are the fundamental causes that, if corrected, would prevent recurrence of 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 1.

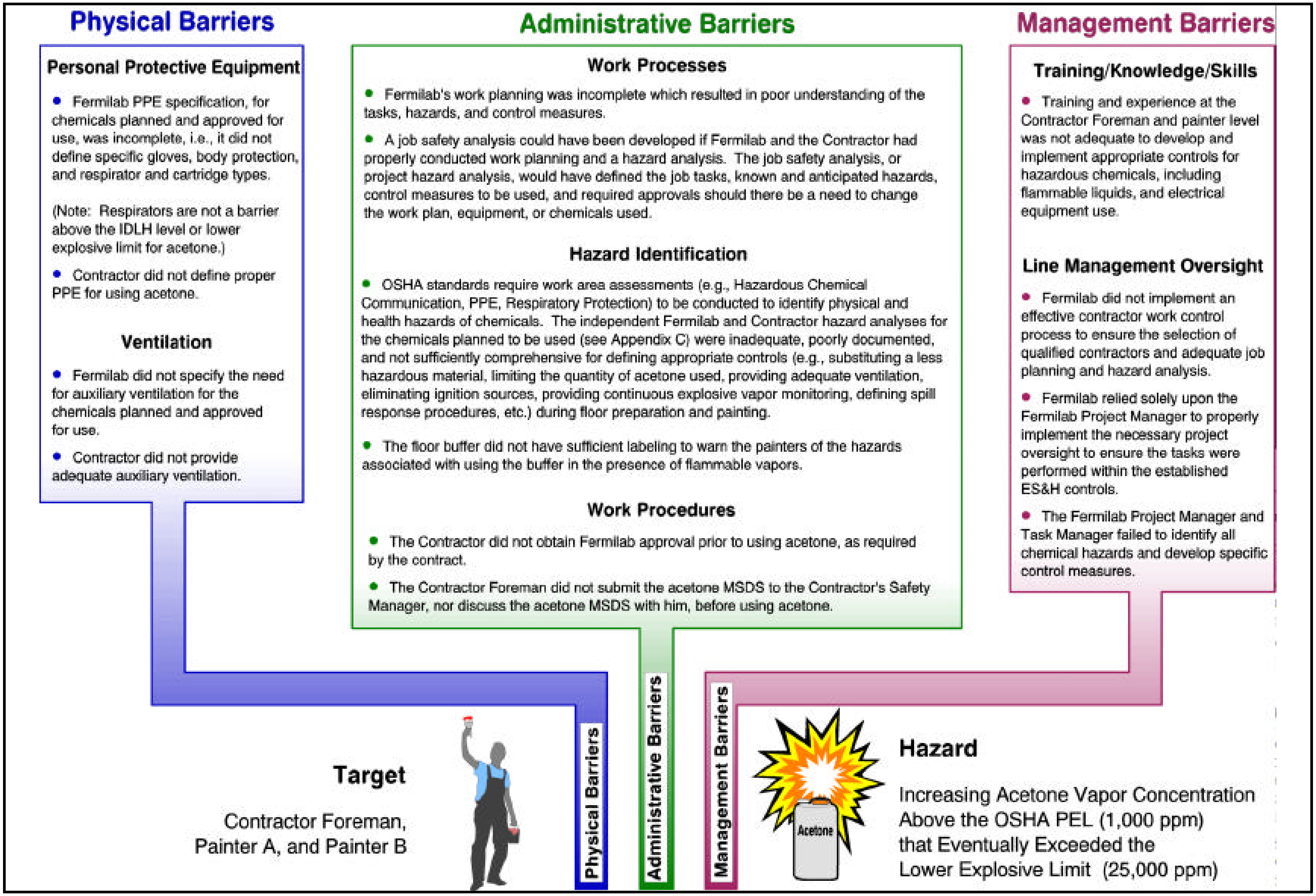

FIGURE 8 Barrier Analysis for the Accident

TABLE 1 Causal Factors Analysis

Cause	Discussion
Root Causes	
Root Cause: The Painting Contractor failed to recognize the hazards of using acetone to clean the dry storage room floor.	The Contractor should have ensured that the painters were properly trained to recognize the hazards of flammable liquids (acetone, MEK, paint thinners, etc.) so that adequate control measures could have been implemented. Acceptable controls include, but are not limited to, substituting a less hazardous material, limiting the quantity of acetone used, providing adequate ventilation, eliminating ignition sources, providing continuous explosive vapor monitoring, and following spill response procedures.
Systemic Root Cause: Management failed to ensure adequate implementation of the Integrated Safety Management core functions relating to definition of work scope, hazard analysis, and development and implementation of controls.	Fermilab Project Manager and the Contractor Project Manager did not integrate their efforts to define the work scope, conduct the hazard analysis, and develop work controls. This resulted in differences in understanding of how the work was to be performed and controlled. CH and Fermilab did not ensure that a comprehensive Integrated Safety Management System was instituted that applied to all activities, so that adequate job planning occurs.
Contributing Causes	
Work planning was inadequate for the work the painters were engaged in at the time of the accident.	Due to the size of the painting job, the work was considered routine and treated informally by all personnel involved.
Work controls were not adequately defined and communicated to the Contractor employees.	Job PPE and respirator requirements were not adequately defined and communicated to the Contractor employees. The failure to identify the need to use the floor preparation chemicals and epoxy paint in well ventilated areas, resulted in no local exhaust ventilation being used. Gloves were not used during the floor cleaning and the air purifying respirators were inadequate.
Fermilab failed to implement a fully integrated process to ensure adequate ES&H considerations are given to jobs that involve the use of hazardous substances.	Fermilab relied upon their Project Manager to determine the need for ES&H technical support to evaluate the work, hazards, and control measures to be implemented. Fermilab ES&H technical support was not requested or used to evaluate the work, hazards, and control measures to be used.
The Contractor Project Manager and Foreman were not informed of work controls contained in the contract or applicable Fermilab ES&H procedures.	Fermilab did not provide evidence to the Board that the contract provisions and/or the applicable ES&H Procedures were ever given to the Contractor Project Manager or Foreman.

TABLE 1 (Cont.)

Cause	Discussion
Contributing Causes (Cont.)	
Fermilab did not provide training for the Contractor employees or ensure that they had adequate knowledge to perform the work safely.	Fermilab did not provide evidence to the Board that the Contractor employees had received job specific training in the Fermilab ES&H procedures and contract provisions applicable to the work. Fermilab and the Contractor did not provide evidence to the Board that Contractor personnel were knowledgeable and trained in hazardous chemical communication, PPE and respiratory protection for the hazards of the work.
Fermilab did not provide adequate oversight of Contractor work activities.	Fermilab did not identify the lack of adequate ventilation and PPE and respirators needed to perform the work safely. Fermilab reviewed MSDSs for materials the Contractor intended to use and identified the need for ventilation, gloves, protective clothing, chemical splash goggles, and appropriate respiratory protection. Evidence was not provided to the Board that indicated ventilation was to have been provided or that proper PPE and respiratory protective equipment was available.
Fermilab did not utilize information from previous accident investigations and assessment reports to ensure continuous improvement in defining and planning contractor work.	The Board reviewed a previous Type B accident investigation report, Electric Arc Blast in October 1997, and an investigation into a contractor employee concern. Both reports identified a lack of Fermilab planning and hazard analysis as contributing causes. An August 1997 "Assessment Report - Fermilab's Triennial Assessment of Integrated Safety Management" identified a deficiency in the area of "formality of operations." The Board did not find any improvements in work planning or hazard analysis that would indicate an adequate feedback process for continuous improvement is in place.

3.0 CONCLUSIONS AND JUDGMENTS OF NEED

Table 2 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 2 Conclusions and Judgments of Need

Conclusion	Judgment of Need
Fermilab's work planning was incomplete, which resulted in poor understanding of the tasks, hazards, and control measures.	Fermilab needs to ensure that a job safety analysis, or project hazard analysis, is completed for contract services and construction that defines the job tasks; known and anticipated hazards; control measures to be used; and required approvals should there be a need to change the work plan, equipment, or chemicals used. Fermilab needs to ensure that the job hazard analysis is reviewed by ES&H and is communicated to its employees, as well as contractor employees.
Fermilab does not have an adequate system in place to ensure that all contractor employees are properly trained in the hazards associated with their work.	Fermilab needs to develop and implement a system to ensure that all outside contractor employees are properly trained in the hazards associated with their work. FRMI needs to oversee the development and implementation of Fermilab's system to ensure that contractor employees are properly trained.
Fermilab does not have an adequate system in place to ensure that all contractor employees are aware of site-specific procedures and ES&H requirements.	Fermilab needs to develop and implement a standard orientation training program that provides contractors with site-specific procedures and ES&H requirements. FRMI needs to evaluate the effectiveness of the Fermilab orientation training program to ensure that it provides adequate site-specific procedures and requirements.
Fermilab did not review the existing contract to ensure compliance with the current contractor Construction Safety Program procedure.	Fermilab needs to review existing contracts involving hazardous work and require contractors to prepare a job hazard analysis and submit it to the Fermilab ES&H Section for review. FRMI needs to assess the effectiveness of Fermilab's program for reviewing existing contracts involving hazardous work.

TABLE 2 (Cont.)

Conclusion	Judgment of Need
Fermilab does not have an adequate feedback process to ensure continuous improvements in its process for defining and performing contractor work.	Fermilab needs to develop and implement a feedback process that ensures deficiencies and corrective actions from precursor accidents and assessments are utilized for continuously improving operations.
FRMI has not adequately assessed the effectiveness of Fermilab's system for procuring and executing contract services and construction.	FRMI needs to assess the effectiveness of the systems that Fermilab uses to communicate and implement ES&H requirements applicable to contractors.
DOE-CH has not assessed Fermilab's Integrated Safety Management system to ensure adequate implementation of the five core functions.	DOE-CH needs to conduct a comprehensive review of Fermilab's Integrated Safety Management system.
The requirements for site accident readiness of DOE Order 225.1A were not met.	FRMI needs to ensure that the requirements of DOE Order 225.1A are met. Fermilab needs to develop and implement a procedure for preserving and securing the scene until arrival of, and transfer to, the Accident Investigation Board; and obtain timely initial statements from all individuals involved in the accident.
All emergency management personnel could not be immediately reached.	Fermilab needs to develop and implement a paging protocol for emergency management personnel so that they can be reached in a timely manner.

4.0 BOARD SIGNATURES

Date: 10/2/98

A. Creig Zook, Chairperson
DOE Accident Investigation Board
U.S. Department of Energy
Chicago Operations Office

Date: 10/2/98

Julie Beck Maddox, Member
DOE Accident Investigation Board
U.S. Department of Energy
Chicago Operations Office

Date: 10/2/98

Matthew B. Cole, Member
DOE Accident Investigation Board
U.S. Department of Energy
Office of Energy Research

Date: 10/2/98

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

5.0 BOARD MEMBERS, ADVISORS, AND STAFF

Chairperson	A. Creig Zook, DOE-CH, ARG
Member	Julie Beck Maddox, DOE-CH, TAS
Member	Matthew B. Cole, DOE-ER, ER-83
Member	Michael O. Saar, DOE-CH, TAS
Advisor	Craig A. Schumann, DOE-CH, ARG
Analyst	Will Brocker, Argonne National Laboratory
Technical Writer	Bryan J. Schmidt, Argonne National Laboratory
Administrative Support	Pamela Lowe, DOE-CH, FRMI

APPENDIX A:

BOARD APPOINTMENT LETTER

Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

September 11, 1998

Andrew E. Mravca
Fermi Group Manager

SUBJECT: APPOINTMENT OF AN ACCIDENT INVESTIGATION BOARD FOR THE SEPTEMBER 4, 1998, INJURY TO THREE FERMI NATIONAL ACCELERATOR LABORATORY (FERMILAB) SUBCONTRACTOR EMPLOYEES

I hereby establish a Type B Accident Investigation Board to investigate the accident which injured three Fermilab subcontractor service employees. I have determined that the accident meets the requirements for a Type B Accident Investigation, as required by Department of Energy (DOE) Order 225.1A, "Accident Investigations."

I appoint A. Creig Zook, Supervisor, Environment, Safety, and Health, Chicago Operations Office (CH), Argonne Group, as the Accident Investigation Board Chairperson. The Board Members will be Matt Cole, Office of Environment, Safety and Health Technical Support (ER-8), Michael Saar, CH-Safety and Technical Services, and Julie Beck, CH-Safeguards and Security Services. The Board will be assisted by advisors and other support personnel as determined by the Chairperson.

The scope of the Board's investigation will include, but is not limited to, identifying all relevant facts, analyzing the facts to determine the direct, contributing, and root causes of the accident, developing conclusion, and determining judgments of need that, when implemented, should prevent the recurrence of the accident. The investigation will be conducted in accordance with DOE Order 225.1 and will specifically address the role of DOE and contractor organizations and management systems as they may have contributed to the accident. The scope will also include an analysis of the application of lessons learned from similar accidents within the Department.

The Board will provide my office with periodic reports on the status of the investigation, but will not include any conclusions until an analysis of all the causal factors has been completed. Draft copies of the factual portion of the investigation report will be submitted to me, the CH Fermi Group, and Fermilab, for factual accuracy review prior to the report finalization.

The report should be provided to me by October 16, 1998. 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.

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Andrew E. Mravca - 2 - **September 11, 1998**

By copy of this memorandum, I am advising the supervisors of each of the Board Members that this assignment is full-time until the investigation and report are completed.

John P. Kennedy
Acting Manager

cc: P. Brush, HQ, EH-1/FORS
M. Krebs, HQ, ER-1/FORS
G. Podonsky, HQ, EH-2/270
M. Johnson, HQ, ER-80/GTN

APPENDIX B:

EMERGENCY RESPONSE CHRONOLOGY

TABLE B.1 Chronology of Emergency Response Actions

Time	Action
7:07 p.m.	Firefighter A, who was coincidentally in the hallway east of the dry storage room, witnessed the explosion. Firefighter A radioed a code 1 for fire. Firefighter A saw three individuals involved in the explosion and yelled to them to get out. The dry storage room sprinklers activated and caused a flow alarm to enunciate, resulting in the actuation of area evacuation alarms. Four Fermilab firefighters responded to the code 1 with a squad (Unit 701) and a pumper (Unit 702). A grassfire truck (Unit 704) was already on the scene with Firefighter A.
7:08 p.m.	Firefighter A followed the Contractor Foreman and two painters out and radioed a code 2, for injuries, indicating there were burn injuries with one person severely burned. Firefighter A reentered the kitchen to look for other injured persons and found no one. Before exiting, Firefighter A noted that some items in the area outside the dry storage room were on fire, including the contents of a bucket. In response to the code 2, the Fermilab Fire Department requested mutual aid from the Batavia Fire Department and notified the TRI-COM central dispatch center to dispatch an advanced life support ambulance to the scene.
7:11 p.m.	Fermilab firefighters entered the building and began fire-fighting activities. Four firefighters and three Chief Officers from the Batavia Fire Department arrived with an aerial ladder truck (Truck 2) and Rescue Squad 7 and assisted with fire-fighting activities and treatment of the burned painters. Firefighters extinguished the remaining fires, inserted sprinkler plugs, and turned off the sprinkler system. Flammable chemicals were removed from the area to prevent further explosions. The chemicals removed were three full containers of MEK and one empty and one full container of acetone. Fermilab security began traffic control to the area and transported Firefighter A to the station to retrieve the Fermilab ambulance, Unit 751.
7:15 p.m.	The St. Charles Fire Department advanced life support ambulance, Unit 151, arrived on the scene with two paramedics and took over treatment of the most severely burned person, Painter B.
7:18 p.m.	The Fermilab Incident Commander notified the DU-COMM central dispatch center to dispatch a second advanced life support ambulance and to dispatch the Loyola Lifestar Helicopter to transport Painter B to Loyola University Medical Center.
7:25 p.m.	The Incident Commander directed the Fermilab Com Center to dispatch a photographer to the scene and to notify the Fermilab Emergency Coordinator, who subsequently notified other Emergency Operations Center (EOC) personnel.

TABLE B.1 (Cont.)

Time	Action
7:26 p.m.	The Warrenville Fire Department advanced life support ambulance, Unit 158, arrived on the scene with two paramedics and took over treatment of Painter A. Fermilab Unit 751 arrived and took over treatment of the Contractor Foreman.
7:38 p.m.	Unit 158 was en route to Central DuPage Hospital with Painter A.
7:39 p.m.	Unit 751 was en route to Delnor Community Hospital with the Contractor Foreman.
7:45- 8:00 p.m.	The Fermilab Emergency Coordinator, Emergency Director, and Public Information Officer responded to the scene and were briefed on the status of the accident, the condition of the Contractor Foreman and two painters, and that there were no life threatening injuries. The Fermilab Emergency Director assumed control of the overall incident and activated the EOC.
7:49- 8:00 p.m.	The Lifestar Helicopter arrived and then departed for Loyola University Medical Center with Painter B.
8:20 p.m.	The Fermilab Public Information Officer began responding to media inquiries and, due to the level of media interest, notified the CH Public Information Director of the need for a possible press release.
8:35 p.m.	The DOE On-Scene Commander arrived.
9:00 p.m.	The DOE On-Scene Commander notified the Acting CH Manager of the accident.
9:05 p.m.	Following photography of the scene, EOC personnel toured the scene and began focusing on cleanup activities and possible causes of the accident. The Contractor Foreman returned to the scene and discussed the accident with Contractor management personnel and Fermilab project management personnel who were also on the scene.
9:28 p.m.	The Fermilab Emergency Director terminated the accident response, and the Fermilab Incident Commander released the fire departments.
9:45 p.m.	The Fermilab Public Information Officer contacted the local hospitals to follow up on the condition of Painters A and B.
10:00 p.m.	The DOE On-Scene Commander and Fermilab Emergency Director determined the categorization of the accident to be an off-normal occurrence. The DOE On-Scene Commander, upon direction from the Acting CH Manager, called the DOE HQ EOC, informed them of media interest, and briefed the Energy Research Duty Officer.
10:05 p.m.	The Fermilab Emergency Director and DOE On-Scene Commander turned control of the scene over to the Fermilab Facilities Engineering Services Section for clean up.
10:15 p.m.	The Fermilab Public Information Officer and CH Public Information Director notified the HQ Press Secretary's Office and discussed issuing a press release; however, one was not issued because information had already been communicated to the local press.
10:38 p.m.	The EOC was deactivated.

APPENDIX C:

REVIEW OF CHEMICALS ASSOCIATED WITH THE ACCIDENT

Table C.1 lists the chemicals approved by Fermilab for use by the Contractor for the dry storage room painting task and also provides safety information from the MSDS and Fermilab's notes associated with MSDS review and approval. Table C.2 list the chemicals used or intended for use in the dry storage room painting task that were not approved by Fermilab and also provides safety information from the MSDS.

TABLE C.1 Chemicals Reviewed by Fermilab for Painting the Dry Storage Room

Chemical/ Material	**Selected MSDS Information**	**Fermilab Review Notes (in MSDS margins)**
Ironclad Retardo Latex Fire Retardant Paint	<u>Safe Handling and Use Information</u> • Respiratory Protection – Use NIOSH-approved respirator specified for protection against paint spray mist and sanding dust in restricted or confined areas • Ventilation – Adequate to maintain working atmosphere below TLV and lower explosive limit; mechanical exhaust may be required in confined areas • Protective Gloves – Waterproof during repeated contact • Eye Protection – Splash goggles or safety glasses with side shields • Other Protective Equipment – Clothing to protect skin	OK to use Safety glasses w/sideshields, Gloves H_2O proof, Approved Resp., Muriatic Acid etch 20% Hazards – Scraping eye prot.; Ladder safety; Muriatic acid – Prot gloves – Apron - Respirator - Glasses – when etch; Paint – Respirator (approved) NIOSH
Muriatic Acid	<u>Exposure Controls/Personal Protection</u> – Protective equipment for normal use conditions: • Safety glasses • Wear an approved respirator, in case of emergency • Wear protective gloves • Acid resistant clothing • Local exhaust at points of emission	OK to use with proper PPE for Etch
Floorshield 948, Parts A and B	<u>Handling Precautions</u> • Ventilation – Forced ventilation • Respiratory Protection – If vapors exceed exposure limits, use a NIOSH-approved respirator • Skin Protection – Rubber gloves and protective clothing to avoid skin contact • Eye Protection: Chemical splash goggles <u>Part B Health Hazard Data, Inhalation</u> • May cause allergic respiratory reaction, effects may be permanent • Harmful if inhaled, may affect the brain or nervous system, causing dizziness, headache or nausea • May cause nose and throat irritation; may cause lung irritation	Ok with below listed – <u>Note</u> Must use with appropriate gear/PPE – Rubber gloves, Safety glasses/side shields, NIOSH approved respirators
SPRED Enamel – Latex Semi-gloss 3700 Series	<u>Special Protection Information</u> • Respiratory Protection – Control environmental concentrations below applicable standards; where respiratory protection is required, use only NIOSH/MSHA approved respirators in accordance with OSHA Standard 29 CFR 1910.134 • Ventilation – Provide dilution ventilation or local exhaust to prevent build-up of vapors • PPE – Eye wash, safety shower, safety glasses or goggles, impervious gloves • Special Precautions – Use only with adequate ventilation	OK/Dorms (No other comments added to the MSDS)

TABLE C.2 Chemicals Not Reviewed or Approved by Fermilab for Painting the Dry Storage Room

Chemical/ Material	Selected MSDS Information
Powerhouse – Heavy Duty Butyl Cleaner	<u>Special Protection Information</u> • Respiratory Protection – Use in well ventilated area • Protective Gloves – Waterproof • Ventilation – Provide local exhaust to keep TLV of ingredients below acceptable limit • Eye Protection: Safety glasses
SURE TRED Non-Skid Additive (100% crystalline-quartz silica sand)	<u>Safe Handling and Use Information</u> • Respiratory Protection – Use of respiratory protection depends on dust concentration above the TLV [0.1 mg/m^3]; use a NIOSH/MESHA approved respirator • Ventilation – General mechanical or local exhaust should be suitable to keep dust concentrations below the TLV. Respiratory masks may be required in extreme cases • Eye Protection – Safety glasses and/or face shield are recommended to safeguard against potential eye contact, irritation or injury <u>Special Precautions</u> • Precautions for Handling and Storing – Use dustless or wet systems when handling and cleanup so that exposure does not exceed the TLV • Other Precautions – Practice good housekeeping; maintain ventilation system and post appropriate warning notices where product is used, stored, and handled
MEK	<u>Protective Equipment</u> • Ventilation – Use general or local exhaust ventilation requirements to meet TLV requirements • Respiratory Protection – Required if airborne concentration exceeds TLV; at concentration up to 1,000 ppm a chemical cartridge respirator with organic vapor cartridge is recommended; above this level SCBA is recommended • Eye/Skin Protection – Safety goggles, uniform, apron, rubber gloves are recommended
Acetone	<u>Personal Protective Equipment</u> • Safety glasses/side protectors • Protective gloves/liquid proof • Approved organic canister mask or air supplied respirator in cases of emergency <u>Ventilation</u> • Local exhaust recommended • General ventilation to maintain suggested TLV