DOE/BHSO-2009-B01

Type B Accident Investigation Board Report

October 9, 2009
Employee Injury at Building 1005H
Upton, New York

December 2009

Brookhaven Site Office
U.S. Department of Energy

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INDEPENDENT REPORT

This report is an independent product of the Type B Accident Investigation Board (Board) appointed by Michael Holland, Manager, Brookhaven Site Office, United States 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 O 225.1A, *Accident Investigations*, and DOE G 225.1a-A, *Implementation Guide for Use with DOE 225.1A, Accident Investigations*.

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

This report neither determines nor implies liability.

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RELEASE AUTHORIZATION

On October 16, 2009, I established a Type B Accident Investigation Board to investigate the October 9, 2009, accident at Building 1005H at the Brookhaven National Laboratory that resulted in an injured worker. The Board's responsibilities have been completed with respect to this investigation. The analysis process, identification of causal factors, and development of judgments of need were performed during the investigation in accordance with DOE O 225.1A, *Accident Investigations*.

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

Michael D. Holland

Michael D. Holland
Manager, Brookhaven Site Office

Date Accepted: 12/11/09

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ACRONYMS

AGS	Alternating Gradient Synchrotron
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ATM	Atmospheres
BHSO	Brookhaven Site Office
Board	Accident Investigation Board
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates, LLC
C-AD	Collider-Accelerator Department
dBA	Decibels
DOE	U.S. Department of Energy
ES&H	Environment, Safety, and Health
ESH&QA	Environmental, Safety, Health and Quality Assurance
F&ES	Facilities and Equipment Support
F&O	Facilities and Operations
FRA	Facility Risk Assessment
ISABELLE	Intersecting Storage Accelerator + "belle"
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
JONs	Judgments of Need
OHSAS	Occupational Health and Safety Assessment Series
OPM	Operations Procedure Manual
ORO	Oak Ridge Office
Psi	Pounds Per Square Inch
RHIC	Relativistic Heavy Ion Collider
SBMS	Standards Based Management System
SC	Office of Science
TS	Technical Supervisor

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EXECUTIVE SUMMARY

The Accident

On the afternoon of October 9, 2009, a Lead Rigger for Brookhaven Science Associates (BSA), LLC at the Brookhaven National Laboratory (BNL) was injured while at the Relativistic Heavy Ion Collider (RHIC) Compressor Building 1005H.

The Lead Rigger and two other Riggers were matrixed by the Facilities and Operations (F&O) Directorate to perform skilled craft work for the Collider-Accelerator Department (C-AD). The F&O Rigger Supervisor dispatched the Riggers to Building 1005H to retrieve an aerial lift that had been left in the building. Upon arriving at the building, the Riggers discovered that the west roll-up door and man-door were locked. There were no signs on these doors to instruct personnel to contact the Cryogenic Control Room or the Building Manager prior to entry.

The Lead Rigger then proceeded around the building in the direction of the C-AD Cryogenic Control Room, located in Building 1005S, looking for an open roll-up door or man-door. Inside the building, a helium venting operation was underway. As the Lead Rigger passed under a building vent, which was approximately 9 feet above his head, the high pressure helium began to vent. A loud noise (>140 decibels [dBA]) was produced by the helium venting which startled the Lead Rigger. The Lead Rigger began to run from the area and injured both of his legs in the process. The Lead Rigger experienced bilateral quadriceps tendon ruptures. The injury required surgery to his legs and a hospital stay with rehabilitation greater than 5 days.

Conclusions

The Accident Investigation Board's (Board) conclusions and Judgments of Need (JONs) are provided in Table ES-1. The conclusions are those the Board considered significant and are based on facts and pertinent analytical results. JONs 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. JONs are derived from the conclusions and causal factors and are intended to assist managers in developing corrective actions. The Board determined the root cause to be BNL's failure to implement an effective Integrated Safety Management Systems (ISMS) program to ensure all hazards associated with the operations of its facilities are identified, analyzed, and controlled.

Table ES-1. Conclusions and Judgments of Need

Conclusion	Judgments of Need
The Building Manager is not required to be notified of personnel access for all work activities in Building 1005H. The 1005H Building Manager was not aware of all health and safety hazards or configuration changes associated with the operation of the building.	**JON-1:** BNL needs to fully develop and effectively implement a Facility Management program that encompasses essential Facility Management functions.
The work order that was initially prepared for retrieval of the aerial lift was vague and did not address hazards that would be encountered inside the building. There was no work order issued for the retrieval of the aerial lift once the location of the lift was identified, thus no hazards were formally documented. There is no Facilities and Equipment Support procedure that controls the Facilities and Equipment Support work order Form No. BNL F 2467E, Revision 11/07. The Riggers' Supervisor failed to instruct the workers on what to do should the building doors be closed.	**JON-2:** BNL needs to improve and enforce its requirements to increase consistency of work planning rigor.
Buildings and facilities need to undergo engineering and operational design reevaluations for inadequate design hazards and equipment concerns.	**JON-3:** BNL should improve its engineering and operational design process to increase the consistency of engineering design rigor.
The Board determined the root cause to be BNL's failure to implement an effective ISMS program to ensure all hazards associated with the operations of its facilities are identified, analyzed, and controlled.	**JON-4:** BNL needs to establish and implement a graded approach to evaluate Legacy Facilities for potential risks.
A C-AD procedure that identified a noise hazard when the roll-up doors are open at Building 1005H was modified in 2004 to put noise protection compensatory actions in place but these compensatory actions were dropped when the procedure was revised in 2009.	**JON-5:** BNL needs to develop and implement an institutional-level program that includes all Configuration Management essential elements.
BNL has a fragmented Environmental, Safety, Health and Quality Assurance program in that Assistant Laboratory Directors have their own Environmental, Safety, Health and Quality Assurance organizations which develop different methodologies of implementation of safety programs and deter communication of important information to upper management. BNL disciplinary action program is not consistent across the lab. The accident scene was not preserved and not appropriately transitioned to the DOE Accident Investigation Team. BNL failed to ensure that workers' Noise Medical Surveillance qualifications were current.	**JON-6:** BNL assessments and corrective action information needs to be analyzed at an institutional-level to ensure that (1) Management System Stewards and Laboratory management are aware of potential vulnerabilities, (2) Laboratory resources can be adequately deployed, (3) process improvements can be effectively implemented into management systems requirements and all Laboratory operations.

Table ES-1. Conclusions and Judgments of Need

Conclusion	Judgments of Need
Lower levels of line management, to a great extent, are left to their own to develop Environmental, Safety, Health and Quality Assurance programs and expectations and don't necessarily work to consistent performance metrics. Integrated Safety Management needs to be communicated more effectively and frequently from BSA upper management to the laboratory work force. Environment, Safety and Health performance data is not trended uniformly across BNL.	**JON-7:** BNL's senior management needs to clearly establish and model those institutional values, line management leadership behaviors and core competencies that will support achieving the Laboratory's goals, requirements, and performance expectations for a more effective Integrated Safety Management Program.
Though Brookhaven Site Office oversight programs are being implemented, corrective actions by BSA are not always timely or effective. Integrated Safety Management program expectations need to be communicated more effectively from BHSO to BSA upper management.	**JON-8:** BHSO needs a more effective method for providing expectations to BSA for improvements in the consistent implementation of Integrated Safety Management across BNL.

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1.0 INTRODUCTION

1.1 Background

On the afternoon of October 9, 2009, a Lead Rigger sustained injuries when running from a loud sound outside of Building 1005H at BNL. The Lead Rigger and two other Riggers were dispatched to the west side of Building 1005H to retrieve an aerial lift that was left in the building. Upon arriving, it was discovered that the man-door and the roll-up door were locked. The Lead Rigger proceeded around the building looking for another door that might be unlocked or for someone who could unlock the door. As he proceeded along the north side of the building, he was startled by a loud noise and ran from the area, injuring his legs in the process.

On October 16, 2009, Michael Holland, Manager of the U.S. Department of Energy (DOE), Office of Science (SC), Brookhaven Site Office (BHSO), informed the management of BNL that a Type B Accident Investigation Board would be initiated to investigate the October 9, 2009, accident at BNL that resulted in leg injuries to a Rigger. The Type B Accident Investigation Board was formally appointed (Appendix A) on October 16, 2009. This report documents the facts of the accident and the analyses and conclusions of the Board.

1.2 Facility Description

BNL, established in 1947 on Long Island, Upton, New York, is a DOE SC, multi-program national laboratory operated by BSA. BNL's support of four DOE strategic missions includes the following:

- To conceive, design, and operate complex, leading-edge, user-oriented facilities in response to the needs of DOE and the international community of users;
- To carry out basic and applied research in long-term, high-risk programs at the frontier of science;
- To develop advanced technologies that address national needs and transfer them to other organizations and to the commercial sector;
- To disseminate technical knowledge; to educate new generations of scientists and engineers; to maintain technical capabilities in the nation's workforce; and to encourage scientific awareness in the general public.

In support of these missions BNL operates several user facilities, including the RHIC. The Laboratory is situated on a wooded, 5,265-acre site in central Long Island, New York (Figure 1-1). BNL has a staff of approximately 3,000 scientists, engineers, technicians, and support staff and hosts over 4,000 guest researchers annually.

Figure 1-1. Brookhaven National Laboratory

1.2.1 BNL Organization and the Collider-Accelerator Department

Nearing its end in July 1999, the RHIC Project began to merge with the existing Alternating Gradient Synchrotron (AGS) Department to form the C-AD. The merger was completed in October 1999. Figure 1-2, the 2009 Laboratory Organization Chart, shows the present day BNL organization, including the C-AD.

1.2.2 DOE Organization

Concurrent with the BNL RHIC Project organization, a DOE Project Manager was assigned for the duration of the project. Following the transition to operations in 1999, BHSO assigned a full-time Facility Representative to provide oversight of RHIC operations.

The C-AD Facility Representative is required to be thoroughly familiar with site and facility characteristics, operating procedures, facility authorization basis, operating organizational structure, and key process control personnel. The Facility Representative is a direct safety oversight extension of BHSO and SC management.

The Facility Representative observes, evaluates, and reports on the effectiveness of the C-AD in multiple areas important to safe, efficient operations, such as operational performance, quality assurance, management controls, emergency response readiness activities, and assurance of worker safety and health.

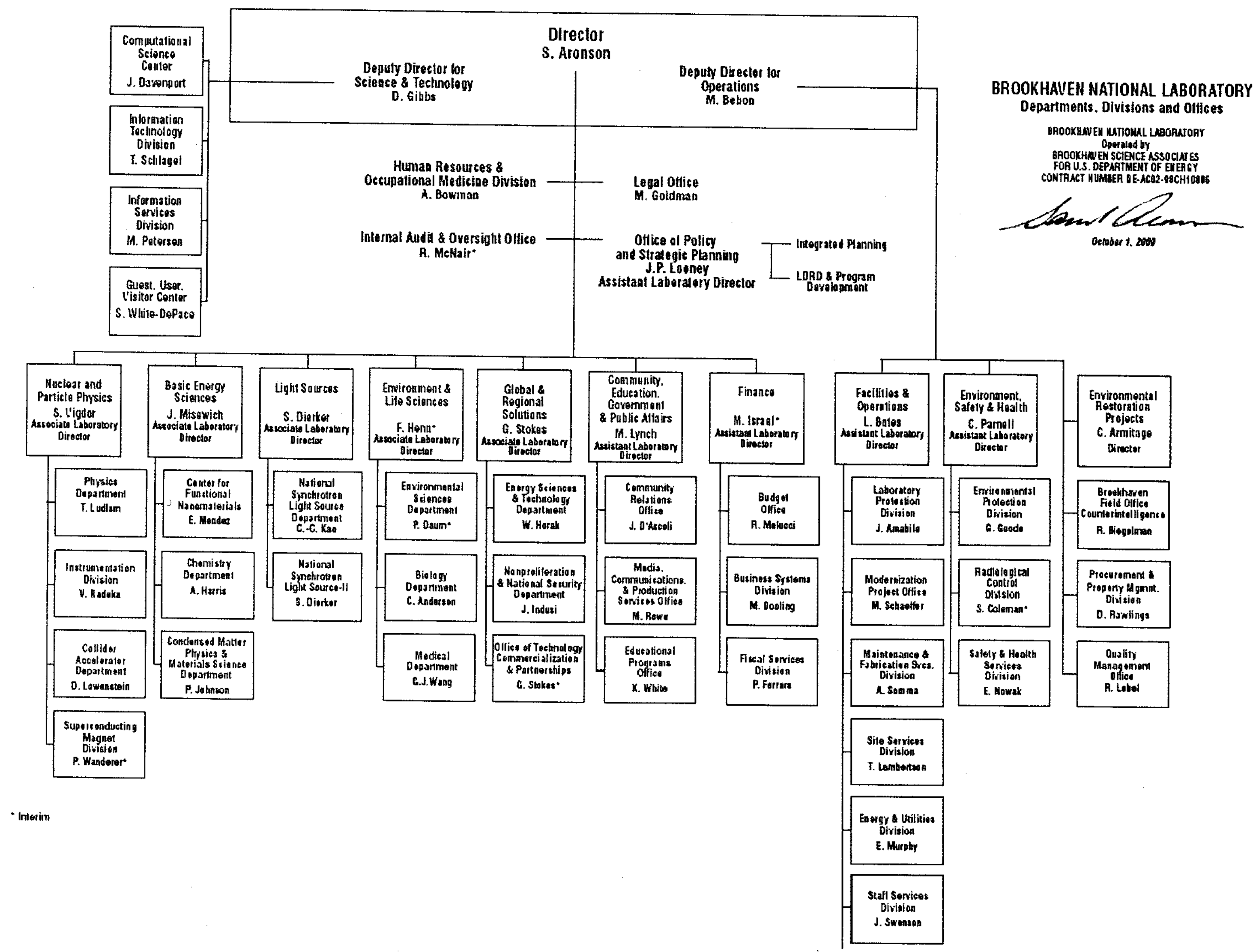

Figure 1-2. BNL Organization Chart (2009)

1.2.3 RHIC Compressor Building 1005H

The injury occurred outside of the RHIC Compressor Building 1005H (Figure 1-3). Building 1005H is a one-story, high bay, steel framed, masonry construction building. It is approximately 10,800 square feet in floor area with a volume of about 200,000 cubic feet. It houses the helium compressors and their associated equipment. It is located just to the northwest of the Cryogenic Building 1005R. Access is through 12-foot roll-up doors or man-doors around the building.

Figure 1-3. Building 1005H, west side

Building 1005H houses the mechanical equipment which compresses the helium for the RHIC Helium Refrigerator. One of the hazards in this building is the very high ambient noise levels when the compressors are in operation. The hazard extends outside the building in the vicinity of the large pipes to and from the refrigerator area. A noise survey was taken in this building during the Compressor Acceptance Test on April 10, 1985. This survey found a fairly uniform noise level of 110 dBA in the area of the compressors. Hearing protection in this building is mandatory and occupancy time is restricted to four hours of exposure per day.

Employees with regular access to the building are included in the Laboratory Hearing Conservation Program. Another hazard is the pressure piping which has a maximum working pressure of 275 psi. Pressure relief valves and rupture disks protect the system from exceeding this pressure. All major piping was analyzed to the requirements of American National Standards Institute (ANSI) B31.1, *Chemical Plant and Petroleum Refinery Piping* requirements. The vessels are built in accordance with the American Society of Mechanical Engineers (ASME) *Pressure Vessel* Code, Section VIII.

Two pipes are located on the north wall approximately 14 feet from the ground and 3 feet from the northwest corner of the building (Figure 1-4). These pipes serve as vents for helium and nitrogen. After summer shutdown, and prior to cool down, the purifier is used to clean process lines throughout the RHIC ring and at the Cryogenic Facility. The removal of contaminants in the purifier is accomplished with a liquid nitrogen cooled heat exchanger and carbon adsorber. There are two parallel trains of heat exchangers and adsorbers. When one becomes saturated, it is isolated and the other is brought online. Isolation consists of closing the manually operated helium process inlet and outlet valves for the heat exchanger and adsorber. At this point, each will have to be regenerated.

The first step of the regeneration process is to vent the trapped high pressure helium left inside the system when it was isolated. This is done with a digital valve. Venting makes a loud noise. After venting, the adsorber is warmed with heated nitrogen gas. Because the adsorber is initially cold, the nitrogen gas that vents from the system is cold and can create a vapor cloud (Figure 1-5). After heating is complete, the adsorber is pumped down with a vacuum pump and then back filled with clean helium. A similar process is performed for the heat exchanger. This process can take up to two days to complete.

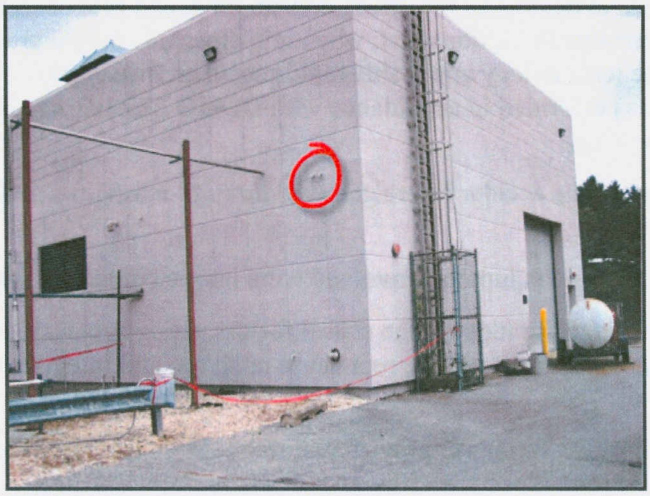

Figure 1-4. Vents on north side of 1005H

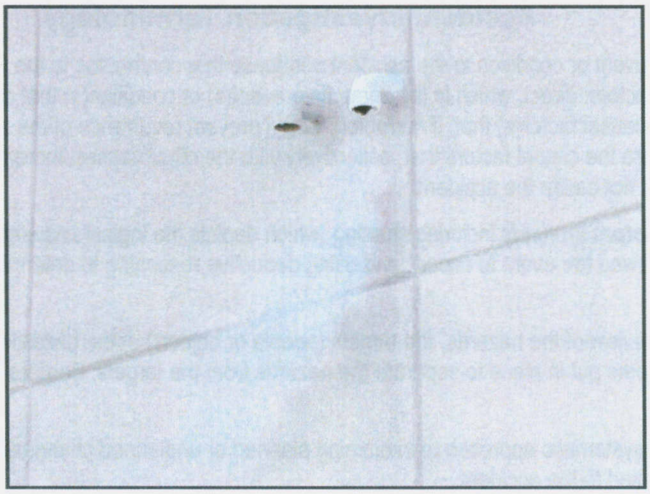

Figure 1-5. Vapor plume from venting

1.3 Scope, Conduct, and Methodology

The Board began its activities on October 20, 2009, and submitted the final report to the DOE-BHSO Manager on December 11, 2009. The scope of the Board's investigation was to identify all relevant facts; analyze the facts to determine the direct, contributing, and root causes of the accident; develop conclusions; and determine the actions that, when implemented, should prevent the recurrence of a similar accident. The terminology applicable to this accident investigation is shown in Figure 1-6. The investigation was performed in accordance with DOE O 225.1A, *Accident Investigations*, using the following methodology.

- Facts relevant to the accident were gathered through interviews and reviews of documents and evidence.
- The event scene and equipment involved were inspected, and photographed.
- Facts were analyzed to identify the causal factors, using event and causal factors analysis, barrier analysis, change analysis, root cause analysis, and Integrated Safety Management (ISM) analysis.
- JONs for corrective actions to prevent recurrence were developed to address the causal factors of the event.

Accident Investigation Terminology

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

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

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

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

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

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

Requirements verification analysis is a forward/backward analysis process to ensure that all portions of the report are accurate and consistent in the flow of facts from analysis to conclusions to the JONs.

Figure 1-6. Accident Investigation Terminology

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2.0 THE ACCIDENT

2.1 Accident Description and Chronology of Events

Approximately three weeks prior to the injury event, an aerial lift was delivered to Building 1005H for electricians to use inside the building. Upon completion of the work, the lift was left in the building. During the Friday C-AD Supervisors' meeting on October 9, 2009, it was determined that work with the aerial lift had been completed and the lift could be returned to the equipment shop. On October 1, 2009 an Facilities and Equipment Support (F&ES) Work Order (A6SC5816) was issued requesting an aerial-lift be delivered to Building 912, however, the F&ES Work Order did not specify where the lift was located. After the meeting, two Technical Supervisors (TS) from the C-AD F&ES Group and a Rigger Supervisor matrixed to C-AD from the F&O Directorate were overheard by an F&O Electrician discussing the location of the aerial lift. After being told by the F&O Electrician that the lift was in Building 1005H, TS1 verbally instructed TS2 to go verify the location of the lift. TS2 drove to Building 1005H, used a master key to look inside the building from the west man-door, and returned to verbally notify TS1 that the lift was there. TS1 instructed the Rigger Supervisor to retrieve the aerial lift from Building 1005H. The Rigger Supervisor in turn instructed the Lead Rigger and two other Riggers to retrieve the lift. The Riggers arrived at Building 1005H, and the Lead Rigger discovered that the west roll-up door and the adjacent man-door were locked. There were no signs on these doors to instruct the Riggers to call the Cryogenic Control Room or the Building Manager prior to entering the building. Therefore, neither the Building Manager nor the Cryogenic Control Room personnel were aware of the Riggers attempting to access Building 1005H. The Lead Rigger told the other Riggers that he would go get the door opened.

Figure 2-1. West Roll-Up Door and Man-Door

The Board concluded that the BNL Facilities Management Program was inadequate.

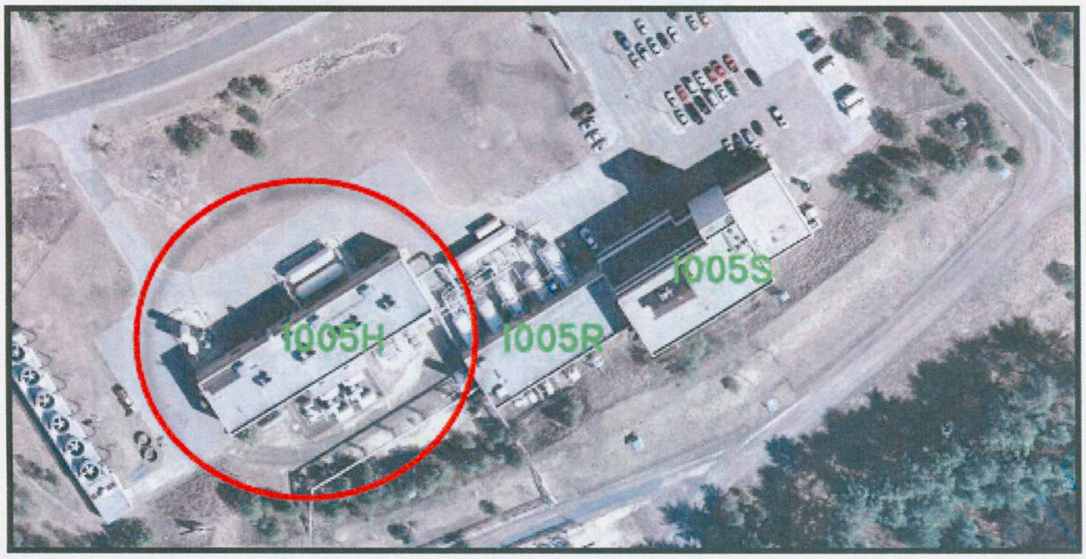

Figure 2-2. BNL North Campus

The Lead Rigger then walked to the north side of the building and proceeded east toward the north doors and the Cryogenic Control Room in Building 1005S (Figure 2-2). As he turned the corner, he passed under two external vent lines (Figure 1-4) for the purification system located inside of the building.

After summer shutdown and prior to cool-down, the purifier in building 1005H is used to clean helium process lines throughout the RHIC ring and the cryogenic facility. This process is often referred to as a scrub. The removal of contaminants in the purifier is accomplished with a liquid nitrogen cooled heat exchanger and carbon adsorber. There are two redundant strings of heat exchangers and adsorbers. When one becomes saturated, it is isolated and the other is brought online. The first step in the regeneration process is to vent the trapped high pressure helium left inside when it was isolated (typically 12 or 13 atm). This is done with a manually operated digital (open/close, non-proportional) valve. This is the cause of the loud venting noise. After venting, the adsorber is warmed with heated nitrogen gas. Because the adsorber is initially cold, the nitrogen gas exits the adsorber cold and leaves the building through the same vent as the helium and can leave a vapor cloud. After heating is complete, the adsorber is pumped down with a vacuum pump, then back-filled with clean helium.

The adsorber regeneration process also requires isolating the liquid nitrogen bath that is used to cool the adsorber. The pressure then builds up to relief valve pressure. This relieves from the vent pipe adjacent to the helium high pressure vent. To prevent the relief valve from lifting, a good practice is to vent the vapor side of the liquid nitrogen bath. This is a low pressure vent which is not very loud, but will cause a vapor cloud, and vents out the same pipe as the high pressure helium.

Shortly after the Lead Rigger passed under the exterior vents, the Cryogenic group began the venting process. The sound of the helium venting (>140 dBA) startled the Lead Rigger and he ran east along the north side of the building (Figure 2-3). The area was covered with gravel. As the Lead Rigger ran, his legs stopped functioning and he fell forward onto his knees.

Figure 2-3. The Accident Scene

When they heard the noise in the vicinity of their co-worker, the other two Riggers, who were standing by the escort van on the west side of the building, proceeded to the north side of the building. There they observed the remaining vapor exiting the vent and the Lead Rigger crawling toward the asphalt pad on the north side of the building. Once they reached the Lead Rigger, they attempted to help him to his feet. At this point the Lead Rigger realized that his legs would not support him and asked to be lowered back to the ground. His co-workers attempted to call the BNL emergency number on his Nextel cellular phone. They were unsuccessful in doing so because they were not familiar with the operation of his phone. They called the Rigging Supervisor using the walkie-talkie function of the phone and requested that he contact emergency services. Emergency services received the call at approximately 2:20 p.m. and responded within five minutes. The Lead Rigger was transported to the hospital. He sustained cuts, abrasions and bilateral quadriceps tendon ruptures in his legs.

Table 2-1 provides the events leading up to the accident on October 9, 2009.

Table 2-1. Event Chronology

Date/Time	Event
Pre-1981	Building 1005H and its operating systems were designed.
1981	Building 1005H was constructed as part of the ISABELLE project.
1983	The Safety Analysis Review conducted for the ISABELLE project was for all facilities including Building 1005H.
1983	The ISABELLE project was curtailed, and the Building 1005H was operated in a maintenance mode.
1991	The Relativistic Heavy Ion Collider (RHIC) project began and, subsequently, start-up operations for Building 1005H were evaluated.
June 1999	A Safety Analysis was performed for RHIC which included a review of Building 1005H.
June 2004	A Facility Risk Assessment and Job Risk Assessment were performed as part of the Occupational Health and Safety Assessment Series 18001 Standard.
July 2009	Off-site contractors reported to BNL Multi-Trades Supervisor during a post-job brief that they heard a loud sound emanating from a release vent on the South side of Building 1005H while they were painting the exterior insulated finish system of the building.
August 21, 2009	The aerial lift platform was moved to Building 1005H in August 2009 for electrical work. (Work Order EP743982)
August 22, 2009 & September 3, 2009	Work was performed at Building 1005H under Work Order EP743982, and the aerial lift was left in Building 1005H.
October 1, 2009	F&ES work order A6S-C-5816 was issued by the Facilities & Experiment Support Group Head to deliver an aerial lift to Building 912.
October 9, 2009	An F&ES Friday Supervisors' Meeting was held to discuss the upcoming week's jobs which included the need for an aerial lift.
October 9, 2009	The F&ES TS1, TS2, and Rigger Supervisor discussed the location of an aerial lift after the Friday Morning Meeting.
October 9, 2009	A F&O electrician overheard the discussion and told TS1, TS2, and the Rigger Supervisor that the aerial lift was in Building 1005H.
October 9, 2009	TS1 verbally instructed TS2 to verify the location of the aerial lift.
October 9, 2009	TS2 drove to Building 1005H to verify location of the aerial lift.
October 9, 2009	TS2 returned and verbally notified TS1 that the lift was is in Building 1005H but did not mention to TS1 that the doors were locked.
October 9, 2009	TS1 instructed the Rigger Supervisor to retrieve the aerial lift from Building 1005H.
October 9, 2009	The Rigger Supervisor verbally instructed Lead Rigger and Riggers B and C to pick up the lift from Building 1005H.

Table 2-1. Event Chronology (continued)

Date/Time	Event
October 9, 2009	Lead Rigger and Riggers B & C drove to Building 1005H to retrieve the lift.
October 9, 2009	Lead Rigger discovered that the West man-door and roll-up door were locked.
October 9, 2009	Neither the Building Manager nor the Cryogenic Control Room were notified of the Riggers' attempt to access the building since there was no sign on the west side doors requiring that they be contacted.
October 9, 2009	Lead Rigger proceeded eastward along north side of Building 1005H.
October 9, 2009	The Cryogenic system was vented.
October 9, 2009	Lead Rigger was beneath the vent and was startled by the venting noise.
October 9, 2009	Lead Rigger ran eastward along the North wall of Building 1005H on loose gravel which was on top of landscape fabric.
October 9, 2009	Lead Rigger was injured.
October 9, 2009	Lead Rigger crawled toward the asphalt pad.
October 9, 2009	Riggers B and C heard a loud sound, saw a vapor plume at the northwest corner of Building 1005H, and went to check on Lead Rigger.
October 9, 2009	Riggers B and C arrived at asphalt pad to assist Lead Rigger.
October 9, 2009	Rigger B dialed the Site emergency response telephone number 2222 using Lead Rigger's Nextel phone but was unfamiliar with its operation.
October 9, 2009	Rigger B contacted the Rigger Supervisor using the walkie-talkie function of the Nextel phone.
October 9, 2009	Rigger B explained the emergency to the Rigger Supervisor and requested that he contact the emergency personnel.
October 9, 2009 2:20 p.m.	The Rigger Supervisor called emergency personnel for assistance.
October 9, 2009 2:25 p.m.	Emergency personnel responded and arrived at the scene.
October 9, 2009 2:38 p.m.	Lead Rigger was transported to the hospital.

2.2 Emergency Response Analysis

The Contractor Requirements Document in DOE O 225.1A, *Accident Investigations*, mandates that contractors will support Type A and B accident investigations, establish and maintain readiness to respond to accidents, mitigate the consequences, assist in collecting and preserving evidence, and assist with the conduct of the investigation by providing office space and equipment; meeting regularly to discuss issues surrounding the accident; and providing general administrative assistance.

After the accident, BNL management secured the scene, made the appropriate notifications, and initiated an investigation. Photographs of the accident scene were taken, initial interview statements were collected, and the next time that high pressure helium venting was necessary on October 13, 2009, noise level measurements and observations of the venting were conducted to determine the magnitude of the hazard.

When the DOE Accident Investigation Team arrived at the accident scene, part of the red boundary tape demarcating the accident scene had been removed. Also, the aerial lift had been removed from Building 1005H.

The Board concluded that the accident scene was not preserved and not appropriately transitioned to the DOE Accident Investigation Team.

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3.0 FACTS AND ANALYSIS

3.1 BNL Integrated Safety Management

DOE utilizes ISM as a framework to evaluate the causes of accidents. The use of ISM ensures that a thorough review of the accident was performed to provide the maximum benefit to all parties involved and to facilitate development of lessons learned to prevent recurrence.

The Board's review of BNL documents and interviews of employees and managers determined that BNL has an ISM program in place. Various Assistant Laboratory Director organizations have their own ESH&QA departments. Fragmentation of the ESH&QA program throughout the Laboratory does not appear to work in ensuring implementation of a uniform and effective Laboratory ISM program. The BNL Standards Based Management System (SBMS) and the C-AD organization have different Employee Disciplinary Action Program. The Board observed, throughout the interview process, that safety direction and expectations from upper laboratory management to lower levels of management occur approximately two to four times per year. Safety-related messages from upper laboratory management to employees are often sporadic and not specific on guidance and expectations.

3.1.1 Define the Scope of Work

Effective work execution begins with the preparation of a well-defined scope of work that translates mission and requirements into terms that those who are to accomplish the work clearly understand. The definition of work scope must provide sufficient detail to support hazard analysis and subsequent development and implementation of controls at the task level. Line management must determine the work to be accomplished and be accountable for completely understanding the scope through every phase of the work cycle.

Based on interviews and analysis of documentation, the Board determined that the retrieval of the aerial lift was performed under the F&ES Work Order A6S-C-5816, issued on October 1, 2009. The work order was generic and was considered to be a type of standing work order used to move aerial lifts, as needed, on a specific Monday, Wednesday, or Friday of the week. It identified the hazard level for the work to be low, and did not list any hazards in the job description section of the work order.

In this event, the work scope was incomplete in that it lacked sufficient detail regarding the location of the aerial lift. Without knowledge of the aerial lift's location, there was insufficient information to render an accurate hazard level assessment rating for this task since the building where it was located has specific hazards associated with operations (i.e., high noise hazards). Also, since the scope of the work was not clearly defined, operators in the Cryogenic Control Room were not made aware of the activity through the work control process.

Upon determining the aerial lift's location, line management should have updated the work order to fully define the scope of work and to re-assess the job hazards. Had this been done, the work would have been coordinated with the Cryogenic Control Room and the 1005H Building Manager to ensure safe access into the building.

The Board concluded that the scope of work for this task was not fully defined.

3.1.2 Identify and Analyze the Hazards

The objective of the hazards analysis process is to develop an understanding of the task-specific hazards that may affect the worker, the public, or the environment. Hazard controls are then established based on this understanding and other factors related to the work.

Two types of analysis methods commonly used for evaluating hazards at the facility and task level are the process hazard analysis and the job hazard analysis. In regards to the process hazard analysis, the Board found that the noise hazard had never been identified. The Board evaluated the design review process, the safety analysis process, the facility risk assessment process, the job risk assessment process, the procedural development process, and the C-AD self-assessment process and found that at any one of these points, the hazard could have been identified. In regards to the job hazard analysis, the Board evaluated the work planning and control process that brought the worker into contact with this hazard. The work scope was to deliver an aerial lift to an instrument station in Building 912. The work scope as documented on the F&ES work order Work Control Log identified this work as low-hazard worker planned work. However, because the work order was generated prior to locating the aerial lift, it did not identify the hazards for Building 1005H. Therefore, there was an insufficient level of hazard identification and analysis as a result of the incomplete definition of work scope.

The Board concluded that the hazards associated with the work performed were not identified or analyzed.

3.1.3 Develop and Implement Hazard Controls

As an ISM Core Function, the objective of developing and implementing hazard controls is to identify and provide all engineering, administrative and PPE requirements consistent with the hazards in the work place. In order to adequately develop and implement hazard controls, the complete work scope must first be known and well defined, and then the hazards thoroughly identified and analyzed. In this accident, identification of the noise/startle hazard was deficient, so controls were never put into place. However, there were two paths that led to this particular accident, one being the unidentified hazard path and the other the path that brought the worker into contact with the hazard.

The Board found that because the noise hazard had never been identified, there were no engineering, administrative or PPE controls in place to protect workers from the hazards associated with the high pressure helium venting outside of Building 1005H. The Board evaluated the design review process, the safety analysis process, the facility risk assessment process, the job risk assessment process, the procedural development process and the department's self-assessment process and found that at any one of these points the hazard could have been identified. With the identification of this hazard, engineering and/or administrative hazard controls would have been put into place to eliminate or control the hazard.

The Board evaluated the work planning and control process that brought the worker into contact with this hazard. The initial work scope was to deliver an aerial lift to Building 912. The initial work scope as documented on the F&ES Work Order, Work Control Log identified this work as low hazard worker planned work. However, because the work order was generated prior to locating the aerial lift needed, it did not identify the hazards for Building 1005H. Developing and implementing hazard controls for accessing Building 1005H was not done because the work was not properly screened or planned.

Building 1005H is normally an unoccupied building due to the hazards within the building. The Cryogenics Group requires personnel to notify the Cryogenic Control Room prior to entry. This requirement was posted on a sign on some of the doors to the building; however, the sign was not posted on the door that the Lead Rigger attempted to enter. Furthermore, neither the F&ES Technical Supervisor nor the F&O Rigging Supervisor instructed the Lead Rigger and the two Riggers accompanying him on how to access the building. The F&O Rigging Supervisor believed that the roll-up door approached by the Riggers had an exterior mechanism to open the door when in fact it did not.

The Board concluded that both C-AD and F&O management failed to develop and implement appropriate hazard controls for the work performed.

3.1.4 Perform Work Within Controls

The five ISMS Core Functions are designated to ensure that safety is effectively considered and implemented during all phases of work activities. The failure of any one of the core functions will result in the failure to effectively accomplish subsequent core functions. For example, if the specific work scope to accomplish is not clearly and effectively identified, or if work scope changes are not recognized, the task-specific hazards associated with the specific work scope cannot be properly identified.

The work order to retrieve the aerial lift identified the hazard level for the work to be low, and it did not list any hazards in the job description section of the work order. There were no modifications made to that work order to address any hazards associated with Building 1005H once it was discovered that the aerial lift was at that location, thus no hazards were formally documented.

The Board concluded that the performance of work within controls failed because there were no controls developed or implemented for the work performed.

3.1.5 Provide Feedback and Continuous Improvement

The key to continuous improvement within ISM is the feedback and improvement process. This process should be utilized to provide information on the adequacy of work controls, to identify and implement opportunities for improvement of work planning and the oversight processes for safety. Feedback and improvement are intended to identify and correct processes or conditions that can lead to unsafe or undesired work outcomes. The process can and should be used throughout work planning, work execution and work review.

In reviewing feedback and improvement processes associated with this accident, the Board reviewed previous lessons learned, self-assessments, risk assessments, work planning feedback from other work in this building and the site Occurrence Reporting and Processing System reports.

On April 14, 2006 a Type B Accident Investigation was conducted for the Arc Flash injury at BNL. The injury involved an arc flash burn pertaining to the omission of ground-fault monitoring in another RHIC building, 1006A. The omission of ground-fault monitoring was a design fault in the RHIC Facility, although the noise hazard associated with Building 1005H predated RHIC facilities, 1005H went through all the same acceptance processes as 1006A, and the hazard was not found. The judgments of need from the Arc Flash investigation concentrated only on electrical hazards and did not require RHIC to undergo a more generic legacy hazard review.

The BNL SBMS subject area "Environment, Safety, Health and Quality (Tier I) Inspections," requires line organizations to identify and track to closure ESH&Q deficiencies and observations identified during work area inspections. Work areas are normally inspected on a quarterly basis unless a rationale is developed and approved for less frequent inspections. C-AD has determined that based on the RHIC machine operating cycle, the inspection frequency for Building 1005H would be semi-annual. Due to the scope, purpose and infrequency of the inspection and the venting operation these inspections did not identify the hazards involved with this accident.

In 2004, BNL began the process of registration to the Occupational Health and Safety Assessment Series (OHSAS) 18001 standard for ESH. As part of the process, BNL and C-AD began performing in depth Facility Risk Assessments and Job Risk Assessments of all of its facilities and the work performed. After initial registration, the lab annually undergoes an ESH review for re-registration. In doing so, the Facility Risk Assessments and Job Risk Assessments are periodically reviewed and updated. During the initial risk assessments and during subsequent reviews, the manually operated venting process was never identified.

C-AD Operations Procedure Manual (OPM) 7.1.28, *Compressor Room – Cryogenic Purifier Operation,* was written in accordance with C-AD OPM 1.4, *Collider-Accelerator Department Plans, Policies and Operating Procedures.* The procedure has gone through several revisions and approvals since its inception. However, the board found no evidence that the procedure was ever walked down nor was there a documented requirement to walk it down. The walk down process would have been an opportune time to discuss the venting hazards.

In July of 2009, a sub-contractor working through F&O was painting the exterior of Building 1005H. The sub-contractor had communicated an incident to the F&O supervisor for the painting work involving a compressor relief vent on the south side of the building. The automatic relief vent had been triggered at the end of the compressor run and it had startled the sub-contractor. The F&O supervisor verbally communicated the incident to someone in the cryogenics group and it was confirmed that it was the expected operation of the compressor. No further actions were taken and the feedback was not recorded on the work permit for the painting job.

The Board concluded that C-AD and F&O failed to effectively utilize the feedback and improvement process to identify and control the hazard associated with this accident.

3.2 Training and Qualification

Management of employee training and qualification needs is established through the BNL SBMS Training and Qualification Management System. The Laboratory uses a Job Training Assessment to develop a training and qualification plan for each employee. This allows managers to tailor ES&H training and qualification requirements applicable to the hazards associated with their specific operations. Through the Brookhaven Training Management System, supervisors have on-screen access to the current Job Training Assessment for each subordinate employee. Managers are required to evaluate the adequacy of these training and qualification requirements on an annual basis or as an individual's duties are changed. The BNL Human Resources Services Training Office is responsible for ensuring that line organizations complete the annual Job Training Assessment evaluations.

The training records of the Lead Rigger and the two Riggers who accompanied him to Building 1005H were reviewed and determined to have been up to date at the time of the accident. The Riggers were also participants of the Noise Medical Surveillance Program which required that they complete audiograms annually. A review of the Noise Medical Surveillance qualifications of the three Riggers indicated that prior to their assignment to retrieve the aerial lift, their qualifications had lapsed.

The Board concluded that BNL failed to ensure that workers' Noise Medical Surveillance qualifications were current.

3.3 Management Systems

3.3.1 DOE Oversight

DOE line oversight has been performed by BHSO. The BHSO Manager serves as the local Federal official responsible for ensuring BNL contractual compliance with ES&H requirements. The BHSO Manager reports directly to the DOE SC Chief Operating Officer, who in turn reports to the Director of DOE SC.

The BHSO Operations Management Division has established four Facility Representative positions for performing day-to-day operational awareness oversight of BNL operations. This oversight is conducted in accordance with BHSO Procedure OA-1, *Conduct of Environment, Safety and Health (ESH) Assessments*, and BHSO Procedure OA-2, *Conduct of Environment, Safety and Health Surveillances and Walkthroughs* and other BHSO procedures.

BHSO Facility Representatives are qualified in accordance with BHSO Procedure BHSO-PPP-07, *Facility Representative Qualification and Training.* This procedure is consistent with the process of qualification established by DOE-STD-1063-2006, *Facility Representatives*, and DOE-STD-1151-2002, *Facility Representative Functional Area Qualification Standard.*

A qualified BHSO Facility Representative has been appointed to oversee work being performed in conjunction with RHIC operations. The BHSO Facility Representative assigned to RHIC operations also covers the C-AD organization and the Superconducting Magnet Division, as well as their other facilities (e.g., AGS, Tandem, Linear Accelerator, and the National Aeronautics and Space Administration Space Radiation Research Laboratory).

DOE line oversight has been performed by BHSO in the form of Facility Representative walk-throughs and programmatic assessments. Five programmatic assessments have been performed in 2009. Findings from these assessments were formally sent to BSA. The *Performance Evaluation Management Plan* developed between BHSO and BSA, for 2009 was reviewed. The 2009 mid-year Performance Feedback, communicated from BHSO to BSA, identified Days Away, Restricted, or Transferred (DART) and Total Recordable Cases (TRC) rates and a "...reluctance to share and address lessons learned at the institutional level" as weaknesses and rated this goal as Red. The goal relating to providing efficient and effective implementation of integrated safety, health, and environment management was rated as Green. The 2009 end-of-year Performance Feedback identified weaknesses in: (1) the DART and TRC rates, (2) the need to strengthen ongoing efforts to implement a robust and effective contractor assurance system, and (3) the concern that the BSA management safety observations were behind schedule. The strengths identified were: (1) BSA's responses to the corrective actions from the Well House investigation, and (2) improvements in the Work Planning and Controls Program, the Chemical Management Program, and the Fire Safety Program. The Board found that BHSO performance feedback has not been effective in driving improvements to ensure integration of safety at all levels and in all activities at BNL.

The Board concluded that BHSO expectations and communications to BSA for ISM improvements were not effective in addressing the weaknesses in uniformity of implementation of ISM across BNL.

3.3.2 BNL Oversight

BNL's Worker Safety and Health (S&H) Management System was established to assist line and operations management in ensuring that a safe and healthy workplace is provided to all staff, guests, contractors, and visitors of the Laboratory. This management system addresses the identification, evaluation, and control of hazards in the workplace by providing direct technical assistance to those conducting work, including line, facility, and project managers, as well as staff, and by providing the opportunity for workers and their elected representatives to become involved in the development of the Worker Safety and Health Program goals, objectives, and performance measures. The objective of the system is to provide processes for identifying and controlling hazards that prevent work-related accidents, injuries, and illnesses involving Laboratory staff, guests, and contractors. This system manages the ISM Program to align Worker Safety and Health with Work Planning and Control.

The purpose of the Work Planning and Control Management System is to establish requirements so that all work is properly managed by using a level of planning commensurate to the Environment, Safety, Security and Health hazards, job complexities, and work coordination needs. The management system establishes work control processes based on the ISM Core Functions of: defining the scope of work, identifying the hazards, developing controls, performing work within the controls, and providing feedback for continuous improvement. For this management system, "work" is defined as the activities that involve the design, set-up, operation, maintenance, modification, construction, demolition, or decommissioning of facilities, systems, or experiments by BNL or non-BNL staff (contractors, visiting scientists, students, and minors).

These systems together with the SBMS identify the processes for performing all work at BNL.

Based on interviews, the Board identified non-uniform implementation of ESH&QA programs and ineffective, non-standard disciplinary action programs across BNL. Discussions with BSA employees at all levels identified weaknesses in the communication of ISM goals and expectations from upper management to middle management and from upper management to the BNL workers. BSA communications relating to ISM were infrequent and non-specific to the expectations of integrating safety at all levels and in all activities at BNL.

The Board concluded that these programs appear adequate at the institutional level, however, implementation at the worker and supervisor level is less than adequate.

3.4 Summary of Analytical Methods and Results

3.4.1 Barrier Analysis

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

3.4.2 Change Analysis

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

A Change Analysis was done by the Accident Investigation Board. After reviewing the facts and timeline, only one change was identified. Previously, Riggers were issued master keys to all buildings. In recent years, the master keys were limited to a few Technical Supervisors. Had the Rigger still had a key, he would not have had to walk around the building to look for an open door, and the injury would not have occurred.

3.4.3 Event and Causal Factors

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

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

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4.0 CONCLUSIONS AND JUDGMENTS OF NEED

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

The first seven JONs in this report are the same as those noted in the report that was submitted to BSA on September 28, 2009, on the investigation of the Well House #12 Fire at BNL. The team concluded that BSA had not had time to develop or implement corrective actions for the JONs listed in the Well House Fire report. Since our Causes fit well into these JONs it was decided to use the same JONs.

Table 4-1. Conclusions and Judgments of Need

Conclusion	Judgments of Need
The Building 1005H Manager is not required to be notified of personnel access for all work activities in Building 1005H. The 1005H Building Manager was not aware of all health and safety hazards or configuration changes associated with the operation of the building.	**JON-1:** BNL needs to fully develop and effectively implement a Facility Management program that encompasses essential Facility Management functions.
The work order that was initially prepared for retrieval of the aerial lift was vague and did not address hazards that would be encountered inside the building. There was no work order issued for the retrieval of the aerial lift once the location of the lift was identified, thus no hazards were formally documented. There is no F&ES procedure that controls the F&ES Work Order Form No. BNL F 2467E – Rev. 11/07.	**JON-2:** BNL needs to improve and enforce its requirements to increase inconsistency of work planning rigor.
Buildings and facilities need to undergo engineering and operational design reevaluations for inadequate design hazards and equipment concerns.	**JON-3:** BNL should improve its engineering and operational design process to increase the consistency of engineering design rigor.
This was the root cause of this accident in that the external noise hazard from the tank purge operations in Building 1005H was not identified and thus compensatory measures were not taken.	**JON-4:** BNL needs to establish and implement a graded approach to evaluate Legacy Facilities for potential risks.
A C-AD procedure that identified a noise hazard when the roll-up doors are open at Building 1005H was modified in 2004 to put noise protection specific compensatory actions in place but these specific compensatory actions were dropped when the procedure was revised in 2009.	**JON-5:** BNL needs to develop and implement an institutional-level program that includes all Configuration Management essential elements.

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

Conclusion	Judgments of Need
BNL has a fragmented ESH&QA program in that Assistant Laboratory Directors have their own ESH&QA organizations which develop different methodologies of implementation of safety programs and deter communication of important information to upper management. BNL disciplinary action program is not consistent across the lab. The accident scene was not preserved and not appropriately transitioned to the DOE Accident Investigation Team. BNL failed to ensure that workers' Noise Medical Surveillance qualifications were current.	**JON-6:** BNL assessments and corrective action information needs to be analyzed at an institutional-level to ensure that (1) Management System Stewards and Laboratory management are aware of potential vulnerabilities, (2) Laboratory resources can be adequately deployed, (3) process improvements can be effectively implemented into management systems requirements and all Laboratory operations.
Lower levels of line management, to a great extent, are left to their own to develop ESH&QA programs and expectations and don't necessarily work to consistent performance metrics. ISM needs to be communicated more effectively and frequently from BSA upper management to the laboratory work force. ES&H performance data is not trended uniformly across BNL.	**JON-7:** BNL's senior management needs to clearly establish and model those institutional values, line management leadership behaviors and core competencies that will support achieving the Laboratory's goals, requirements, and performance expectations.
Though BHSO oversight programs are being implemented, corrective actions by BSA are not always timely or effective. ISM program expectations need to be communicated more effectively from BHSO to BSA upper management to.	**JON-8:** BHSO needs a more effective method for providing expectations to BSA for improvements in the consistent implementation of ISM across BNL.

5.0 BOARD SIGNATURES

Harold J. Monroe, III
DOE Accident Investigation Board Chairperson
Office of Science – Oak Ridge Office
Technical Support and Assessment Division

Craig Booker
DOE Accident Investigation Trained Board Member
Office of Science – Oak Ridge Office
Technical Support and Assessment Division

Jeffrey Makiel
DOE Accident Investigation Board Member
Office of Science – Princeton Site Office
Project and Engineering Management Team

Patrick Sullivan, CSP, RRPT
DOE Accident Investigation Board Member
Office of Science – Brookhaven Site Office
Operations Management Division

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6.0 BOARD MEMBERS, ADVISORS, AND STAFF

Board Members

Chairperson	Harold J. Monroe, III, Director of Technical Support & Assessment Division, DOE Oak Ridge Office (ORO)
Member	Craig Booker, Health Physicist, DOE ORO
Member	Jeffrey Makiel, Project Engineer DOE Princeton Site Office
Member	Patrick Sullivan, Facility Representative, DOE BHSO

Advisors

Advisor	Louis Sadler, Assistant Chief Counsel, DOE CH

Technical and Administrative Support

Coordinator	Jodi Jenkins, Senior Health Physicist, Dade Moeller & Associates, Inc.
Technical Editor	Mona Hamby, Quality Assurance Specialist III, Navarro Research and Engineering Inc.

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Appendix A – Appointment of Type B Accident Investigation Board

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Department of Energy
Brookhaven Site Office
P.O. Box 5000
Upton, New York 11973

OCT 16 2009

Harold J. Monroe, III
Technical Support and
Assessment Division
Office of Science
Oak Ridge Office

SUBJECT: APPOINTMENT OF TYPE B ACCIDENT INVESTIGATION BOARD TO INVESTIGATE THE OCTOBER 9, 2009 INJURY AT THE COLLIDER-ACCELERATOR DEPARTMENT AT BROOKHAVEN NATIONAL LABORATORY

I hereby establish a Type B Accident Investigation Board to investigate the injury that occurred on October 9, 2009 at the Collider-Accelerator Department at Brookhaven National Laboratory (BNL). You are hereby appointed Chairperson of the Investigation Board to investigate the subject accident. You are to perform a Type B Accident Investigation of this accident and prepare an investigation report. The report shall conform to requirements detailed in Department of Energy (DOE) Order 225.1A, *Accident Investigations*, and DOE G 225.1a-1, *Implementation Guide for Use with DOE O 225.1A, Accident Investigations.* The Board will be comprised of the following members:

Jeffrey Makiel
Project and Engineering Management Team
Office of Science - Princeton Site Office

Craig Booker
Technical Support and Assessment Division
Office of Science - Oak Ridge Office

Patrick Sullivan
Operations Management Division
Office of Science - Brookhaven Site Office

Louis Sadler, Office of Chief Counsel, Chicago Office, will serve as the legal liaison for the Board. The Board will be assisted by advisors, consultants, and other support personnel as determined by you. If additional resources are required to assist you in implementing this task, please let me know and it will be provided.

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

The Board will provide the Brookhaven Site Office (BHSO) with weekly reports on the status of the investigation. Draft copies of the factual portion of the investigation report will be submitted to BHSO and the contractor for factual accuracy review prior to report finalization.

The final investigation report should be provided to me by November 20, 2009. Any delay in this date shall be justified and forwarded to BHSO. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report. If you have any questions, please contact me at (631) 344-3424.

M. Holland

Michael D. Holland
Site Manager

cc: G. Malosh, SC-3, FORS
P. Dehmer, SC-2, FORS
E. Henry, SC-26.1, GTN
M. Jones, SC-31, GTN
C. Lewis, HS-31, GTN
C. Booker, SC-ORO
M. Dikeakos, SC-BHSO
R. Desmarais, SC-BHSO
P. Sullivan, SC-BHSO
J. Makiel, SC-PSO
J. Faul, SC-PSO
L. Sadler, SC-CH
S. Aronson, BSA
M. Bebon, BSA
S. Vigdor, BSA
C. Parnell, BSA

Appendix B – Barrier Analysis

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Table B-1: Barrier Analysis

Item	What were the barriers?	How did each barrier perform?	Why did the barrier fail?	How did the barrier affect the accident?
			[illegible]	
1	Direct Supervision	Failed	The Riggers was not given adequate instructions for building access.	The Lead Rigger searched to find an access to the building
2	Building Manager Program & Cryogenic Control Room	Failed	Neither the Building Manager nor the Cryogenic Control Room were contacted prior to attempting to enter Building 1005H.	Neither the Building Manager nor the Cryogenic Control Room were aware that the Riggers were attempting to access the facility.
			[illegible]	
1	Building Postings	Failed	The west side building doors were not posted with access instructions.	The Lead Rigger searched to find an access to the building.
2	Work Planning/Hazard Communications	Failed	No work instructions were given to the Riggers to address building access.	The Lead Rigger searched to find an access to the building.
3	Hazard Identification/Analysis	Failed	Prior or current operations of the facility did not identify all noise hazards.	An unidentified noise hazard existed.
			[illegible]	
1	Physical Design & Installation of Process Vents	Failed	Safety analysis reviews/documents did not identify the noise hazard from the vent pipe.	An unidentified hazard existed.
2	Physical Barrier	Failed	There was no physical barrier to prohibit the Lead Rigger from entering the noise envelope of the vent pipe.	The Lead Rigger was allowed to traverse the noise envelope of the vent pipe.

Appendix C – Events and Causal Factors Analysis

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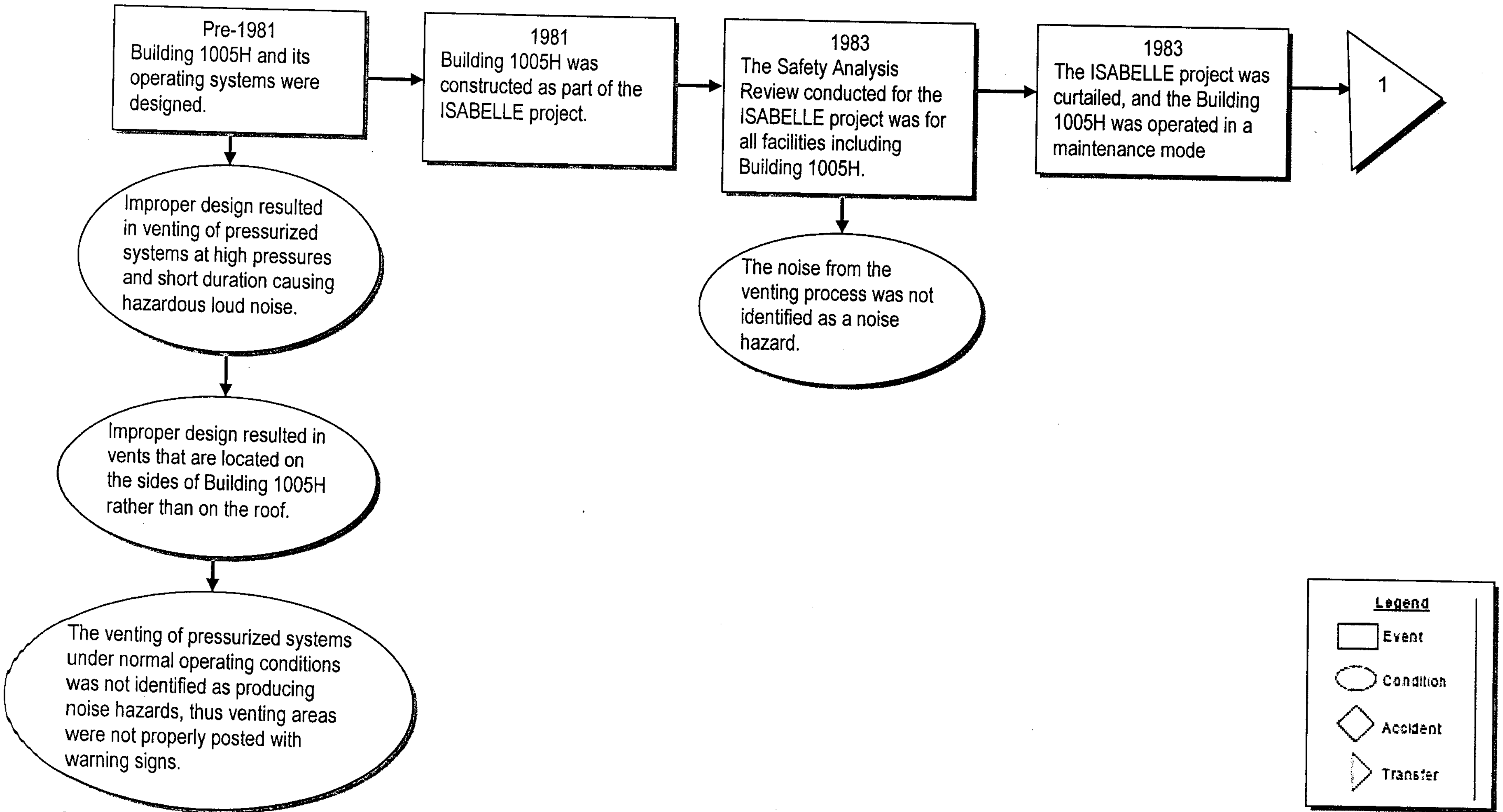
Table C-1. Events and Causal Factors Analysis

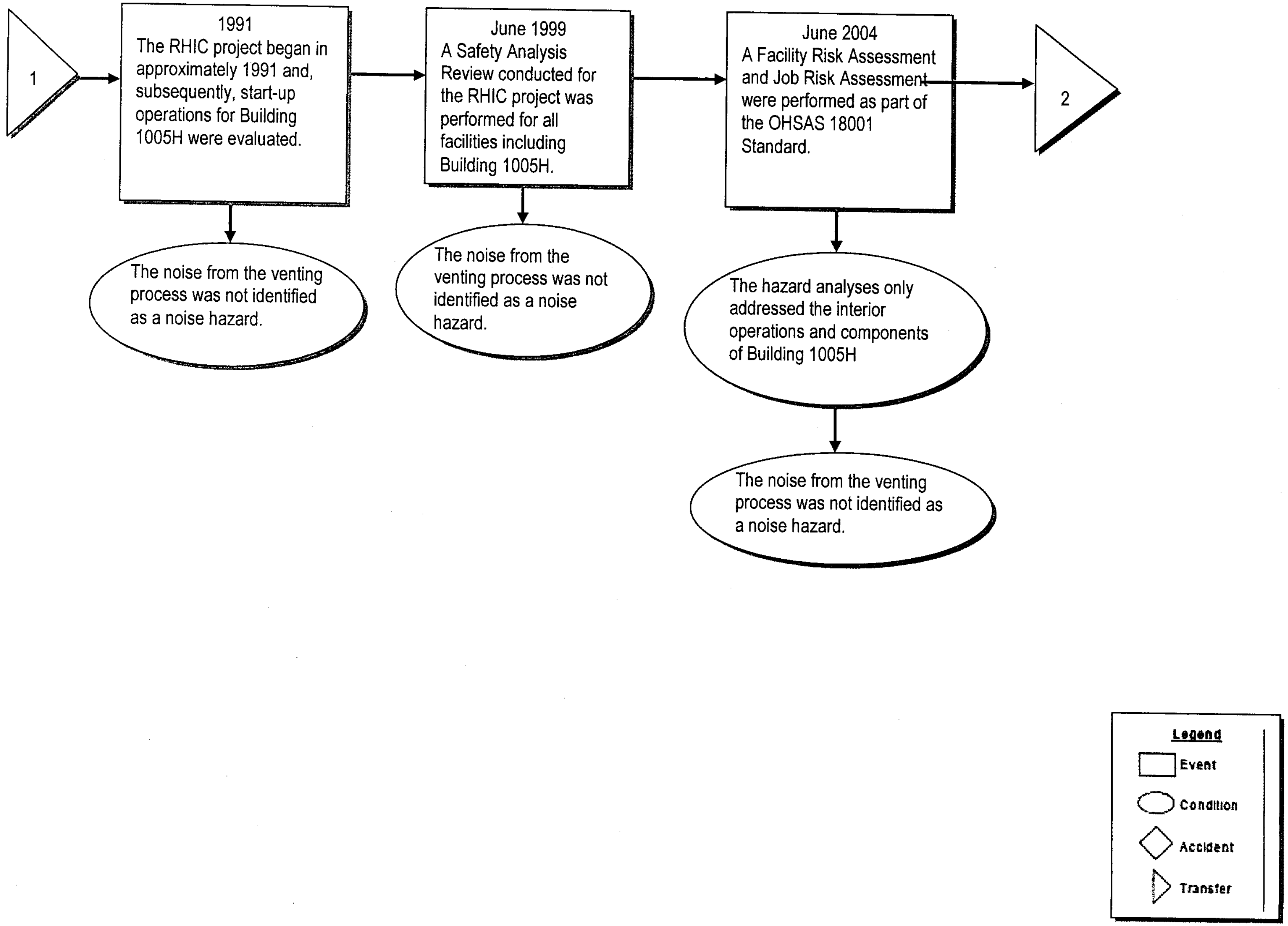
CC No.	Contributing Causes	Discussion	Related JONs
CC-1	BNL failed to implement an effective Work Control Process.	The work order that was used to retrieve the aerial lift was not changed once the aerial lift was determined to be in Building 1005H. Therefore, the hazards associated with Bldg. 1005H were not identified in a new work order.	JON-2
CC-2	BNL failed to establish formal controls for building access.	The Facilities Management program does not give complete control over a building to the Building Manager. Building Managers need to be knowledgeable of all activities occurring within their buildings. Not all access doors to Building. 1005H were posted requiring a call to the Cryogenics Control Room or to the Building Manager.	JON-1
CC-3	BNL failed to perform adequate operational awareness.	The Riggers were not instructed on what to do should the access doors be locked. The Riggers were not made aware of the possibility of high noise outside of the building.	JON-5
CC-4	BNL failed to address all safety hazards in design.	There were several opportunities from the time Building. 1005H was designed to when the accident occurred to have properly identified the vent relief noise hazard.	JON-3 JON-4
Root Cause	The Board determined the root cause to be BNL's failure to implement an effective ISMS program to ensure all hazards associated with the operations of its facilities are identified, analyzed, and controlled.	Though BNL does have a documented ISM program, incidents and accidents that have occurred in the last couple of years appear to indicate that safety is not being integrated sufficiently into all activities at BNL. Most of these incidents appear to be related to inattention by workers and inadequate line management attention. Constant reminders by management and supervision along with an effective disciplinary action program will be needed. The safety program throughout BNL is fragmented and not uniform in the implementation of ISM.	JON-6 JON-7
Direct Cause	The direct cause was the unanalyzed loud sound produced by the Cryogenic venting process.	Legacy buildings need to be analyzed for all hazards. Building Managers need to be completely familiar with the operations of buildings for which they are responsible.	JON-4

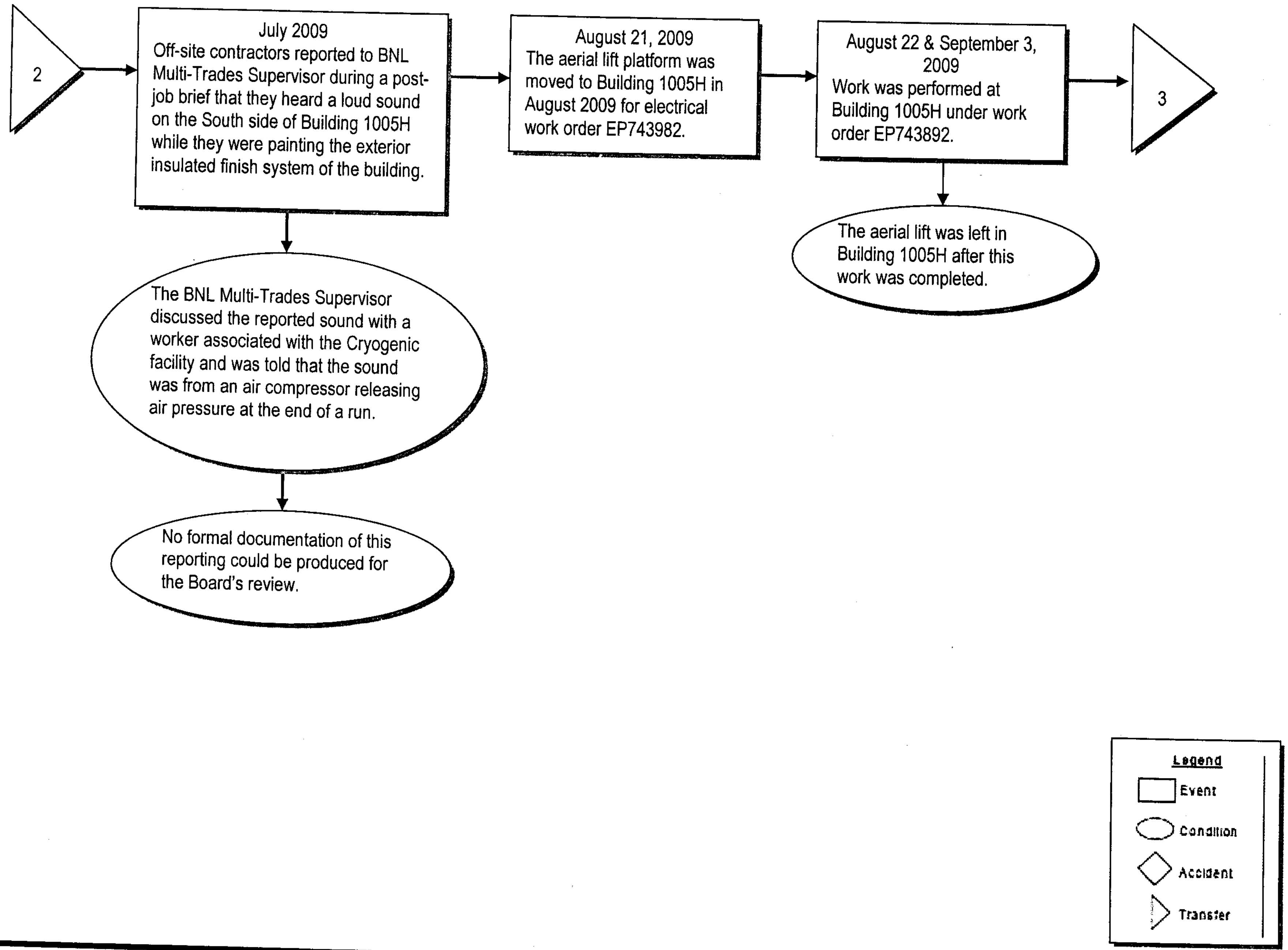
Figure C-1. Events and Causal Factors Chart

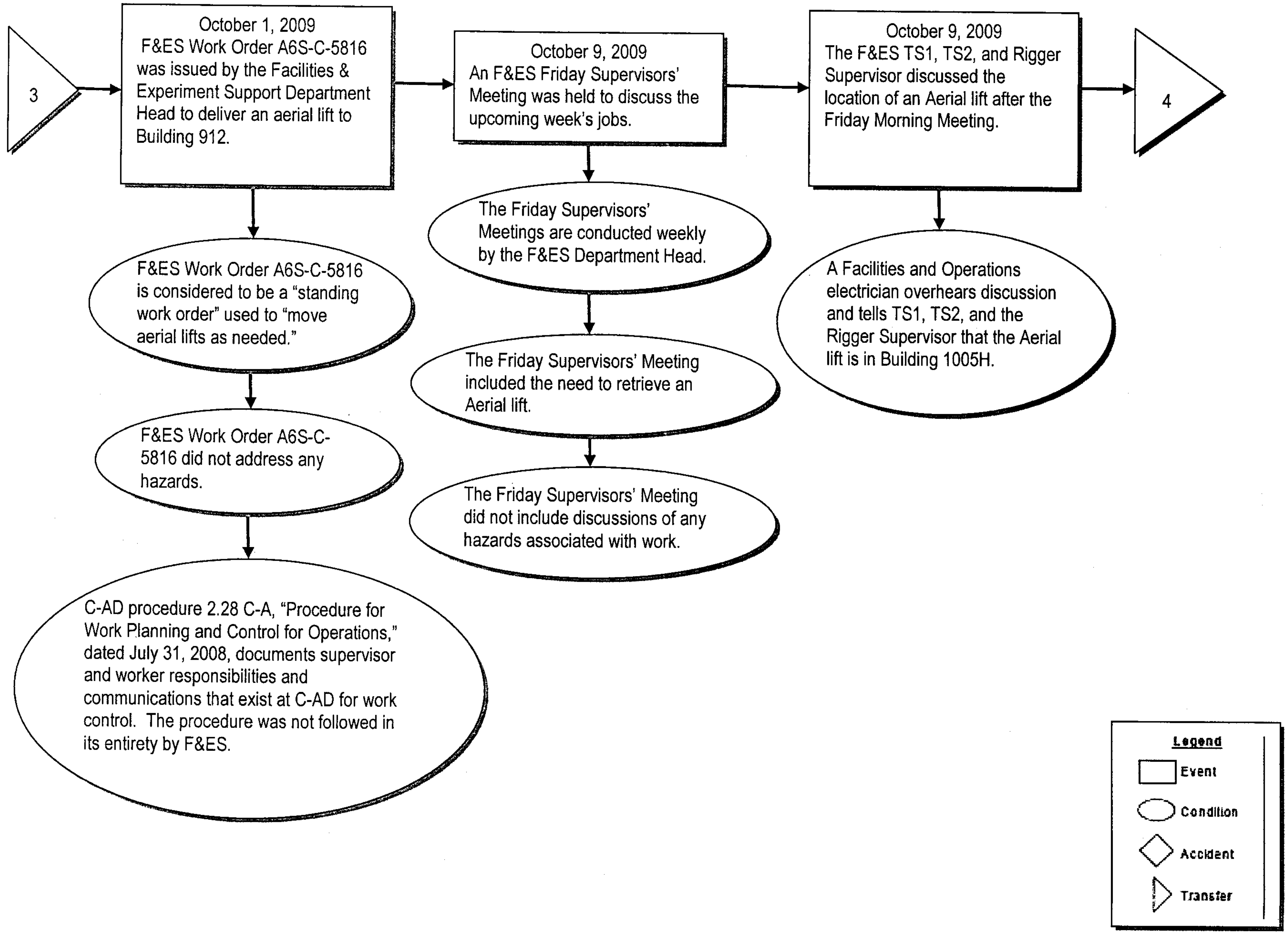
An events and causal factors analysis was performed in accordance with the DOE Workbook *Conducting Accident Investigations*. The events and causal factors analysis requires deductive reasoning to determine which events and/or conditions contributed to the accident. Causal factors are the events or conditions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

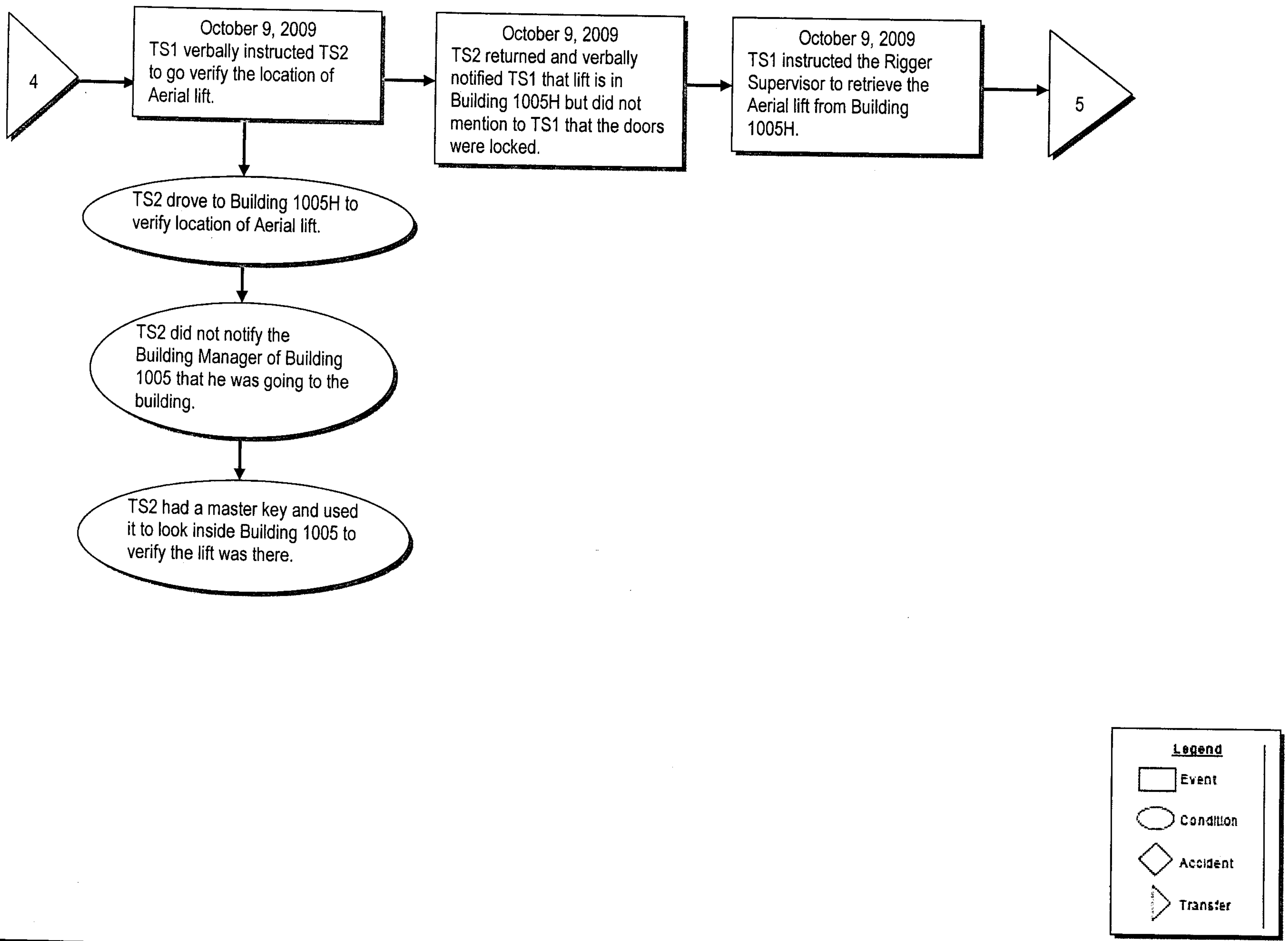
The direct cause is the immediate events or conditions that caused the accident. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the accident but which did not cause the accident. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar accidents. Below is the "Events and Causal Factors Chart."

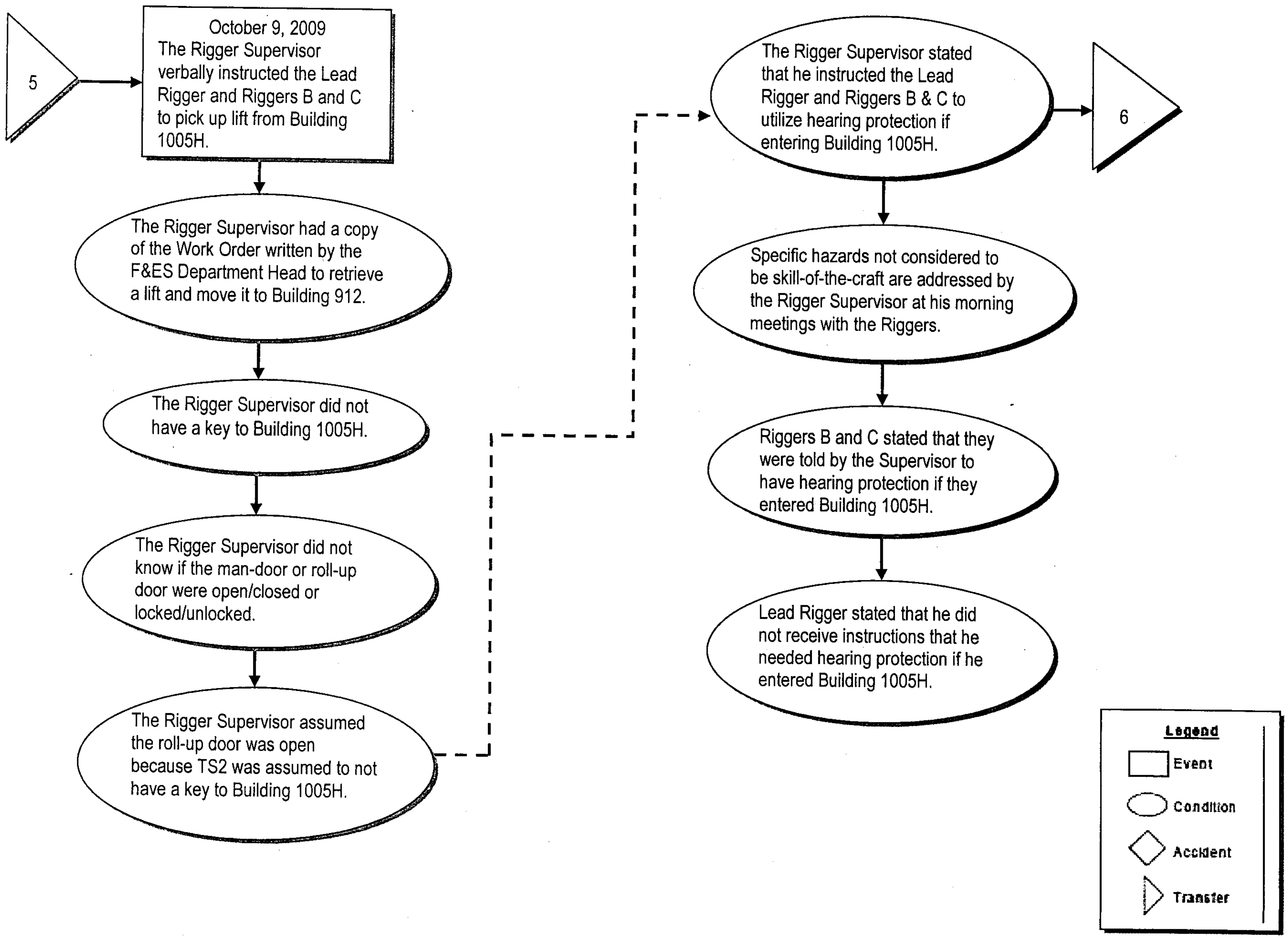



1
1991
The RHIC project began in approximately 1991 and, subsequently, start-up operations for Building 1005H were evaluated.
The noise from the venting process was not identified as a noise hazard.
June 1999
A Safety Analysis Review conducted for the RHIC project was performed for all facilities including Building 1005H.
The noise from the venting process was not identified as a noise hazard.
June 2004
A Facility Risk Assessment and Job Risk Assessment were performed as part of the OHSAS 18001 Standard.
The hazard analyses only addressed the interior operations and components of Building 1005H
The noise from the venting process was not identified as a noise hazard.
2
Legend
Event
Condition
Accident
Transfer

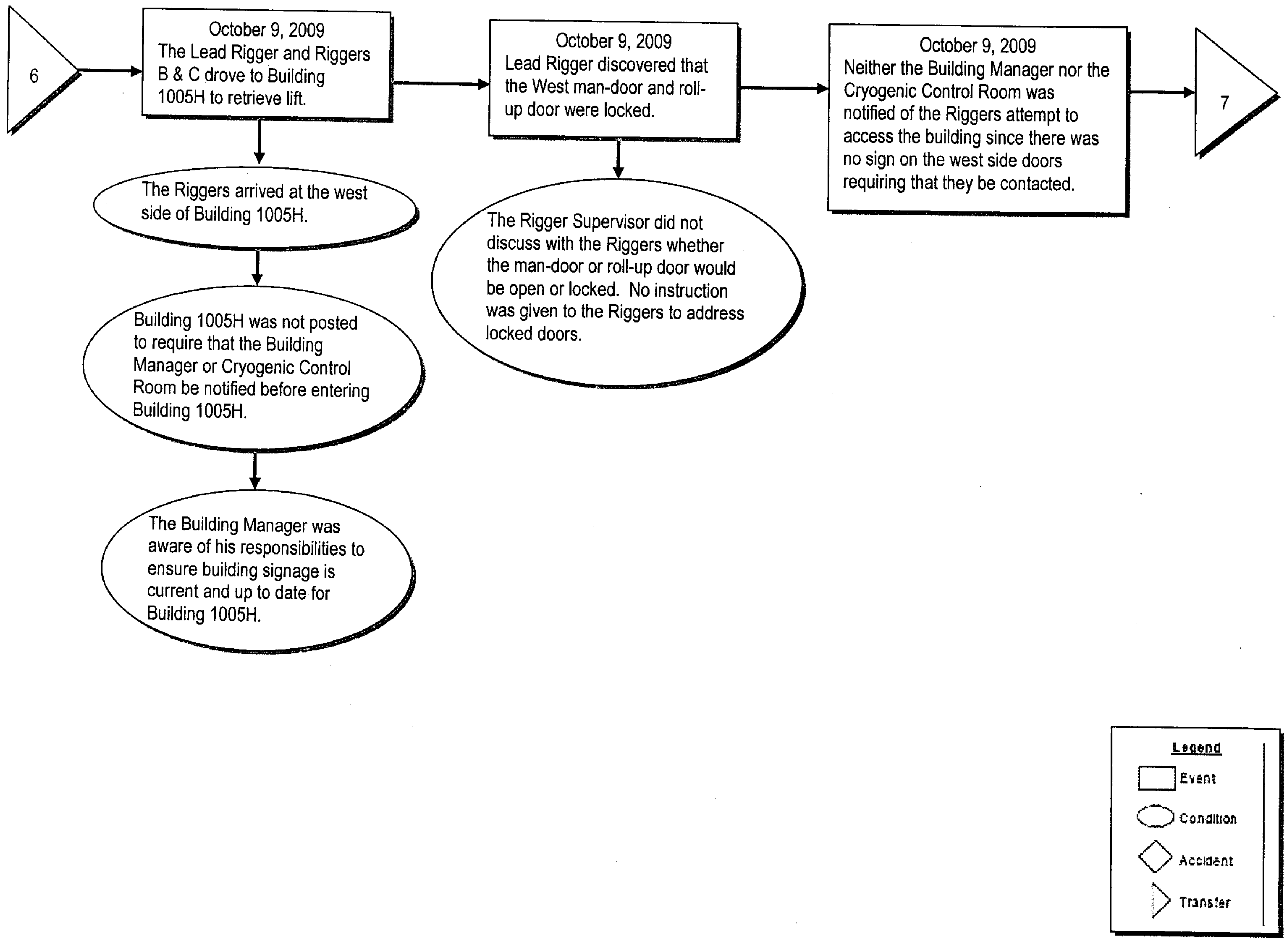

2
July 2009
Off-site contractors reported to BNL Multi-Trades Supervisor during a post-job brief that they heard a loud sound on the South side of Building 1005H while they were painting the exterior insulated finish system of the building.
August 21, 2009
The aerial lift platform was moved to Building 1005H in August 2009 for electrical work order EP743982.
August 22 & September 3, 2009
Work was performed at Building 1005H under work order EP743892.
3
The BNL Multi-Trades Supervisor discussed the reported sound with a worker associated with the Cryogenic facility and was told that the sound was from an air compressor releasing air pressure at the end of a run.
No formal documentation of this reporting could be produced for the Board's review.
The aerial lift was left in Building 1005H after this work was completed.
Legend
Event
Condition
Accident
Transfer

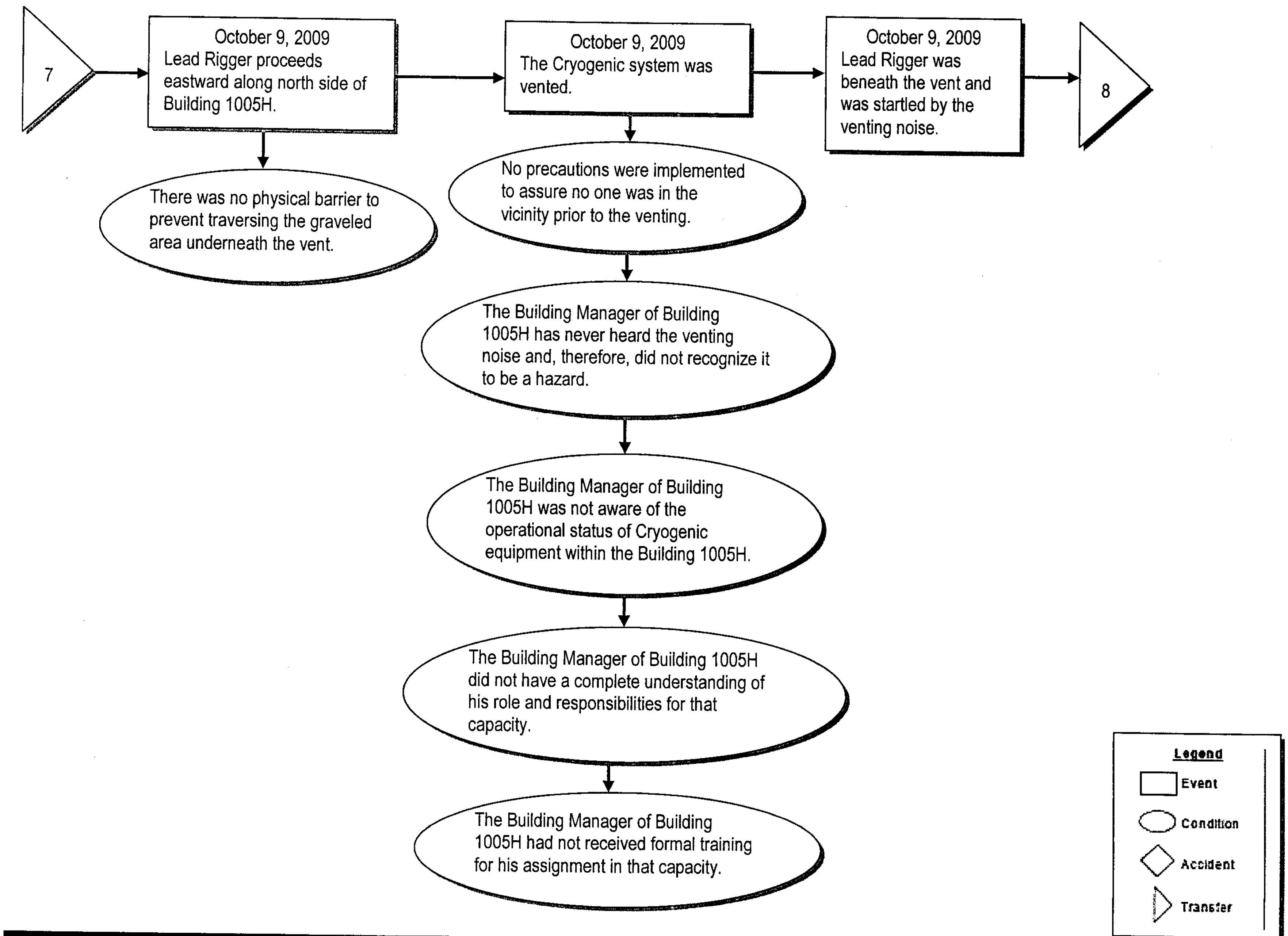

3
October 1, 2009
F&ES Work Order A6S-C-5816 was issued by the Facilities & Experiment Support Department Head to deliver an aerial lift to Building 912.
F&ES Work Order A6S-C-5816 is considered to be a "standing work order" used to "move aerial lifts as needed."
F&ES Work Order A6S-C-5816 did not address any hazards.
C-AD procedure 2.28 C-A, "Procedure for Work Planning and Control for Operations," dated July 31, 2008, documents supervisor and worker responsibilities and communications that exist at C-AD for work control. The procedure was not followed in its entirety by F&ES.
October 9, 2009
An F&ES Friday Supervisors' Meeting was held to discuss the upcoming week's jobs.
The Friday Supervisors' Meetings are conducted weekly by the F&ES Department Head.
The Friday Supervisors' Meeting included the need to retrieve an Aerial lift.
The Friday Supervisors' Meeting did not include discussions of any hazards associated with work.
October 9, 2009
The F&ES TS1, TS2, and Rigger Supervisor discussed the location of an Aerial lift after the Friday Morning Meeting.
A Facilities and Operations electrician overhears discussion and tells TS1, TS2, and the Rigger Supervisor that the Aerial lift is in Building 1005H.
4
Legend
Event
Condition
Accident
Transfer


4
October 9, 2009
TS1 verbally instructed TS2 to go verify the location of Aerial lift.
October 9, 2009
TS2 returned and verbally notified TS1 that lift is in Building 1005H but did not mention to TS1 that the doors were locked.
October 9, 2009
TS1 instructed the Rigger Supervisor to retrieve the Aerial lift from Building 1005H.
5
TS2 drove to Building 1005H to verify location of Aerial lift.
TS2 did not notify the Building Manager of Building 1005 that he was going to the building.
TS2 had a master key and used it to look inside Building 1005 to verify the lift was there.
Legend
Event
Condition
Accident
Transfer



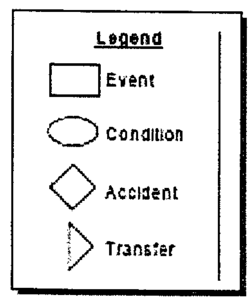
5
October 9, 2009
The Rigger Supervisor verbally instructed the Lead Rigger and Riggers B and C to pick up lift from Building 1005H.
The Rigger Supervisor had a copy of the Work Order written by the F&ES Department Head to retrieve a lift and move it to Building 912.
The Rigger Supervisor did not have a key to Building 1005H.
The Rigger Supervisor did not know if the man-door or roll-up door were open/closed or locked/unlocked.
The Rigger Supervisor assumed the roll-up door was open because TS2 was assumed to not have a key to Building 1005H.
The Rigger Supervisor stated that he instructed the Lead Rigger and Riggers B & C to utilize hearing protection if entering Building 1005H.
6
Specific hazards not considered to be skill-of-the-craft are addressed by the Rigger Supervisor at his morning meetings with the Riggers.
Riggers B and C stated that they were told by the Supervisor to have hearing protection if they entered Building 1005H.
Lead Rigger stated that he did not receive instructions that he needed hearing protection if he entered Building 1005H.
Legend
Event
Condition
Accident
Transfer

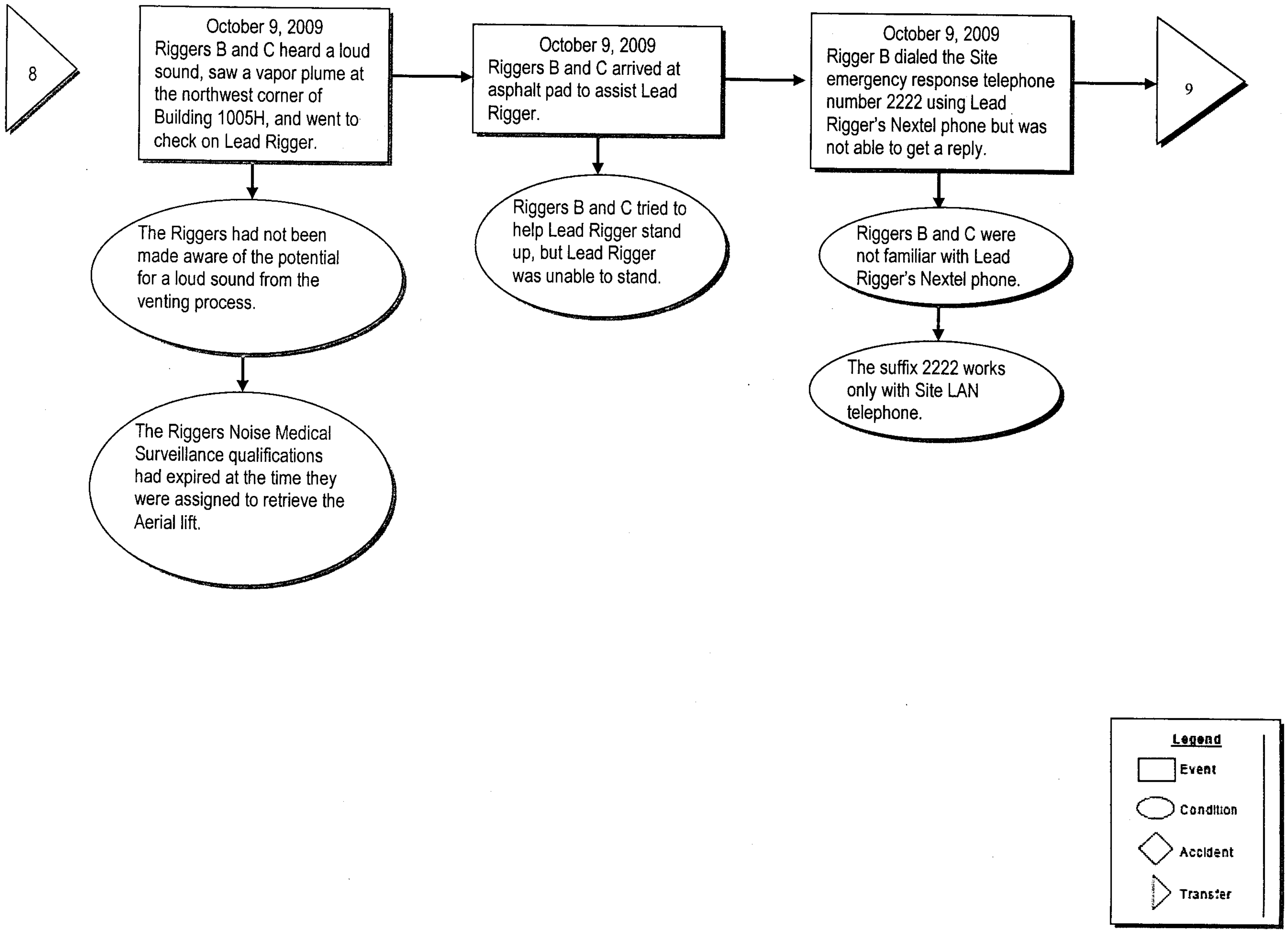

6
October 9, 2009
The Lead Rigger and Riggers B & C drove to Building 1005H to retrieve lift.
The Riggers arrived at the west side of Building 1005H.
Building 1005H was not posted to require that the Building Manager or Cryogenic Control Room be notified before entering Building 1005H.
The Building Manager was aware of his responsibilities to ensure building signage is current and up to date for Building 1005H.
October 9, 2009
Lead Rigger discovered that the West man-door and roll-up door were locked.
The Rigger Supervisor did not discuss with the Riggers whether the man-door or roll-up door would be open or locked. No instruction was given to the Riggers to address locked doors.
October 9, 2009
Neither the Building Manager nor the Cryogenic Control Room was notified of the Riggers attempt to access the building since there was no sign on the west side doors requiring that they be contacted.
7
Legend
Event
Condition
Accident
Transfer

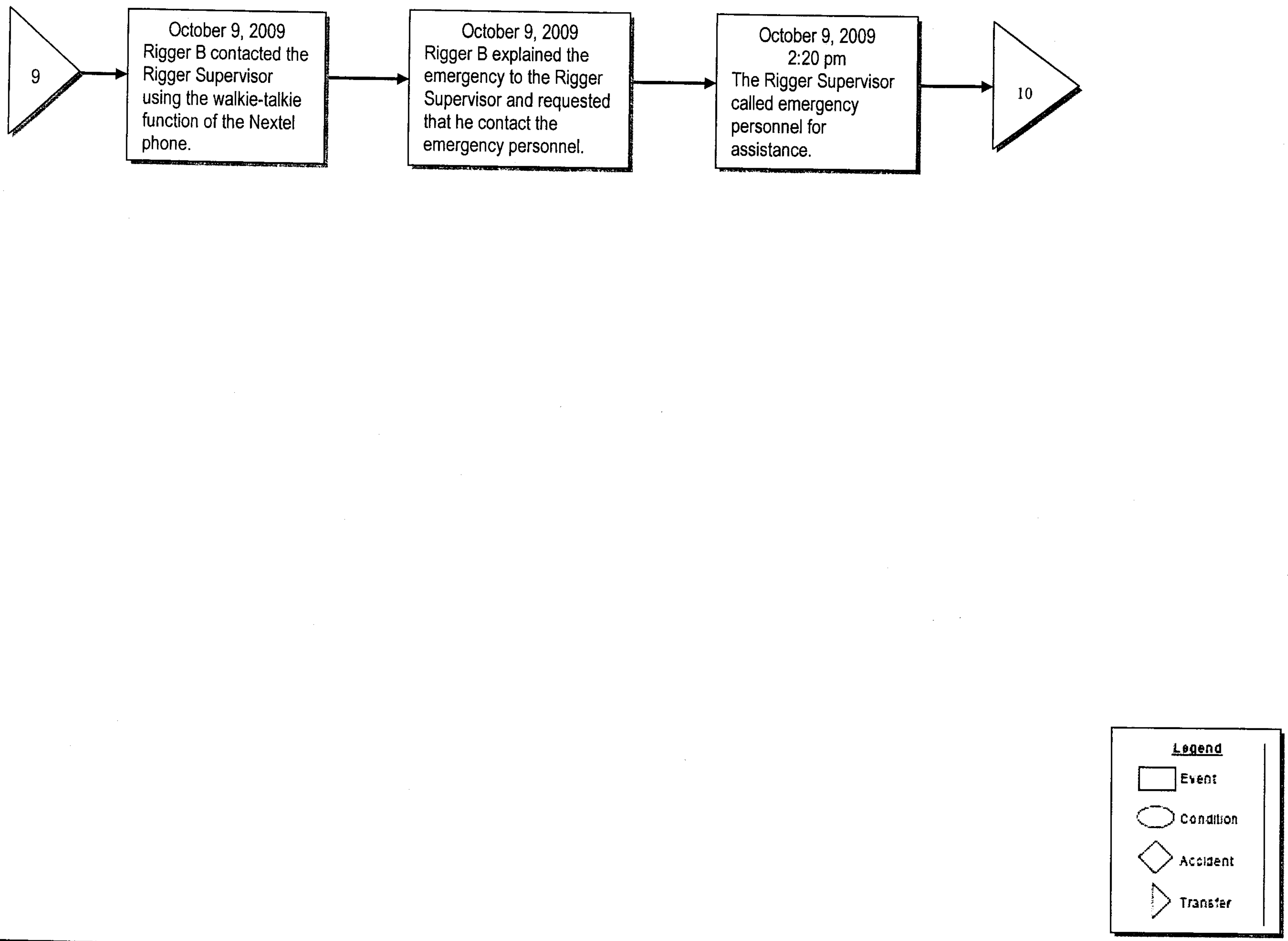


7
October 9, 2009
Lead Rigger proceeds eastward along north side of Building 1005H.
There was no physical barrier to prevent traversing the graveled area underneath the vent.
October 9, 2009
The Cryogenic system was vented.
No precautions were implemented to assure no one was in the vicinity prior to the venting.
The Building Manager of Building 1005H has never heard the venting noise and, therefore, did not recognize it to be a hazard.
The Building Manager of Building 1005H was not aware of the operational status of Cryogenic equipment within the Building 1005H.
The Building Manager of Building 1005H did not have a complete understanding of his role and responsibilities for that capacity.
The Building Manager of Building 1005H had not received formal training for his assignment in that capacity.
October 9, 2009
Lead Rigger was beneath the vent and was startled by the venting noise.
8
Legend
Event
Condition
Accident
Transfer

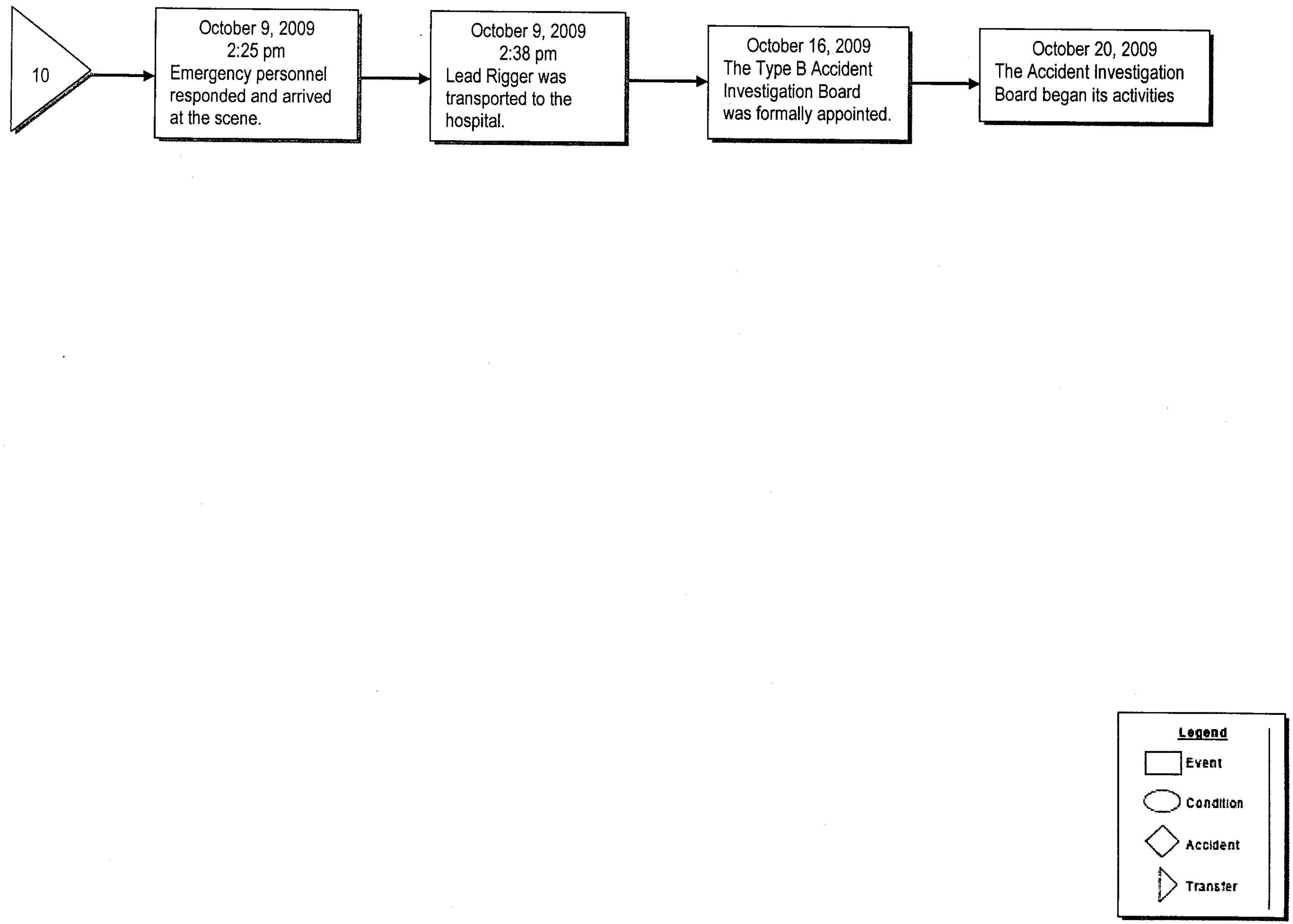

7
October 9, 2009
Lead Rigger ran eastward along the North wall of Building 1005H on loose gravel which was on top of landscape fabric.
October 9, 2009
Lead Rigger sustained injuries to his legs.
October 9, 2009
Lead Rigger crawled toward asphalt pad.
8


Legend
Event
Condition
Accident
Transfer


8
October 9, 2009 Riggers B and C heard a loud sound, saw a vapor plume at the northwest corner of Building 1005H, and went to check on Lead Rigger.
The Riggers had not been made aware of the potential for a loud sound from the venting process.
The Riggers Noise Medical Surveillance qualifications had expired at the time they were assigned to retrieve the Aerial lift.
October 9, 2009 Riggers B and C arrived at asphalt pad to assist Lead Rigger.
Riggers B and C tried to help Lead Rigger stand up, but Lead Rigger was unable to stand.
October 9, 2009 Rigger B dialed the Site emergency response telephone number 2222 using Lead Rigger's Nextel phone but was not able to get a reply.
Riggers B and C were not familiar with Lead Rigger's Nextel phone.
The suffix 2222 works only with Site LAN telephone.
9
Legend
Event
Condition
Accident
Transfer



9
October 9, 2009
Rigger B contacted the Rigger Supervisor using the walkie-talkie function of the Nextel phone.
October 9, 2009
Rigger B explained the emergency to the Rigger Supervisor and requested that he contact the emergency personnel.
October 9, 2009
2:20 pm
The Rigger Supervisor called emergency personnel for assistance.
10
Legend
Event
Condition
Accident
Transfer


10
October 9, 2009
2:25 pm
Emergency personnel responded and arrived at the scene.
October 9, 2009
2:38 pm
Lead Rigger was transported to the hospital.
October 16, 2009
The Type B Accident Investigation Board was formally appointed.
October 20, 2009
The Accident Investigation Board began its activities
Legend
Event
Condition
Accident
Transfer