
Final Report

July 1998

**Type B Accident
Investigation Board Report
May 24, 1998
Electrical Arc Blast
at the
Kansas City Plant**



Albuquerque Operations Office

This report is a product of an accident investigation board appointed by Bruce G. Twining, Manager, Albuquerque Operations Office, 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*.

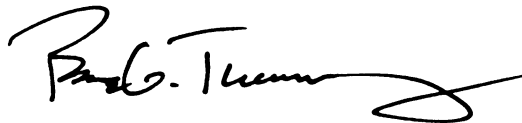
The discussion of facts, as determined by the Board, and the views expressed in this report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier,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

This report neither determines nor implies liability.

On May 28, 1998, I established a Type B Accident Investigation Board to investigate the electrical arc blast accident at the Kansas City Plant, managed and operated by AlliedSignal Federal Manufacturing & Technologies, Kansas City, Missouri.

The Board's responsibilities have been completed with respect to this investigation. The analysis process; identification of direct, contributing and root causes; and development of judgments of need during the investigation were done in accordance with DOE Order 225.1A, *Accident Investigations*.

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

A handwritten signature in black ink, appearing to read "Bruce G. Twining", with a stylized flourish at the end.

**Bruce G. Twining
Manager
Albuquerque Operations Office**

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ACRONYMS

ACB	Air Circuit Breaker
AL	Albuquerque Operations Office
CFR	Code of Federal Regulation
CPR	Cardiopulmonary Resuscitation
DOE	United States Department of Energy
ES&H	Environment Safety & Health
FM&T	Federal Manufacturing & Technologies
FM&T/KC	Federal Manufacturing & Technologies / Kansas City
FPE	Federal Pacific and Electric
GFP	Ground Fault Protection
GSA	Government Services Administration
HV	High Voltage
HVPJSC	High Voltage Pre-Job Safety Checksheet
IRS	Internal Revenue Service
ISM	Integrated Safety Management
JHA	Job Hazard Analysis
JON	Judgment of Need
KCAO	Kansas City Area Office
KCP	Kansas City Plant
kV	kilovolts
kVA	kilovolt amperes
LOTO	Lockout/Tagout
M&O	Maintenance & Operating
MAST	Metropolitan Ambulance Service Trust
MMIS	Maintenance Management Information System
MOPS	Management Observing and Promoting Safety
MVA	megavolt amperes
ORPS	Occurrence Reporting and Processing System
PD	Process Description
PPE	Personal Protective Equipment
S&H	Safety and Health
SI	Switching Instructions
VPP	DOE Voluntary Protection Program
WI	Work Instruction
WO	Work Order

PROLOGUE

INTERPRETATION OF SIGNIFICANCE

The non-fatal, electrical arc blast accident at the Kansas City Plant on May 24, 1998, occurred due to a lack of effective integration and failure to responsibility implement the high voltage work control process. Deviation from AlliedSignal FM&T/KC's established electrical safety procedures contributed to this accident. Supervision did not perform assigned responsibilities to protect the worker. Individuals did not fulfill responsibilities to work safely and in accordance with AlliedSignal FM&T/KC's policies and procedures.

This accident highlights the importance of an integrated approach to safety that stresses clear goals and policies; individual and management accountability and ownership; implementation of requirements and procedures; and thorough and systematic oversight by AlliedSignal FM&T/KC management.

AlliedSignal FM&T/KC must take a comprehensive look at day-to-day implementation of its existing electrical program requirements to ensure effective implementation and feedback. KCAO needs to ensure that AlliedSignal FM&T/KC effectively implements the high voltage electrical program that meets contractual requirements.

EXECUTIVE SUMMARY

INTRODUCTION

An electrical accident which occurred on May 24, 1998, at the Department of Energy's (DOE) Kansas City Plant, was investigated. An electrician cleaning a high voltage (HV) switch at an outdoor substation received second and third degree burns from an arc blast on a 13.8 kilovolt (kV) switch. The Manager of the DOE Albuquerque Operations Office appointed a Type B Accident Investigation Board (the Board) on May 28, 1998. The Board was chartered to review the accident and to determine the causes of the accident in accordance with DOE Order 225.1A, *Accident Investigations*.

In conducting its investigation, the Board used various analytical techniques including barrier analysis, change analysis, and event and causal factors analysis. The Board inspected and photographed the accident site, reviewed events surrounding the accident and conducted extensive interviews and document reviews to determine the factors that contributed to the accident. Relevant management systems were evaluated in accordance with the Order 225.1A, and against the five safety management functions of Integrated Safety Management.

ACCIDENT DESCRIPTION

The accident occurred at approximately 12:18 p.m., on Sunday, May 24, 1998, at the Kansas City Plant (KCP), when an electrician was cleaning a high voltage switch at an outdoor substation. This substation (Substation 37) is part of the KCP's electrical distribution system, composed of 65 separate electrical power substations. The Board considered several accident scenarios. The Board concluded that one of two scenarios was the most probable. The injured electrician worked unknowingly in close proximity to energized electrical equipment and while using a paintbrush to clean the inside of the switchgear cabinet either:

- falling debris (such as a cobweb) fell onto the energized "C" phase knife blade creating a fault, or
- Electrician #1's tee shirt sleeve contacted the energized "C" phase knife blade creating a fault.

The electrician's proximity to the arc blast, caused both second and third degree burns to the right arm and left hand. The Ground Fault Protection (GFP) de-energized the switchgear quickly; limited the amount and duration of fault current; and limited both the severity of the electrician's injuries and damage to the switchgear. The electrician was hospitalized and received skin grafts to the third degree burns. On June 2, 1998, the electrician was discharged from the hospital.

CAUSAL FACTORS

The direct cause of the accident was that material associated with the electrician's activities contacted the energized equipment resulting in an arc blast.

Root causes are the causal factors that, if corrected, would prevent the accident. The Board identified lack of effective integration and failure to responsibly implement the high voltage work control process as the root cause of this accident.

Contributing causes are events or conditions that collectively with other causes increased the likelihood of an accident, but that individually did not cause the accident. The Board identified the following contributing causes of this accident:

- Deviations from AlliedSignal FM&T/KC's established electrical safety procedures contributed to this accident.
- Supervision did not perform assigned responsibilities to protect the worker.
- Individuals did not fulfill responsibilities to work safely and in accordance with AlliedSignal FM&T/KC's policies and procedures.

CONCLUSIONS AND JUDGMENTS OF NEED

Table ES1-1 presents the Board's Conclusions and Judgments of Need. The Board's Conclusions are those considered significant, based upon facts and pertinent analytical results. From the Conclusions, the Board developed Judgments of Need to guide managers in developing follow-up actions. Follow-up actions should include managerial controls and maintenance practices necessary to prevent a recurrence of this type of accident.

Table ES1-1: Conclusions and Judgments of Need

Conclusions	Judgments of Need
A breakdown in communication occurred between the Utilities Department and the Maintenance Department. Line Management failed to identify inconsistencies in the scopes of work. Multiple hazard identification processes exist and are not clearly delineated or integrated effectively into the work. An effective pre-job briefing was not provided to the electricians before the start of HV work activities.	The AlliedSignal FM&T/KC Division 100 needs to ensure that work package documents clearly communicate scope of work, source of hazards and hazard controls and are coordinated and communicated between the Utilities and the Maintenance Departments.

Conclusions	Judgments of Need
<p>Neither the Maintenance Team Manager nor the Cleaning Team reviewed or followed SI#103B in the performance of the work.</p> <p>The failure to properly implement and oversee the LOTO program exposed workers to unrecognized and uncontrolled hazards.</p> <p>The failure to properly implement and supervise the installation of grounding clusters per SI#103B exposed workers to unrecognized and uncontrolled hazards.</p> <p>The failure to properly implement the two-person rule and to exercise individual stop work authority exposed workers to unrecognized and uncontrolled hazards.</p> <p>The electrical glove program is not functioning properly to ensure electrical glove integrity.</p> <p>Supervisory safety responsibilities were not fully implemented on the day of this accident.</p> <p>Although formal training was completed, the actions of several individuals during the May 24, 1998, outage were not consistent with the training received.</p>	<p>The AlliedSignal FM&T/KC Division 100 and ES&H need to ensure that safe work practices and procedures are coordinated between line and support organizations and followed when conducting HV activities.</p> <p>AlliedSignal FM&T/KC needs to provide refresher training for line managers and other associates on site high voltage electrical requirements.</p>
<p>Feedback and improvement processes are not effective in identifying procedural noncompliances and providing feedback on HV electrical work.</p>	<p>AlliedSignal FM&T/KC Division 100 must take a comprehensive look at day-to-day implementation of its high voltage electrical program to ensure effective implementation and feedback.</p> <p>KCAO needs to ensure that AlliedSignal FM&T/KC effectively implements the high voltage electrical program that meets contractual requirements.</p>

Conclusions	Judgments of Need
<p>Although emergency response to the accident was timely, it was, in large part, a result of fortunate circumstances. The number of failures in communication and transportation could have significantly delayed the transportation and medical treatment of Electrician #1.</p>	<p>AlliedSignal FM&T/KC management needs to ensure that communication systems are capable of communicating with Emergency Medical Services, that KCP emergency responders are trained to make informed decisions regarding the treatment of individuals involved in electrical accidents, and appropriate means of emergency transportation are used.</p>
<p>Control of the accident scene was not consistent with DOE Order 225.1A, <i>Accident Investigations</i>.</p>	<p>AlliedSignal FM&T/KC needs to ensure that accident scene preservation is effective and consistent with DOE O 225.1A requirements.</p>

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**Type B Accident Investigation Board Report
On the May 24, 1998,
Electrical Arc Blast Accident
At the
Kansas City Plant**

1. INTRODUCTION

1.1 BACKGROUND

On Sunday, May 24, 1998, at approximately 12:18 p.m., an AlliedSignal FM&T/KC high voltage (HV) electrician (Electrician #1) received second and third degree burns to 15.5% of his body. He was working at the outdoor Substation 37 at the Kansas City Plant, Kansas City, Missouri. Electrician #1 was transported to St. Joseph's Medical Center where he underwent initial care. He was transferred to the University of Kansas burn unit on May 25, 1998. Electrician #1 received a total of ten days inpatient treatment and was released on June 2, 1998, to home health care nursing.

Monday, May 25, 1998, was the Memorial Day holiday. On Tuesday, May 26, 1998, the accident was reported to the Occurrence Reporting Processing System (ORPS), occurrence report number: ALO-KC-AS-KCP-1998-0010.

The extent of Electrician #1's injuries and the anticipated duration of hospital stay required the appointment of the Board per the DOE Order. On Thursday, May 28, 1998, Bruce G. Twining, Manager, Albuquerque Operations Office (AL) established a Type B Accident Investigation Board (See Appendix A) to investigate the May 24, 1998, accident in accordance with DOE Order 225.1A, *Accident Investigations*.

1.2 FACILITY DESCRIPTION

The KCP was built in 1942 as a defense plant, producing Navy aircraft engines. In 1949, the facility was transferred to the United States Atomic Energy Commission, which began production operations in support of the nuclear weapons program. The KCP is located in Kansas City, Missouri, and is operated by

On May 24, 1998, Electrician #1 received second and third degree burns while working on an outdoor substation.

On May 28, 1998, the Albuquerque Operations Office established a Type B Accident Investigation Board.

AlliedSignal FM&T, under contract to DOE, is responsible for assembly and manufacturing of non-nuclear weapons components.

AlliedSignal FM&T under contract to DOE. The primary mission of the KCP is to assemble and manufacture a wide array of non-nuclear mechanical, electronic, and engineered material components for the nuclear weapons stockpile. The KCP is co-located in the Bannister Federal Complex with the General Services Administration (GSA), Internal Revenue Service (IRS), US Marine Corps and other federal agencies.

Electricity is supplied to the Bannister Federal Complex by two 161,000 volts (161 kV) overhead transmission lines, both owned and maintained by the local utility, Kansas City Power and Light. An on-site, utility-owned and maintained substation converts this energy to 13,800 volts (13.8 kV) through two 50 MVA step-down transformers. The electricity is delivered underground to the government-owned 15kV Main Switchgear, which is operated and maintained by AlliedSignal FM&T/KC. The map of the facility is located in Figure 1-1.

The 15 kV Main Switchgear provides 13.8 kV electrical service to KCP, GSA, IRS, and other tenants at the Bannister Federal Complex. Service is provided to 65 substations owned by the DOE, operated and maintained by AlliedSignal FM&T/KC.

Substation 37 is an outdoor pad-mounted unit substation, located between Building 15 (Polymer Building) and Building 98 (Industrial Wastewater Pretreatment Facility). It was manufactured by Federal Pacific Electric (FPE) and includes two HV air switches, 1,500 kVA transformer, and 480 volt switchgear. This equipment was installed in 1980 and has a 25-year projected life expectancy.

Substation 37 is connected to the Main Switchgear by 15 kV Cables 57 and 34, allowing redundant service capabilities through permanent interconnecting jumpers. These cables are supplied through Main Switchgear Air Circuit Breakers (ACB) 57 and 34 to Substation 37, as well as other connected loads. These cables are routed through separate underground conduits. Overcurrent

Cables 34 and 57 supply Substation 37.
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Facility East Area Map

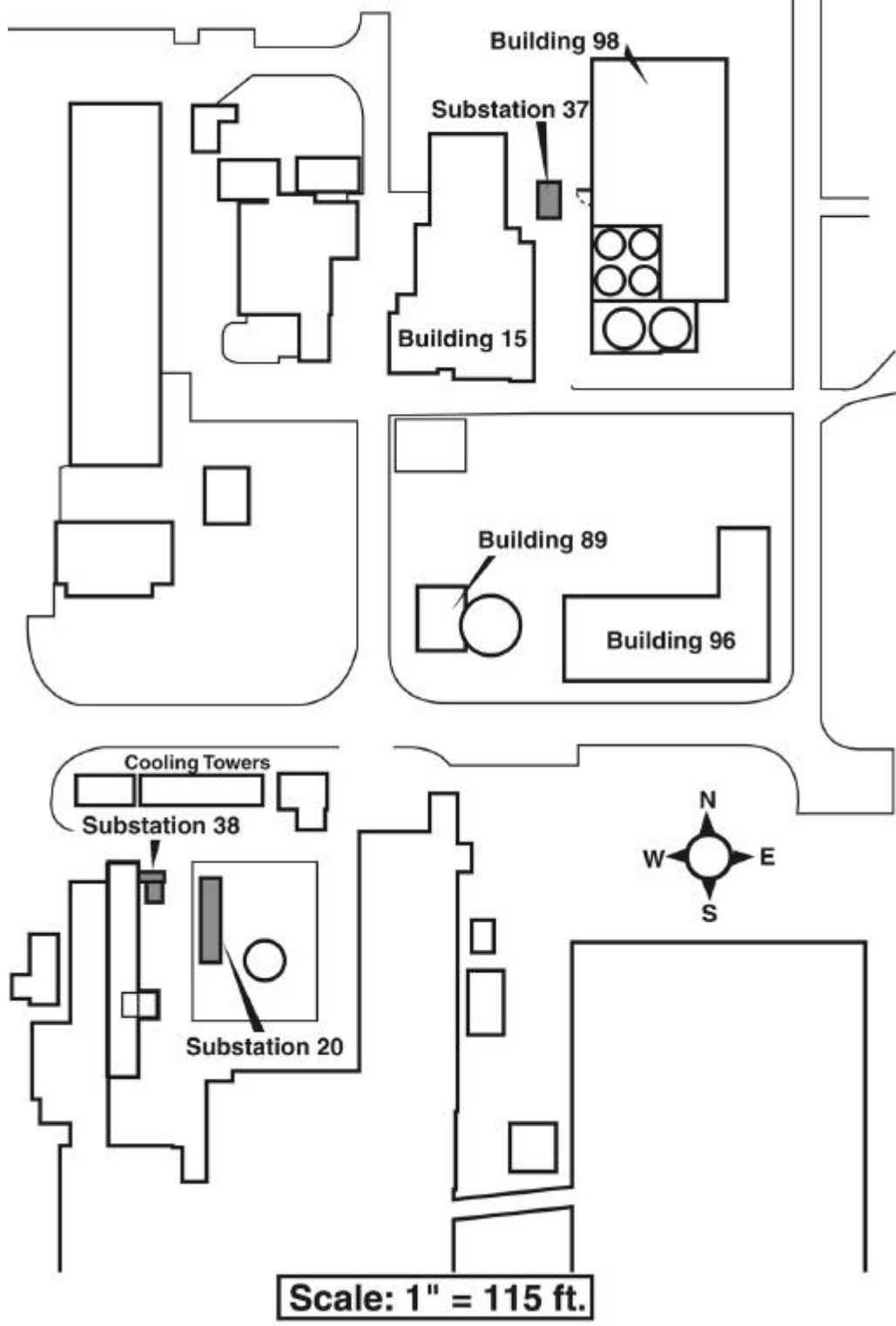


Figure 1-1: Site Map

protection for the HV switches is set at 240 amperes. Ground fault protection (GFP) is also provided and is set at 10 amperes / 6 Hertz. Figure 1-2 provides a view of the backside of Substation 37.

There are no markings or signs at Substation 37 to indicate that it is configured with jumpers that connect the load sides of Cable 34 and Cable 57 switches together. The industry standards adopted by AlliedSignal FM&T/KC do not require markings or signs, since this electrical configuration is commonly used to provide redundant feed. Of the sixty-five KCP substations four have permanent jumpers. No markings or signs exist at similarly configured KCP substations.

1.3 SCOPE, PURPOSE, AND METHODOLOGY

The Board began its investigation on May 31, 1998, and submitted its findings to the AL Manager on July 2, 1998.

The scope of the Board's accident investigation included all activities required to determine the relevant facts and to review and analyze the facts and circumstances surrounding the accident. Using these facts, the Board determined the direct, root and contributing causes; developed conclusions; and determined the judgments of need that, when implemented, should reduce the probability of similar reoccurrence.

The purpose of this investigation was to identify causal factors of the accident, including deficiencies, if any, in safety management systems. The investigation report will also provide the DOE community with an opportunity for lessons learned to promote program improvement and reduce the potential for similar accidents.

During the investigation, the Board inspected and photographed the accident scene, reviewed documentation presented by AlliedSignal FM&T/KC, reviewed critical events leading to the accident, and reviewed emergency response activities. In addition,

The Board determined the direct, root and contributing causes; developed conclusions; and determined the judgments of need that, when implemented, should reduce the probability of similar reoccurrence.

The purpose of this investigation was to identify causal factors of the accident and inform the DOE community of lessons learned.

Permanent Jumpers

High Voltage Switch 57

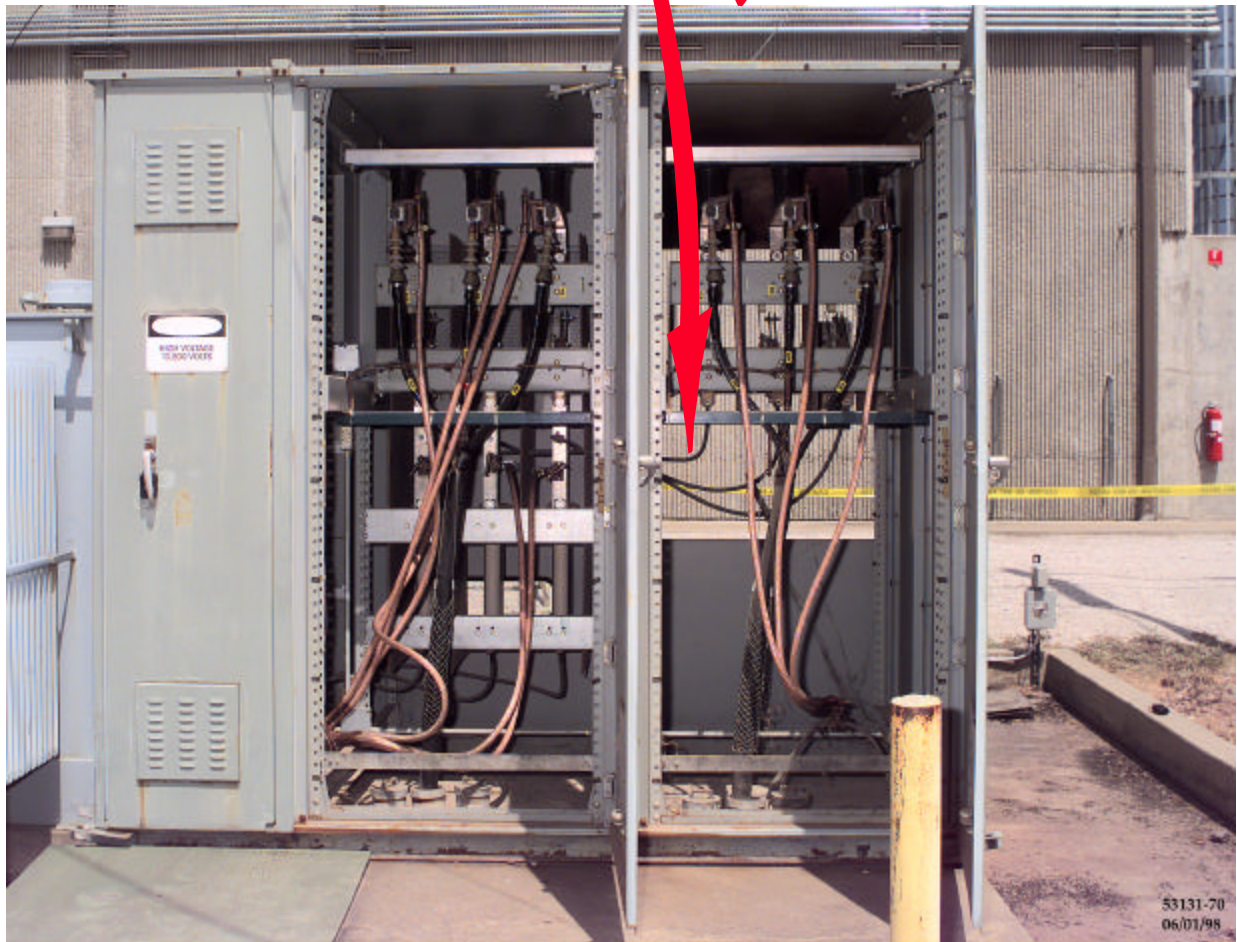


Figure 1-2: Back Side of Substation 37

the Board conducted interviews with appropriate individuals, conducted analyses of physical evidence, and performed causal analysis. The Board evaluated the adequacy of AlliedSignal FM&T/KC's safety management systems and work control practices relevant to the accident, and identified judgments of need.

2. FACTS AND ANALYSIS

2.1 ACCIDENT DESCRIPTION

2.1.1 Accident Background

On Saturday, Sunday, and Monday (May 23 through May 25, 1998) the Facilities Management Organization scheduled a utility shutdown to permit outages of specific utility systems (electrical, chilled water, steam).

A utility shutdown was scheduled for May 23 through May 25, 1998.

Limited electrical work was scheduled for this shutdown period. Tasks included: replacing a power transformer, cleaning HV switches, repairing a faulty HV switch, and switching of electrical loads to support this work. Work packages were prepared by the Maintenance Department and Utilities Engineering to identify and direct the work activities. Five HV electricians were scheduled to work on Saturday, May 23, 1998, and six HV electricians were scheduled to work on Sunday and Monday, May 24 and 25, 1998. All HV work was conducted under the field direction of one electrical Maintenance Team Manager.

The Electrician #1 had previously decided to voluntarily separate from AlliedSignal FM&T/KC after this outage. His letter of resignation formally documented the decision and he was scheduled to start his new employment on June 1, 1998.

2.1.2 Accident Description And Chronology Of Events

On Saturday, May 23, 1998, five HV electricians worked at the West Boilerhouse and performed switching operations. At the end of that day, the Maintenance Team Manager and five electricians (including Electrician #1) met to discuss the work to be performed on Sunday, May 24, 1998. Two HV electricians were assigned to work unrelated to the accident. The remaining four HV electricians (Main Switchgear Team and Cleaning Team) were assigned the work required per "Power Distribution System Switching Instructions--SI #103B," (SI#103B) dated May 22, 1998, and Work Order (WO) 98019244.

Four HV electricians (the Main Switchgear Team and the Cleaning Team) performed work required per Power Distribution System Switching Instructions - SI #103B, dated May 22, 1998.

Sunday, May 24, 1998, was a sunny day. The temperature at noon was 75° Fahrenheit, with 55% humidity, and winds of one to four miles per hour from the north-northwest.

The Main Switchgear Team met at approximately 6:30 a.m. at the Main Switchgear. They did not have a copy of SI#103B and awaited for verbal instructions from the Maintenance Team Manager.

The Cleaning Team (Electrician #1 and Electrician #2) and Maintenance Team Manager met at the Electrical Shop sometime between 6:45 and 7:15 a.m. The Cleaning Team started later than planned because Electrician #2 arrived late. The Cleaning Team received SI#103B that morning from the Maintenance Team Manager; however, the required review of SI#103B did not occur.

SI#103B required the Cleaning Team to isolate Cable 57 for preventive maintenance. Figure 2-1 is a schematic describing the configuration of the circuit upon which work was to be performed at Substation 37.

The Cleaning Team left the electrical shop without grounding clusters required by SI#103B. Electrician #2 did not take his locks, tags, or personal protective equipment. They went to Substation 37 and transferred the load from Cable 57 to the redundant service provided by Cable 34 at approximately 7:25 a.m. The load side of HV Switch 57 continued to be energized through permanently connected jumpers to the load side of energized HV Switch 34.

The Cleaning Team then isolated Cable 57 from Substation 20. Electrician #1 applied lockout/tagout (LOTO) at Substations 20B and 20C.

The Cleaning Team proceeded to Substation 38 to perform preventive maintenance per SI#103B. To completely isolate Substation 38, ACB 33 and ACB 57 at the Main Switchgear were opened by the Main Switchgear Team to de-energize service to this substation. This isolation was required due to

The Cleaning Team had the only copy of the SI#103B.

The Cleaning Team performed switching operations at Substation 37.

The Cleaning Team performed switching operations at Substation 20.

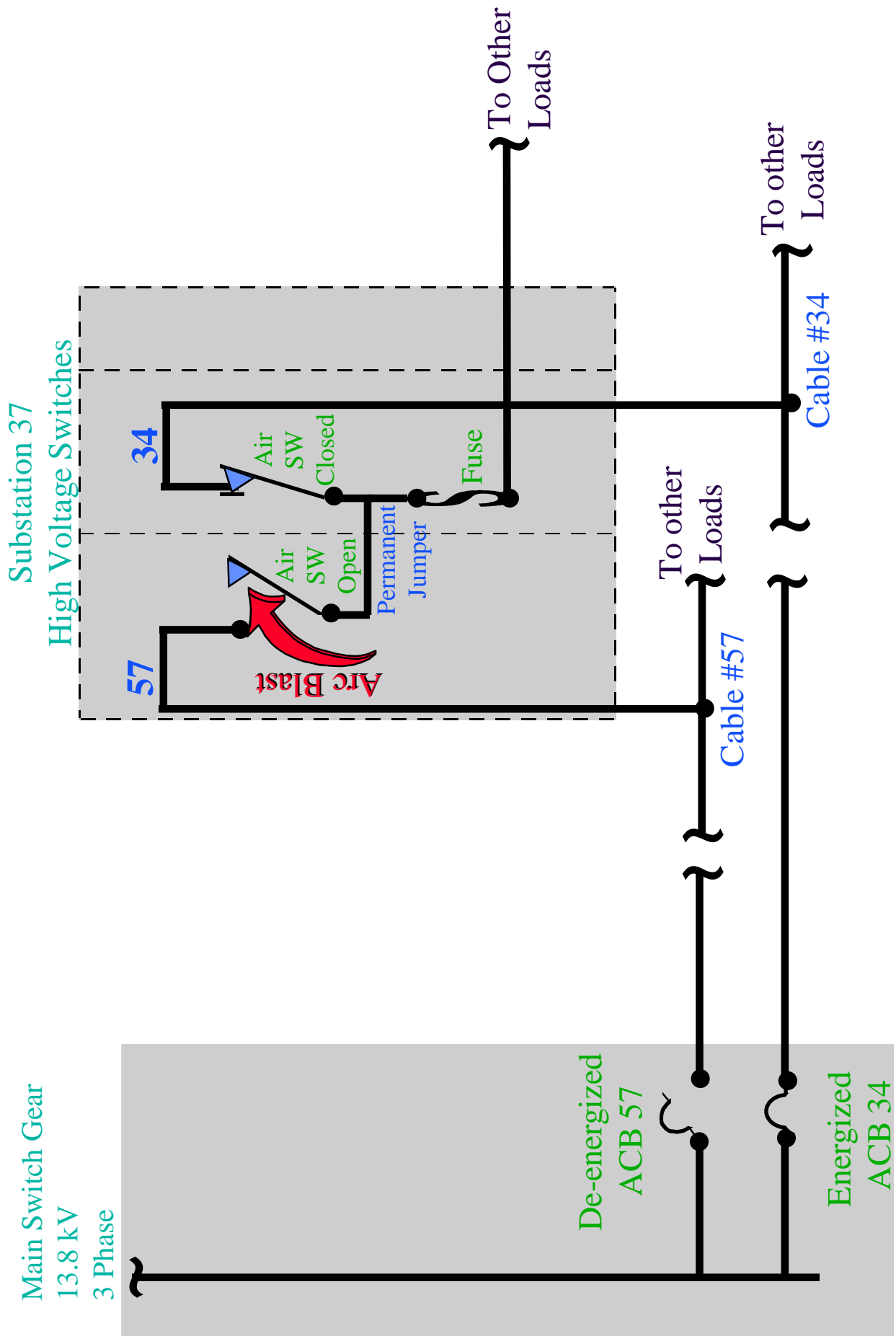


Figure 2-1: Diagram of Circuit Configuration at the Time of the Accident

jumpers between the two HV switches, similar to those at Substation 37.

With ACB 57 and ACB 33 de-energized, work at the Main Switchgear was performed by the Main Switchgear Team. The Cleaning Team did not go to the Main Switchgear and apply locks or tags at ACB 57 or ACB 33 as required by SI#103B.

The Cleaning Team verified zero voltage at Substation 38 and proceeded to perform preventive maintenance. The Cleaning Team did not apply grounding clusters at Substation 38 as required by SI#103B, because they had not taken grounding clusters to the job site.

At approximately 9:00 a.m., the Safety and Health (S&H) Shutdown Oversight person observed and talked with Electrician #1 working alone on Substation 38. Electrician #2 returned to the site and joined the conversation between the Shutdown Oversight person and Electrician #1. The S&H Shutdown Oversight person left Substation 38 at approximately 9:05 a.m. without noting any concerns.

The Cleaning Team individually completed their preventive maintenance tasks at Substation 38 and proceeded to Substations 20B and 20C. Electrician #1 began preventive maintenance on Substation 20C, and Electrician #2 later began preventive maintenance on Substation 20B.

NOTE: SI#103B did not include a step to perform preventive maintenance at Substation 20C.

SI#103B required the application of grounding clusters during the Substation 20B cleaning operation, but none were applied. At approximately 10:45 a.m., the Cleaning Team separated for lunch.

At approximately 11:50 a.m., Electrician #1 returned to Substation 20, arriving before Electrician #2. The Maintenance Team Manager directed Electrician #1 to start on Substation 37. Electrician #1 proceeded to Substation 37 on an industrial tricycle with his tools, an A.B. Chance Company Multi-Range Voltage

The Cleaning Team performed maintenance on Substation 38.

The Cleaning Team completed work at Substation 38 and began work at Substations 20B and 20C.

Detector and hot stick. The Maintenance Team Manager remained near Substation 20.

Electrician #2 returned to Substation 20 from lunch. The Maintenance Team Manager directed Electrician #2 to complete the preventive maintenance of Substation 20B and then proceed to Substation 37.

At Substation 37, Electrician #1 removed the padlock securing the switch enclosure, opened the front door and removed the bolted cover. This exposed Electrician #1 to the energized equipment inside the substation, because Cable 34 was energized and jumpered to the load side of Cable 37.

NOTE: SI#103B directed Electrician #1 to transfer the load from Cable 34 back to Cable 57. Transferring the load did not necessitate opening the cabinet.

Electrician #1 then went to the rear door of Substation 37, removed the padlock securing the switch enclosure, opened the door, and removed the fiberboard barrier. Electrician #1 used the voltage detector to verify zero voltage on the three phases at the rear of the cabinet. Electrician #1 did not test all potentially live parts within the compartment. Load side components were still energized by the permanent jumpers. Electrician #1 stated that he could not remember whether he wore electrical gloves while testing voltage on the line side of the HV switches.

NOTE: Both 29 CFR 1910.269(l) and AlliedSignal FM&T/KC Work Instruction (WI) 21.01.02.12.03, *How to Obtain, Test, and Use Electrical Related Equipment* require electrical gloves to be worn when working on or near energized electrical equipment. Electrical gloves are not required for cleaning operations on de-energized equipment.

Equipment can not be considered de-energized until grounding clusters and lockout/tagout are installed.

The Maintenance Team Manager directed Electrician #1 to start on Substation 37.

Electrician #1 placed the voltage meter on an empty cables pool nearby. Electrician #1 went to the front of the cabinet to begin cleaning operations.

Electrician #1 was wearing a 98% cotton crew neck tee shirt, bib overalls, and standard work boots. Electrician #1 was wearing safety glasses and used a paintbrush to clean the interior of the switch.

As Electrician #1 cleaned the switch, an electrical phase-to-phase and phase-to-ground fault occurred (arc blast), resulting in an electrical arc and flash. This fault was detected and cleared by GFP equipment located at the Main Switchgear. Total clearing time is estimated to be 11 cycles, or approximately 1/6 of a second, based on previous testing of the equipment. Figure 2-2 shows the front of Substation 37.

Due to the fault, GFP opened ACB 34, interrupting electrical power to Building 15, Building 96 and other locations. Fire protection enunciator panels in each of these buildings signaled a loss of power and a trouble alarm at 12:18 p.m., establishing the accident time.

The electrical arc generated a flash, heat, and overpressure. Electrician #1's proximity to the arc resulted in burns from the heat and a mild concussion. Electrician #1, stunned by the event, briefly wandered in a gravel area between Substation 37 and Building 98.

2.1.3 Emergency Response

The Maintenance Team Manager was located on the north side of the cooling tower approximately 220 yards away from Substation 37 on an electric scooter. He was awaiting completion of Substation 20B work activities and was preparing to proceed with Electrician #2 to Substation 37. The Maintenance Team Manager was talking to two millwrights when he heard a loud noise and saw smoke from the area of Substation 37. The Maintenance Team Manager and the millwrights proceeded immediately to Substation 37.

Electrician #1's proximity to the arc resulted in burns and a concussion.

The Maintenance Team Manager heard a loud noise and saw smoke in the area of Substation 37. He immediately proceeded to the scene.

**C-Phase of High Voltage
Switch 57**

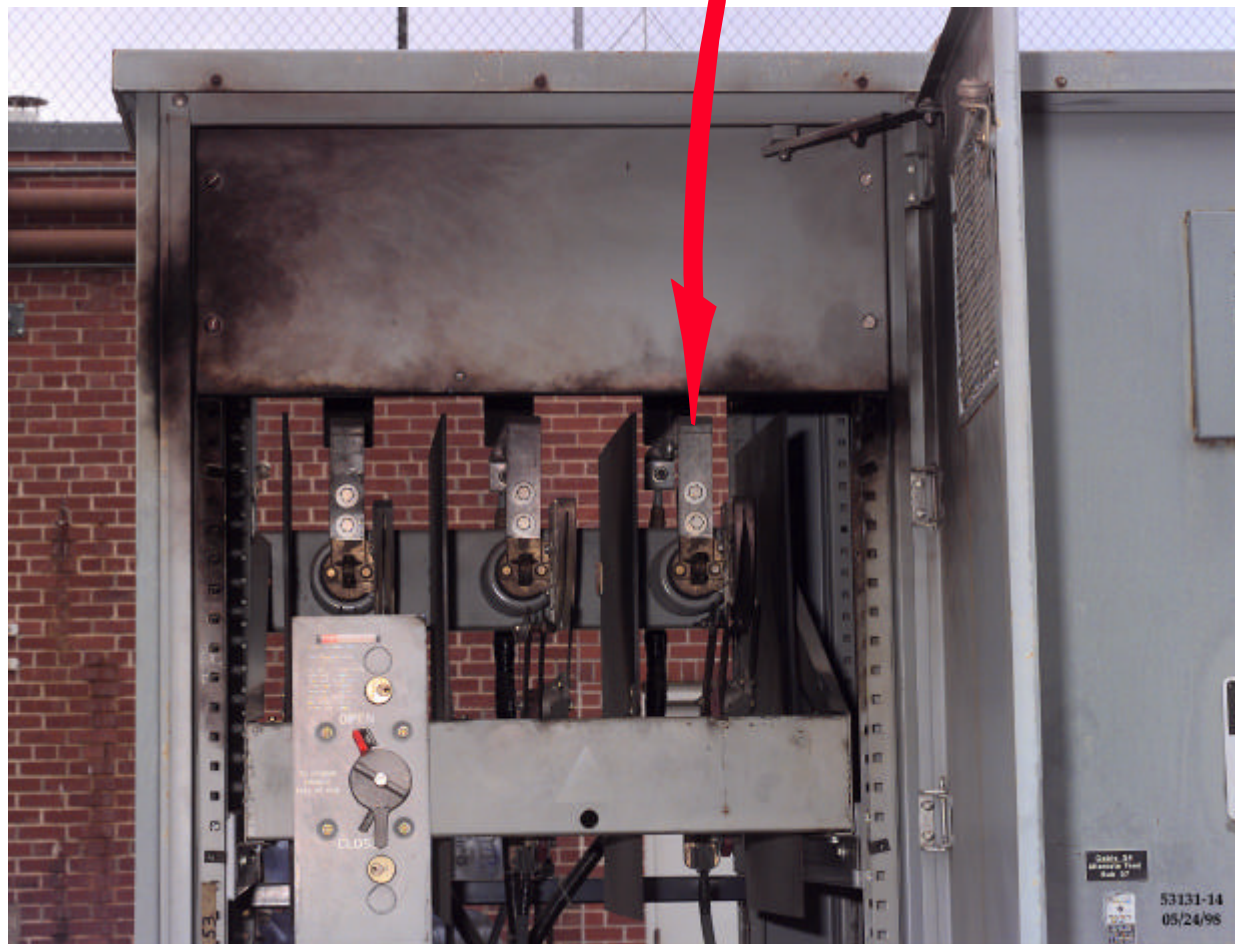


Figure 2-2: Front Side of Substation 37

Upon arriving at Substation 37, the Maintenance Team Manager and the millwrights observed Electrician #1 doubled over and staggering between Substation 37 and Building 98. The Maintenance Team Manager and a millwright assisted Electrician #1 to a shaded area along the west wall of Building 98 and helped Electrician #1 sit down on the pavement. Electrician #1 repeatedly stated that he had tested the circuit and asked what had happened.

After assisting Electrician #1, the Maintenance Team Manager went to Building 98 and dialed the in-plant emergency number. The call was logged by Patrol (the KCP protective force) at 12:19 p.m.

The Maintenance Team Manager then radioed the Main Switchgear Team to ask them if they had re-energized ACB 57. The Main Switchgear Team responded that they had not re-energized ACB 57.

A Fire Protection Sergeant and Fire Protection Specialist were working in Building 89, heard a radio transmission for assistance, and proceeded to the scene to assist Electrician #1. The Fire Protection Sergeant radioed Patrol Headquarters and requested that Metropolitan Ambulance Service Trust (MAST) be called.

The Patrol Sergeant at the Patrol Headquarters Control Desk tried to reach MAST but could not get an outside line by dialing 911. All 911 calls from within KCP are routed to the Control Desk. His attempts to reach an outside line cycled back to another phone on the Control Desk. A dedicated outside line is located at the Control Desk for placing off-plant 911 calls. The Patrol Sergeant normally serves as the Patrol Rangemaster and had not been trained on the use of the dedicated outside line.

The Patrol Lieutenant on duty that day arrived at the scene and assumed incident command. The Patrol Lieutenant could not reach Patrol Headquarters using his hand-held radio, because the battery was loose.

The Maintenance Team Manager called the in-plant emergency number at 12:19 p.m.

Per AlliedSignal FM&T/KC emergency procedures, the Patrol Lieutenant assumed responsibility for coordinating emergency medical response. He decided to transport Electrician #1 to St. Joseph's Hospital emergency room, approximately four miles away, with the KCP ambulance. The Patrol Officer tasked with driving the ambulance had trouble starting the engine, but drove the KCP ambulance to the accident scene arriving at 12:24 p.m.

Electrician #1 was assisted to his feet, helped onto the gurney, and placed in the ambulance. At 12:25 p.m. the ambulance left for St. Joseph's Hospital. Two Fire Protection personnel in the back of the ambulance with Electrician #1 did not administer treatment to the electrician while in route to St. Joseph's Hospital.

Patrol Headquarters called the St. Joseph's Emergency Department number at 12:28 p.m. to advise them that the KCP ambulance was transporting Electrician #1 to the Emergency Room.

While in route the ambulance's brakes failed to operate properly at an intersection. Controls for the external emergency lights on the ambulance could not be located. Neither the Patrol Officer nor the Fire Protection Specialists in the ambulance were familiar with the vehicle operation and equipment. The Fire Protection Sergeant who accompanied Electrician #1 was unfamiliar with the ambulance and could not locate first aid supplies.

At 12:39 p.m., the ambulance arrived at St. Joseph's Hospital. St. Joseph's Hospital emergency medical personnel began administering initial care to Electrician #1 at 12:50 p.m.

At 1:00 p.m., the Patrol Officer returned the ambulance to KCP. Due to the problems starting the ambulance and the brake problems, the Patrol Lieutenant took it out of service. The master brake cylinder and carburetor were repaired the following day.

The decision was made to transport Electrician #1 to St. Joseph's Hospital with the site ambulance.

Controls for the exterior emergency lights on the ambulance could not be located. Braking problems occurred with the ambulance.

At 12:39 p.m., Electrician #1 arrived at St. Joseph's Hospital.

On May 26, 1998, AlliedSignal FM&T/KC re-trained Patrol Officers on ambulance operations. AlliedSignal FM&T/KC management has removed the ambulance from service and is in the process of returning it to the GSA. The telephone in the Control Room has been labeled to indicate its use for contacting outside medical support (e.g., MAST).

Emergency Response Analysis

Communication

The following examples of communication failures occurred during accident response:

- Immediately following the accident, the Patrol Sergeant at the Control Desk tried to telephone MAST by dialing 911, but could not complete this call. The Sergeant is the Patrol Rangemaster and had not routinely manned the Control Room within the past 3 months. He was not familiar with the telephone equipment.
- The Patrol Lieutenant at the accident scene had to borrow a radio from one of the Fire Protection Specialists to communicate with Patrol Headquarters.
- Patrol did not have a ready reference of emergency telephone numbers for contacting local hospitals. The Patrol Sergeant at the Control Desk looked up St. Joseph's Hospital's number in Yellow Pages. The emergency room staff did not receive the initial telephone call. The emergency room staff eventually received information that the KCP ambulance was in route.

Transportation

The KCP ambulance for off-site transportation was built in 1982. The mechanic who inspected the ambulance following the accident stated that since the ambulance has a carburetor and is not used on a regular basis, the ambulance could be prone to starting and stalling problems.

The off-site ambulance has many controls including those to operate the lights and sirens. The Patrol Officer driving the ambulance had been trained in its

operation in April 1998. The Fire Protection Specialist riding in the front of the ambulance had no training on the operation of the ambulance. Neither individual was able to find the emergency lights controls, but the driver activated the siren.

The mechanical defects and driver's unfamiliarity with the ambulance's controls did not adversely impact the timely transportation of Electrician #1.

First Aid Training and In Route Treatment

Because Patrol Headquarters could not contact MAST, local emergency medical services were not summoned. The Patrol Lieutenant stated that he had decided to transport Electrician #1, whether other emergency medical services were in route or not.

General industry standards do not require EMTs on site. Although Patrol Officers and Fire Protection Specialists are trained in both First Aid and Cardiopulmonary Resuscitation (CPR), they did not administer first aid treatment to Electrician #1 while in route to the hospital.

The Board concluded that although emergency response to the accident was timely, it was, in large part, a result of fortunate circumstances. The number of failures in communication and transportation could have significantly delayed the transportation and medical treatment of Electrician #1.

2.1.4 Investigative Readiness

Electrician #2 arrived at the accident scene as the ambulance was leaving. The Maintenance Team Manager directed him to close doors on de-energized Substation 37 and to remove Electrician #1's voltage detector from the hotstick.

At approximately 12:35 p.m., the Patrol Officers cordoned off the accident scene with barrier tape. The Patrol Officers directed people to leave the vicinity and return the scene to the conditions observed immediately following the accident.

At approximately 12:35 p.m., the accident scene was marked with barrier tape.

Following an inspection of the HV switch, the Maintenance Team Manager decided to re-energize ACB 34 to restore power to special process equipment in Buildings 15 and 96.

Patrol Headquarters paged an AlliedSignal FM&T/KC Safety Engineer (Safety Engineer). He responded from home to the accident scene at approximately 1:05 p.m. The Safety Engineer took initial video and still photographs of the accident scene.

The Safety Engineer had Patrol Headquarters summon the S&H Oversight person on site that day to the accident scene. The Safety Engineer collected evidence and established a chain of custody. The Safety Engineer released Substation 37 for normal operation at 4:52 p.m.

On May 26, 1998, AL determined the accident warranted a Type B Accident Investigation. AlliedSignal FM&T/KC placed tamper-resistant evidence tape on the Substation 37 doors following AL's determination. The Safety Engineer maintained custody of the evidence, accident scene videotapes and photographs until approximately 5:30 p.m. on Sunday, May 31, 1998, when the Board arrived at the KCP.

On Monday, June 1, 1998, AlliedSignal FM&T/KC personnel de-energized Substation 37 at the Board's request. The Board inspected the accident scene, collected a sample from the "C" phase knife blade, and took additional video footage and photographs. Inspection of the electrical distribution equipment revealed Substation 37 to be operational and no equipment malfunction or defect was identified. Components had been properly maintained and functioned as designed. The Board released the accident scene to AlliedSignal FM&T/KC on June 2, 1998.

NOTE: Due to carbon deposits and residues on the equipment, AlliedSignal FM&T/KC has not re-energized HV Switch 57 at Substation 37. This switch will not be returned to service until cleaning and preventive maintenance is performed.

On Thursday, June 4, 1998, Board members interviewed Electrician #1 and took into evidence the tee shirt worn at the time of the accident and SI#103B.

Analysis of Investigative Readiness

The Patrol Lieutenant did not take immediate actions to preserve the accident scene. The Maintenance Team Manager directed Electrician #2 to close Substation 37's doors and remove Electrician #1's voltage meter from the hotstick. When Patrol Officers returned to establish control of the accident scene, they directed the maintenance personnel to return items to the original location at the time of the accident.

Individuals interviewed offered differing recollections as to whether Electrician #1's electrical gloves were at the scene immediately following the accident. The gloves were not at the scene when the Safety Engineer arrived and did not appear in any video footage or photographs taken immediately following the accident. The Board could not determine whether Electrician #1 had used the electrical gloves when he tested the voltage on the switch in Substation 37.

The Board found Electrician #1's gloves on his work bench on Friday, June 5, 1998. The gloves' required six-month test date had expired. The Board could not determine how the gloves could have gotten from the accident scene back to the electrician's work area.

The Board concluded control of the accident scene was not consistent with DOE Order 225.1A, *Accident Investigations*. The Board considered that the control deficiencies did not impact their ability to conduct the investigation.

2.1.5 Medical Report

Electrician #1 remained conscious throughout the event. No entry or exit wounds were immediately or subsequently identified on the electrician.

At St. Joseph Hospital, the attending emergency room physician treated Electrician #1, and he was admitted to the hospital in "critical" condition with first and second-degree burns and a mild concussion.

On Monday, May 25, 1998, Electrician #1 was upgraded to "serious" condition. He was transferred to the University of Kansas Medical Center burn unit.

On Tuesday, May 26, 1998, Electrician #1 was upgraded to "fair" condition. Burned areas on his right arm and a portion of his left hand were re-classified as third degree burns. The remainder of the burns remained classified as first and second degree burns.

On Wednesday, May 27, 1998, the third degree burns required skin grafting (1.5% of the total body surface area) which ultimately included the upper right arm, right forearm and back of the left hand. Figure 2-3 identifies the areas of skin grafting.

Second-degree burns (14% of the total body surface area) primarily involved the head, neck, left forearm, back of left hand, right upper arm and right forearm.

Electrician #1's postoperative course was uneventful and he was discharged from the hospital on June 2, 1998.

2.2 ACCIDENT ANALYSIS

Accident Description

The Board considered several accident scenarios. The Board concluded that two scenarios are most probable. While using the paintbrush to clean the inside of the switch cabinet either:

- falling debris (such as a cobweb) fell onto the energized "C" phase knife blade creating a fault, or
- Electrician #1's tee shirt sleeve contacted the energized "C" phase knife blade creating a fault.

Electrician #1's proximity to the arc blast caused his thermal burns. The GFP de-energized the switchgear

On May 25, 1998, Electrician #1 was transferred to the University of Kansas Medical Center burn unit.

On May 27, 1998, Electrician #1 received skin grafting on his upper right arm, right forearm and back of the left hand.

On June 2, 1998, Electrician #1 was discharged to home.

Burnett Burn Center Burn Diagram Estimate

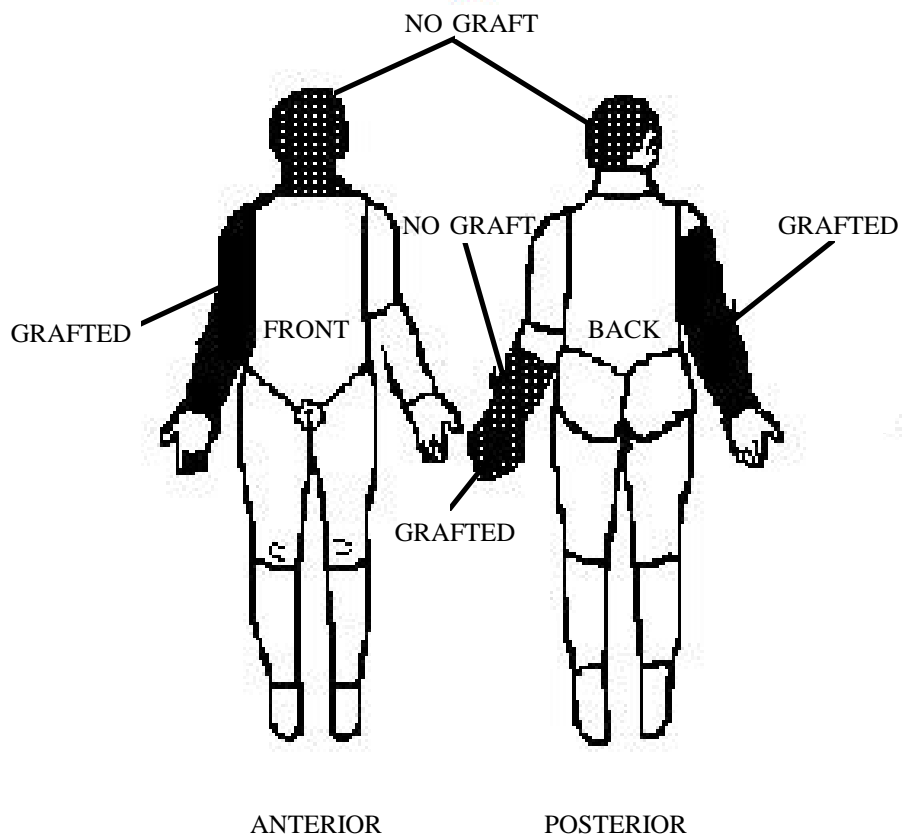


Figure 2-3: Burn Center Diagram Estimate

quickly; limited the amount and duration of fault current; and limited both the severity of the electrician's injuries and damage to the switch.

The following evidence supports the Board's conclusion:

1. The Board analyzed a sample found on the "C" phase switch knife blade. AlliedSignal FM&T/KC tested the sample and provided the Board an *Analytical Sciences Test Report*. This report stated that the sample was protein material from a human source.

The Board believes Electrician #1 may have touched the knife blade after the arc blast occurred, although no specific indication of this fact could be traced to any of the electrician's injuries. In addition, no portion of Electrician #1's anatomy was part of the fault current path, but he was in close proximity to the "C" phase.

Based on the evidence identified, the Board believes Figure 2-4 shows a possible position of Electrician #1 at the time of the accident.

2. Medical personnel did not identify any entry or exit wounds on Electrician #1.
3. The only tool in the immediate vicinity of the switch, a two inch nylon polyester paint brush, did not exhibit signs of thermal damage except for a few deformed bristles and blackening on the end of the handle.
4. Evidence suggesting the source of current flow was found on the "C" phase of the switch and surrounding surfaces. The end of the "C" phase knife blade showed carbon deposits and metal degradation.
5. Carbon deposits on the interior surfaces of the switch enclosure suggest that the current flowed from the "C" phase. Elliptical arc flash patterns on the interphase barriers indicate phase-to-phase current flow.
6. Evidence indicates that the electrician was not using a cleaning solution at the time of the accident. A bottle of Windex® was on

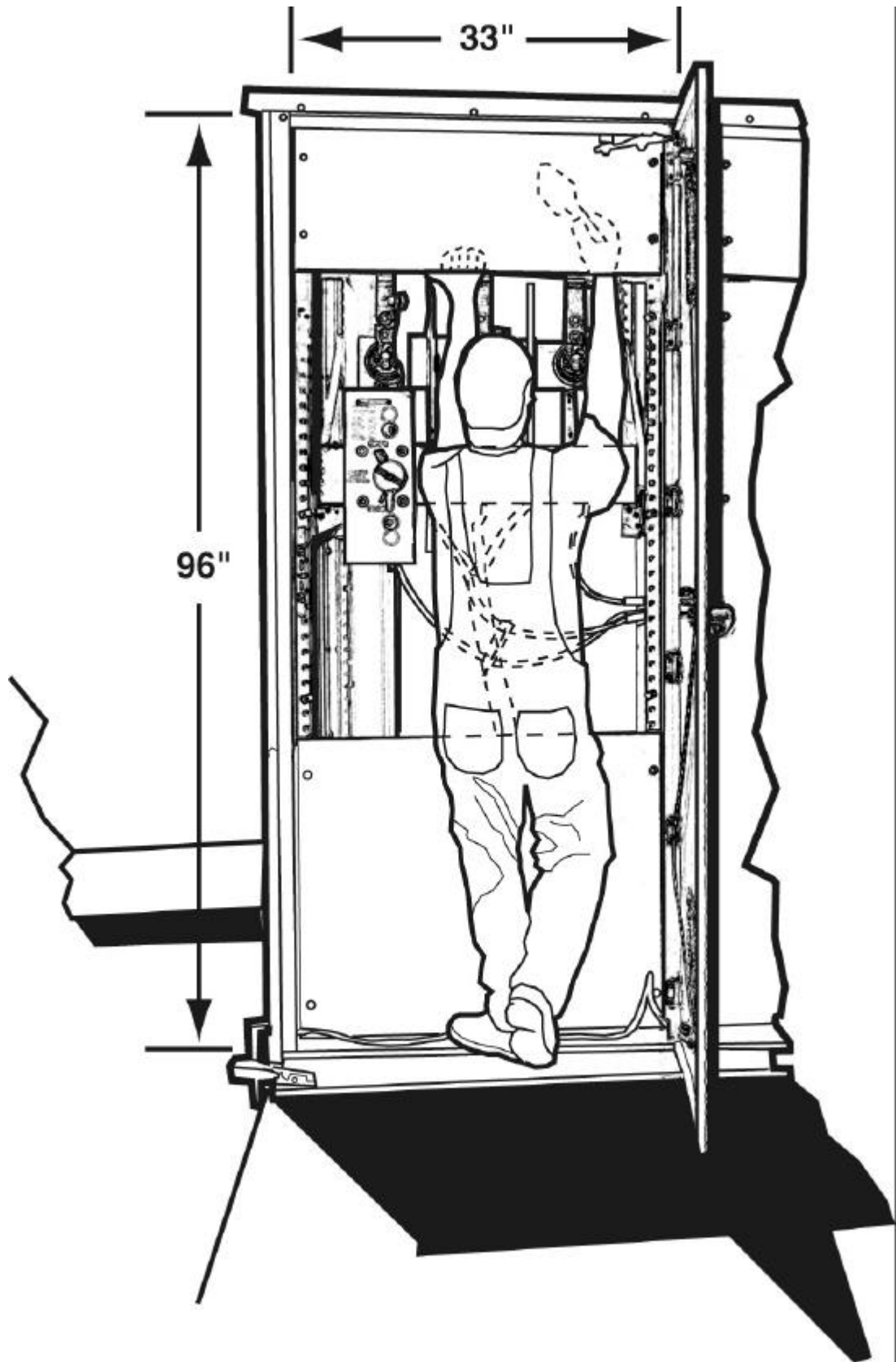


Figure 2-4: Estimated Position of Electrician #1 at the Time of the Accident

Electrician #1's industrial tricycle parked approximately 20 feet away.

7. Electrician #1's 98% cotton tee shirt was burned and scorched on the inner edge of the right sleeve (See Figure 2-5).
8. Electrician #1 suffered third degree burns on his right upper arm in the immediate vicinity of the scorched tee shirt sleeve. He suffered second degree burns on his right, forearm head, neck, and face.
9. The polycarbonate safety glass lenses exhibited surface glazing, but no deformation (See Figure 2-6).
10. Previous testing documented the GFP cleared fault current in approximately 1/6 of a second. The GFP was set at 10 Amperes/6 Hertz.
11. The GFP tripped, de-energizing all three phases of the switchgear. The ACB overcurrent protection did not trip.

Fitness for Duty

The Board reviewed AlliedSignal FM&T/KC's training program and determined it to be consistent with 29 CFR 1910.269(a) requirements. The Board reviewed Electrician #1's training records and determined he had received the training required for the HV system work being performed during the outage.

The Board also examined Electrician #1's work experience. He had voluntarily transferred out of the HV crew in March 1997 to provide electrical support for production machinery and tools. Since that transfer, Electrician #1 continued to perform HV work during weekend outages, due to a vacancy in the HV crew. Electrician #1 had worked eight of twelve weekend outages since 1997 with the HV crew.

Electrician #1 had voluntarily submitted a letter of resignation to AlliedSignal FM&T/KC. He was leaving to accept another position in the private sector on June 1, 1998. The change was a positive career move for the electrician.



Figure 2-5: Tee Shirt Worn by Electrician #1



Figure 2-6: Safety Glasses Worn by Electrician #1

Interviewed AlliedSignal FM&T/KC employees stated that Electrician #1 did not appear to be ill, tired, distracted, or otherwise impaired on the day of the accident. The Board found no evidence of a decrease in Electrician #1's fitness for duty that contributed to the accident.

While his pending separation from AlliedSignal FM&T/KC might have had a minor distracting effect, the Board could not conclude such effect was sufficient to explain Electrician #1's actions.

2.3 MANAGEMENT SYSTEMS

The KCP is a non-nuclear facility. AlliedSignal FM&T/KC's primary mission is to assemble and manufacture a wide array of non-nuclear mechanical, electronic, and engineered material components for the nuclear weapons stockpile.

AlliedSignal FM&T/KC's Integrated Safety Management program is described in the document titled *Integrated Safety Management FY98 (ISM)*. The AL Manager approved AlliedSignal FM&T/KC's original ISM implementation plan in November 1997 and the plan was updated in 1998

The ISM implementation plan states: "The ES&H Management System is founded on the principles of internationally recognized standards and applicable Federal regulation including ISO 14001, DOE Voluntary Protection Program (VPP), and DEAR requirements on Integration of ES&H Into Work Planning and Execution."

DOE awarded AlliedSignal FM&T/KC VPP Star status in 1996. AlliedSignal FM&T/KC is an ISO 9001 and 14001 certified site.

In 1996, DOE and AlliedSignal FM&T/KC completed an initiative to streamline the safety and health contractual requirements. Based on the work and hazards at the KCP, DOE determined that AlliedSignal FM&T could transition from DOE Orders to applicable regulations and general industry standards. Therefore, AlliedSignal FM&T's ES&H

program is comparable to a general industry manufacturing facility.

Appendix B of the ISM implementation plan provides a crosswalk between the DOE's ISM criteria and the processes used by the AlliedSignal FM&T/KC.

The Management and Operating (M&O) contract between DOE and AlliedSignal FM&T/KC documents the safety and health requirements. The Operating Requirements Database portion of the M&O contract contains applicable portions of United States Code of Federal Regulations (CFR), Missouri Code of State Regulations, DOE Orders, and national consensus standards. The Database identifies the following electrical safety standards and requirements:

- 29 CFR 1910.137, Electrical protective equipment;
- 29 CFR 1910.147, The control of hazardous energy (lockout/tagout);
- 29 CFR 1910.269, Electric power generation, transmission, and distribution;
- 29 CFR 1910 Subpart S, Electrical;
- DOE O 440.1, Worker Protection Program for DOE Federal and Contractor Employees; and
- ANSI/NFPA-70, *National Electrical Code*.

2.3.1 Define Scope of Work and Analyze Hazards

2.3.1.1 Work Control Process – As Designed

This section describes how the AlliedSignal FM&T/KC work control process is designed to be implemented by the Department 183-43 HV electrical shop. Appendix B identifies the AlliedSignal FM&T's document hierarchy and high voltage work process.

Work Orders

AlliedSignal FM&T/KC craftsmen must have a Work Order number to charge their time and material against before work can begin. Work Orders can be originated by a number of individuals such as the Maintenance Planner, the Preventive Maintenance Coordinator or the Utilities Engineer. Work Orders

specify the scope of work to be done. A completed Work Order for HV electrical work remains within the Maintenance Department.

Switching Instructions

Chapter 4.1 of the Utilities Manual requires Utilities Engineering to prepare Switching Instructions. Utilities Engineering uses the electrical distribution system engineering drawings to develop the sequence of switch transfers in the Switching Instructions. The Switching Instructions direct the HV electricians to safely perform the scope of work identified in the Work Order and, when the work is finished, to return the electrical distribution to full service.

Chapter 4.1 outlines specific responsibilities for the development, review and application of Switching Instructions. Utilities Engineering is required to submit the draft Switching Instructions to the Maintenance Team Manager three or four days before an outage to allow ample time for review. The Maintenance Team Manager is required to review and verify the instructions. The electricians are required to perform the work using the exact Switching Instructions sequence.

Hazards Analysis

The Division 183 - 43 HV Electrical Maintenance Shop should use Job Hazards Analysis (JHA) JHA 54.04.03.03.01, *How to Perform Maintenance on an Electrical Substation in Accordance with ES&H Requirements in D/183-43*, to direct the identification and analysis of generic hazards associated with electrical substation work.

This AlliedSignal FM&T/KC JHA differs from traditional JHAs, in that it does not provide a comprehensive description of the hazards and controls for a specific job. The AlliedSignal FM&T/KC JHA references other documents that sequentially refine the job-specific hazards analysis and identification of specific controls.

The other documents referenced by the JHA include Process Descriptions and Work Instructions. These

lower tier documents progressively refine the identification of job-specific hazards and recommended controls.

High Voltage Pre-Job Safety Checklist (HVPJSC)

WI 21.01.02.12.08 *How to Determine When to Issue an Electrically Energized Permit or a High Voltage Pre-Job Checksheet* requires a pre-job safety checksheet be completed before work begins. The Maintenance Team Manager prepares a HVPJSC, using the PDs and WIs referenced in JHA 54.04.03.03.01 *How to Perform Maintenance on an Electrical Substation in Accordance with ES&H Requirements in D/183-43*. The Maintenance Team Manager uses information from the HVPJSC and Switching Instructions to develop the Pre-Job Safety Briefing.

Pre-Job Safety Briefing

29 CFR 1910.269(c) requires a pre-job safety briefing before work begins.

The Maintenance Team Manager uses the HVPJSC to develop the pre-job briefing. This checksheet summarizes the work plan and identifies hazards and required support equipment. Human factors, safety supplies, and contingency planning are included in the checksheet to remind workers of these issues immediately before starting work.

2.3.1.2 Work Control Process – As Implemented on May 24, 1998

The Work Order, Switching Instructions, and High Voltage Pre-Job Safety Checksheet form a Work Package. All three documents play a role in accomplishing the work. This section describes how the AlliedSignal FM&T/KC work control process was implemented to accomplish the preventive maintenance described in the Work Package for May 24, 1998.

Work Order 98019244

The Maintenance Team Manager directed the Maintenance Planner to generate WO 98019244. The WO 98019244 work description was “all switch’s

associated with Cable 57” and the task title was “clean/repair switch’s.” The work was scheduled as routine maintenance for the Memorial Day weekend. Scheduling HV work on weekends minimizes the impact of required power outages to KCP operations.

Switching Instructions SI#103B

Utilities Engineering developed Switching Instructions SI#103B and identified the following scope of work:

- “Reason for Switching: Preventive and corrective maintenance; Substations/Cables involved: HV Switches 37, 38, 20B, 20C and Air Circuit Breakers 33 and 57.”
- “Item #1 Work Description: Perform preventive maintenance work on Main Switchgear Air Circuit Breaker 57. Perform corrective maintenance on high voltage Switch 57 at Substation 38. Perform preventive maintenance work on both 57 and 33 high voltage Switches at Substation 38. Perform preventive maintenance on high voltage Switches 20B and 20C.”

SI#103B contained 58 steps to be performed in sequence to accomplish the scope of work. Several of these steps specifically directed the HV electricians to install grounding clusters and LOTO locks and tags.

SI#103B used non-specific nomenclature in the section entitled “Substations/Cables Involved,” in that it referred to “High Voltage Switches 37, 38, 20B, and 20C.” These numbers refer to substation numbers and do not specify particular switches.

NOTE: Preventive maintenance of HV Switch 20C was not included in the specific work steps of the SI#103B.

High Voltage Pre-Job Safety Checklist **98019244**

JHA 54.04.03.03.01 *How to Perform Maintenance on an Electrical Substation in Accordance with ES&H Requirements in D/183-43*, references the following Process Descriptions and Work Instructions:

- PD 21.01.03.01, Personal Protective Equipment
- PD 21.01.02.01, Lockout/Tagout (LOTO)
- PD 21.01.02.12, Electrical Safety
- WI 22.02.02.09.03, *How to Prepare, Maintain, and Review a Job Hazard Analysis*

These referenced documents subsequently refer to the following Work Instructions:

- WI 21.01.02.12.01, *How to Determine if an Associate is an Unqualified or a Qualified Electrical Associate*
- WI 21.01.02.12.02, *How to Determine and Conduct Necessary Training*
- WI 21.01.02.12.03, *How to Obtain Test, and Use Electrical Related Personal Protective Equipment*
- WI 21.01.02.12.09, *How to Apply Temporary Grounding Sets (Grounding Clusters)*

High Voltage Pre-Job Safety Checksheet 98019244 listed the scope of work as “clean switch” and described the scope of the outage as “20 B Sub.” The only other portions of the Checksheet that contained safety-relevant information listed a special precaution as “volt meter,” required electrical gloves, and identified the nominal voltage of the system as “13 800.” The Checksheet listed no other safety-relevant information.

Analysis of Defined Scope and Analyze Hazards

The scopes of work differed on SI#103B, the HVPJSC and the Work Order. Line management failed to identify inconsistencies in the scopes of work. Furthermore, SI#103B contained internal conflicts regarding the scope of work.

The non-specific nomenclature used in SI#103B could have been confusing, resulting in work on HV Switch 57 at Substation 37 and the HV switch at Substation 20C.

The Board concluded a breakdown in communication occurred between the Utilities Department and the Maintenance Department. Line Management failed to identify inconsistencies in the scopes of work.

Line management failed to identify inconsistencies in the scopes of work.

The HVPJSCs and SI#103B were methods used to communicate hazards and controls. Neither of these documents clearly outlined the hazards associated with the work on May 24, 1998. The Maintenance Team Manager, the owner of JHA 54.04.03.03.01 *How to Perform Maintenance on an Electrical Substation in Accordance with ES&H Requirements in D/183-43* stated that he vaguely remembered that the document existed. The JHA summarizes general HV electrical hazards, but provides limited value in identifying task specific hazards in the HVPJSC.

The Board concluded that multiple hazard identification processes exist and are not clearly delineated or integrated effectively into the work.

2.3.2 Implement Controls and Perform Work

Pre-Job Safety Briefing

The Maintenance Team Manager conducted an informal pre-job safety briefing on the afternoon of May 23, 1998, for work to be performed on May 24, 1998. Electrician #1 and Electrician #2 were present on May 23, 1998. The HV electricians scheduled to perform the work did not sign the HVPJSC as required by WI 21.01.02.12.08. In addition, the HVPJSC section requiring PPE was not completed.

Analysis of Pre-Job Safety Briefing

The pre-job safety briefing shall be conducted by the Maintenance Team Manager immediately prior to the start of work to ensure workers are aware of the scope, job hazards, work procedures, special precautions, energy source controls, and PPE requirements. The pre-job safety briefing provided on May 23, 1998, did not meet the intent of providing essential information to workers immediately prior to starting work. Also, the informal pre-job briefing did not cover required PPE, was not signed by any of

electricians in attendance, and was not attended by all HV electricians.

The Board concluded that an effective pre-job briefing was not provided to the electricians before the start of HV work activities.

Switching Instructions SI#103B

The Maintenance Team Manager did not review or sign SI#103B. A review of past Switching Instructions identified similar documents without signature. The Cleaning Team did not initial or date any completed steps within SI#103B. Chapter 4.1 of the Utilities Manual requires the Maintenance Team Manager's signature and the electricians' initials.

Analysis of Switching Instructions SI#103B

Various personnel involved with the preparation and use of SI#103B did not meet the requirements described in Chapter 4.1 of the Utilities Manual.

The Maintenance Team Manager did not receive a draft of SI#103B enough in advance to coordinate a review and have comments incorporated in the final version. The Maintenance Team Manager did not review the required steps of SI#103B and enforce them accordingly.

The electricians did not follow the steps in sequence or initial and date them when completed, apply locks and tags, or install grounding clusters as required.

Evidence indicates the Cleaning Team was not using SI#103B and was working solely under the assumption that all switches associated with Cable 57 (which would have included Switch 57 in Substation 37) were to be cleaned. SI#103B did not include steps to perform preventive maintenance on Switch 57 at Substation 37.

The Board concluded that neither the Maintenance Team Manager nor the Cleaning Team reviewed or followed SI#103B in the performance of the work.

The pre-job safety briefing was not conducted on the day of the work.

Lockout Tagout (LOTO)

The Process Description (PD) 21.01.02.01, *Lockout/Tagout* and WI 21.01.02.01.01, *How to Apply Lockout/Tagout* provide specific instructions on applying LOTO. WI 21.01.02.01.02, *How to Perform Annual Lockout/Tagout Surveillance*, provides the process to perform inspection of LOTO.

Review of training records indicates that the electricians involved in this accident had attended the required training. LOTO supplies are readily available and had been issued to the HV crew.

Periodic reviews are conducted on LOTO applications. However, the review process does not include a representative evaluation of lockouts completed on weekends and shutdowns when HV work is performed.

Switching Instruction #103B required the Cleaning Team to apply LOTO locks and tags at the following locations:

- Substation 37
- Substation 20B
- Substation 20C
- Substation 38
- ACB 57
- ACB 33

Electrician #1 and Electrician #2 were both required to apply personal locks and tags in each location. If SI#103B had been followed, the LOTO requirements would have dictated each electrician to apply six individual locks and tags for a total of 12 locks and 12 tags in use simultaneously. Only Electrician #1 took locks and tags to the field on May 24, 1998.

The Board identified the following lock and tag application discrepancies:

- Neither member of the Cleaning Team applied locks or tags at the HV Switch 57 at Substation 37.

- For ACB 57, one of the Main Switchgear Team electricians maintained possession of the interlock key to ensure ACB 57 could not be re-energized. The interlock key was not kept in a lock box secured with proper Cleaning Team locks and tags.
- ACB 33 was physically removed from service; however, no Cleaning Team locks or tags were applied.
- Only Electrician #1 of the Cleaning Team applied locks and tags at Substations 20B, 20C, and 38. Electrician #2 had not taken his locks to the work area.
- The Maintenance Team Manager did not identify a Designated Authorized Associate (single person responsible for group lockout) for the multi-team work.

In addition to the application of locks and tags, the LOTO program requires verification of zero energy prior to work. All components were not verified to be de-energized.

Analysis of Lockout/Tagout (LOTO)

Based on the LOTO discrepancies described above, the LOTO program was not fully implemented in accordance with AlliedSignal FM&T/KC's programmatic policies and procedures.

The Board concluded that the failure to properly implement and oversee the LOTO program exposed workers to unrecognized and uncontrolled hazards.

Grounding Clusters

29 CFR 1910.269(m) requires all HV systems to be treated as energized until zero voltage has been verified and grounding clusters installed.

JHA 54.04.03.03.01, *How To Perform Maintenance on an Electrical Substation in Accordance with ES&H Requirements in D/183-43* reinforces the use of grounding clusters and requires supervision to be present during the installation of grounding clusters.

<p>The LOTO program was not implemented per training or program requirements.</p>

Review of training records indicates that the electricians involved in this accident had attended the required training that included instruction on when and how to install grounding clusters. Grounding clusters are readily available and maintained by the HV crew.

29 CFR 1910.269(a)(2) requires an annual review of HV electrical operations. The 1998 AlliedSignal FM&T/KC annual review of HV electrical operations did not record deviations from the requirements to install grounding clusters.

On May 24, 1998, the Cleaning Team did not take grounding clusters to the work site. Grounding clusters were not installed in accordance with WI 21.01.02.12.09 and SI#103B. The Maintenance Team Manager was not present when SI#103B required the grounding clusters to be installed in Substations 20B and 38.

NOTE: SI#103B did not include steps to do preventive maintenance at Substation 37.

Electricians interviewed stated that they knew grounding clusters should have been installed during the preventive maintenance on May 24, 1998.

Analysis of Grounding Clusters

Based on the discrepancies described above, the use of grounding clusters was not fully implemented in accordance with AlliedSignal FM&T/KC's programmatic policies and procedures.

The Board recognized that the installation of grounding clusters at Substation 37 would not have prevented this accident if SI#103B had been followed. SI#103B did not include instructions to do preventive maintenance at Substation 37.

The Board concluded that the failure to properly implement and supervise the installation of grounding clusters per SI#103B exposed workers to unrecognized and uncontrolled hazards.

Grounding clusters were not applied per the WI and SI#103B.

Two-Person Rule

As required by WI 21.01.02.12.03 and Chapter 4.1 of the Utilities Manual, switching must be performed by a minimum of two qualified electricians. These electricians must be familiar with the equipment and must be under the direction of the Utilities Engineer, the electrical Maintenance Team Manager, or job-specific written Switching Instructions.

Early on May 24, 1998, the S&H Oversight person stated he observed Electrician #1 working alone at Substation 38. WI 21.01.02.12.03 requires “qualified electrical backup” for the work in which Electrician #1 was engaged. Later that same day, the Maintenance Team Manager directed Electrician #1 to begin cleaning activities at Substation 37.

NOTE: SI#103B did not include steps to do preventive maintenance at Substation 37.

Analysis of Two-Person Rule

The Maintenance Team Manager directed Electrician #1 to start work at Substation 37. This resulted in both members of the Cleaning Team working alone. The direction to work alone by the Maintenance Team Manager indicates this first line supervisor endorsed the practice of working alone.

Although the Maintenance Team Manager has the authority to direct work per the Utilities Manual, the Maintenance Team Manager directed work that did not comply with the “qualified electrical backup” requirement by sending Electrician #1 to Substation 37 alone.

AlliedSignal FM&T/KC’s *VPP Bill of Rights* expresses management’s expectation that employees use “stop work authority” when deemed necessary. Most employees interviewed said they feel empowered to do so. On May 24, 1998, unsafe work practices occurred that warranted suspension of work, but stop work authority was not applied.

The Board concluded that the failure to properly implement the two-person rule and to exercise

The two-person rule was not followed.

individual stop work authority exposed workers to unrecognized and uncontrolled hazards.

Personal Protective Equipment (PPE)

Process Description (PD) 21.01.02.12 *Electrical Safety, Overview* requires Team Management to ensure that PPE is obtained and used and references a PPE matrix for specific requirements. (Reference WI 21.01.02.12.03).

Work Instruction (WI) 21.01.02.12.03 *How to Obtain, Test, and Use Electrical Related Equipment*, provides guidance for selecting proper PPE for specific electrical work activities. HV work is described in Appendix 3 - *Electrical Safety Requirements for a Distribution System Utilizing 2,400 VAC or 13,800 VAC*. This appendix lists specific tasks and related safety precautions such as PPE, approvals, and attendants. The Work Order document template contains a section to identify required PPE, but was not completed on Work Order 98019244.

Electrician #1 was wearing safety glasses at the time of the accident and did not receive injury to his eyes. HV electrically insulated gloves were reportedly used by the electrician before the accident. The gloves were required for several outage activities, but were not required for cleaning operations on de-energized equipment.

Analysis of Personal Protective Equipment (PPE)

The use of PPE is required for potentially energized electrical work. The gloves used by Electrician #1 were beyond the six-month inspection date required for dielectric testing. These gloves were reportedly used by Electrician #1 for voltage testing on the day of the outage. In addition, a review by the Board of all HV gloves showed 24 gloves had been issued to electrical workers at KCP. However, 11 gloves exceeded their date for re-test at the time of the electrical accident. A deficiency with the glove inspection program was identified as a finding by KCAO during the HV electrical review in April 1998.

As of June 1, 1998, a corrective action plan to address the electrical PPE finding had not been received by KCAO.

Electrician #1 was wearing safety glasses as required by WI 21.01.02.12.03. Although the electrician suffered facial burns, he did not sustain any injuries to the eyes. Damage to the safety glasses provided tangible evidence that serious eye injury was prevented by their use. Figure 2-6 shows the safety glasses worn by the electrician.

The Board concluded that AlliedSignal FM&T/KC electrical glove program is not functioning properly to ensure electrical glove integrity.

Supervision

AlliedSignal FM&T/KC's *Integrated Safety Management, FY98* delineates the following line management safety and health responsibilities:

“Accepting responsibility and accountability for ES&H performance associated with the work performed under their direct supervision, including:

- a) Determining and allocating the resources necessary to comply with ES&H related policies, laws, regulations, and program requirements;
- b) Assuring that associates operate in strict compliance with the policies and applicable procedural requirements in command media;
- c) Making associates aware of their roles and responsibilities relative to the ES&H programs, including emergency preparedness and response;
- d) Determining and assuring completion of training requirements for their associates;
- e) Motivating associates to continually improve through encouragement to make suggestions to improve ES&H performance and recognition for effecting associated improvements; and

- f) Controlling processes, including suspension of operations for ES&H reasons.”

Site supervisors must take several corporate driven courses that explain their responsibilities. *Leadership Safety Training*, SA-80, and its refresher *Leadership Development, Series 12* explain the supervisors ES&H responsibilities. The Maintenance Team Manager completed these courses in May 1994 and December 1996, respectively.

Analysis of Supervision

The Maintenance Team Manager was trained and qualified to perform supervisory and electrical responsibilities. However, working alone, the lack of grounding clusters, improper/missing LOTO application, and deviation from SI#103B were conditions which were not noted or corrected by site supervision on May 24, 1998. In addition, the verbal directions provided to Electrician #1 were not in full accord with site electrical procedures, safety practices, or line management safety and health responsibilities.

The Board concluded that supervisory safety responsibilities were not fully implemented on the day of this accident.

Training

WI 21.01.02.12.02 *How to Determine and Conduct Necessary Training*, applies to AlliedSignal FM&T/KC electrical workers. A review of the HV engineers', electricians', and Maintenance Team Manager's training records indicated that courses were identified and taken in lockout/tagout, electrical safety, and HV requirements. The following related training courses were taken by the HV workers:

- SA-110 Electrical Safety for Electrical Workers
- SA-112 Electrical Safety for Energized Electrical Workers
- SA-114 High Voltage Electrical Safety
- SA-119 Electrical Associate Training

- National Electrical Code Updates (high and low voltage)
- SA-087 Lockout / Tagout (LOTO)
- GN-027 CPR Training - Adult

The HV electrical safety course SA-114 consisted of a review of applicable sections of 29 CFR 1910.269; lessons learned from other DOE high and low voltage incidents; CPR training requirements; equipment overview; and the introduction and application of the HVPJSC.

Off-site vendor training was provided to all HV electricians and the Maintenance Team Manager. This classroom and hands-on training was specific to substation activities.

The following items were identified during the investigation:

- No training findings were noted during the DOE-KCAO "Facility Review of High Voltage Operations, Maintenance, and Safety," dated April 9, 1998.
- A review of the Patrol Control Room lesson plan showed that the training focused primarily on receiving calls from within the KCP and did not discuss communication with outside emergency medical services.
- Annual training had been given to Patrol Officers in the correct operation of the site ambulance. No such training has been required or given to the Fire Protection Staff.

Specific actions were identified during the investigation that were contrary to the training received:

- the HVPJSC was not completed
- the pre-job briefing was not conducted the day of the work
- individual LOTO was not applied
- the two-person rule was not implemented

- all potentially energized parts were not tested
- ambulance controls were not located
- the accident scene was not immediately secured by Patrol
- the accident scene was disturbed

Analysis of Training

AlliedSignal FM&T/KC has a Qualifications/Training System, which identifies and monitors training provided to workers. This system identifies regulatory and contractual requirements and specific training required for each job function and task.

The Board reviewed the training records of the HV electricians and the Maintenance Team Manager and found they had received the training required by the Qualifications/Training System. All six HV electricians, as well as the Maintenance Team Manager, were journeyman electricians. These HV electricians had demonstrated an understanding of electrical safe work practices in order to achieve journeyman status and to be accepted into the HV crew.

The Patrol Sergeant had not been trained on the use of the dedicated outside telephone line.

The accident scene was not fully preserved in accordance with SA-113, *Electrical Safety for Emergency Responders*.

The Board concluded that although formal training was completed, the actions of several individuals during the May 24, 1998, outage were not consistent with the training received.

2.3.3 Feedback and Improvement

AlliedSignal FM&T/KC Feedback and Improvement

AlliedSignal FM&T/KC provides environment, safety and health (ES&H) oversight of work activities through external and internal processes. Numerous periodic external reviews are conducted including a semi-annual ISO 14001 review, annual third party reviews, and program specific reviews. Six external ES&H

Training was not effectively applied or demonstrated during outage activities.
--

assessments are scheduled for Fiscal Year 1998, including a HV electrical review.

Contractor management provides limited ES&H oversight through the Management Observing and Promoting Safety (MOPS) program. This oversight is not targeted towards electrical work and primarily awards positive behaviors. It is used to maintain visibility of safety involvement by management personnel, and may be announced or unannounced. No one interviewed reported a MOPS tour during weekend activities and utility shutdowns.

The Board found that AlliedSignal FM&T/KC had submitted four safety related DOE Occurrence Reporting System (ORPS) reports over the last two years before the May 24, 1998, accident. None of these reports involved electrical incidents.

Three of the four reports noted either personnel errors (procedures not being used or used incorrectly) or management problems (inadequate or disregarded controls).

AL approved the modification of the AlliedSignal FM&T ORPS reporting process for off-normal occurrences, starting in January 1996. AlliedSignal FM&T resumed ORPS reporting of off-normal occurrences in January 1998. One nonelectrical off-normal occurrence has been reported since the resumption of off-normal reporting.

AlliedSignal FM&T/KC management identified deviations from written procedures, specifically in production areas. Senior management recently re-emphasized the expectation to follow procedures through various meetings and in other communications with employees.

Internally, the ES&H organization conducts formal annual inspections, performs incident investigations, solicits and resolves employee concerns, and conducts informal process and equipment reviews. It also coordinates approximately 20 shift, topical and line ES&H committees which identify and resolve related issues. ES&H personnel are on-site from

6:30 a.m. to 8:00 p.m. weekdays. No scheduled ES&H oversight is provided on weekends except during utility shutdowns.

General ES&H oversight is provided during utility shutdowns. This support includes review of scheduled work, periodic monitoring of work activities, and a general ES&H presence for concerns, questions, or response.

One S&H professional has been deployed to the Maintenance organization since December 1997. He has not observed any HV operations or associated documentation since being deployed. No documentation of field oversight activities is kept by the deployed S&H staff.

The Safety Engineer assigned overall electrical safety program responsibility provides matrix support to line organizations such as Maintenance. Electrical safety activities account for 20% of this individual's time. The majority of this 20% is spent coordinating the KCP Electrical Safety Committee and responding to employees' concerns. He performs minimal field oversight activities.

WI 21.01.02.12.08 requires the Maintenance Team Manager to return the completed HVPJSC to the Utilities Engineer, who returns the checksheet to S&H. WI 21.01.02.12.08 requires the S&H Department to file the completed HVPJSC. A review of previous HVPJSC in the S&H files showed many were incomplete.

All levels of oversight for HV electrical activities are hindered by logistical factors such as locked access, multiple work locations and off-shift work schedules.

DOE Feedback and Improvement

The Kansas City Area Office (KCAO) performs DOE line management oversight of AlliedSignal FM&T/KC. The ES&H staff and the Facilities staff conduct periodic oversight. Four Operations Representatives are assigned specific geographical areas of KCP to monitor and provide day-to-day observations to KCAO and Contractor management.

A KCAO quarterly ES&H Facility Review included a review of AlliedSignal FM&T/KC's HV activities. The report, issued in April 1998, identified one finding, two positive and four negative observations and seven suggestions. The finding dealt with electrical gloves and is discussed in Section 2.3.2.

The April 1998 KCAO report stated, "Observation from Section 7.0: Configuration management for HV equipment is noteworthy because of the operational process in place to collect and organize the necessary information used for developing work instructions for HV operations and maintenance processes." This noteworthy observation was directed at the process for maintaining drawings in Utilities Engineering and not the process for Switching Instructions.

AL provides matrix ES&H support to KCAO as requested. AL conducted a Technical Assistance Review in 1996 at the request of KCAO. However, HV electrical safety was not part of the scope of this review.

Analysis of Feedback and Improvement

AlliedSignal's *Safety Principles* state that "safety performance is a responsibility of line management and every employee." AlliedSignal FM&T/KC's safety and health procedures are designed to implement that corporate philosophy.

Accordingly, the responsibility for safety and health performance (including operational awareness) rests with the line management organizations. Line management organizations are closest to the work and have the technical expertise to recognize hazards and effect corrective action. AlliedSignal FM&T/KC Safety and Health professionals are deployed to support line management in the accomplishment of their responsibilities.

The Maintenance Team Manager was trained and qualified to perform supervisory and electrical oversight responsibilities. However, on May 24, 1998, the supervisor did not correct unsafe acts and conditions such as, electricians working alone, the

lack of grounding clusters, improper/missing LOTO application, and deviations from SI#103B.

Interviews with the S&H supervision indicated that, in general, there is no expectation for non-electrical oversight individuals to know HV safety requirements. The expectations for the S&H oversight person is to provide a general S&H point of contact for line organizations on utility shutdowns. Their presence is intended by AlliedSignal FM&T/KC management to increase safety awareness and accessibility, and monitor compliance with general industry standards.

Although the S&H Oversight person was on site and could have been paged, he was not aware of the accident until notified, approximately one hour after the accident occurred. The radio normally carried by the S&H Oversight person was in for maintenance. No one paged him on the off-shift pager he was carrying, because the pager number had not been provided to Patrol for the automatic paging system.

S&H did not follow up on incomplete HVPJSC forms. WI 21.01.02.12.08 only requires the S&H Department to file the completed HVPJSC. This process does not incorporate feedback and trending to appropriate individuals to correct the deficiencies.

There is management presence, and an established process and resources for announced and unannounced oversight during the traditional workweek. This support is not provided during off-shift and weekend work.

Oversight by the KCAO has been primarily conducted as announced assessments. This may provide AlliedSignal FM&T/KC the opportunity to prepare for these assessments.

The Board concluded that feedback and improvement processes are not effective in identifying procedural noncompliances and providing feedback on HV electrical work.

2.4 BARRIER ANALYSIS

The Board identified physical, administrative, and management barriers between Electrician #1 and the energized switch. These barriers are summarized in Figure 2-7, and are discussed in detail in Section 2.3.

2.5 CHANGE ANALYSIS

A change analysis was conducted to determine any changes or differences that may have been causal factors in this accident. Analysis of changes and differences was performed to determine direct or indirect factors in the accident. These changes are presented in summary form in Table 2-1, and are discussed in detail in Section 2.3.

High Voltage Electrician

**Physical
Barrier**

Enclosed Switchgear

**Management
Barriers**

Internal Oversight

External Oversight

**Administrative
Barriers**

LOTO (Lockout/Tagout)
Grounding Clusters
Job Hazard Analysis
Personal Protective Equipment
Two-Person Rule
Individual Judgment
Pre-job Safety Briefing
Switching Instructions
Stop Work Authority
Training

Energized Electrical Equipment

Figure 2-7: Barrier Analysis Summary

Table 2-1: Change Analysis Summary

Change or Difference		Analysis	
Planned/Normal	Present Condition	Difference or Change	Analysis
Emotional condition of the HV electrician was stable	The HV electrician may have been preoccupied during last week of work before separating from AlliedSignal FM&T/KC	The HV electrician may not have been as attentive to activities being performed	The HV electrician performed activities contrary to safe work practices and procedures
AlliedSignal FM&T/KC's JHA process is established and followed for electrical substation work.	JHA 54.04.03.03.01 was not followed	The hazards were not assessed with this required document	Hazards and controls were not identified using the JHA document
Electricians arrive at a work location with all needed equipment	One electrician did not have his LOTO equipment and no grounding clusters were brought to the work locations	Electrical safety devices could not be installed as required	Substations could not be considered de-energized per AlliedSignal FM&T /KC policy
A formal review process is used to ensure Switching Instructions are correct	The review of Switching Instructions was an informal process	The draft SI#103B were not available to all HV electricians prior to the outage	Not all HV affected electricians provided input and review of substation work to be performed
Final SI#103B are signed as "verified" by the Maintenance Team Manager	The final SI#103B were not signed by the Maintenance Team Manager	The Maintenance Team Manager did not document and finalize the instructions used by HV electricians	The HV electricians performed hazardous work without formal supervisory approval
All HV electricians have access to and are briefed on the Switching Instructions prior to use	Not all of the HV electricians were provided a briefing or reviewed the SI#103B prior to use	Information was not exchanged with HV electricians prior to work	The HV electricians performed hazardous work without formal supervisory briefing or approval

Change or Difference		Analysis	
Planned/Normal	Present Condition	Difference or Change	Analysis
A pre-job safety briefing is performed and signed immediately before work is performed	An informal pre-job safety briefing was conducted the previous day, but was not adequately documented	A pre-job safety briefing was not conducted in accordance with AlliedSignal FM&T/KC procedures	The formality of the pre-job safety briefing was not appropriate for the hazardous work being performed
Electrical oversight is comprehensive and effectively conducted	Reliance on skill of the craft, individual compliance and supervisory monitoring	Electrical oversight was limited	Deviations from established electrical safety practices were not detected
Switching Instructions are used by the HV electricians in the correct sequence	Tasks were not performed in the order specified in SI#103B	Hazardous work was not performed as required by SI#103B	A critical process for controlling hazardous work was not followed
Switching Instructions are used by HV electricians to identify specific equipment to be serviced	Work tasks were performed on equipment which was not identified in SI#103B	Out of scope work was performed	Hazardous work was performed outside the steps of SI#103B
Electrical LOTO oversight is comprehensive and is effectively conducted	LOTO oversight was not provided for utility outage and swing shift activities	Limited HV LOTO oversight was performed	HV LOTO was not independently reviewed
A Designated Authorized Associate has overall responsibility for control of Group LOTO activities	No one individual had control of LOTO activities for both the Main Switchgear Team and the Cleaning Team	Group lockouts not applied as required at the Main Switchgear	LOTO requirements were not implemented
Electrical workers must test all potentially energized components before working "on or near"	Load side conductors (permanent jumpers) and switch blades were not tested	Energized jumpers were not identified by the HV electricians	Hazardous work was performed without attention to detail and standard work practices

Change or Difference		Analysis	
Planned/Normal	Present Condition	Difference or Change	Analysis
Supervision is performed to ensure work is conducted safely and in accordance with procedures	Direction by AlliedSignal FM&T/KC first line supervision was not in accordance with electrical procedures and safety practices	Work was directed outside the requirements established to protect the worker	Hazardous work was directed which placed the HV electrician out of established safety controls
Stop work authority is used whenever work places an employee in a potentially hazardous condition	HV electrician did not stop work when directed to perform work tasks alone in violation of the Two Person Rule	HV electrician performed work in violation of the Two-Person Rule	Hazardous work was performed alone
Electricians follow safe electrical work practices	HV electricians did not apply grounding clusters prior to hands-on work with 13.8 kV switchgear	HV electricians worked without required safety controls	Established controls to safeguard the electrician were not implemented
Patrol immediately notifies on-site ES&H representatives of incidents and injuries	Patrol was unaware of on-site ES&H coverage and the ES&H pager number	ES&H representative did not participate in post accident activities until later	General ES&H assistance was not available immediately following accident activities
Emergency medical notifications to local hospitals are made to receive incoming AlliedSignal FM&T/KC ambulance	Patrol did not have an appropriate listing of emergency phone numbers for contacting local hospitals	Information regarding the transportation of the electrician was temporarily delayed	Communication between AlliedSignal FM&T/KC and the local hospital was not timely or reliable
AlliedSignal FM&T/KC ambulance is maintained and ready for use	AlliedSignal FM&T/KC ambulance was not functionally ready for emergency use	The ambulance had trouble starting up and stopping at an intersection	Ambulance was not maintained for ready operation
AlliedSignal FM&T/KC ambulance drivers are trained and familiar with its use	AlliedSignal FM&T/KC Patrol was not familiar with the operation of ambulance emergency lights	The emergency lights were not used in route to the hospital	Patrol did not have comprehensive knowledge of how to use the ambulance

Change or Difference		Analysis	
Planned/Normal	Present Condition	Difference or Change	Analysis
Emergency responders are familiar with First Aid supplies available	Responders were unable to locate desired First Aid supplies in the ambulance	The electrician was not provided initial care	Responders were not able to provide the electrician initial care
Patrol Officers use hand-held radios to communicate with Patrol HQ and with other officers in the field	Patrol Lt.'s hand-held radio battery was loose	The Patrol Lt. had trouble communicating with Patrol HQ and other officers in the field. Used Fire Protection Specialist radio.	Communication among Patrol was not reliable
Patrol maintains continuous control of the accident scene until released to site investigators	Patrol allowed the accident scene to be disturbed prior to arrival of the site investigators	Accident scene preservation was not initially controlled after amelioration	Accident readiness was not effectively implemented

3. CAUSAL FACTORS

The Board concluded that one of two scenarios was the most probable. The injured electrician worked unknowingly in close proximity to energized electrical equipment and while using a paintbrush to clean the inside of the switch cabinet either:

- falling debris (such as a cobweb) fell onto the energized “C” phase knife blade creating a fault, or
- Electrician #1’s tee shirt sleeve contacted the energized “C” phase knife blade creating a fault.

The direct cause of the accident was that material associated with the electrician’s activities contacted the energized equipment resulting in an arc blast.

There were also contributing causes and a root cause. An Events and Causal Factors Chart used to analyze the causal factors is presented as Figure 3-1. A tabular summary of the analysis is in Table 3-1.

Root causes are the causal factors that, if corrected, would prevent the accident. The Board identified lack of effective integration and failure to responsibly implement the high voltage work control process as the root cause of this accident.

Contributing causes are events or conditions that collectively with other causes increased the likelihood of an accident, but that individually did not cause the accident. The Board identified the following contributing causes of this accident:

- Deviations from AlliedSignal FM&T/KC’s established electrical safety procedures contributed to this accident.
- Supervision did not perform assigned responsibilities to protect the worker.
- Individuals did not fulfill responsibilities to work safely and in accordance with Allied Signal FM&T/KC’s policies and procedures.

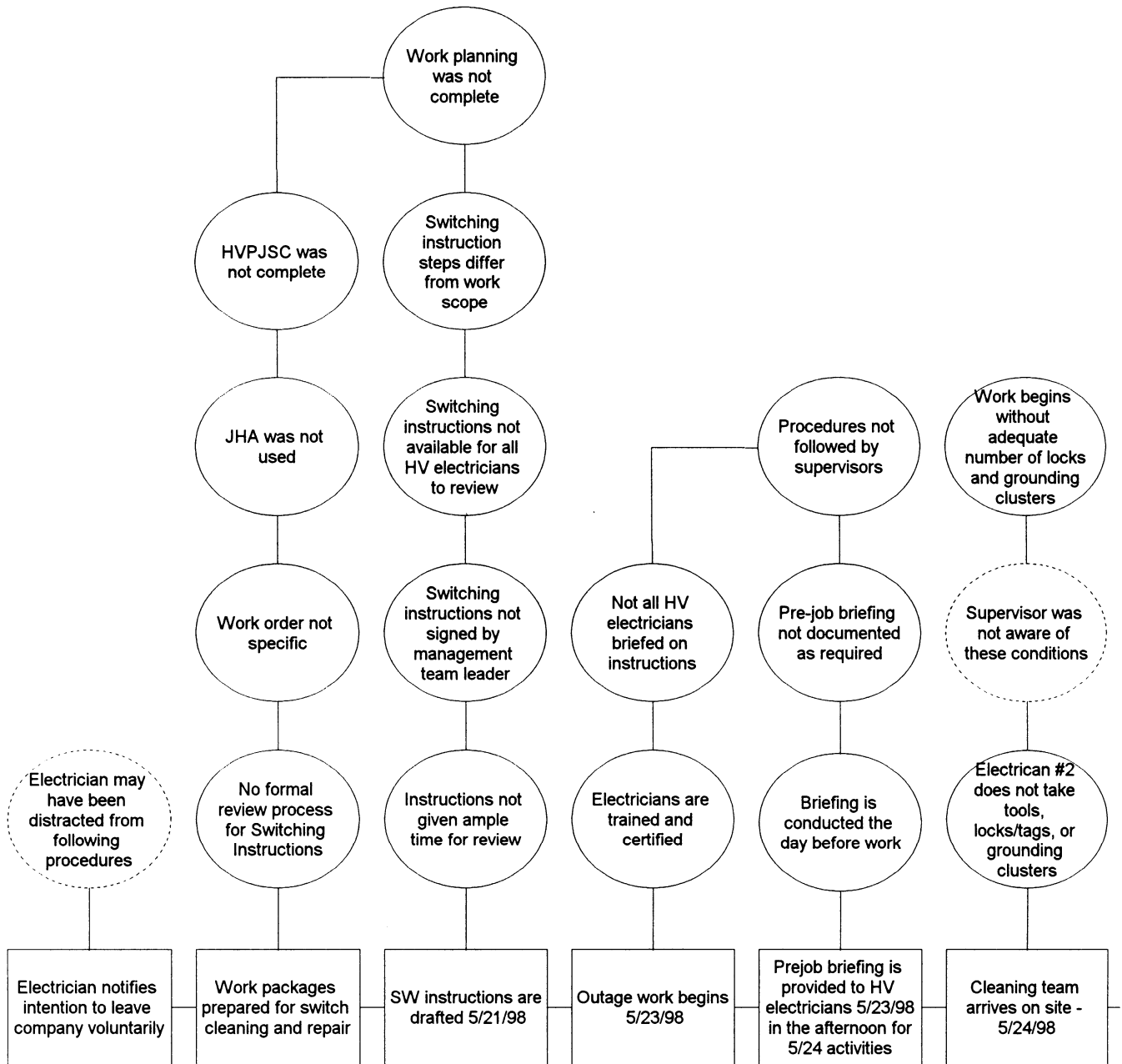
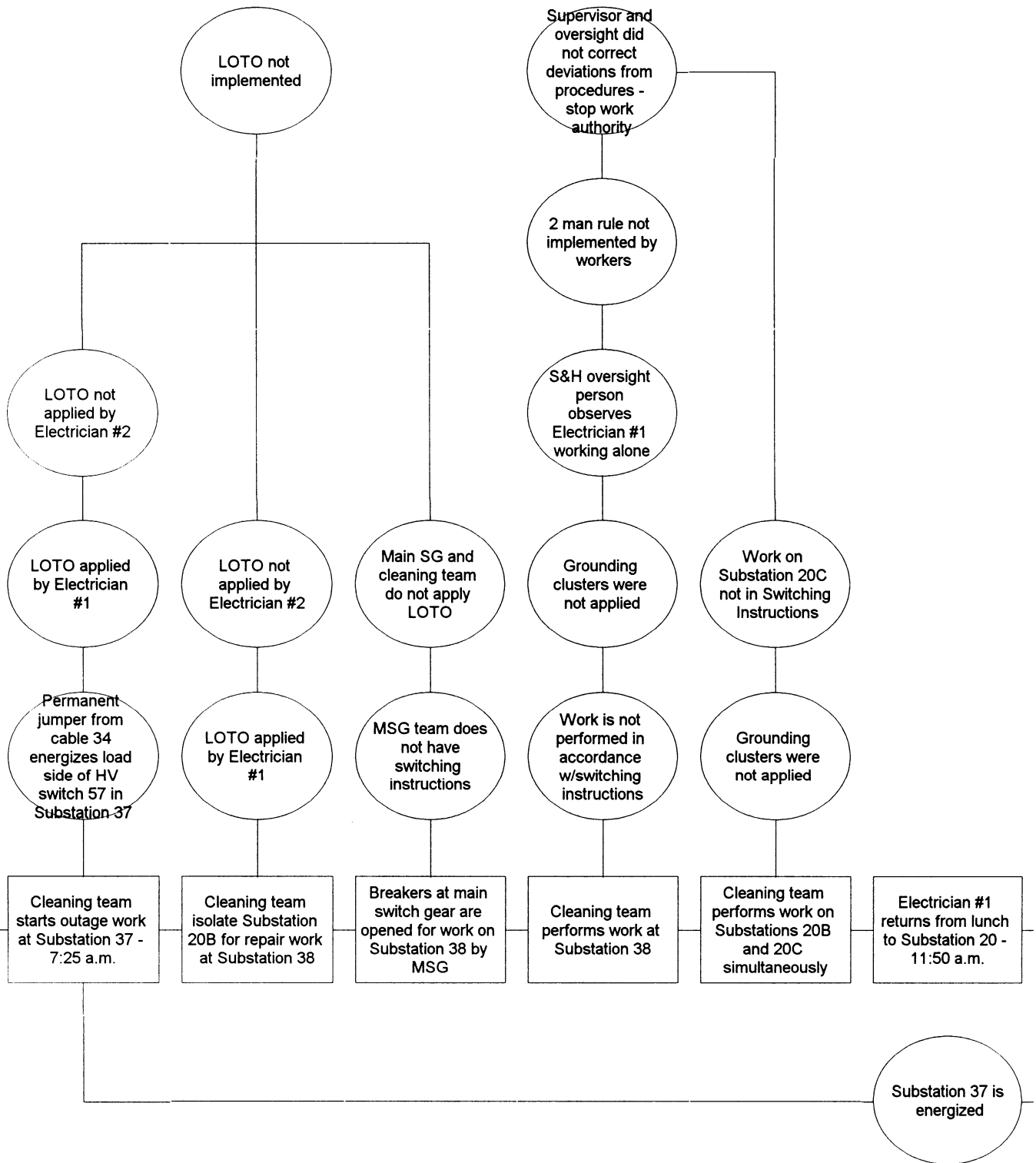
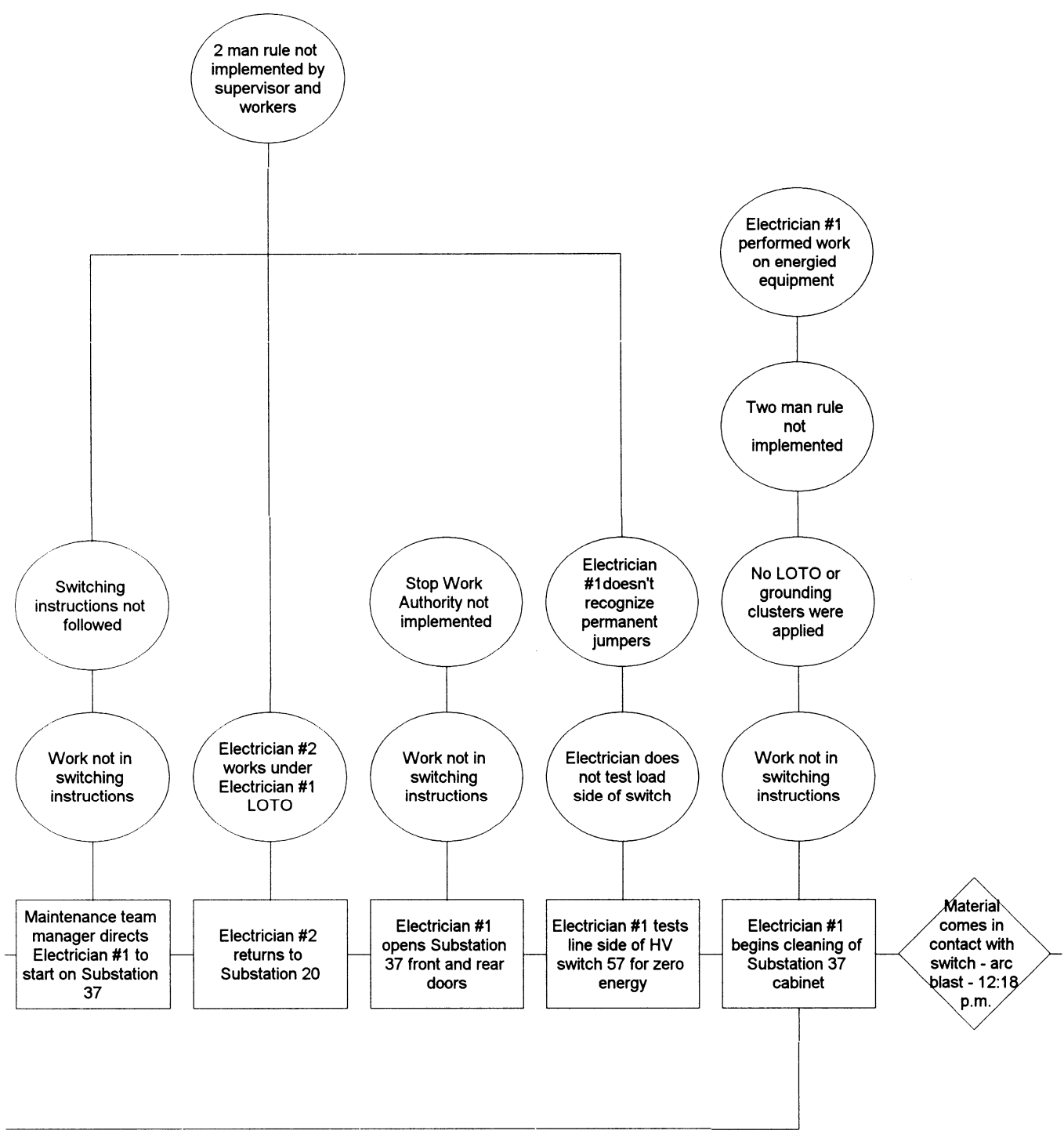


Figure 3-1: Events and Causal Factor Analysis







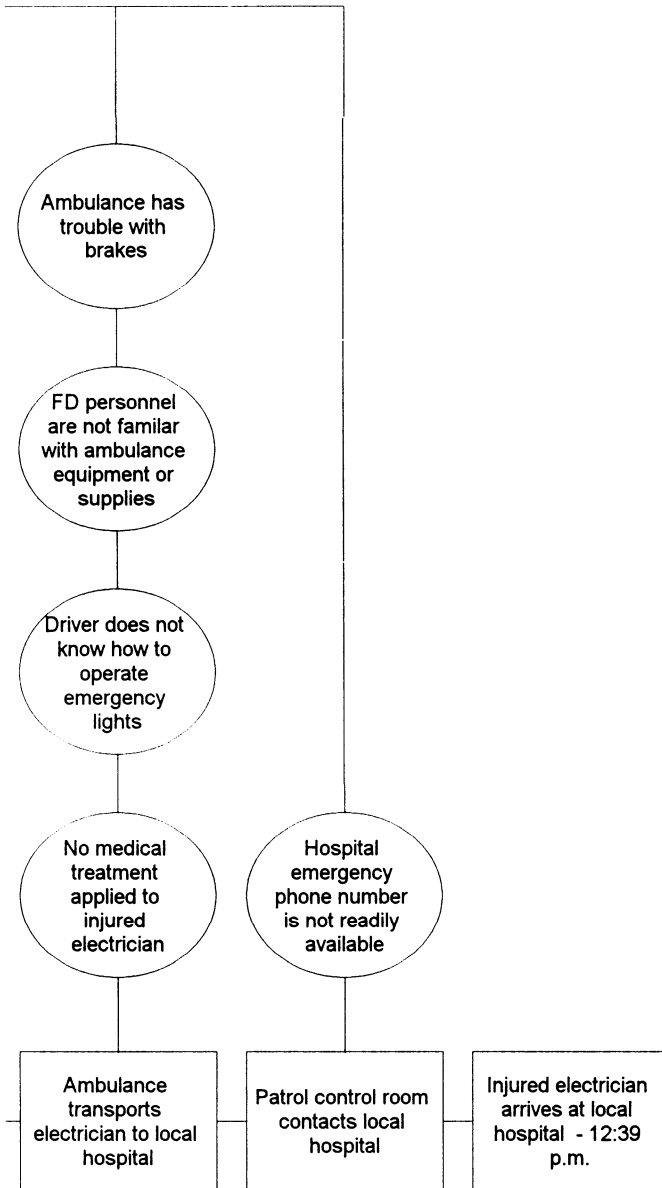


Table 3-1: Causal Factors Analysis Summary

Root Cause	Discussion
Lack of effective integration and failure to responsibly implement the high voltage work control process.	Work control is established to ensure that activities are carried out under specified conditions. The work control process failed to adequately plan and coordinate, direct, perform, monitor, and enforce established requirements associated with the work.
Contributing Causes	Discussion
Deviations from AlliedSignal FM&T/KC's established electrical safety procedures contributed to this accident.	<p>Requirements, including the training and qualification of individuals, are well established at the KCP. Proper application of these requirements are further communicated in procedures and work instructions.</p> <p>The steps in SI#103B were not documented as having been completed. The workers did not adhere to work procedures and safe work practices, such as switching instructions, LOTO, grounding clusters, two person rule, PPE use, and stop work authority.</p>
Supervision did not perform assigned responsibilities to protect the worker.	Supervisors are directly responsible for the safety of their work crews. Supervision failed in its responsibilities by not thoroughly reviewing the work package and identifying inconsistencies; not conducting a comprehensive pre-job briefing; directing work in violation of two person rule; and not monitoring adherence to work procedures and safe work practices.
Individuals did not fulfill responsibilities to work safely and in accordance with AlliedSignal FM&T/KC's policies and procedures.	All individuals have the responsibility to perform work in a safe manner. Regardless of having knowledge and skills, individuals did not follow requirements instituted for their protection and others. Supervision did not ensure a safe work environment.

4. CONCLUSIONS AND JUDGMENTS OF NEED

This section of the report identifies the Conclusions and Judgments of Need. Table 4-1, was developed using the analytical methods described in Section 2.0.

The Board reached Conclusions based upon facts and pertinent analytical results. Based on the Conclusions, the Board rendered Judgments of Need (JONs) to identify potential improvements to administrative and engineering controls and safety management systems. The Board believes corrective actions taken in response to the JONs could minimize the likelihood of recurrence or mitigate the severity of this type of accident.

Table 4-1: Conclusions and Judgments of Need

Conclusions	Judgments of Need
<p>A breakdown in communication occurred between the Utilities Department and the Maintenance Department. Line Management failed to identify inconsistencies in the scopes of work.</p> <p>Multiple hazard identification processes exist and are not clearly delineated or integrated effectively into the work.</p> <p>An effective pre-job briefing was not provided to the electricians before the start of HV work activities.</p>	<p>The AlliedSignal FM&T/KC Division 100 needs to ensure that work package documents clearly communicate scope of work, source of hazards and hazard controls and are coordinated and communicated between the Utilities and the Maintenance Departments.</p>
<p>Neither the Maintenance Team Manager nor the Cleaning Team reviewed or followed SI#103B in the performance of the work.</p> <p>The failure to properly implement and oversee the LOTO program exposed workers to unrecognized and uncontrolled hazards.</p> <p>The failure to properly implement and supervise the installation of grounding clusters per SI#103B exposed workers to unrecognized and uncontrolled hazards.</p>	<p>The AlliedSignal FM&T/KC Division 100 and ES&H need to ensure that safe work practices and procedures are coordinated between line and support organizations and followed when conducting HV activities.</p> <p>AlliedSignal FM&T/KC needs to provide refresher training for line managers and other associates on site high voltage electrical requirements.</p>

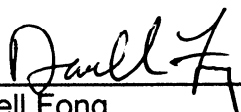
Conclusions	Judgments of Need
<p>The failure to properly implement the two-person rule and to exercise individual stop work authority exposed workers to unrecognized and uncontrolled hazards.</p> <p>The electrical glove program is not functioning properly to ensure electrical glove integrity.</p> <p>Supervisory safety responsibilities were not fully implemented on the day of this accident.</p> <p>Although formal training was completed, the actions of several individuals during the May 24, 1998, outage were not consistent with the training received.</p>	
<p>Feedback and improvement processes are not effective in identifying procedural noncompliances and providing feedback on HV electrical work.</p>	<p>AlliedSignal FM&T/KC Division 100 must take a comprehensive look at day-to-day implementation of its high voltage electrical program to ensure effective implementation and feedback.</p> <p>KCAO needs to ensure that AlliedSignal FM&T/KC effectively implements the high voltage electrical program that meets contractual requirements.</p>
<p>Although emergency response to the accident was timely, it was, in large part, a result of fortunate circumstances. The number of failures in communication and transportation could have significantly delayed the transportation and medical treatment of Electrician #1.</p>	<p>AlliedSignal FM&T/KC management needs to ensure that communication systems are capable of communicating with Emergency Medical Services, that KCP emergency responders are trained to make informed decisions regarding the treatment of individuals involved in electrical accidents, and appropriate means of emergency transportation are used.</p>
<p>Control of the accident scene was not consistent with DOE Order 225.1A, <i>Accident Investigations</i>.</p>	<p>AlliedSignal FM&T/KC needs to ensure that accident scene preservation is effective and consistent with DOE O 225.1A requirements.</p>

5. BOARD SIGNATURES



Karen Boardman
Accident Investigation Board Chairperson
U.S. Department of Energy
Albuquerque Operations Office

Date 7/2/98



Darrell Fong
Board Member
DOE Accident Investigator
U.S. Department of Energy
Kirtland Area Office

Date 7/2/98



Nathan Morley, Board Member
U.S. Department of Energy
Albuquerque Operations Office

Date July 2, 1998



Kent Kerr, Board Member
U.S. Department of Energy
Kansas City Area Office

Date July 2, 1998

6. BOARD MEMBERS, ADVISORS AND STAFF

Chairperson	Karen Boardman, DOE Albuquerque Operations Office
Member	Darrell Fong, DOE Kirtland Area Office
Member	Nathan Morley, DOE Albuquerque Operations Office
Member	Kent Kerr, DOE Kansas City Area Office
Advisor	Scott Gilmore, AlliedSignal FM&T/KC
Administrative Support	Lorenzo Carrillo, DOE Albuquerque Operations Office Raquel Rodrigues, DOE Albuquerque Operations Office

APPENDIX A

memorandum

DATE: MAY 28 1998
REPLY TO: OSHD(98006)
SUBJECT: Establishment of an Investigation Team
TO: David Gurule, Area Manager, KCAO

I hereby establish a Type B Investigation Board to investigate the electrical arc burn of an AlliedSignal Employee at the Kansas City Plant that occurred on May 24, 1998, at approximately 12:16 p.m.

The following individuals are appointed to the Team in the listed capacity:

Team Chairperson: Karen Boardman, T ASD, AL
Accident Investigator: Darrell Fong, Safety Engineer, KAO
Team Members: Nathan Morley, Safety Engineer, OSHD, AL
Kent Kerr, Operations Representative, KCAO
Advisor: Scott Gilmore, Safety Engineer, AlliedSignal,
FM&T/KC

Administrative Support: To Be Determined by KCAO

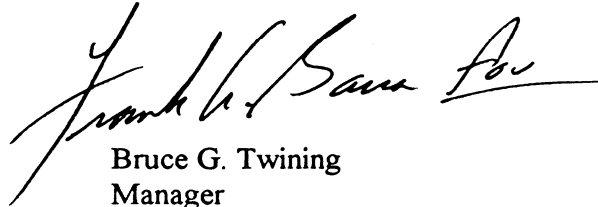
The Board will be assisted by advisors and consultants and other personnel as determined by the Chairperson.

The scope of the Board's investigation will include, but not limited to, identifying all relevant facts; analyzing the facts to determine the direct, contributing, and root causes of the incident; developing conclusions; and determining the judgments of need that, when implemented, reduce the probability of similar recurrence. The investigation will be conducted in accordance with DOE Order 225.1A and will specifically address the role of DOE and contractor organizations and management systems as they may have contributed to the electrical incident. The scope will include the adequacy of the contractor's management system and work practices and make any recommendations as appropriate.

MAY 28 1998

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 casual factors have been completed. Four copies of the draft report should be provided to me by June 29, 1998, for review prior to its preparation in final form. Any delay to this date should 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.

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. The advisors to the Board shall assist the Board in the investigation on a priority basis and provide input to the chairman, as requested. Board Members and advisors are requested to attend an opening briefing with KCAO and Allied Signal to be held in the DOE Manager's Conference Room at the Kansas City Plant, at 8:00 a.m. on June 1, 1998.



Bruce G. Twining
Manager

cc:

V. Reis, DP-1, HQ
E. Ives, DP-20, HQ
D. Rhoades, DP-24, HQ
G. Podonsky, EH-2, HQ
D. Vernon, EH-21, HQ
P. Hoopes, KCAO
M. Zamorski, KAO
L. Kirkman, OTMO, AL
G. Runkle, OSHD, AL
K. Clegg, AlliedSignal

APPENDIX B

**AlliedSignal Federal Manufacturing & Technologies
Document Hierarchy**

Contractual Operating Requirements Database
(Laws, Regulations, Specific DOE Orders, etc.)



Policy Statements
(Corporate and Site Vision and Values -- ISO, ES&H Policy, Safety Principles, VPP Bill of Rights, etc.)



Business Models and ES&H Management Plan
(Functional Business Processes -- Quality Manual, ES&H Manual, etc.)



Process Descriptions
(Program Requirements -- Electrical Safety, LOTO, PPE, Utilities Manual, etc.)



Work Instructions (and Support Forms)
(Implementation Requirements -- Electrical Grounding Clusters, Electrical Training, LOTO Application, LOTO Removal, PPE for Electrical Testing, Development of Switching Instructions, etc.)



Task-Specific Guidance
(Task Requirements -- Production Traveler, Switching Instructions, Maintenance Work Order, Maintenance PM Worksheet, HVPJSC, etc.)



Job Assists
(Support Documentation -- Drawings, Manufacturer's Literature, Operator Manuals, Charts, Diagrams, Guidelines, etc.)

**AlliedSignal Federal Manufacturing & Technologies
High Voltage Work Process**

TECHNICAL ASPECTS

Work Identified



Work Order Generated
(Authorizes and Directs Labor)



Utilities Manual - Chapter 4.1
(HV Switching)



Current System Configuration
(Engineering Drawings)



Job Specific Switching Instructions
Identified



HV Crew Reviews draft SIs



Final Switching Instructions Issued



HVPJSC Safety and Technical Briefing



WORK PERFORMED

(SI and HVPJSC at work site and used in work performance)



SI and HVPJSC Returned to Utilities



HVPJSC Forwarded to S&H

ES&H ASPECTS

Work Identified



Generic HV JHA
(Directs Safety Protocols)



ES&H Process Descriptions
(LOTO, PPE, Electrical Safety)



ES&H Work Instructions
(Electrical Matrix)



Job Specific Safety Related
Requirements Identified



Final Safety Requirements Documented
in HVPJSC



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