



**U. S. Department of Energy
Oak Ridge Operations Office**

**Type B
Accident Investigation
Board Report**

**Subcontractor Employee
Personal Protective Equipment
Ignition Incident
on February 18, 2003
Bechtel Jacobs Company LLC,
East Tennessee Technology Park,
Oak Ridge, Tennessee**

March 2003

**Type B Accident Investigation Board Report of the
Subcontractor Employee Personal Protective
Equipment Ignition Incident on February 18, 2003
Bechtel Jacobs Company LLC,
East Tennessee Technology Park,
Oak Ridge, Tennessee**

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**Oak Ridge Operations Office
U.S. Department of Energy**

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INDEPENDENT REPORT

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

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


This report neither determines nor implies liability.

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RELEASE AUTHORIZATION

On February 21, 2003, I appointed a Type B Accident Investigation Board to investigate the February 18, 2003, personal protective equipment ignition incident at Pad K-1302 at the East Tennessee Technology Park. The responsibilities of the Accident Investigation Board have been satisfied with respect to this investigation. The analysis and the identification of contributing and root causes and Judgments of Need resulting from this investigation were performed in accordance with Department of Energy Order 225.1A, *Accident Investigations*.

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


for Gerald G. Boyd
Manager
Oak Ridge Operations Office

Date Accepted: 3-17-03

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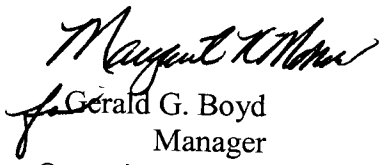
PROLOGUE

This Type B Accident Investigation is an important reminder that the activities we carry out every day have important safety and health implications.

Many of the activities performed for the Oak Ridge Operations Office (ORO) involve the routine use of potentially dangerous industrial equipment to accomplish the work. This equipment has the potential to cause serious personal injury and property damage unless appropriate safety measures are implemented. Therefore, it is imperative that the guiding principles and core functions of Integrated Safety Management are carried out from the highest level of the organization down to the work being performed.

This Type B Accident Investigation report is important in improving safety at Oak Ridge. The lessons learned contained in this report are applicable to all types of work activities. The report provides lessons on many aspects of conducting work safely and represents ORO's continued commitment to support the U.S. Department of Energy's *Safety Management System Policy*.

I trust that all Federal employees and contractors supporting ORO will take the time to read this report, think about its applicability to their work, and recognize that every piece of equipment represents a unique challenge to identify and negate its hazards. I encourage all Federal and contractor employees to vigorously continue their efforts to fully implement Integrated Safety Management.


Gerald G. Boyd
Manager
Oak Ridge Operations Office

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ACRONYMS

AHA	Activity Hazard Analysis
Anti-c	Anticontamination
ASTM	American Society of Testing and Materials
BJC	Bechtel Jacobs Company LLC
Board	Type B Accident Investigation Board
CAP	Corrective Action Plan
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
COR	Contracting Officer's Representative
D&D	Decontamination and Decommissioning
DEAR	Department of Energy Acquisition Regulation
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
EMEF	Environmental Management/Enrichment Facilities
EMWMF	Environmental Management Waste Management Facility
ES&H	Environment, Safety, and Health
ETTP	East Tennessee Technology Park
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
M&I	Management and Integration
MACTEC	MACTEC Constructors, Inc.
Main Plant ES&H Plan	MACTEC <i>Environmental, Safety, and Health Plan for Main Plant Demolition Project</i>
NFPA	National Fire Protection Association
NTS	Noncompliance Tracking System
ORO	Oak Ridge Operations Office
ORPS	Occurrence Reporting and Processing System
POD	Plan of the Day
PPE	Personal Protective Equipment
PSS	Park Shift Superintendent
Rep	Representative
RWP	Radiological Work Permit
safety manual	<i>Cut-Off Machine Safety Manual</i>
STR	Subcontract Technical Representative
WSS	Work Smart Standards

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EXECUTIVE SUMMARY

The Event

On February 18, 2003, a general laborer employed at the East Tennessee Technology Park (ETTP) by MACTEC Constructors, Inc. (MACTEC) was performing rebar removal with a gas-powered cut-off machine. MACTEC is a subcontractor to Bechtel Jacobs Company LL (BJC). The sparks from the cut-off machine ignited the right leg of his 100% cotton anticontamination (anti-c) coveralls and the plastic bootie. The laborer extinguished the smoldering portion of his anti-c coveralls by patting the area with his leather-gloved hand. His coworker, who was standing by with a water-pump sprayer for dust control, sprayed water to extinguish the smoldering Personal Protective Equipment (PPE). The anti-c PPE coveralls had been ignited by sparks generated from the Stihl Model TS 510 AV Cutquik® cut-off machine that was being used to remove rebar protruding from the concrete at the K-1302 pad in this decontamination and decommissioning/demolition project. A hole approximately six-inches in diameter was burned through the lower right leg of the cotton anti-c coveralls and the bootie. The laborer was not injured.

A previous incident in May 2002 also resulted in a laborer's PPE being burned by sparks from the same type of Stihl Cutquik® cut-off machine. The PPE did not ignite, but the material was charred, and it resulted in a lessons learned by the subcontractor. However, this lessons learned was only disseminated internally and was not included in the BJC or Department of Energy (DOE) lessons learned system. The laborer was not injured in the incident. Four similar events (two at Hanford facilities and two at Oak Ridge Operations Office [ORO] facilities) have resulted in laborers' anti-c coveralls being burned.

Although the May 2002 incident was only known to MACTEC personnel and neither of the incidents resulted in injuries to the laborers, the significance of these incidents is heightened due to an occurrence involving a welder's death at ETTP on February 13, 1997. (*Type A Accident Investigation Board Report on the February 13, 1997, Welding/Cutting Fatality at the K-33 Building, K-25 Site, Oak Ridge, Tennessee, EH2MGT/04-97/01AI*, April 1997; also available at the DOE Accident Investigation web site at www.eh.doe.gov/cas/aip/). The welder suffered fatal burns after his anti-c clothing caught fire during a cutting operation.

ORO management, after evaluating the conditions associated with this incident and considering the previous events, determined that a Type B Accident Investigation should be conducted in accordance with DOE Order 225.1A, *Accident Investigations*. The Accident Investigation Board convened on February 24, 2003, and began investigating the circumstances involving the ignition of the laborer's PPE and determining root causes and Judgments of Need to prevent recurrence.

Background

MACTEC is a subcontractor to Bechtel Jacobs Company LLC (BJC), the management and integration contractor for ORO's Environmental Management Program, which includes work at ETPP. MACTEC had been subcontracted to decontaminate and demolish buildings at ETPP as part of the Main Plant Decontamination and Decommissioning (D&D) Project. MACTEC performed characterization, removed contaminated components, decontaminated selected materials when economically practical, demolished the superstructures to the slab or grade, and disposed of the waste. At the time of the incident, work was at a point that rubble piles were being loaded on trucks for shipment to the Environmental Management Waste Management Facility (EMWMF), which is the Oak Ridge Reservation on-site Comprehensive Environmental Response Compensation and Liability Act disposal landfill. The waste shipments were halted because the EMWMF was temporarily closed due to heavy rain. To keep the labor force occupied during this shipping stoppage, a decision was made to have them remove protruding rebar from the K-1302 concrete pad. Since the work area was considered to be a contamination area, entry required the workers to wear anti-c PPE. Although the MACTEC *Activity Hazard Analysis for General Construction Hazards* required this operation to be carried out using a hot work permit, the permit was not obtained because BJC procedure BJC-EH-2007, *Welding/Burning/Hotwork*, dated December 15, 2002, does not address grinding. This decision was made based on the advice of the BJC Safety Advocate who had determined that the BJC hot work permit procedure was not applicable to this operation.

Significant changes had occurred in the project staffing for both BJC (safety advocate and subcontract technical representative) and MACTEC (environment, safety, and health representative, project manager, and site superintendent). Over the last 11 months, there had been 25 individuals who have occupied 10 positions that were involved in the Main Plant D&D Project. Due to this large staff changeover in key critical positions over a short period, lack of project and work knowledge contributed to failures that allowed the incident to occur.

Conclusions

The Board concludes that this accident was preventable. The direct cause of this incident was the impingement of hot sparks on the leg of the laborer's 100% cotton anti-c coveralls. MACTEC project staff selected the cut-off machine based only on its availability. The hazards and its appropriateness for the task were not evaluated. The laborer did not have sufficient knowledge of the proper techniques and the hazards associated with the cut-off machine, and he allowed the hot sparks to impact his leg, which resulted in the ignition of the anti-c coveralls. This incident was allowed to occur because the hazard control process failed to evaluate the hazards caused by operation of the cut-off machine. Neither BJC's nor MACTEC's hazard analysis process properly evaluated this hazard. Although the *Activity Hazard Analysis for General Construction Hazards* indicates that a hot work permit is required for the task, MACTEC accepted the BJC's advice (taking it as direction) that the BJC procedure for hot work did not require

a hot work permit for this activity. That decision allowed the laborer to wear 100 % cotton anti-c coveralls. His body position was incorrect when using the cut-off machine, and the combustible anti-c coveralls were ignited when the sparks impinged on his leg.

The Board identified one root cause for this event: *BJC's and MACTEC's work control process was inadequate.*

Table ES-1. Judgments of Need

JON No.	Judgment of Need	Direct, Contributing, and Root Causes
JON 1	BJC and its subcontractors need to fully implement the ISM program. Particular emphasis is needed in the identification of hazards, work controls, and feedback mechanisms.	D1, R1 C2, C3, C4, C5, C6, C9
JON 2	BJC needs to develop an effective process that ensures formal, two-way communication with its subcontractors.	C1, D1
JON 3	BJC and its subcontractors need to ensure that the requirements for training are appropriately identified and personnel are adequately trained.	C9
JON 4	BJC and its subcontractors need to develop and implement a system to facilitate sharing of work practices, issues, and solutions for effective lessons learned.	C2, C7
JON 5	ORO needs to establish a policy that clearly defines the use of fire-retardant, anti-c coveralls.	C5, C6, C7
JON 6	ORO needs to develop a risk-based policy for balancing the assignment of facility representatives and subject matter experts on special projects with contractor oversight responsibilities.	C8

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1.0 INTRODUCTION

1.1 Background

On February 18, 2003, an employee of MACTEC Constructors, Inc. (MACTEC) was working on the K-1302 pad at the East Tennessee Technology Park (ETTP). The employee was using a cut-off machine with an abrasive wheel to cut rebar when the sparks ignited the 100% cotton anticontamination (anti-c) coveralls and the plastic bootie on his right leg. The ignition was evident by the smoldering Personal Protective Equipment (PPE). The smoldering PPE was extinguished, and no injuries were sustained from this incident. MACTEC is a subcontractor to Bechtel Jacobs Company LLC (BJC). Figure 1 is a photograph of the K-1302 pad.

On February 19, 2003, U. S. Department of Energy (DOE) Oak Ridge Operations Office (ORO) management categorized the incident as a Type B. Gerald Boyd, ORO Manager, formally appointed a Type B Accident Investigation Board (Board) to investigate the incident in accordance with DOE Order 225.1A, *Accident Investigations* (see Appendix A) on February 21, 2003. This report documents the facts of the incident and the conclusions of the Board.



Figure 1. K-1302 Pad at ETTP

1.2 Facility Description

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

The mission of ETTP is environmental cleanup and reindustrialization/reuse of the assets (i.e., facilities, equipment, materials, utilities, and trained workforce) of the shutdown gaseous diffusion plant. This mission is being accomplished by cleaning up the site through the DOE Environmental Management Program's Management and Integration (M&I) contract with BJC and by forming partnerships with commercial interests who conduct environmental restoration, Decontamination and Decommissioning (D&D), waste treatment and disposal, and diffusion technology development in exchange for reduced rents.

ETTP serves as the base of operations for environmental management of ORO's facilities. These activities include management of the Toxic Substances Control Act Incinerator, which is the only United States facility capable of incinerating certain radioactive and/or hazardous wastes within permitted air emission requirements. Other activities at ETTP include treatment, storage, and disposal of hazardous and radioactive waste and support of risk-based environmental cleanup programs for contaminated facilities and natural resources at DOE's facilities in Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio.

1.3 Scope, Conduct, and Methodology

The Board began its activities on February 24, 2003, and completed its investigation on March 14, 2003. The scope of the Board's investigation was to identify all relevant facts; analyze the facts to determine the direct, contributing, and root causes of the incident; develop conclusions; and determine Judgments of Need that, when implemented, should prevent recurrence of the incident. The investigation was performed in accordance with DOE Order 225.1A, *Accident Investigations*, using the following methodology:

- Facts relevant to the incident were gathered through interviews and reviews of documents and evidence.
- The incident scene was inspected, and photographs were taken of the scene, the laborer's PPE, and the cut-off machine. In addition, photographs were taken of a demonstration of the laborer dressed in his PPE re-enacting his movements with the cut-off machine.
- Facts were analyzed to identify the causal factors using event and causal factors analysis, barrier analysis, root cause analysis, and change analysis.
- Judgments of Need for corrective actions to prevent recurrence were developed to address the causal factors of the incident.

Accident Investigation Terminology

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

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

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

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

2.0 FACTS

2.1 Event Description and Chronology

2.1.1 Event Description

During the investigation, numerous MACTEC and BJC personnel changes were evident to the Board, and it was difficult to keep track of just who was on the job site when important incidents occurred. Tracking personnel changes became pivotal to the Board's analysis, especially in the area of feedback and improvement. Over an 11-month period, there were 25 individuals occupying 10 positions in the BJC and MACTEC project staffs. Figures 3 and 4 illustrate the BJC and MACTEC personnel changes on the project. For convenience, each successive change in personnel for a single position has been numbered.

The scope of the BJC contract with DOE (DE-AC05-98OR22700) is to conduct environmental restoration, D&D, and waste treatment and disposal activities. MACTEC's subcontract with BJC was for the work associated with the Main Plant D&D Project (23900-SC-ET081F). During the normal progression of the MACTEC project, operations switched focus from demolition to waste removal, demobilization, and final area disposition. During this transition phase in March 2002, MACTEC began self-performing the work as its teaming partner, DEMCO, demobilized and left the job site.

On May 16, 2002, MACTEC had a burnthrough incident on the knee of a pair of FR MarGard® disposable, flame-retardant, anti-c coveralls while using a Stihl Model TS 510 AV Cutquik® cut-off machine. (See Figure 2.) Use of the cut-off machine was allowed to continue when MACTEC decided to use conventional cotton, fire-retardant coveralls for



future hot work. In addition, BJC Safety Advocate-1 told MACTEC Project Manager-1 to have the workers wear leathers chaps when using the cut-off machine, since MACTEC had them on the job site. He also cautioned them on body positioning. The AHA was revised to include grinding activities as hot work but without mention of the leather chaps. MACTEC performed a lessons learned on the spark

Figure 2. Stihl Cut-Off Machine

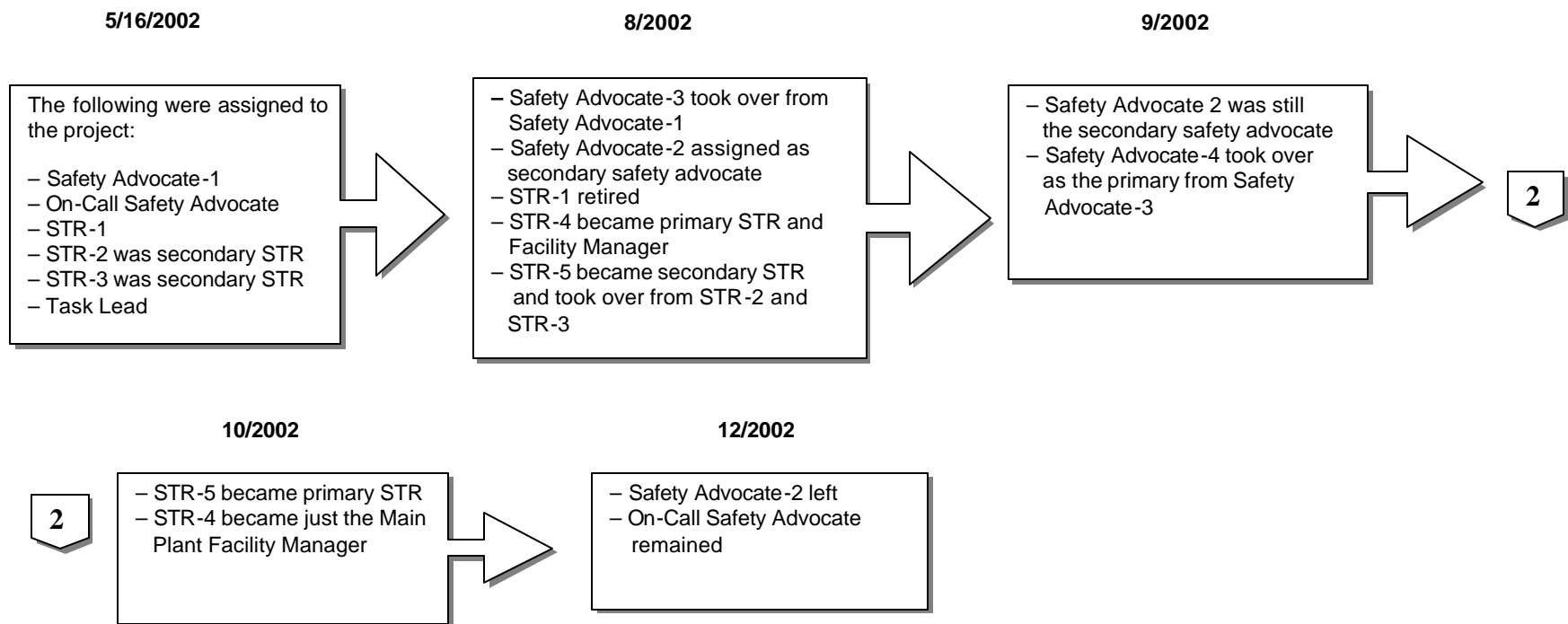


Figure 3. BJC Personnel Changes

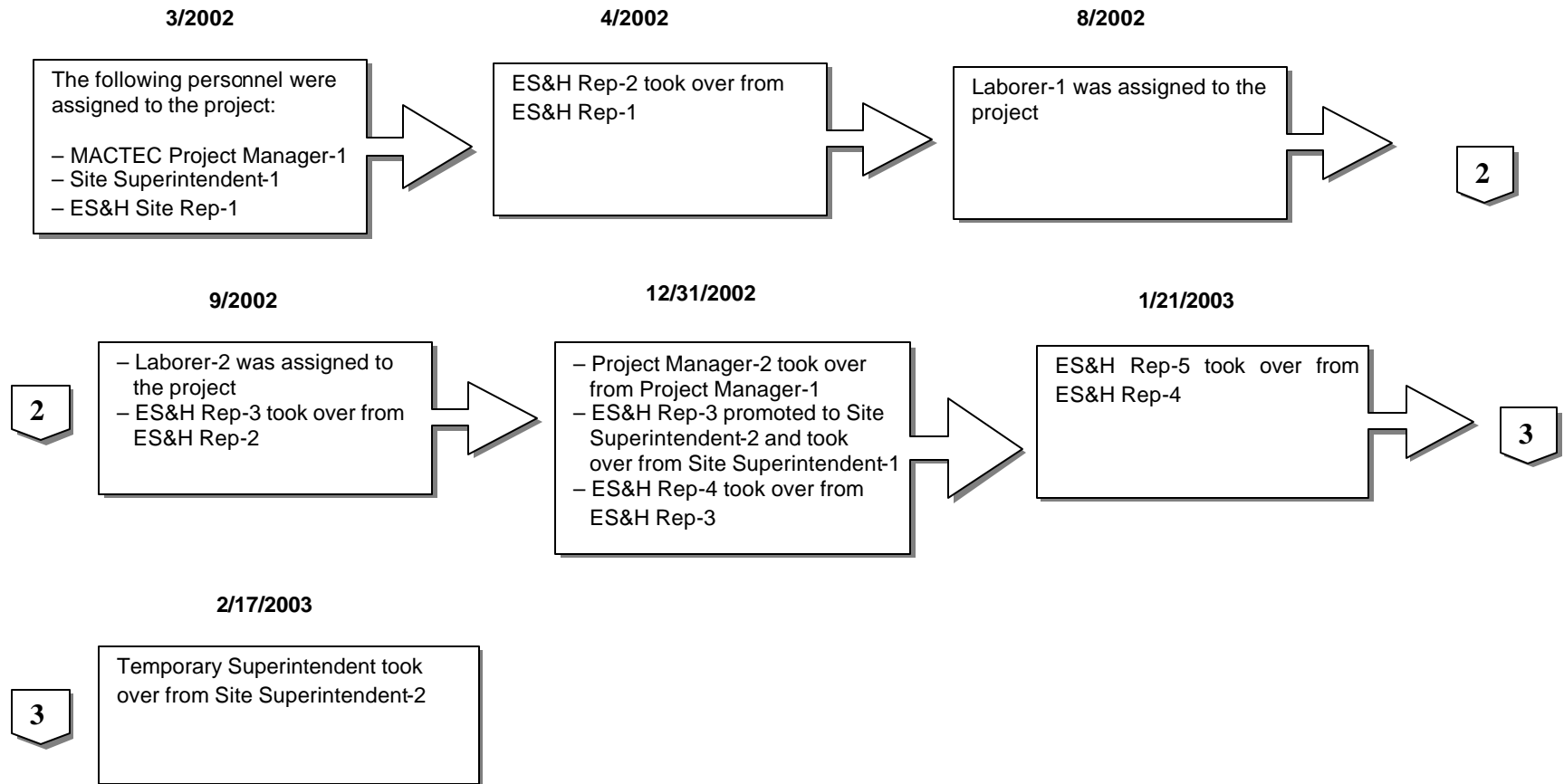


Figure 4. MACTEC Personnel Changes

incident, but it was only documented and shared internally. The lessons learned was never entered in the BJC Lessons Learned System or, subsequently, the DOE Lessons Learned System. BJC personnel never followed up on the incident or the status of the lessons learned.

In August 2002, BJC required MACTEC to have a two-week safety stand-down for work control problems. The incidents prompting the stand-down were as follows:

- June 25, 2002 – Rebar went through the glass of a trackhoe
- July 10, 2002 – A worker received a minor cut through his glove
- July 15, 2002 – A worker in Building K-1413 was contaminated (reported in the DOE Occurrence Reporting and Processing System [ORPS])
- July 22, 2002 – A worker fell on pavement
- July 23, 2002 – A worker entered a B-25 box to retrieve a bolt
- August 1, 2002 – A four-inch vent line was dropped from the jaws of a trackhoe, causing a contamination incident
- August 2, 2002 – A pipe hanger broke on a four-inch vent line
- August 5, 2002 – A rhenium hexafluoride cylinder was opened without authorization; the activity was not in the hazard analysis

The root cause of these incidents was determined to be MACTEC's "Management Deficiency."

In October 2002, BJC issued Revision 4 of BJC-GM-1400, *Integrated Safety Management System Description*. BJC is currently working toward reverification of the implementation of its Integrated Safety Management System (ISMS). The ORO Manager revoked BJC's ISMS implementation on November 1, 2001, due to lack of progress in maturing the program, that improvements based on feedback were too slow, and the October 15, 2001, letter from the Defense Nuclear Facilities Safety Board (DNFSB) to Under Secretary Robert Card concerning the same topics.

In December 2002, MACTEC had two similar contamination incidents that led to the removal of several key MACTEC personnel. Both incidents involved the loss of contamination control while removing piping from the same system, although in different locations. Both pipes were internally contaminated, with glovebags taped to the ends. Both incidents were entered into ORPS, and both of them had the same direct, contributing, and root causes (ORO-BJC-K25GENLAN-2002-0021 and ORO-BJC-K25GENLAN-2002-0022). In the case of the second incident, BJC, SEC RadCon Alliance (the radiological controls subcontractor to BJC), and some MACTEC personnel had recommended against going forward with the removal activity due to the late start of the job. Starting that late would result in the work being performed with inadequate lighting, which would be a violation of the MACTEC Activity Hazard Analysis (AHA). However, MACTEC Project Manager-1 proceeded anyway. As a result of these incidents and BJC's verbal request, the following personnel changes occurred on December 31, 2002:

- MACTEC Project Manager-2 took over from Project Manager-1
- MACTEC Environment, Safety, and Health Representative (ES&H Rep)-3 was promoted to Site Superintendent-2 and took over from Site Superintendent-1
- MACTEC ES&H Rep-4 took over from ES&H Rep-3

A stipulation of the MACTEC subcontract (Exhibit GC-15, “Superintendence of Subcontractor,” effective August 15, 2000) is that all BJC requests for removal of any subcontract personnel must be in writing. To date, BJC has not transmitted a formal letter to MACTEC to request removal of those personnel.

On January 7, 2003, the DOE Facility Representative was assigned full time to the Documented Safety Analysis Review Team. As a result, his time in his assigned facilities dropped from 40% to 10% of his time at work. Also in January 2003, many of the DOE Site Office ES&H staff members were assigned to the joint DOE/BJC Safety Management Programs Review of BJC.

On February 17, 2003, the MACTEC Temporary Superintendent took over from Site Superintendent-2 due to the latter’s absence for one week of sick leave. The MACTEC Temporary Superintendent was superintendent of a heavy construction site on another MACTEC project at the Oak Ridge National Laboratory. Due to the heavy rain during the previous weekend, the Environmental Management Waste Management Facility (EMWMF), which is the on-site Comprehensive Environmental Response Compensation and Liability Act (CERCLA) landfill, was shut down. That halted all DOE disposal shipments, including shipments from MACTEC. With the day’s planned work halted, the MACTEC Temporary Superintendent and BJC Subcontract Technical Representative (STR)-5 discussed the outstanding work that could be used to keep the two laborers busy. BJC STR-5 and the MACTEC Temporary Superintendent discussed three tasks, and the only one that could be performed was rebar removal from the K-1302 pad. See Figure 5 for a closeup of some of the rebar on the K-1302 pad.

A tool selection discussion between the MACTEC Temporary Superintendent and BJC STR-5

ensued, resulting in selection of the cut-off machine. The cut-off machine was the third choice because the acetylene torches had been removed as part of the demobilization activities and the hand-held band saws on site were contaminated with fissile material and thus not available. The cut-off machine was last used in May 2002, but none of the personnel involved in the tool selection discussion on February 17, 2003, were on the project in May.



Figure 2. Closeup of Rebar at K-1302 Pad

The Board found no evidence that the cut-off machine had been maintained in accordance with the manufacturer's *Cut-Off Machine Safety Manual* (safety manual). The Board determined that BJC Safety Advocate-4 had professed to have experience in the cut off machine's use and hazards but believed that it was not his place to recommend a different tool. The Board has also determined that BJC Safety Advocate-4 had excused himself from several work scope discussions, claiming that "contract scoping matters" were out of a safety advocate's scope of work.

BJC STR-5 had no experience with the cut-off machine and asked MACTEC ES&H Rep-5 to confirm that rebar removal and use of the cut-off machine were covered in the AHA (2000-2, Revision 14). The MACTEC Temporary Superintendent asked Laborer-1 if he could operate a cut-off machine. Laborer-1 responded that he had used one on a previous job. The Board later determined that Laborer-1's experience was on cutting concrete and large bar stock.

MACTEC ES&H Rep-5 noted that the AHA required a hot work permit. He asked BJC Safety Advocate-4 to verify in BJC-EH-2007, *Welding/Burning/Hotwork*, the need for a hot work permit to cut rebar. MACTEC ES&H Rep-5 understood that the BJC hot work procedure had changed from the last time he was assigned to the project in 2000. At that time, grinding/spark-producing activities were covered in the procedure. After completing his review of BJC-EH-2007, Safety Advocate-4 concluded that it might not apply to the job because they did not plan to use a flame to cut the rebar, but he was unsure. BJC Safety Advocate-4 attempted to locate a subject matter expert on BJC-EH-2007 but failed due to the late time of day. BJC STR-5 left a message for one of the hot work permit approval authorities (STR-3) concerning the need for a hot work permit the following morning. STR-5 believed that a hot work permit was required and was not aware of the interaction between MACTEC ES&H Rep-5 and BJC Safety Advocate-4.

On February 18, 2003, before the MACTEC Plan of the Day (POD) Meeting, BJC Safety Advocate-4 informed MACTEC ES&H Rep-5 that a hot work permit was not needed per the BJC procedure but that he planned to verify that after the MACTEC POD Meeting. BJC Safety Advocate-4 rendered the applicability decision before contacting a subject matter expert. MACTEC ES&H Rep-5 accepted the "not applicable" decision as direction from BJC despite the AHA requirement. One of the minor issues in the August 2002 stand-down was that BJC personnel had been improperly directing MACTEC employees, without MACTEC management's knowledge, in an informal manner that was not in accordance with BJC's procedures. Believing that a hot work permit would be required, MACTEC ES&H Rep-5, a qualified fire watch trainer, was prepared to give fire watch training if a hot work permit was required.

At 6:30 am, the MACTEC POD Meeting/Prejob Brief covered waste disposal work and the rebar removal job. During the POD Meeting, MACTEC ES&H Rep-5 announced that a hot work permit would not be used for the rebar removal job. Laborer-1 and Laborer-2 were assigned to the rebar removal job, with Laborer-1 assigned to the cut-off machine and Laborer 2 assigned to control dust with a water-pump sprayer. (See Figure 6 on the next page for a photograph of the sprayer.) No one in attendance at the POD Meeting was aware of the previous MACTEC incident with the cut-off machine, so the lessons learned write-up from

that May 2002 MACTEC incident was not reviewed. The Board has determined that the manufacturer's safety manual for the cut-off machine was not present at the job site, so no one could have reviewed it prior to the start of the rebar removal job. The manufacturer's warning label on the cut-off machine was not reviewed, even though it covers the risk of fire. (See Figure 11 on page 2-23 for a photograph of the warning label.) Just before the POD Meeting ended, BJC Safety Advocate-4 left to call a subject matter expert on the applicability of BJC-EH-2007 to rebar removal.



Figure 3. Water-Pump Sprayer

At the same time everything described in the previous paragraph was occurring, BJC STR-5 informed the MACTEC Temporary Superintendent that a hot work permit would be available after the Park Shift Superintendent (PSS) Safety Stand-Up Meeting. BJC STR-5 received a cellular telephone call from the BJC STR for the EMWFM landfill, who requested startup of the MACTEC waste shipments. BJC STR-5 relayed the landfill availability status in a discussion with the MACTEC Temporary Superintendent. The Board has determined that at the end of the POD Meeting, BJC STR-5 still believed that a hot work permit was needed, although all of the others in attendance believed that one was not needed.

Immediately after the POD Meeting, the BJC Safety Lead informed BJC Safety Advocate-4 via cellular telephone that the BJC hot work procedure (BJC-EH-2007) does not require a hot work permit for a rebar removal job if grinding will be performed. The BJC Safety Lead is a mentor for the safety advocates and provides assistance if any safety advocate requests help or needs a second opinion. BJC Safety Advocate-4 had not provided any specifics on the task other than the fact that grinding and use of an abrasive disk would be involved. The BJC Safety Lead's answer was strictly based on procedural applicability. The Safety Lead did not ask for specific details on the planned task before rendering his decision.

BJC-EH-2007 does not reflect the latest changes from the 1999 version of National Fire Protection Association (NFPA) 51B, which includes grinding as hot work. BJC revised the procedure, and it was approved on December 15, 2002. BJC Fire Protection Engineering personnel were included in the revision process, but not all of their comments were reflected in the revision. As a result, not all of the requirements from NFPA 51B were incorporated. In addition, the American Society of Testing and Materials (ASTM) standards referenced in the procedure were not updated to reflect the most current standards.

BJC Safety Advocate-4 informed BJC STR-5 that a hot work permit was not required. Still believing a permit was required, BJC STR-5 asked if BJC Safety Advocate-4 understood the hazards and operation of the cut-off machine. Although BJC Safety Advocate-4 restated his knowledge of the cut-off machine, BJC STR-5 called the MACTEC Temporary Superintendent. There is a conflict in the testimony, and the Board could not determine the subject of the conversation.

Just before the PSS Safety Stand-Up Meeting, Safety Advocate-4 confirmed to MACTEC ES&H Rep-5 and the Temporary Superintendent that a hot work permit was not needed per the BJC hot work procedure. MACTEC ES&H Rep-5 and the Temporary Superintendent accepted that a hot work permit was not required, even though the decision was in conflict with the AHA requirements. They were not aware of the May 2002 MACTEC incident with the cut-off machine. MACTEC ES&H Rep-5, therefore, did not train Laborer-2 as a fire watch. Instead, Laborer-2 was assigned to control the dust generated by the cut-off machine with a water-pump sprayer. The laborers did not review the lessons learned from the May 2002 incident, since no one from May 2002 was on the project, and no one looked for any applicable lessons learned. In addition, the laborers did not know that the warning in the manufacturer's safety manual included the risk of setting clothing on fire, and they did not know if the manufacturer's safety manual was on the job site. The Board has determined that the manufacturer's safety manual on the cut-off machine was not on the job site and was printed from the manufacturer's web site after the February 18 incident.

At 7:30 am, the PSS held the usual Safety Stand-Up Meeting to discuss all work scheduled to be performed at ETPP that day. The only MACTEC work that was discussed at the PSS Safety Stand-Up meeting was the waste-handling task and the K-1302 pad-washing activities. The rebar removal job was not mentioned. At the PSS Safety Stand-Up Meeting, BJC STR-5 confronted BJC Safety Advocate-4 about the issue of a hot work permit while the BJC hot work approval authority (STR-3) was present. BJC Safety Advocate-4 reconfirmed to STR-5 the judgment call that a hot work permit was not applicable to the rebar removal job, although his question to the BJC Safety Lead had been on generic grinding activities. After being reassured several times by all of the subject matter experts on their knowledge of the use and hazards of the cut off machine, BJC STR-5 let the issue drop.

During the PSS Safety Stand-Up Meeting, BJC STR-5 informed the Main Plant Facility Manager about MACTEC's planned activities for the day. However, since rebar removal had been performed before, BJC STR-5 did not consider it a "new" task; therefore, the STR did not mention the planned rebar removal activity or use of the cut-off machine to the Facility Manager. The Facility Manager was aware of the risks involved in the cut-off machine's operation and had sufficient knowledge to recommend against its use.

At 8:00 am, SEC RadCon Alliance personnel entered the K-1302 pad and performed a radiological and contamination survey of the rebar and the pad. The contamination and radiation levels were below the detectable limits of the instruments. These results were not new, since all of the contamination and radiological surveys of the K-1302 pad have been below the detectable limits of the instruments since 2001. The area posting is based on surveys performed prior to 2001, and it has not been downposted due to "suspect contamination" concerns.

At 8:30 am, Laborer-1 and Laborer-2 entered the Boundary Control Station. In accordance with Radiological Work Permit (RWP) RWP-2002-1075, dated April 23, 2002, they dressed in standard anti-c clothing that included clear, 3-mil polyethylene booties supplied by MACTEC and leather gloves. (See Figure 7 on the next page.) This level of required anti-c

is equivalent to a contamination level of 5,000 dpm/100 cm². The RWP discusses the PPE requirements when a hot work permit is required and references MACTEC AHA-2000-02, which covers rebar removal. Abrasive work is similarly addressed, but it excludes reference to hot work PPE.

Laborer-1 and Laborer-2 walked onto the job site with all of the necessary tools (cut-off machine and water-pump sprayer). Laborer-1 cut ten pieces of rebar with his left hand on the throttle, which aligned the cut-off machine at his torso's centerline and put the abrasive cutting wheel horizontal to the pad. (See Figure 13 on page 2-30 for a photograph of Laborer-1 holding the cut-off machine in the



incorrect position.) This technique allowed the resultant sparks to strike and ignite the PPE on Laborer-1's right leg. The Board has determined that Laborer-1 used this technique due to a physical impairment from a previous (nonjob related) double compound fracture of his left arm. This injury limits use of Laborer-1's arm. The manufacturer's safety manual for the Stihl Model TS 510 AV Cutquik® cut-off machine states that the authorized technique to use the machine is to put the right hand on the throttle (for both left- and right-hand dominance), position the machine to the right of the body (the same as if using a chain saw) to prevent the sparks created during use from igniting the operator's clothes, and only use the machine in a vertical cutting motion to prevent catastrophic failure of the abrasive wheel by excess lateral forces.

Standard Anti-C PPE

- 1 pair 100% cotton coveralls
- 1 pair cotton gloves
- 2 pair surgical gloves
- 1 pair leather work gloves
- 1 pair booties
- 1 pair shoe covers

All seams that are not sealed with a zipper must be taped.

Figure 4. Laborer Wearing Standard Anti-C PPE



Figure 5. Burned PPE - Clear Plastic Bootie

At approximately 9:00 am, both laborers noticed that Laborer-1's plastic bootie was smoldering. Laborer-1 patted the smoldering pant leg with his gloved hand, and Laborer-2 used the water-pump sprayer to extinguish the same area. The smoldering anti-c PPE was successfully extinguished, even though Laborer-2 was not trained as a fire watch and the water-pump sprayer had been supplied for dust control. The sprayer was a model PCT-25, 2½-gallon, pump-tank

fire extinguisher. Laborer-1 and Laborer-2 walked back to the Boundary Control Station, removed their PPE, and placed it into the disposal receptacles. Only some of the PPE (one bootie, one shoe cover, and the anti-c coveralls) was recovered for this investigation because it had not been segregated. (See Figures 8, 9, and 10.) (This discrepancy did not hinder the

Board's investigation.) Laborer-1 and Laborer-2 exited the Boundary Control Station and reported the incident to MACTEC Temporary Superintendent at approximately 9:15 am.

The MACTEC Temporary Superintendent reported the incident to the MACTEC ES&H Rep-5 and BJC STR-5. MACTEC ES&H Rep-5 directed Laborer-1 and Laborer-2 to write up statements concerning the incident. This took the laborers until approximately 9:45 am. MACTEC ES&H Rep-5 and BJC STR-5 independently contacted BJC Safety Advocate-4.



Figure 6. Burned PPE - Anti-C Pant Leg



Figure 7. Burned PPE - Shoe Scuff

BJC STR-5, BJC Safety Advocate-4, and the MACTEC personnel were at the site. Over the course of the rest of the afternoon, the following personnel arrived at the site:

DOE ETP Closure Director
DOE Facility Representative
DOE Site Office ES&H contractor
BJC Manager of Projects
BJC Task Lead

BJC On-Call Safety Advocate
BJC Safety Lead
BJC D&D Project Manager
PSS representative

At 5:52 pm, BJC senior management issued an electronic mail message directing a hot work stand-down for all plants where BJC performs work. Hot work would be approved on a task-by-task authorization basis only.

BJC performed a critique on February 19, 2003, to review the findings of the initial investigation of the incident. Also on February 19, 2003, the ORO Manager determined that the incident warranted a Type B Accident Investigation. The ORO Manager commissioned the Board on February 21, 2003.

2.1.2 Chronology of Events

Table 2-1 provides the events leading up and immediately following the PPE ignition incident on February 18, 2003. The information in this table is also presented in a graphical illustration in Appendix E, Events and Causal Factors Chart.

Table 2-1. Event Chronology

Date	Time	Event
3/2/2002		MACTEC Project Manager-1, Site Superintendent-1, and ES&H Rep-1 were assigned to the project. MACTEC began self-performed work.
4/2002		MACTEC ES&H Rep-2 took over from ES&H Rep-1.
5/16/2002		<p>The BJC personnel assigned to the project at the time were as follows:</p> <ul style="list-style-type: none"> – Safety Advocate-1 and the On-Call Safety Advocate – STR-1 – STR-2 was a secondary STR – STR-3 was a secondary STR – Task Lead
		MACTEC had a burnthrough incident on the knee of flame-retardant, anti-c clothing while using a cut-off machine (i.e., a Stihl Model TS 510 AV Cutquik® cut-off machine).
		MACTEC performed a lessons learned on the spark incident, but it was only documented and shared internally. BJC did not follow up on the lessons learned.
5/2002		MACTEC decided to continue use of the cut-off machine with conditions imposed by BJC (i.e., use conventional cotton, fire-retardant coveralls for future hot work and workers are to wear leather chaps when using the cut-off machine).
8/2002		MACTEC had a two-week safety stand-down for work control problems. Eight incidents had occurred between June 25 and August 5, 2002.
		<p>The BJC personnel changes on the project at this time were as follows:</p> <ul style="list-style-type: none"> – BJC STR-1 retired – BJC STR-4 became the primary STR and was also made the Main Plant Facility Manager – BJC STR-5 became the secondary STR and took over from STR-2 and STR-3 – BJC Safety Advocate-3 took over from Safety Advocate-1 as the primary safety advocate – BJC Safety Advocate-2 was assigned as the secondary safety advocate

**Table 2-1. Event Chronology
(continued)**

Date	Time	Event
9/2002		Laborer-2 was assigned to the project.
		<ul style="list-style-type: none"> – MACTEC ES&H Rep-3 took over from ES&H Rep-2. – BJC Safety Advocate-4 took over from Safety Advocate-3 as primary. – Safety Advocate-2 was still the secondary safety advocate.
10/2002		BJC issued Revision 4 of BJC-GM-1400, <i>Integrated Safety Management Description</i> .
		<p>The BJC personnel changes on the project at this time were as follows:</p> <ul style="list-style-type: none"> – BJC STR-5 took over as the primary STR from STR-4 – BJC STR-4 was no longer assigned the role of STR and became just the Main Plant Project Facility Manager
11/2002		<ul style="list-style-type: none"> – BJC Safety Advocate-2 left. – The On-Call Safety Advocate remained assigned to the project.
12/26/2002		<p>MACTEC had a second contamination incident for the month, which led to management changes requested by BJC. However, BJC’s direction for removal was verbal and was never provided in writing.</p>
12/31/2002		<ul style="list-style-type: none"> – MACTEC ES&H Rep-3 was promoted to Site Superintendent-2 and took over from Site Superintendent-1. – MACTEC Project Manager-2 took over from Project Manager-1. – MACTEC ES&H Rep-4 took over from ES&H Rep-3.
1/7/2003		The DOE Facility Representative was assigned full time to the Documented Safety Analysis Review Team.
1/2003		Many of the DOE Site Office ES&H staff members were assigned to the joint DOE/BJC Safety Management Programs Review of BJC.
1/21/2003		MACTEC ES&H Rep-5 took over from ES&H Rep-4.
2/17/2003		MACTEC Temporary Superintendent took over from the Site Superintendent, who was on one-week of sick leave.
		<p>The EMWMF had been closed due to the heavy rain over the weekend. Since waste shipments could not be made, the Board has determined that the MACTEC Temporary Superintendent and BJC STR-5 discussed the outstanding work that could be used to keep the two laborers busy.</p>
		BJC STR-5 and the MACTEC Temporary Superintendent discussed three work tasks, and the only one that could be performed was the waste rebar removal job at the K-1302 pad.

**Table 2-1. Event Chronology
(continued)**

Date	Time	Event	
2/17/2003 (continued)		BJC STR-5 and the MACTEC Temporary Superintendent discussed which tool to use for the rebar removal job, which resulted in selection of the cut-off machine.	
		BJC STR-5 asked MACTEC ES&H Rep-5 if the rebar removal job and use of the cut-off machine were covered in the AHA (2000-2, Revision 14).	
		The MACTEC Temporary Superintendent asked Laborer-1 if he could operate a cut-off machine. Laborer-1 indicated that he had used a cut-off machine on another job.	
		MACTEC ES&H Rep-5 confirmed that the AHA required a hot work permit.	
		BJC STR-5 left a message for one of the hot work permit approval authorities (STR-3) requesting a hot work permit in the morning.	MACTEC ES&H Rep-5 asked BJC Safety Advocate-4 to verify whether BJC-EH-2007 required a hot work permit for cutting rebar.
			BJC Safety Advocate-4 attempted to locate a subject matter expert on BJC-EH-2007 to assist in responding to MACTEC ES&H-Rep-5's request for verification.
2/18/2003	Before the MACTEC POD Mtg	BJC Safety Advocate-4 informed MACTEC ES&H Rep-5 that a hot work permit was not needed per the BJC procedure but that he would verify that after the POD Meeting.	
	6:30 am	MACTEC POD Meeting	
	During the MACTEC POD Mtg	BJC STR-5 informed the MACTEC Temporary Superintendent that a hot work permit would be available after the PSS Safety Stand-Up Meeting.	MACTEC ES&H Rep-5 announced that a hot work permit would not be used for the rebar removal job.
		The BJC STR for EMWMF called the BJC STR-5 to say the facility was now open and to ask for waste shipments to start.	Laborer-1 and Laborer-2 were assigned to the rebar removal job.

**Table 2-1. Event Chronology
(continued)**

Date	Time	Event	
2/18/2003 (continued)		BJC STR-5 relayed the EMWMF availability in a discussion with the MACTEC Temporary Superintendent.	BJC Safety Advocate-4 left the MACTEC POD Meeting early to call a subject matter expert on the applicability of BJC-EH-2007 to rebar removal.
		BJC STR-5 left the POD Meeting still believing that a hot work permit was required	
	Immediately after the MACTEC POD Mtg	BJC Safety Advocate-4 asked the BJC Safety Lead whether BJC-EH-2007 applies to grinding or abrasive disk use.	
		The BJC Safety Lead informed Safety Advocate-4 that the BJC hot work procedure does not require a hot work permit for grinding.	
		BJC Safety Advocate-4 informed BJC STR-5 that a hot work permit was not required.	
		BJC STR-5 confirmed that BJC Safety Advocate-4 understood the hazards and operation of the cut-off machine.	
		BJC STR-5 called the MACTEC Temporary Superintendent. The Board could not determine the subject of the conversation.	
	Immediately before the PSS Safety Stand-Up Meeting	BJC Safety Advocate-4 informed MACTEC ES &H Rep-5 and the Temporary Superintendent that a hot work permit was not needed according to the BJC procedure.	
	7:30 am	PSS Safety Stand-Up Meeting	
	During the PSS Safety Stand-Up Meeting	With the hot work permit approval authority (STR-3) present, BJC STR-5 reconfirmed with BJC Safety Advocate-4 that a hot work permit was not needed.	
	8:00 am	SEC RadCon Alliance personnel performed a radiological survey of the K-1302 pad and the rebar.	
	8:30 am	Laborer-1 and Laborer-2 dressed in anti-c clothing at the Boundary Control Station.	
		Laborer-1 and Laborer-2 walked to the job site carrying all of the necessary tools.	
		Laborer-2 removed ten pieces of rebar with the cut-off machine.	
		Sparks ignited the PPE on Laborer-1's right leg.	

**Table 2-1. Event Chronology
(continued)**

Date	Time	Event
2/18/2003 (continued)	9:00 am	Both laborers noticed that Laborer-1's plastic bootie was smoldering.
		Laborer-1 patted the smoldering PPE with his gloved hand.
		Laborer-2 used the water-pump sprayer to extinguish the smoldering PPE.
		Laborer-1 and Laborer-2 walked back to the Boundary Control Station and removed their PPE.
	9:15 am	Laborer-1 and Laborer-2 exited the Boundary Control Station and reported the incident to the MACTEC Temporary Superintendent.
		The MACTEC Temporary Superintendent reported the incident to MACTEC ES&H Rep-5 and BJC STR-5.
		MACTEC ES&H Rep-5 directed Laborer-1 and Laborer-2 to write up their statements.
		MACTEC ES&H Rep-5 and BJC STR-5 independently contacted BJC Safety Advocate-4.
	During the afternoon	<p>BJC STR-5, BJC Safety Advocate-4, and the MACTEC personnel were at the job site. The following personnel arrived at the job site during the course of the afternoon:</p> <ul style="list-style-type: none"> - DOE ETPP Closure Director - DOE Facility Representative - DOE Site Office ES&H contractor - BJC Manager of Projects - BJC Task Lead - BJC On-Call Safety Advocate - BJC Safety Lead - BJC D&D Projects Manager - PSS representative
	5:52 pm	BJC senior management sent an electronic mail message on a hot work stand-down for all plants where BJC performs work. Hot work would be authorized on a task-by-task basis only.
2/19/2003		BJC convened a critique to review the findings of the initial investigation of the incident.
		ORO determined that a Type B Accident Investigation was necessary.
2/21/2003		The ORO Manager commissioned the Board.

2.1.3 Previous Events

With the exception of the MACTEC incident on May 16, 2002, all of the following incidents involving the ignition of anti-c clothing came from ORPS. Contractor ES&H personnel and DOE Federal personnel can access this database. Accessing the system to acquire information on previous events can help with lessons learned to prevent the reoccurrence of incidents of fire-damaged anti-c coveralls and injuries.

Previous Hot Work Damage to Anti-C Clothing Using a Cut-Off Machine on the Main Plant D&D Project

On May 16, 2002, a MACTEC worker at the Main Plant D&D Project at ETTP was assigned to cut flanges off several metal tanks located in a radiological contamination area. The worker was using a gas-powered cut-off machine because the configuration of the existing equipment would not permit the use of a sawzall or port-a-band saw. The cut-off machine used for this work was the same cut-off machine involved in the incident being investigated by the Board. Although not required, a fire watch was positioned and provided support to the worker using the cut-off machine. A prejob briefing had been held to discuss the work activity and the required PPE. During the first cut, the worker repositioned himself to better hold the cut-off machine, which allowed the sparks to strike the inside of his left leg. The sparks charred the fabric but did not ignite it. The worker experienced some heat through his clothing and PPE. After shutting off the cut-off machine and storing it safely on the floor, the worker patted the smoldering material with his leather gloves. Once the material appeared to be safely extinguished, the worker reported the burned coveralls to the sampling technician, who contacted the project's health and safety officer.

The workers exited the contamination area. The worker removed his clothing in layers to permit health physics personnel to survey each layer. The worker's personal jeans and skin were undamaged. There was no redness to the skin, but the worker had felt the heat during the cutting operation. At first, the worker assumed that the heat was just part of the work activity. The fire watch was unable to see the area where the sparks were striking.

Work was halted while all workers exited the contamination area, and an assessment was performed. Fire-resistant coveralls made of cloth were obtained that were thicker and provided a higher level of protection. Workers were briefed to position themselves away from sparks and other sources of heat or flame. The worker was not injured.

Subsequent to this incident, the following recommended actions were established:

- All PPE will be inspected prior to use.
- All personnel who use PPE will be briefed that the equipment will not provide them with unlimited protection in every situation.
- All employees will be briefed that they have the responsibility to stop work and report unsafe conditions to supervision.
- Workers will wear leathers chaps to continue work with the cut-off machine.

Hot Work Damage to Anti-C Clothing At DOE Facilities

February 13, 1997 – Fatal Fire/Acetylene Torch Cutting

A fatal accident occurred at the K-33 Building at ETPP. The welder was performing a cutting operation in a poorly lit, constricted space when a spark or a hot piece of metal ignited his anti-c coveralls at, or somewhat below, his left knee.

The welder was wearing multiple layers of anti-c clothing that were not flame-retardant and radiological PPE that limited his ability to detect and extinguish the flames quickly. A fire watch was not used.

May 7, 1997 – Anti-C Coveralls/Acetylene Torch Cutting

Two subcontractor laborers at the Hanford Site were cutting contaminated steel into 4' x 15' plates. One of the laborers noticed a smell that was not consistent with his cutting operation. The laborer stopped cutting and noticed that the leg of his anti-c coveralls was on fire. The laborer put out the flame by patting down the fire with his gloved hand and then notified supervision. The hot work permit required use of the "buddy system" (mutual monitoring of the other person's work activity) and did not require a designated fire watch. The laborer also wore welders leather chaps and jacket over the anti-c clothing. These leathers were worn as added individual protection and because flame-resistant coveralls were not readily available. The laborer was not injured.

November 12, 1999 – Rubber Boot and Canvas Bootie/Acetylene Torch Cutting

During remedial work actions, while cutting a 60-inch pipe in a trench at the Hanford Site, a subcontractor employee's PPE caught on fire. The worker was using a "slice torch" to cut the pipe. Initial indications were that the worker stepped on a piece of molten metal which ignited one of the rubber boot covers and then the fire-retardant, canvas inner boot cover (bootie) near the lower back leg area of the anti-c clothing. The employee was not injured.

April 29, 2002 – Flame-Retardant Coveralls/Acetylene Torch Cutting

Workers at the Portsmouth Gaseous Diffusion Plant were using a cutting-torch to downsize scrap metal when hot slag generated from the cutting operation burned multiple holes (ranging from pin-hole size up to approximately 3/8" inch in diameter) through one prime contractor worker's flame-retardant, anti-c coveralls and the work coveralls. The laborer was not injured.

2.2 Integrated Safety Management

The Board examined management systems as potential contributing and root causes of the incident. The DOE Accident Investigation Program requires that accidents be evaluated in terms of ISM to foster continued improvements in safety and to prevent or minimize future accidents. The core function and guiding principles of ISM are the primary focus for

contractors in conducting work efficiently and in a manner that ensures the protection of workers, the public, and the environment. Properly implemented, ISM is a standards-based approach to safety, requiring rigor and formality in the identification, analysis, and control of hazards.

The Board reviewed the contract mechanisms to better understand how ISM was implemented. BJC has a direct, performance-based incentive fee M&I contract to manage the DOE Office of Environmental Management programs at multiple DOE sites (Contract No. DE-AC05-98OR22700, dated December 18, 1997). The MACTEC fixed-price subcontract with BJC is for D&D of ten buildings, including Building K-1302 (Subcontract No. 23900-SC-ET081F, dated August 15, 2000). Under the BJC prime contract, the roles and responsibilities of the prime and subcontractors are defined. BJC is fully responsible and accountable for effectively integrating ES&H into all work planning and execution and for the safe accomplishment of all work, whether it is performed by its own personnel or subcontractors. The BJC contract incorporates and flows down to its subcontractors an ES&H clause that states in part:

*“The Contractor is fully accountable for an integrated safety management program that accomplishes all work in a manner that meets technical quality objectives and is protective of workers, the public and the environment. The Contractor shall manage and perform work in accordance with a documented Safety Management System as required by the clause in Section I entitled, “Integration of Environment, Safety and Health into Work Planning and Execution.” The Contractor shall provide a description of this system to DOE for review and approval. Along with its subcontractors, the Contractor must comply with all applicable laws, regulations and DOE directives as required by other provisions of this contract. Where appropriate, the Contractor will continue to develop “work smart standards” that bring the best commercial practices to a job, consistent with the clause in Section I entitled “Laws, Regulations and DOE Directives.” Performance-based measures may be used to incentivize ES&H performance. **While the Contractor must oversee and is accountable for all ES&H under the contract, implementation of ES&H practices is generally conducted through the individual subcontractors who perform the majority of the work tasks. Subcontractors must demonstrate an ability to perform work in an acceptable manner with performance-based oversight. Therefore, the ability to achieve the desired ES&H performance and accomplish the work must be built into the selection of subcontractors.**”*

BJC also flowed down to the MACTEC subcontract BJC/OR-64, Revision 16, *Environmental Management and Enrichment Facilities (EMEF) Operations Work Smart Standards*. This document correlates the hazards that are anticipated to be encountered in the performance of EMEF work with the Work Smart Standard (WSS) set that provides the necessary and sufficient protection from those hazards. MACTEC charted the anticipated activity hazards with the WSS set in the *Environmental, Safety & Health Crosswalk (WSS)*, Revision 2, dated January 27, 2003.

BJC has developed a detailed ISMS description document, *Integrated Safety Management System Description* (BJC-GM-1400, Revision 4, dated October 2002), that describes how employees and subcontractors implement ISM. Revision 4 of the BJC ISMS description has

never been formally transmitted to MACTEC. MACTEC met the minimum requirement under the subcontract for its commitment to ISM in a one-page matrix that responds to a list of ISM requirements by referencing other MACTEC work planning documents (*ISMS Matrix*, dated July 7, 2000).

The Board reviewed BJC's and MACTEC's safety performance and the specific events that indicated the status and effectiveness of each company's ISMS. A series of events, safety concerns, and corrective actions had occurred over the past two and a half years. Despite the apparent increased focus on ISM by BJC, MACTEC had several safety incidents. The major BJC and MACTEC events include the following:

- In September 2000, after a follow-up ISMS verification by ORO, BJC's ISMS was declared implemented, subject to completion of some corrective actions.
- On November 1, 2001, the ORO Manager revoked approval of BJC's implementation of its ISMS subsequent to a letter from the DNFSB to DOE Under Secretary Robert Card, dated October 15, 2001. The DNFSB letter cited several issues and deficiencies relating to adherence to safety authorization bases, ISM implementation, the WSS set, roles and responsibilities, and the flowdown of requirements. Currently, the revised BJC ISMS implementation declaration is pending final approval by DOE. Reverification of the BJC ISMS is scheduled for late spring 2003.
- In April 2002, BJC and ORO jointly prepared and issued the *Corrective Action Plan (CAP) for Integrated Safety Management System Improvement*. BJC identified 126 actions in the CAP, and 123 of those actions had been completed as of December 31, 2002.
- In July 2002, BJC chartered an Independent External Evaluation of its ISMS and its implementation. This team identified opportunities for improvement and proficiencies within the BJC ISMS. The evaluation resulted in 27 actions and recommendations intended to help BJC meet the reverification of its ISMS.
- On August 5, 2002, all MACTEC work at ETTP was suspended due to a series of safety incidents. After an "ISMS Wheel Analysis" and root cause evaluation (TapRoot® Analysis) of the series of incidents, MACTEC proposed a CAP that BJC considered adequate. MACTEC was allowed to resume work on August 20, 2002. As part of this evaluation, BJC determined that no corrective actions for BJC were required; however, BJC did increase its on-site presence by temporary assignment of an additional STR and safety advocate. The root cause of these incidents was identified as "6A – Inadequate Administrative Controls" in ORPS Occurrence Report ORO-BJC-K25GENLAN-2002-0015. The TapRoot® Analysis identified the root cause as a "Management System Deficiency."
- On December 2, 2002, BJC notified ORO that, based on progress in ISMS improvements, it was prepared for the DOE ISMS reverification.

- In December 2002, MACTEC had two similar contamination occurrences that led to the removal of several key MACTEC personnel. Both incidents involved the loss of contamination control as previously described in this report.

After the MACTEC safety stand-down in August 2002, BJC acknowledged a decline in safety performance and identified two common causal factors as part of its ISMS evaluation. These causal factors were as follows:

- ***“Inadequate Recognition of Changed/New Work Conditions – Given the general nature and broad scope of D&D work, the authorized daily work plan covers a broad range of activities. During the course of performing these activities, workers frequently encounter changed or new conditions. Although some of the changed or new conditions are actually outside the scope of work and require further evaluation/authorization, many activities simply encounter conditions unforeseen that may not have been discussed in sufficient detail in plan-of-the-day or pre-job meetings. Worker reactions or response to the change/new conditions evaluated in three out of four incidents were less than adequate. Workers must recognize changed/new conditions and appropriately report to management such that ISMS functions and principles can be appropriately implemented.***
- ***Inadequate Level of Rigor in Performing Hazard Analysis – The D&D subcontractor, although performing work in accordance with an approved activity hazard analysis (AHA), has not been successful in analyzing hazards that are encountered from changed/new work conditions. Workers are performing more of a hands-on approach to addressing field-identified hazards instead of utilizing project work control practices that would invoke the ISMS process. Because most of the task level work is performed under a general AHA, it is imperative that workers have the knowledge and understanding that additional hazard analysis, whether formal or informal, be performed with appropriate personnel if changed or new conditions arise. Another weakness identified was the under utilization of subject matter experts in job walk-downs performed to support hazard analysis. Although this was not determined to be a direct cause, it further substantiated inadequacy in the performance of hazard analysis and could have led to the avoidance of at least one of the incidents.” (Evaluation of Main Plant Trend of Safety-Related Incidents, Occurrence BJC-K25GENLAN-2002-0015, dated August 15, 2002)***

The Board evaluated the facts associated with the rebar removal incident for each of the ISM core functions and guiding principles. (See Table 3-1 and Table 3-2.) This method of analysis provides a clear understanding of the work processes and allows an accurate determination of the Judgments of Need.

2.2.1 Define the Work

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

Effective work execution begins with the preparation of a well-defined scope of work that translates the mission and requirements into terms that those who are to accomplish the work can clearly understand. The definition of the work scope must provide sufficient detail to support the hazard analysis and development and implementation of controls at the task level. To fulfill its responsibilities, line management must determine the work to be performed and be accountable for understanding it as completely as possible through every phase of the work cycle. This process applied in general to the BJC and MACTEC work at the K-1302 pad and was defined in series of tiered documents that vary in detail.

The mission of ETPP is environmental cleanup and reindustrialization/reuse of the assets for the decommissioned gaseous diffusion plant formerly known as the K-25 Site. This mission is being accomplished in part by cleaning up ETPP through the DOE Environmental Management Program's M&I contract with BJC.

The Main Plant D&D Project work that is performed by MACTEC is for D&D of ten buildings, including Building K-1302. The subcontract was awarded using performance specifications that were developed by the BJC project team, and it allowed MACTEC to select the method of accomplishment that met BJC's requirements to perform the full scope of the project. These facilities were demolished under a CERCLA time-critical removal action. The buildings were contaminated with uranium as the primary radiological concern, along with standard industrial contaminants including asbestos, polychlorinated biphenyls, and small quantities of hazardous materials. These buildings were selected for demolition because of their poor condition and the high cost of necessary surveillance and maintenance. An action memorandum and a removal action work plan were approved for the removal action and provided the regulatory authority for the project.

The BJC "functional organization," which is its policy and procedure management organization, utilized subject matter experts to develop the general contractual requirements. The project team developed the specific scope and technical specifications. Exhibit D of the subcontract defines the scope of work for the Main Plant D&D Project in general terms as follows:

"This project will characterize, sample, abate, radiologically decontaminate, demolish, efficiently segregate and package, treat as necessary to meet the waste acceptance criteria of the selected disposal facility, and safely transport for permanent disposal all wastes generated from Buildings K-1045-A, K-1300, K-1301, K-1302, K-1303, K-1404, K-1404-A and K-1404-B, K-1405, K-1407, K-1407-D, K-1407-L, K-1408-A and K-1413 and their associated appurtenances."

BJC divided this broad work scope and the approach for executing the work into the following activities:

1. Establish site access controls to prevent unauthorized personnel from entering the site.
2. Perform radiological surveys and hazardous material sampling to establish worker protection requirements and to support the specific D&D approach.
3. Before abatement activities, plug the floor drains, roof drains (at grade), and any building slab penetration.
4. Remove asbestos-containing materials for disposal.
5. Dismantle and remove contaminated and hazardous equipment and materials.
6. Perform limited decontamination of radiologically-contaminated materials.
7. Survey, segregate, and release recyclable materials for unrestricted use.
8. Demolish each of the buildings to top-of-foundation slab or grade. (This portion did not include the cleanup of surrounding soils, utility lines, or groundwater.)
9. Decontaminate the building concrete slabs.
10. Dispose of the waste.

MACTEC subsequently defined the scope in their implementing plans and procedures. The primary subcontract documents that apply to all tasks are as follows:

- *Comprehensive Work Plan for Main Plant Demolition Project*, Revision 1, dated July 19, 2002
- *Environmental, Safety and Health Plan for Main Plant Demolition Project* (Main Plant ES&H Plan), Revision 3, dated October, 23, 2002
- *Quality Assurance Project Plan for Main Plant Demolition Project*, QAPP-2.012, Revision 8, dated October 29, 2002
- *ISMS Matrix*, dated July 7, 2000
- *Environmental, Safety & Health Crosswalk (Work Smart Standards) for Main Plant D&D Project*, Revision 2, dated January 27, 2003

These documents cover the scope of all primary work activities and include requirements such as training, permits, and readiness assessments. The documents also provide procedures related to specific hazards (e.g., radiological contamination and asbestos), but they are not specific to the individual task level.

The next level of documentation is the facility-specific D&D plans (K-1302-3.002, Revision 1). These plans define the facility history, including any safety basis requirements, and list the facility-specific hazards. These documents are used in conjunction with the AHA documents that are a requirement under the MACTEC Main Plant ES&H Plan. According to the subcontract language, AHAs shall be developed by the subcontractor at the activity/task level and shall provide a detailed, job-specific hazard assessment that addresses each step of the work process.

As noted later in Section 2.2.2, “Analyze the Hazards,” a task-specific AHA was not developed for the rebar removal job. In fact, as noted in Section 2.2.2, most of the task-level work is performed under the general AHA.

MACTEC held a POD Meeting at the beginning of every workday in which the scope of work for that day was reviewed and tasks were identified and assigned to the workers. At the February 18, 2003, POD Meeting, the rebar removal job was assigned to Laborer-1 and Laborer-2. They were informed that the work did not require a hot work permit. A discussion had been held the previous evening to ascertain if Laborer-1 was comfortable using the cut-off machine. The manufacturer's safety manual for use of the cut-off machine was not available and, therefore, was not reviewed. In addition, the lessons learned from previous use of the cut-off machine were not discussed, nor was the warning label on the grinding wheelguard noted or read. (See Figure 11.)

The specific work scope for the rebar removal job was to remove, by cutting, rebar from the K-1302 concrete pad in preparation for power-washing the slab. The K-1302 pad is posted as a contamination area. The scope also included a radiological survey to check for contamination hazards prior to the start of rebar removal. An important part of the scope of this task pivoted on the determination of whether this rebar removal job was classified as hot work. MACTEC ES&H Rep-5 determined that rebar cutting was covered by the AHA (2000-2, Revision 14) and confirmed that the AHA requires a hot work permit. MACTEC ES&H Rep-5 asked BJC Safety Advocate-4 to verify whether a hot work permit

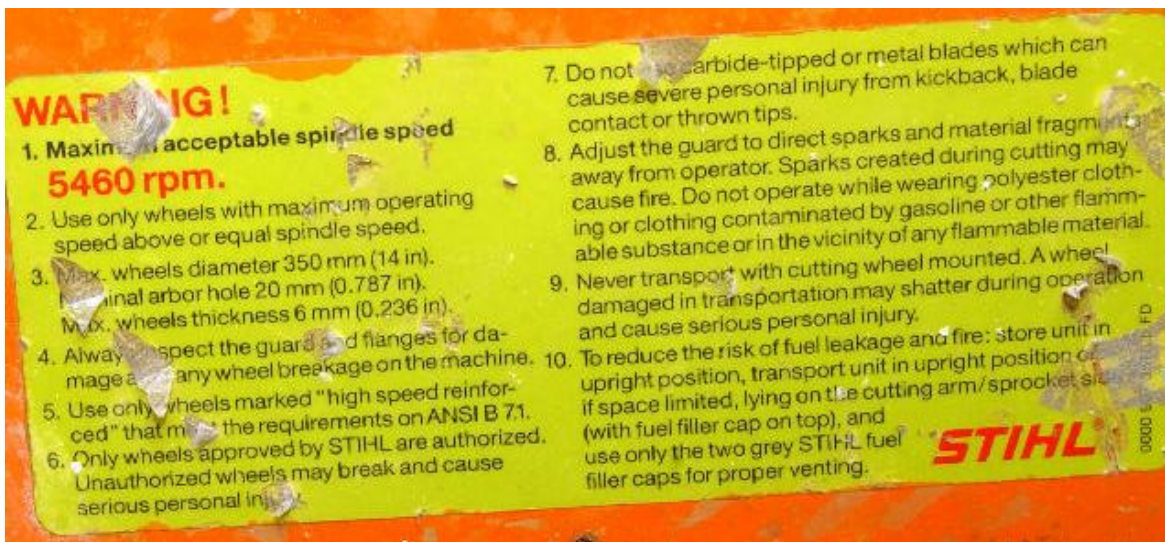


Figure 8. Warning Label on Cut-Off Machine

was required by the BJC procedure. The specifics about the method of cutting and the operational hazards associated with the cut-off machine were not part of the verbal exchange between BJC Safety Advocate-4 and the BJC Safety Lead, who was consulted for a determination on the applicability of BJC-EH-2007, *Welding/Burning/Hotwork*, to grinding operations. MACTEC personnel accepted the judgment of the BJC personnel regarding the need for a hot work permit. So, at this point, MACTEC overrode its AHA and changed the scope of the work to "non-hot work," thereby allowing use of 100% cotton anti-c coveralls. The cutting task required two laborers, one to do the cutting and one to spray the areas to be cut with water for dust suppression. The cutting tool, as mentioned previously, was a cut-off

machine that had been used on a previous job by other MACTEC personnel and resulted in the May 16, 2002, incident. That was the last time the cut-off machine was used by MACTEC. The Board found no evidence that the cut-off machine had been maintained in accordance with the manufacturer's safety manual.

2.2.2 Analyze the Hazards

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

The objective of the hazard analysis is to develop an understanding of task-specific hazards that may affect the worker, the public, and/or the environment. Each level of the hazard analysis is the foundation for a more detailed analysis; that is, a demolition project hazard analysis is, in turn, used as the basis for an activity-level or task-level hazard analysis. Hazard identification and analysis must occur at each phase of the work cycle to which it applies, including demolition. MACTEC's AHAs contain the procedures used to carry out hazard assessments at the project level. Workers are involved in this process or are afforded the opportunity to review and comment on AHAs prior to starting work. Some of the other applicable MACTEC contract requirements are as follows:

- *“AHAs shall be developed at the activity/task level and provide a detailed, job-specific hazard assessment that addresses each step of the work process, the hazards involved, and the controls for those hazards.”*
- *“AHAs should clearly identify each step of the work process in sufficient detail to provide assurance that all hazards, including those introduced by the method of accomplishment of the work, have been identified and that appropriate controls have been developed and are in place to eliminate or mitigate those hazards.”*
- *“All equipment and tools shall be subject to a safety inspection and an incoming radiological survey, conducted by CONTRACTOR, upon arrival at the Site, before being placed into service.”*

On February 11, 2003, MACTEC ES&H Rep-5, Site Superintendent-2, and Laborer-1 signed AHA 2000-02, *General Construction Hazards for Main Plant D&D Project*, Revision 14, which had been revised the previous day. This is the overriding AHA for the Main Plant D&D Project, and it does not specifically identify the rebar removal job, although it does cite the following:

“Demolition activities to include but not limited to the use of hand tools, power tools, ladders, fall protection equipment, aerial lifts, and mobile equipment such as forklifts, trackhoes with demolition attachments. Potential hazards associated with this work activity include fire and associated grinding activities.”

This sign-off indicated that recent changes to the AHA were reviewed by a worker as part of MACTEC's process to involve workers in AHA development. As noted elsewhere in this report, the AHA requires a hot work permit before using torches, grinders, or other

flame/spark-producing tools. A task-specific AHA was not developed for the rebar removal job.

The task to remove rebar from the K-1302 pad was selected one day prior to execution in lieu of other work that was postponed due to the heavy rain which closed the EMWMF, which is BJC's on-site CERCLA landfill. The cut-off machine was chosen because it was readily available, and equipment employing other cutting techniques was not available. The acetylene torches had already been removed from the site, and the portable band saws were contaminated with fissile material. AHA 2002-2, Revision 14, states, "Obtain a Welding/Burning/Hot Work Permit before using torches, grinders, or other flame/spark producing tools."

The Board has determined that BJC Safety Advocate-4 took responsibility for determining the applicability of BJC-EH-2007, *Welding/Burning/Hotwork*, Revision 2, dated December 15, 2002. After reviewing the procedure, he was unclear. Safety Advocate-4 asked the BJC Safety Lead for confirmation of his determination that it was not applicable to this work. However, BJC Safety Advocate-4 asked a focused question about general grinding instead of the proposed rebar removal job. The BJC Safety Lead confirmed that BJC-EH-2007, Revision 2, did not apply to grinding. BJC Safety Advocate-4 told BJC STR-5, the MACTEC Temporary Superintendent, and MACTEC ES&H Rep-5 that a hot work permit was not needed. As a result, work proceeded without a hot work permit being issued. MACTEC and BJC personnel did not follow their process to "red-line" the requirements in AHA 2000-2, Revision 14, for obtaining a hot work permit for the rebar removal job in order to document this deviation from the approved contract document.

Several significant hazards are related to the use of this machine. The safety manual for the cut-off machine is available from the manufacturer, and the Board has determined that MACTEC printed one from the manufacturer's web site after the incident occurred. The manufacturer's safety manual was not available at the job site at the time of the incident, and the laborers had no knowledge of the manufacturer's web site. The hazards associated with use of the cut-off machine include fire and burn injury caused by sparks produced by the abrasive grinding wheel of the cut-off machine during operation. The hazards associated with the cut-off machine were not analyzed by either MACTEC or BJC for the rebar removal job. The manufacturer's safety manual for the machine was not reviewed prior to this task. As discussed in Section 2.2.5 of this report, lessons learned from a previous incident in May 2002 involving the cut-off machine were not communicated to the laborers.

At the time of the incident, radiological contamination hazards associated with the K-1302 pad and the resulting PPE requirements were based on the K-1302 pad being located within a posted contamination area. The posting was based on surveys from prior years and a perceived potential for contamination. A review of six surveys performed between 1999 and 2001 support posting portions of the entire K-1302 area as a contamination area. The contamination area posting was for the entire area. Survey 20030218KA36151004, taken on February 18, 2003, listed 20 locations that were surveyed on the rebar and the concrete pad. All of the results were below the Title 10 Code of Federal Regulations, Part 835, *Occupational Radiation Protection*, Appendix D, alpha and beta surface contamination values

for uranium/associated decay products and Technetium-99. Overprescribing PPE follows a pattern recognized in Defense Program report *Personal Protective Equipment Use in DOE Programs*, dated March 1998. The report states that in some cases ORPS drives operational practices, such as adding levels of PPE to minimize personnel contamination reports. The report says that “some of the significant accidents, and at least one fatality, may be the result of protective clothing selection requirements that are too restrictive for the hazards present or without adequate attention to balancing of all industrial hazards in an integrated fashion.”

2.2.3 Develop and Implement Controls

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

The objective of developing and implementing controls is to identify and provide the full range of controls (i.e., engineering, administrative, and PPE) consistent with the level and nature of the hazards to be encountered during task performance. The development and implementation of work controls assumes that the contractor has adequately and completely identified the hazards associated with the defined scope of work.

The DOE work control process begins with contractual requirements to establish the terms and conditions that define DOE’s safety expectations for its contractors. As indicated in the previous sections, these conditions flowed down through BJC to MACTEC, who has established a formal set of work control documents and procedures. These documents include requirements under the WSS set, work scope management, procedure development, hazard analysis, permits, occurrence reports, lessons learned, training, maintenance, and general worker safety. BJC has two specific documents that define work control requirements and the process to be used in job planning to establish safe work requirements (BJC-FS-1001, *Work Control Process*, Revision 2; and BJC ET-1001, *Work Control Process for ETTP Projects*, Revision 0).

Actual execution of work control is carried out by the oversight, support, and worker staff. As part of this D&D work, the Board notes that a cadre of BJC staff is involved with each project, including the STR, safety advocate, facility manager, subject matter experts, subcontract quality assurance specialist, safety lead, task lead, and the project manager. The MACTEC personnel assigned to the project included the site superintendent, ES&H representatives, the laborers, and the project manager. Figure 12 on the following page is a chart showing line management for this project.

Despite the (1) existence of adequate staff and opportunities to ensure proper controls for the rebar removal job, (2) formal procedures and adequate knowledge of the formal procedures, and (3) the AHA, which indicates that this rebar removal job required a hot work permit, the decision made by BJC and MACTEC deviated from the AHA without first revising the AHA. BJC identified that a hot work permit was not required. BJC did

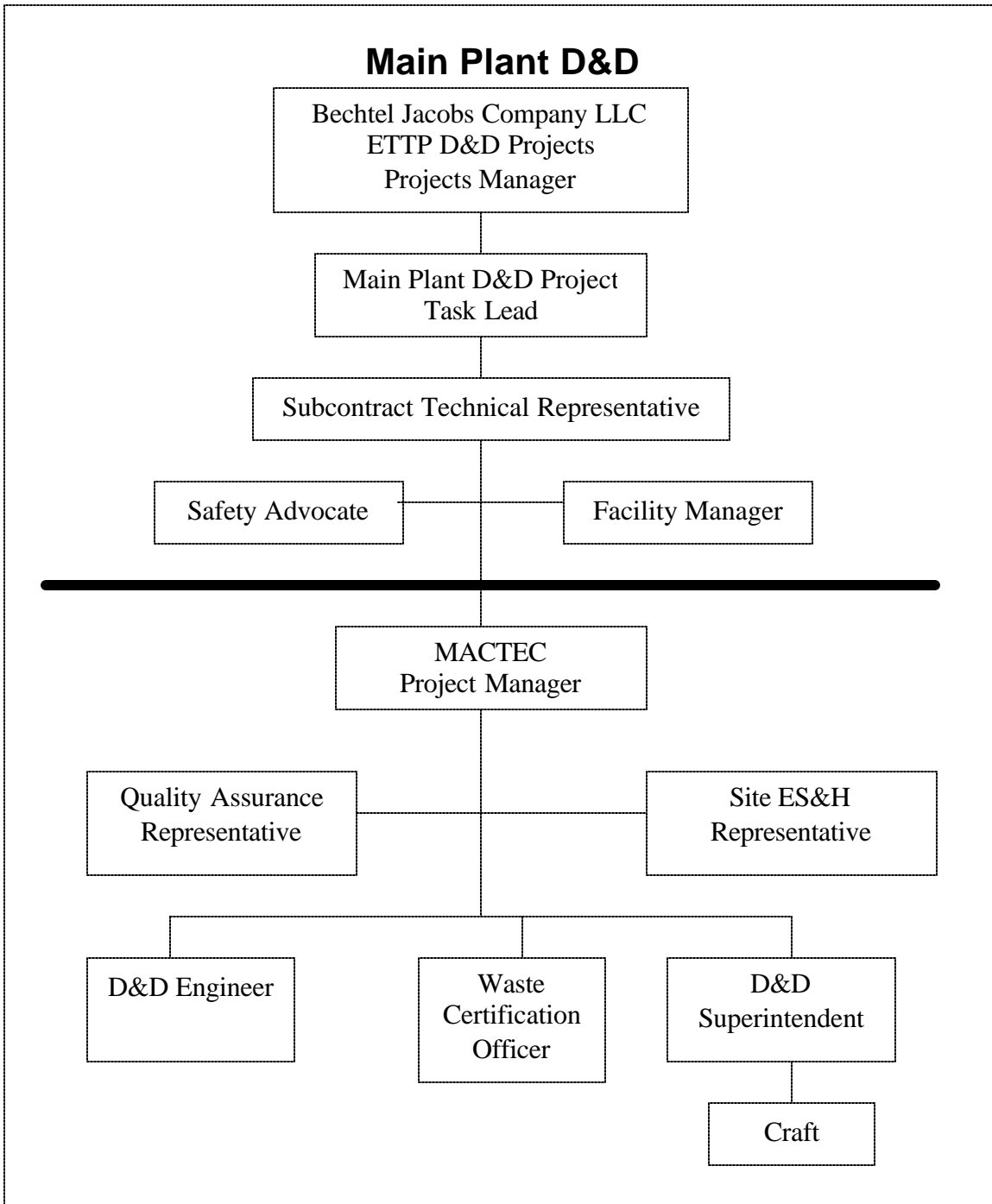


Figure 9. Line Management Organization for BJC and MACTEC on the Project

not execute its management role over the subcontractor to ensure the work was performed in accordance with the applicable requirements. The BJC contract with DOE, Part 1, Section C-1, "Role of Prime Contractor and Subcontractor" states, "The contractor is fully responsible and accountable for the safe accomplishment of all work, whether performed by its own personnel or subcontractors." The specific activities that contributed to this decision are noted in Section 2.1.1, "Event Description." Based on this description and other factors related to work planning, the Board noted the following issues related to the work controls for this incident:

- BJC procedure, BJC-EH-2007, *Welding/Burning/Hotwork*, does not cite grinding and spark-producing activities as activities that require a hot work permit. This procedure is required for all welding, burning, and hot work. However, welding, burning, and hot work are defined in the procedure as follows:

"All methods of welding, arc and torch cutting, and open-flame brazing, open-flame burning, open-flame soldering, and other portable torch open-flame operations for construction or maintenance activities. Electric soldering, and drilling are not considered hotwork. If a question exists, contact the BJC ES&H Department for a determination."

- Attachment C of BJC-EH-2007, "Consultant List," addresses grinding in a list of exposures or conditions for which the site Fire Protection Engineer should be consulted prior to issuing a hot work permit. The BJC Fire Protection Engineer was not consulted about the MACTEC rebar removal job.
- Communications between BJC Safety Advocate-4 and the BJC Safety Lead were limited. BJC Safety Advocate-4 questioned the need for a hot work permit after reviewing the procedure. He posed the question to the BJC Safety Lead about whether a grinding operation to "shorten rebar" required a hot work permit. The BJC Safety Lead did not request further details on the operation but referred to the aforementioned procedure to determine whether grinding required a permit. The BJC Safety Lead confirmed to BJC Safety Advocate-4 that the procedure did not define grinding as hot work. BJC Safety Advocate-4 was then firm in his decision, and he communicated to MACTEC that a hot work permit was not required. The AHA, a required document, was not followed. The AHA identifies the need for a hot work permit, but the requirement was questioned by MACTEC and BJC and then not implemented.
- The Board has determined that BJC Safety Advocate-4 had observed cut-off machines in operation previously on a different job site. The Board has also determined that BJC Safety Advocate-4 believes he does not have the authority to stop work unless there is imminent danger to life or property.
- The BJC Main Plant Facility Manager was not made aware of the rebar removal activity and the planned use of the cut-off machine. The Board has determined that the BJC Facility Manager was aware of the hazards associated with use of a cut-off

machine. In addition, there was no discussion between the BJC Facility Manager, BJC STR-5, and BJC Safety Advocate-4 concerning the use of the cut-off machine.

- A task-specific AHA was not developed for this task. AHA 2000-2, Revision 14, includes 48 work activities ranging from “Demolition activities . . .” to “Off loading of rubble at dump site.”
- The MACTEC Temporary Superintendent, MACTEC ES&H Rep-5, BJC Safety Advocate-4, and BJC STR-5 did not observe Laborer-1 perform the work. The Board found that Laborer-1 operated the cut-off machine with an incorrect body position. Laborer-1 held the machine so that sparks were not directed away from his body.
- Lessons learned from the May 16, 2002, incident were not communicated to DOE, BJC, or throughout the MACTEC organization.
- Equipment controls for the cut-off machine were not developed and implemented. There were no maintenance records for the cut-off machine. Training on the machine was not made available. The posted warnings on the cut-off machine were not read or reviewed with Laborer-1. The manufacturer’s safety manual for the cut-off machine was not available at the job site.

Both BJC and MACTEC personnel conveyed an understanding of the procedures and a basic knowledge of work control practices. BJC provided documentation to the Board which confirmed that all BJC personnel assigned to the project at the time of the incident were qualified in accordance with BJC’s procedures. Stop work authority was understood and implemented by the two laborers after the incident occurred.

2.2.4 Perform Work Safely

Readiness is confirmed and work is performed safely.

Controls must be identified and implemented before starting work on any task. To ensure proper control of operations, MACTEC, with oversight by BJC, relies on its AHAs and on workers following the identified controls.

In the POD Meeting, MACTEC ES&H-5 told Laborer-1 and Laborer-2 that a hot work permit was not being used for the rebar removal job. Laborer-1 was assigned to operate the cut-off machine, and Laborer-2 would provide dust suppression using a 2½-gallon, pump-water fire extinguisher. The laborers read the RWP and were instructed on the appropriate anti-c clothing required by RWP 2002-1075.

In addition to clothing required by the RWP, Laborer-1 was required to meet the “Required actions, controls, or methods of compliance,” section from AHA 2000-2 Revision 14, which is the main procedure for the Main Plant D&D Project. Work Activity 33 covers torch-cutting, welding, burning, and grinding. This section includes the following requirements:

- *“A welding/burning/hot work permit will be obtained prior to beginning torch-cutting.*
- *Cuttin-torch fuel lines shall be preceded by flashback preventions at connection to fuel source.*
- *Proper face shield should be utilized to prevent flash burns and/or impingement injuries.*
- *Proper fire prevention measures such as a fire watch, removal of combustibles, and/or wetting of the surfaces shall be utilized to prevent potential of fire occurring from sparks or hot slag.*
- *All tools shall have the manufacturer’s guards in place.*
- *Noise levels will be monitored to determine exposure levels during scaling, grinding, blasting or scabbling.*
- *Hearing protection will be required until levels are determined to be less than 85 dBA.”*

The first two requirements were not used, since the planned activity did not involve torch-cutting, welding, or burning. The rebar removal job was to be a grinding operation utilizing a STIHL model TS-510 AV Cutquik® cut-off machine.



On the day of the job, Laborer-1 and Laborer-2 attended the POD Meeting. After the POD Meeting, they proceeded to the Boundary Control Station, where they dressed in the anti-c clothing and PPE on which they had been instructed. They used their badges to electronically log their entry to the K-1302 pad (which was a radiological contamination area), then they took their equipment out onto the pad, and set it up. Laborer-1 had indicated on the previous day and during the morning POD Meeting that he was familiar with the operation of the cut-off machine and had used this type of equipment at other job sites. Although the MACTEC Temporary Superintendent knew about the rebar removal job, he did not actually watch the two laborers perform removal of the rebar.

Figure 10. Laborer Demonstrating Use of Cut-Off Machine (Held in Incorrect Position)

The Board determined that Laborer-1 told his management that he had used a cut-off machine before. However, he was not knowledgeable enough in its exact use to ensure that he did not put lateral force on the wheel. Laborer-1 had not read the manufacturer’s safety manual, nor

had he read the warning label on the wheelguard of the cut-off machine. The Board's inspection of the cut-off machine indicated excessive wear on one side of the grinding wheel.

The Board watched a demonstration where Laborer-1 dressed in the anti-c coveralls and other PPE that he was wearing on the day of the incident and then demonstrated his body position when he cut the rebar. (See Figure 13 above.) The Board noted that, according to the manufacturer's safety manual, Laborer-1 did not hold the cut-off machine as directed by the safety manual. The safety manual for the Stihl model TS-510 AV Cutquik® cut-off machine directs the operator to "Place your left hand on front handle bar and your right hand on rear handle and throttle trigger. Left-handed users should follow this instruction too." During the demonstration for the Board, Laborer-1 used a hand position opposite to this warning because of a previous injury that weakened his left arm. He held the grinding wheel in a plane with the centerline of his body. The cut-off machine manufacturer's representative stated in a telephone conversation that the operator's body should never be in the plane of the grinding wheel. The manufacturer's safety manual also provides the following warnings:

- *"When cutting metal, a cut-off machine generates sparks which can ignite clothing. Most fabrics used in clothing are combustible – even flame-retardant fabrics will ignite at higher temperatures. To reduce the risk of burn injury STIHL recommends wearing clothing made of leather, wool, flame-retardant-treated cotton or tightly woven, heavier cotton such as denim. Some flame-retardant synthetic fabrics are also suitable but others such as polyester, nylon, rayon and acetate can melt during fire into a tar-like matter that burns into the skin. Check the clothing manufacturer's instructions. Keep clothing free of oil, fuel, grease and other flammable substances.*
- *Sparks from cutting metal can burn or cause clothing to catch fire. Do not use a cut-off machine on flammable ground. Always direct sparks away from the operator or any flammable surroundings.*
- *The wheel guard is adjustable. It is extremely important that the wheel guard is in place and set to suit the type of work and your stance. The guard should always be adjusted so that the user is not endangered by particles of the material being cut; sparks or pieces of damaged wheels either directly or by ricochet. Failure to follow this instruction could result in serious or fatal injury."*

On February 18, 2003, on learning that the BJC personnel had decided that a hot work permit was not necessary per BJC-EH-2007, MACTEC personnel did not stop the job to highlight the requirements in AHA 2000-2 nor to question BJC's decision. The AHA requires a hot work permit for this type of activity. The selection of appropriate PPE was primarily governed by the RWP, with the addition of a face shield. According to the MACTEC AHA, a hot work permit is required for grinding activities. When a hot work permit is issued, workers wear fire-retardant, anti-c coveralls, a trained fire watch is established, and an appropriate fire extinguisher is put in place before the start of the job. In addition, according to the MACTEC lessons learned from the May 16, 2002, incident, the worker would also wear leather chaps to

provide further protection from the sparks thrown by the grinding wheel of the cut-off machine, as well as from the wheel itself.

Another Danger in Using a Cut-Off Machine

The following Fernald occurrence illustrates one of the dangers of the cut-off machine. This near miss occurrence was found by searching the ORPS database.

On June 13, 2002, the Assistant Emergency Duty Officer at Fernald was notified of an event that had occurred outside Trailer 540 (the Maintenance laborers' trailer). The abrasive wheel came off of a cut-off machine, struck two personal vehicles, and almost struck an employee walking between the automobiles.

At approximately 7:00 am, a Fluor Fernald Maintenance laborer supervisor demonstrated how to change the abrasive wheel on a STIHL Model TS-760 Cutquik® cut-off machine. The cut-off machine was a newer model than the other ones in use and had last been used in the spring of 2001. The wheel was being changed in preparation for a job at another location. The abrasive wheel that the supervisor installed came with the cut-off machine when it was purchased. The wheel was held in place by a bolt through a double-tabbed thrust washer. According to the Maintenance supervisor, the wheel was properly installed and torqued onto the spindle. This model of cut-off machine has a 6.42 horsepower engine and a maximum spindle speed of 5350 rpm. The abrasive wheel that he installed was 14 inches in diameter, with a thickness of 4 mm, and was rated for a maximum surface speed of 5460 rpm.

At approximately 7:12 am, after the new wheel was installed, a laborer took the cut-off machine outside and set it down on the ground. He started the engine to make sure that it ran properly. He engaged the throttle lock and stepped back to allow the engine to warm up.

At the same time, the Fluor Fernald D&D Projects Manager pulled into a parking space approximately 40 feet northwest of where the cut-off machine was sitting on the ground. He got out of his car, walked back to the trunk, and took out some belongings. He later stated that he could hear the cut-off machine running loudly nearby (at high speed, not just idling). After closing his vehicle, he was walking around to the driver's side door when he heard the laborer yell. The laborer stated that as the cut-off machine continued to run, the thrust washer fell off, spun forward several feet on the asphalt to hit the skirt of the trailer, and came to rest, while the abrasive wheel spun forward on the pavement about 15 feet and then became airborne. The wheel traveled about 25 feet in the air and bounced on the hood of a vehicle parked on the east side of the spot where the D&D Projects Manager had parked. When the D&D Projects Manager heard the laborer yell, he looked up and saw the wheel in the air, coming down directly toward him. He lunged forward several steps and saw the wheel bounce off the hood of the first car, travel another six feet through the air, and impact the spot where he had been walking a moment before. The wheel impacted the driver's side rear wheelwell area of his car, fell to the ground, and spun out its remaining momentum.

2.2.5 Feedback and Improvement

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

MACTEC Feedback and Improvement

The MACTEC contractual requirements for lessons learned, as well as feedback and improvement, are identified as “Status One” documents (meaning that “work may proceed”) in the August 14, 2000, *BJC EM/EF-M&I Project Subcontractor Submittal Status Sheet*. These requirements are identified in Appendix G-1, “Contractor Integrated Safety Management System (ISMS) Matrix,” of the MACTEC subcontract with BJC. This matrix identifies the MACTEC lessons learned process as Section 8.5 of the Main Plant ES&H Plan. Feedback and continuous improvement processes are identified as contained in Sections 7, 8.4, and 8.6 of the Main Plant ES&H Plan. The current MACTEC Main Plant ES&H Plan is Revision 3, dated October 23, 2002.

Section 8.5, “Lessons Learned,” of the MACTEC Main Plant ES&H Plan indicates that lessons learned pertinent to the scope of work are obtained from the BJC STR and the safety advocate. They are discussed with workers via topics for prejob briefings, toolbox meetings, and “back-to-work” morning sessions. MACTEC generated a lessons learned write-up for the May 16, 2002, incident in which the knee of a pair of flame-retardant anti-c coveralls was damaged by use of the same cut-off machine that was used in the February 18, 2003, incident. However, this lessons learned was only generated internally to MACTEC, and it was not entered into the BJC Lessons Learned System or the DOE Lessons Learned System. In addition, the information from the lessons learned was not used during the MACTEC POD Meeting on February 18.

The MACTEC Main Plant ES&H Plan, Section 7, “Hazard Assessment,” describes the process by which AHAs are developed for work hazards. This process is described in Section 2.2.2 above. The AHA process includes reviewing, addressing, and sharing lessons learned. These activities take place during prejob and postjob briefings, safety meetings, and other meetings. MACTEC’s current AHA is 2000-2, Revision 14, dated February 11, 2003. In the “Potential Hazard – “Fire” section, the first work activity indicates that a hot work permit is necessary. Work activity 33, “Torch Cutting/ Welding/Burning and Grinding,” is somewhat less specific and indicates that “A Welding/Burning/Hot Work Permit will be obtained prior to beginning torch-cutting.”

MACTEC ES&H Rep-5 signed the most recent change to the AHA (2002-02, Revision 14) and was the author of Revision 0. The information concerning a hot work permit was not reviewed at the POD Meeting because a hot work permit was not issued for the rebar removal job to be performed. The lessons learned from the May 16, 2002, incident was not reviewed with Laborer-1 and Laborer-2 during the POD Meeting on the morning of February 18, 2003.

The MACTEC Main Plant ES&H Plan Section 8.4, "Employee Feedback and Involvement," states that workers take part in safety and job planning walkdowns and the development of AHAs. This section also discusses prejob briefings, where workers are given the opportunity to ask questions and offer suggestions. It states, "Safety/ toolbox meetings will be conducted on a daily and weekly basis." It further indicates that MACTEC utilizes the BJC "I Care/We Care" forms and procedures for obtaining suggestions and concerns.

MACTEC workers are involved in the hazard assessment process. Laborer-1 reviewed the most recent revision to the AHA (2000-2, Revision 14) as part of this process. The AHA is used during the POD Meetings with the workers present. However, AHA 2000-2 includes 48 items with numerous subtopics, and it is over 19 pages in length. The POD Meeting carried out on February 18 did not include the information that AHA 2000-02 requires a hot work permit for grinding because BJC had indicated that a hot work permit was not needed.

The MACTEC Main Plant ES&H Plan Section 8.6, "Continuous Improvement," indicates that feedback and suggestions contributed by workers from various sources are documented. When issues require immediate attention, work is suspended until corrective measures are taken. Issues that are not immediately dangerous to life and health are corrected, and the status of the progress made is provided during the back-to-work morning sessions.

The current MACTEC *Quality Assurance Project Plan for the Main Plant D&D Project* is QAPP-2.012, Revision 8, dated October 29, 2002. The purpose of Section 5.0, "Quality Improvement," is to "describe the processes established and implemented to promote continuous improvement." The "Quality Improvement" section describes the system that MACTEC uses to achieve continuous improvement. The process described requires discrepancies to be documented on a "Corrective Action Request Form." This form is used to record the pertinent data concerning a discrepancy. The MACTEC Quality Assurance Representative is required to enter the information from the "Corrective Action Request Form" into an electronic file that the Quality Assurance Representative maintains. A responsible party is assigned action, and BJC is provided with a copy of the "Corrective Action Request Form." Prior to implementing corrective or preventative action, MACTEC provides BJC with a copy. Corrective actions must be completed within five working days or a plan must be submitted to BJC. All open "Corrective Action Request Forms" are reported to the Project Manager on a monthly basis via a Corrective Action Report. The *Quality Assurance Project Plan for the Main Plant Project*, Section 10, "Independent Assessment," requires each element to be audited at least on an annual basis. Discrepancies are identified and documented following the procedures outlined for the "Corrective Action Request Form." In addition, a management review must be conducted on an annual basis. These management reviews cover all applicable Quality Assurance Program elements and include the status of the monthly Corrective Action Reports.

In August 2002, the BJC Main Plant D&D Project conducted a safety stand-down at MACTEC due to eight safety-related incidents that occurred between June 25 and August 5, 2002. BJC, MACTEC, and DOE were participants in cross-functional teams to investigate the negative trend in work control practices. As the first phase of the evaluation, the team conducted an ISMS Wheel Analysis. The ISMS Wheel Analysis is an evaluation of the ISM

core functions as they apply to the incident being evaluated. The ISMS Wheel Analysis identified two causal factors, “Inadequate Recognition of Changed/ New Work Conditions” and “Inadequate Level of Rigor in Performing Hazard Analysis.” A TapRoot® Analysis was then conducted on the two common causal factors and identified “Management System Deficiency” as the root cause. On August 19, 2002, MACTEC generated a Corrective Action Request, CAR 2002-001, with actions for the two causal factors identified in the ISM Wheel Analysis. Examples of the corrective actions for the causal factor of “Inadequate Level of Rigor in Performing Hazard Analysis” are as follows:

- Increase ES&H evaluation of work activities to include a thorough review of the related AHA by management and workers.
- Ensure management evaluations of work activities and scheduling includes a thorough briefing of all personnel to ensure understanding of safety and hazard controls.
- MACTEC management will review with all employees the command and control responsibilities of each employee working on this project.
- Increase ES&H staffing for improved oversight.
- MACTEC Quality Assurance will increase the frequency of internal surveillances and evaluation to monthly instead of quarterly.
- The Self-Assessment Checklist is to be completed weekly instead of monthly.
- The ES&H Representative is now required to attend the afternoon debriefing with workers to solicit feedback; all meetings will have a sign-in sheet.
- Employee Communication:
 - Institute the “I Care/We Care” Program.
 - Provide an avenue for employee feedback, such as a suggestion box.

Examples of the corrective actions for the causal factor of “Inadequate Recognition of Changed/New Conditions” are as follows:

- Update the *Quality Assurance Project Plan for the Main Plant D&D Project*, concentrating on trending, when, where, and root causes.
- Perform monthly self-assessments of the Quality and Safety Programs.
- Institute a lessons learned program within the MACTEC Development organization. The program will include the following:
 - Sharing incident information with other MACTEC sites
 - Feedback from corporate-level safety reviews
 - Identification of trending, corrective actions, and training of personnel
- Review training of key and new personnel, including peer review and training as part of the formal orientation process.
- Pass on to the workforce the expectations for safety performance through safety meetings and prejob briefings. Emphasize employees’ responsibility to report changed conditions to supervision.
- Review the basic ISM functions and principles with all project personnel. Focus on discussions of how these items apply to work scope and daily work activities.
- After the morning POD Meeting, a separate daily prejob briefing will be held with the workers and foreman for a more in-depth review of the AHAs and tasks to be performed. An attendance sheet will document those present and the subject matter

covered. AHAs for new tasks will be reviewed in-depth prior to start of these activities. AHAs for various routine activities will be reviewed weekly.

- Review and strengthen prejob briefings. The prejob briefing is to include the following:
 - Scope of work for that day.
 - Limitations and hold points.
 - Review of the applicable AHA sections for that day's activities.
 - Emphasize to the workforce that directions are to be taken from MACTEC supervision only unless there is an imminent danger situation.
 - Emphasize workers' responsibility to stop work and contact supervision when a changed condition occurs.

BJC has monitored the actions identified in the Corrective Action Reports that were implemented in response to the August 2002 safety stand-down. The activities that MACTEC was to carry out have continued. The scaling back of MACTEC's activities on the project has reduced some of the actions. For example, MACTEC no longer conducts a separate prejob briefing with workers after the POD Meeting. Monthly MACTEC Quality Assurance oversight has continued, but some topics selected for assessment of work activities were for activities that MACTEC no longer performs. The *Quality Assurance Project Plan for the Main Plant D&D Project* was revised to address trending and root cause analysis, but no procedures have been put in place to indicate an acceptable method for conducting the analyses.

BJC Feedback and Improvement

The BJC process for feedback and improvement consists of evaluations of BJC and subcontractor performance to assure conformance to specified requirements and effective implementation. STRs review subcontractors' submittals and deliverables. Safety advocates assess subcontractors' ES&H performance, subcontractor scorecards, and subject matter expert assessments. Quality engineers monitor project performance. In addition, management assessments and independent assessments are conducted to provide ongoing formal feedback. The issues that are identified are documented, causal analyses are performed, and corrective actions are developed and tracked to closure. The BJC procedures that cover these activities are BJC-PQ-1420, *Management Assessment*, BJC-PQ-1450, *Performance Monitoring*, and BJC-PQ-1401, *Independent Assessment*. Issues identified during these various assessments and feedback processes are tracked through the BJC Issues/Corrective Action Tracking System. Root cause analyses are performed on issues in accordance with BJC-PQ-1230, *Root Cause Analysis*. Lessons learned from the DOE complex and other sources are captured using BJC-PQ-1240, *Lessons Learned Program*.

BJC performed many assessments of the Main Plant D&D Project and identified issues that required corrective actions to be taken. BJC carried out a safety stand-down of MACTEC in August 2002, based on negative trends that had occurred in the project operations. Although BJC required MACTEC to develop a lessons learned for the May 16, 2002, incident with the cut-off machine, the lessons learned document was not captured in BJC Lessons Learned

System. Three months after the lessons learned was generated, there were five BJC staff changes.

BJC uses a monthly subcontractor performance “score card” as a tool for STRs to apprise BJC management of their subcontractors’ performance during the previous month. The score card is color-coded in red, yellow, and green. Limited criteria have been established to allow the project teams (and especially the STRs) to give BJC management their analysis of their subcontractor’s performance. The score cards are due to management shortly after the beginning of each month. MACTEC’s safety and health scores for January 2003 identified improvements needed in the areas of ISMS implementation, environmental compliance, and occurrences.

DOE Feedback and Improvement

In July 1998, the Office of Environment, Safety, and Health Evaluations (then the Office of Oversight within the Office of Environment, Safety, and Health) conducted a follow-up review of the 1997 Type A Accident Investigation at ETTP. This evaluation determined the progress made on the corrective actions to address the Judgments of Need that resulted from the welding/cutting fatality at Building K-33 at ETTP. That 1998 evaluation found that 4 of the 15 Judgments of Need were fully satisfied and the remaining had efforts underway to complete the corrective actions. Since that time, all of the corrective actions have been closed.

From April through October 2000, the Office of Environmental, Safety, and Health Evaluations conducted an independent investigation of ETTP. This review was part of a Departmental investigation of gaseous diffusion plants that examined concerns about past operations and work practices and the current management of legacy materials at those plants. A portion of this investigation examined work control systems and occupational safety and health program at ETTP. The team identified issues in work control programs and activity-level hazard controls. All of the issues identified by this investigation were addressed in an approved CAP. ORO reported in the Department’s Corrective Action Tracking System that the CAP was completed on December 19, 2002.

A portion of the ORO Feedback and Improvement Program consists of oversight carried out by Facility Representatives assigned to specific facilities, as well as periodic, focused oversight conducted by subject matter experts. Both of these types of oversight have been an active presence since this project began. Records reviewed for the previous 18 months indicate that various DOE oversight activities have occurred, almost on a monthly basis. However, the Board found no indication that oversight had been conducted after December 2002. The Board determined that this was due to assignment of many of the Site Office ES&H staff to the joint DOE/BJC Safety Management Programs review of BJC. In addition, the Facility Representative assigned to the Main Plant D&D Project facilities has been assigned to the Documented Safety Analysis Team and has been unable to carry out his normal oversight activities since this assignment. Oversight activities carried out by the DOE Facility Representative and subject matter experts are tracked and trended, and the status is maintained in a database.

Lessons Learned from the 1997 Welding/Cutting Fatality at ETPP

The only MACTEC person who was aware of the 1997 welding/cutting fatality at ETPP was ES&H Rep-5. Neither Laborer-1 nor Laborer-2 was trained as a fire watch, and neither of them had viewed the video from the 1997 welding/cutting fatality. BJC Safety Advocate-4 was aware of the 1997 welding/cutting fatality. The BJC D&D Projects Manager had not read the 1997 Type A Accident Investigation Report on the fatality. Knowledge of the 1997 welding/cutting fatality at ETPP has lessened with the change of DOE prime contractor and the method of contracting. The BJC contract requires 90% of the work to be performed by subcontractors. A high turnover of personnel has been experienced. Ten BJC and MACTEC positions were filled by 25 individuals over an 11-month period.

3.0 ANALYSIS

The Board used several analytical techniques to determine the causal factors of the incident. Events and causal factors were charted using the ISM core functions. The Board used change and barrier analysis techniques to analyze the facts and identify the causes of the incident. The causal factors related to weaknesses in implementation of the ISM core functions collectively contributed to the incident. The Judgments of Need are presented in Table ES-1 and Table 4-1.

3.1 Barrier Analysis

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

3.2 Change Analysis

Change is anything that disturbs the “balance” of a system which is operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Change analysis examines planned or unplanned changes that caused undesired results or outcomes related to the incident. This process analyzes the difference between what is normal (or “ideal”) and what actually occurred. The results of the change analysis are used to support the development of the causal factors. Appendix C, Table C-1, contains the change analysis.

3.3 Events and Causal Factors Analysis

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

The direct cause is the immediate events or conditions that caused the accident/incident. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the incident but which did not cause this PPE ignition incident. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar events. *The direct cause of the incident was sparks that impinged on the*

laborer's right leg, which ignited the PPE. A summary of the Board's causal factors analysis is presented in Appendix D, Table D-1.

3.4 Integrated Safety Management

Table 3-1. Weaknesses in Implementation of the ISM Core Functions

<p><i>There are significant weaknesses in BJC's and MACTEC's implementation of the five core functions of ISM that contributed to this event.</i> These weaknesses include the following:</p>
<p><u>Core Function 1</u> – Define the Work Scope</p> <ul style="list-style-type: none"> • The BJC ISMS declaration was revoked in November 2001 and is still not approved. • The flowdown of requirements from BJC to MACTEC did not include the 1999 version of NFPA 51B. • The PSS Safety Stand-Up Meeting did not discuss the K-1302 pad rebar removal job, which was a last-minute task. • The work scope was not formally analyzed.
<p><u>Core Function 2</u> – Analyze the Hazards</p> <ul style="list-style-type: none"> • The hazards associated with use of the cut-off machine were not completely identified and analyzed. • The hazard controls were not tailored to cutting rebar with a cut-off machine. • The hazard analysis did not consider or question the actual state of contamination of the concrete pad (K-1302 pad). • The AHA is too broad in scope to adequately address cut-off machine operation. • Tool selection was based on availability, not appropriateness.
<p><u>Core Function 3</u> – Develop and Implement Controls</p> <ul style="list-style-type: none"> • The AHA identifies the need for a hot work permit, but the requirement was not implemented.
<p>[continued on next page]</p>

**Table 3-1. Weaknesses in Implementation of the ISM Core Functions
(continued)**

<p><i>There are significant weaknesses in BJC's implementation of the five core functions of ISM that contributed to this event. These weaknesses include the following:</i></p>
<p><u>Core Function 3 – Develop and Implement Controls</u></p> <ul style="list-style-type: none"> • Although the site was posted as radiologically contaminated prior to 2001, the surveys performed after 2001 showed results below the detectable range, which would support re-evaluation of the anti-c PPE requirements. • Equipment controls for the cut-off machine were not developed and implemented. • The BJC management system to control the work of subcontractors failed in the following ways: <ul style="list-style-type: none"> ➤ High turnover of personnel ➤ No push-back by the subcontractor ➤ Willingness to accept a questionable answer versus acting on a perceived risk ➤ Overrode the MACTEC AHA (requirements document) with the BJC hot work procedure ➤ Failed to follow the subcontract requirements for written direction from BJC for removal of key MACTEC personnel from the project • Laborer-1 did not have proper training on how to use cut-off machine and the hazards associated with it. • The MACTEC Temporary Supervisor did not have adequate hazard and task-specific training to adequately supervise employees. Following are two examples: <ul style="list-style-type: none"> ➤ He did not validate Laborer-1's experience operating a cut-off machine. ➤ He did not observe the work in progress.
<p><u>Core Function 4 – Perform the Work Within Controls</u></p> <ul style="list-style-type: none"> • The work performed with the cut-off machine was not performed in accordance with the manufacturer's safety manual. • The AHA requirement to obtain a hot work permit was not followed. • Inadequate work controls were applied to the cut-off machine operation and conduct of the rebar removal job.

**Table 3-1. Weaknesses in Implementation of the ISM Core Functions
(continued)**

There are significant weaknesses in BJC's and MACTEC's implementation of the five core functions of ISM that contributed to this event. These weaknesses include the following:

Core Function 5 – Feedback and Improvement

- A lessons learned from a prior incident involving the cut-off machine and spark damage to anti-c PPE was not communicated outside of the subcontractor.
- A Judgment of Need from the 1997 Type A fatality report (EH2MGT/04-97/01A1) and the Defense Program's report *Personal Protective Equipment Use in DOE Programs*, dated March 1998, have indicated the need to emphasize that PPE can, by itself, create significant worker hazards and that overprotection should be avoided, where possible.
- Continuity of the feedback and improvement systems is hampered by high turnover of subcontractor and BJC personnel.
- The BJC ISMS has still not been approved by ORO.
- ORO, BJC, and BJC's subcontractors have not emphasized the 1997 Type A welding/cutting fatality. MACTEC employees stated that they had never read the report or seen the Lockheed Martin Energy Systems, Inc., video.

Table 3-2. Weaknesses in Implementation of the ISM Principles

There are significant weaknesses in BJC's and MACTEC's implementation of the eight guiding principles of ISM that contributed to this incident. These weaknesses include the following:

Guiding Principle 1 – Line management is directly responsible for the protection of the public, workers, and the environment.

- BJC and MACTEC did not provide effective line management, so the rebar removal job resulted in a near-miss, preventable incident.
- BJC line management never followed up on lessons learned for the May 2002 PPE burnthrough incident.
- BJC line management made an incorrect determination that the rebar removal job did not require a hot work permit based on limited knowledge of the hazards and no knowledge of the previous cut-off machine incident.
- BJC line management failed to discuss the work and safety concerns with the BJC Facility Manager.
- MACTEC line management did not properly communicate lessons learned from the previous incident involving the cut-off machine.
- MACTEC line management did not assure that Laborer-1 was properly trained and fully aware of the hazards associated with operation of the cut-off machine.
- MACTEC line management failed to follow the AHA.

Guiding Principle 2 – Clear and unambiguous lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels within the Department and its contractors.

- MACTEC deferred to BJC's determination and did not act on its authority under the AHA to proceed with requiring a hot work permit. MACTEC was responsible for performing its own hazard analysis and following its AHA. In this case, lack of specifics in the AHA and deference to BJC's procedural determination removed barriers that would have prevented the incident.

**Table 3-2. Weaknesses in Implementation of the ISM Principles
(continued)**

<p><i>There are significant weaknesses in BJC's and MACTEC's implementation of the eight guiding principles of ISM that contributed to this incident. These weaknesses include the following:</i></p>
<p><u>Guiding Principle 3</u> – Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.</p> <ul style="list-style-type: none"> • BJC, MACTEC line management, and Laborer-1 did not have adequate experience with the cut-off machine to make a judgment that the machine was inherently hazardous, particularly when used in conjunction with combustible anti-c coveralls.
<p><u>Guiding Principle 4</u> – Resources shall be effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment shall be a priority whenever operations are planned and performed.</p> <ul style="list-style-type: none"> • The single DOE Facility Representative, who had been assigned additional duties, was not sufficient to provide effective oversight of the Main Plant D&D Project. No backup DOE Facility Representative was assigned.
<p><u>Guiding Principle 5</u> – Before work is performed, the associated hazards shall be evaluated and an agreed-upon set of standards shall be established that, if properly implemented, will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.</p> <ul style="list-style-type: none"> • BJC-EH-2007, <i>Welding/Burning/Hotwork</i>, does not reflect the latest changes from the 1999 version of NFPA 51B that includes grinding as hot work. It also references the wrong versions of ASTM standards. • The implementation of the MACTEC AHA process, whereby a broad, overarching AHA was used for much of the Main Plant D&D Project, was insufficient to thoroughly define all of the hazards and related work procedures at the task level.
<p><u>Guiding Principle 6</u> – Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work being performed and the associated hazards.</p> <ul style="list-style-type: none"> • BJC personnel were unable to make accurate procedural determinations because the procedure did not include the latest NFPA modifications. • The MACTEC overarching AHA is too broad. Task-specific details need to be incorporated, or task-specific AHAs need to be developed.

**Table 3-2. Weaknesses in Implementation of the ISM Principles
(continued)**

There are significant weaknesses in BJC's and MACTEC's implementation of the eight guiding principles of ISM that contributed to this incident. These weaknesses include the following:

Guiding Principle 7 – The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed upon.

- BJC has not formally transmitted its latest ISMS description to MACTEC.
- BJC has not demonstrated that its ISMS implementation has reached into the subcontractor level.

Guiding Principle 8 – Worker Involvement. (ORO Manager memorandum adopting worker involvement as the eighth principle of ISM, dated September 1999)

- Laborer-1 and Laborer-2 were not involved in the discussion of the hazards of the cut-off machine due to BJC and MACTEC failures.

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4.0 CONCLUSIONS AND JUDGMENTS OF NEED

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

The Board reviewed the work controls involving the cut-off machine work and the corrective actions associated with previous PPE ignition events. The results of these reviews were factored into the five core functions and the eight principles of ISM. Judgments of Need were developed that considered what actions were necessary to prevent recurrence of this incident and other similar events.

Table 4-1. Judgments of Need

JON No.	Judgment of Need	Direct, Contributing, and Root Causes
JON 1	BJC and its subcontractors need to fully implement the ISM program. Particular emphasis is needed in the identification of hazards, work controls, and feedback mechanisms.	D1 – Sparks impinged on the worker’s right leg, which ignited the PPE. R1 – BJC’s and MACTEC’s work control process was inadequate. C2 – The lessons learned systems were not used properly. C3 – The BJC hot work procedure (BJC-EH-2007) is inadequate. C4 – The MACTEC AHA is not clear. C5 – There was no review of the anti-c PPE requirements when the contamination and radiological surveys significantly changed. C6 – The RWP does not recognize abrasive work as hot work. C9 – MACTEC’s and BJC’s training of its personnel was inadequate.
JON 2	BJC needs to develop an effective process that ensures formal, two-way communication with its subcontractors.	C1 – Project execution discipline was lost. D1 – Sparks impinged on the laborer’s right leg, which ignited the PPE.
JON 3	BJC and its subcontractors need to ensure that the requirements for training are appropriately identified and personnel are adequately trained.	C9 – MACTEC’s and BJC’s training of its personnel was inadequate.

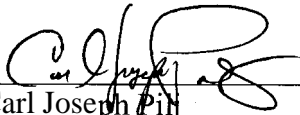
**Table 4-1. Judgments of Need
(continued)**

JON No.	Judgment of Need	Direct, Contributing, and Root Causes
JON 4	BJC and its subcontractors need to develop and implement a system to facilitate sharing of work practices, issues, and solutions for effective lessons learned.	C2 – The lessons learned systems were not used properly. C7 – MACTEC personnel did not have knowledge of the 1997 welding/cutting fatality at ETTP.
JON 5	ORO needs to establish a policy that clearly defines the use of fire-retardant, anti-c coveralls.	C5 – There was no review of the anti-c PPE requirements when the contamination and radiological surveys significantly changed. C6 – The RWP does not recognize abrasive work as hot work. C7 – MACTEC personnel did not have knowledge of the 1997 welding/cutting fatality at ETTP.
JON 6	ORO needs to develop a risk-based policy for balancing the assignment of facility representatives and subject matter experts on special projects with contractor oversight responsibilities.	C8 – The facility representative assigned to the Main Plant D&D Project has not performed his regular duties on a full-time basis since January 2003.

5.0 BOARD SIGNATURES



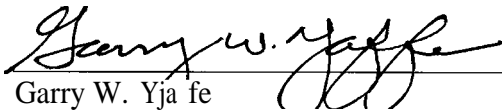
Justin T. Zamirovski
DOE Accident Investigation Board Chairman
U.S. Department of Energy
Chicago Operations Office



Carl Joseph Pin
DOE Accident Investigation Board Member
U.S. Department of Energy
Oak Ridge Operations Office



Mary H. Rawlins
DOE Accident Investigation Trained Board Member
U.S. Department of Energy
Oak Ridge Operations Office



Garry W. Yaffe
DOE Accident Investigation Board Member
U.S. Department of Energy
Savannah River Operations Office

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6.0 BOARD MEMBERS, ADVISORS, AND STAFF

Chairperson Justin Zamirowski, DOE

Member Carl Pilj, DOE

Member Mary Rawlins, DOE

Member Garry Yaffe, DOE

Advisor Mike Henderson, DOE

Advisor Nancy Carnes, DOE

Coordinator/Technical Editor Karen Brown, Informatics Corporation

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**Appendix A – Appointment of Type B Accident
Investigation Board**

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United States Government

Department of Energy
Oak Ridge Operations Office

memorandum

DATE: February 21, 2003

REPLY TO
ATTN OF: SE-2:Mullins

SUBJECT: TYPE B INVESTIGATION - SUBCONTRACTOR EMPLOYEE PERSONAL PROTECTIVE EQUIPMENT IGNITION INCIDENT - BECHTEL JACOBS COMPANY LLC, OAK RIDGE, TENNESSEE

To: Justin T. Zamirowski, Chicago Operations Office

You are hereby appointed Chairperson of the Investigation Board to investigate the subject incident that occurred at the East Tennessee Technology Park on February 18, 2003.

You are to perform a Type B investigation of this incident and to prepare an investigation report. The report shall conform to requirements detailed in the Department of Energy (DOE) Order 225. IA, *Accident Investigation*, and DOE G 225.1A-1, *Implementation Guide for Use with DOE 225. IA, Accident Investigations*. The Board will be comprised of the following members:


Justin Zamirowski, Chairperson
Mary Rawlins, Program Coordination Division, Accident Investigator
Ron Kirk, EM Facility Representative, Team Member
Garry Yaffe, Fire Protection, Subject Matter Expert, Team Member
Mike Henderson, Radiological Protection, Team Advisor
Nancy Carries, Legal Advisor

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

If additional resources are required to assist you in completing this task, please let me know and it will be provided. You and members of the Board are relieved of your other duties until this assignment is completed.

The Board will provide my office with weekly reports on the status of the investigation but will not include any findings or arrive at any premature conclusions until an analysis of all the causal factors have been completed. Draft copies of the factual portion of the investigation report will be submitted to my office and the contractor for factual accuracy review prior to the report finalization.

The final investigation report should be provided to me by March 24, 2003. Any delay to this date shall be justified and forwarded to this office. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report. A copy of the Oak Ridge Accident Investigation Guidelines is attached for your use. If you have any questions, please contact me or Robert Poe at 576-0891.

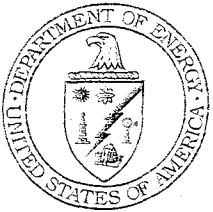


Gerald G. Boyd
Manager

Attachment:
ORO AI Guidelines

cc w/attachment:
Garry Yaffe, Savannah River Operations
Mary Rawlins, LM-12, ORO
Ron Kirk, EM-94, ORO
Mike Henderson, SE-31, ORO
Nancy Carnes, CC-10, ORO

cc w/o attachment:
B. A. Cook, EH-1, HQ/FORS
J. H. Roberson, EM-1, HQ/FORS
R. P. Berube, EH-4, HQ/FORS
M. D. Johnson, SC-3, HQ/FORS
R. H. (Chip) Lagdon, EH-21, HQ/270/GTN
T. H. Rollow, EH-21, HQ/FORS
D. L. Vernon, EH-24, HQ/270/GTN
T. Z. Smith, DOE SR
C. L. Nealy, DOE CH
M. K. Morrow, M-2, ORO
S. L. Wyatt, M-4, ORO
R. W. Poe, SE-30, ORO
R. C. Smyth, EM-90, ORO
D. M. Perez, EM-911, ORO
G. M. Manthey, LM-12, ORO
H. J. Monroe, SE-31, ORO
T. Noe, EM-94, ORO



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Oak Ridge Operations Office
P.O. Bo:: 200
Oak Ridge, Tennessee 37831L-

March 12, 2003

vlr. Steven D. Liedle, President
Bechtel Jacobs Company LLC
P. O. Box 4699
Oak Ridge, Tennessee 37830-7294

Dear Mr. Liedle:

TYPE B INVESTIGATION - SUBCONTRACTOR EIVIPLOYEE PERSONAL,
PROTECTIVE EQUIPMENT IGNITION INCIDENT - BEC TEL JACOBS
COMPANY LLC, OAK RIDGE, TENNESSEE

This is to document a change in the membership of the Type B Accident Investigation Board formed to investigate the subject incident which occurred on February 18, 2003. Mr. Ron Kirk, EM Facility Representative, has been replaced as a Board member by Mr. Carl Pilj, EM Facility Representative.

If you have any questions and/or comments, please contact Robert W. Poe at (865) 576-0891.

Sincerely,

A handwritten signature in cursive script, appearing to read "Gerald & Boyd".

~Gerald & Boyd
Manager

cc:

B. A. Cook, EH-1, HQ/FORS
J. H. Roberson, EM-1, HQ/FOBS
R. P. Berube, EH-4, HQ/FORS
M. D. Johnson, SC-3, HQ/FORE
R. H. (Chip) Lagdon, EH-21, HQ/270/GTT~T
D. L. Vernon, EH-24, HQ/270/GTi\T
M. K. Morrow, M-2, ORO
S. L. Wyatt, M-4, ORO
R. W. Poe, SE-30, ORO
R. C. Smyth, EM-90, ORO
D. M. Perez, EM-911, ORO
T. Noe. E.II-94, ORO
J. T. Zamirowski, Board Chairperson

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Appendix B – Barrier Analysis

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Table B-1. Barrier Analysis

Barrier	Purpose	Analysis/Effect on Incident
<i>Physical Barriers</i>		
Anti-c coveralls	Protection against a potential contamination event	The survey data since 2001 supported relaxing the requirements for anti-c coveralls. The anti-c coveralls contributed to the fire. The survey data was not taken into consideration. The lack of flexibility in the requirements for coveralls put the laborers at increased risk of the fire hazard.
Manufacturer's safety manual and the warnings on the cut-off machine wheelguard	Instruct the user on the proper use of and the hazards associated with use of the cut-off machine	The manual was not read and was not available for review prior to the incident. It had no effect on the decision to use the cut-off machine.
Proper use of the cut-off machine in relation to the operator's body	Injury prevention	Laborer-1 apparently held the cut-off machine so that sparks were directed at his right leg. The wheelguard was not adjusted to redirect the spray of sparks away from his body. His hand position was not in accordance with the manufacturer's safety manual. The cut-off machine is designed as a vertical cutting tool, not a horizontal or angled cutting tool.
Use of leather chaps	Prevention of injury from sparks	Leather chaps were not worn, which increased the probability of the incident occurring.
Management Barriers		
Hot work permit	Provide proper procedures for (spark-producing) hot work	A hot work permit was not issued. The worker was placed in 100% cotton coveralls instead of flame-retardant coveralls.

Table B-1. Barrier Analysis
(continued)

Barrier	Purpose	Analysis/Effect on Incident
Management Barriers (continued)		
MACTEC AHA indicates grinding as hot work	Analysis and planning of job activities per the contract	AHA Item 1 – Sites – “Obtain a WBHWP before using . . . grinders or other flame/spark producing tools.” Item 33 also indicated a hot work permit “will be obtained prior to beginning torch-cutting.” The AHA was not followed after MACTEC ES&H Rep-5 and the Temporary Superintendent accepted that a hot work permit was not required by the BJC procedure. The AHA had no effect in preventing the incident.
Lessons learned from the May 16, 2002, incident	Hazard analysis awareness and accident prevention	The lessons learned was not communicated outside of the MACTEC personnel who were directly involved. Neither the MACTEC personnel nor the BJC personnel assigned to the project were aware of the May 16, 2002, lessons learned document until after this incident.
Work procedures	To standardize methods of planning, documenting, analyzing hazards, permitting, etc.	BJC and MACTEC personnel relied on the BJC procedure, BJC-EH-2007, <i>Welding/Burning/Hotwork</i> , to determine whether a hot work permit was required. That procedure is inadequate in the case of grinding, spark-producing work. (See the AHA barrier discussion above.)
Daily PSS Safety Stand-Up Meeting	Exchange of information pertinent to work, safety, and administrative activities at ETPP	There was no discussion of the rebar removal job at the PSS Safety Stand-Up Meeting.
BJC STR-5	Knowledge and control of all work on the project	The incident was not prevented. STR-5 accepted that a hot work permit was not necessary.

**Table B-1. Barrier Analysis
(continued)**

Barrier	Purpose	Analysis/Effect on Incident
Management Barriers (continued)		
BJC Safety Lead and Safety Advocate-4	Make good judgments for the best work protection, based on complete knowledge	The incident was not prevented. The determination that a hot work permit was not required was made based on a limited knowledge of the activity.
BJC Facility Manager	– Facility and work oversight – Full knowledge of facility activities	BJC STR-3 did not inform the BJC Facility Manager of the rebar removal job or the planned use of the cut-off machine.
Laborer-1's response to the incident	Perform work safely	Laborer-1 patted out the smoldering clothing as soon as it was observed. He acted quickly and decisively, and then he stopped work and reported the incident in accordance with the company policy/procedure.
Laborer-2's response to the incident	Perform work safely. Suppress dust.	Laborer-2 responded by spraying water on Laborer-1's smoldering clothing, and then she stopped work and reported the incident with Laborer-1.
MACTEC ES&H Rep-5	Ensures work is covered and executed per the safety documentation	ES&H Rep-5 requested clarification of the applicability of the BJC hot work procedure. He accepted a "not applicable" determination in violation of the AHA.
MACTEC Supervision (Temporary Superintendent)	Oversight and supervision of the work	He did not supervise the laborers to ensure proper knowledge of the cut-off machine. He accepted that a hot work permit was not necessary in violation of the AHA.
MACTEC Project Manager	Overall execution and management of the job	He was the Southeast Area Manager, and he was stationed at the Savannah River Site. He was not routinely at the job site.
ISMS implementation	Integrated process for doing work safely	BJC has not demonstrated that its ISMS implementation reaches into the subcontractor level.

Table B-1. Barrier Analysis
(continued)

Barrier	Purpose	Analysis/Effect on Incident
Management Barriers (continued)		
Training	Set a constant level of knowledge for MACTEC workers to perform to expectations	The training could not keep up with the number of changes in the period, thereby contributing to the incident.
Prime contract and subcontract requirements	Cite the scope of work and all applicable requirements in addition to the laws, DOE Orders, WSS set, etc.	The NFPA 51B requirements in the BJC WSS set were not flowed down into the MACTEC subcontract.
DOE oversight	Oversee the execution of the BJC contract and BJC's oversight of its subcontractors	Since January 7, 2003, the DOE Facility Representative had only attended the MACTEC POD Meetings (rather than being frequently on the job site) due to his assignment to the Documented Safety Analysis Review Team on a full-time basis. In addition, the DOE Site Office ES&H staff's monthly visits had not occurred since December 2002 due to staff special assignments.

Appendix C – Change Analysis

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Table C-1. Change Analysis

Normal “Ideal”	Actual	Analysis
Low/no turnover of BJC project staff	High turnover of BJC project staff within the last year	Success depended on the strength of the support systems and not on personnel experience.
Low turnover of MACTEC project staff	High turnover of MACTEC project staff within the last year	Success depended on the strength of the support systems and not on personnel experience.
Normal supervisor of MACTEC craft personnel is the Site Superintendent	Temporary Site Superintendent of MACTEC craft personnel	The Temporary Site Superintendent did not have knowledge of the job, but he wanted to keep the laborers busy.
Formal equipment training	Informal/no equipment training	The equipment was not used in accordance with the manufacturer’s safety manual, which placed the worker at increased risk of injury.
DEMCO continues to perform the work	MACTEC self-performed the work	The result was a loss of the experience base on the project. In August 2002, MACTEC had a safety stand-down for work controls.
MACTEC selects the proper tool for the rebar removal job (rebar size #4)	MACTEC used a 5.35 horsepower, 5460 rpm, 28-pound cut-off machine to cut the rebar	The normal tool for the task was an acetylene torch or a band saw, but neither of these was available. This increased the probability of an incident.
All BJC and MACTEC project personnel are experienced in the use and hazards of a cut-off machine	No BJC or MACTEC project personnel were experienced with a cut-off machine	The result was inadequate application of the ISMS.
Last minute fill-in task that was preplanned and on an approved list	Last minute fill-in task with minimal planning	The result was inadequate application of the ISMS.

**Table C-1. Change Analysis
(continued)**

Normal “Ideal”	Actual	Analysis
BJC requests removal of the MACTEC Project Manager in compliance with contract requirements	BJC requested removal of the MACTEC Project Manager without formal documentation per the contract	The requested removals suppressed MACTEC’s willingness to engage BJC in professional disagreements.
MACTEC enforces the hot work permit requirement in the AHA by demanding that BJC prepare a hot work permit	MACTEC asked if the BJC hot work procedure requires a hot work permit	Lack of a hot work permit caused incorrect selection of PPE and increased the probability of the incident.
All of the comments from BJC Fire Protection Engineering on the hot work procedure revision are accepted	Not all of the comments for the hot work procedure revision from BJC Fire Protection Engineering are accepted	Elements of the 1999 NFPA standard 51B have not been not included in the hot work procedure revisions
The Facility Manager is informed of <u>all</u> work to be performed in the facility	The Facility Manager was not informed of plans to use a cut-off machine to cut rebar	The barrier of the Facility Manager to protect the worker was bypassed.
All information is provided and available before a professional determination is made	Job-specific details were not provided to nor asked for by the BJC Safety Lead regarding the hot work permit question	Incomplete or inadequate information led to the inadequate or incorrect result.
The EMWMF is open and accepting waste shipments	The EMWMF was shut down due to excessive rainwater runoff	The MACTEC workforce was idle, resulting in the need for alternate activities.
The BJC STR is comfortable with the inherent hazards of the tools and the methods selected	The STR was still uncomfortable with the inherent hazards of the tools and the methods selected after consultation with the project staff	The BJC project staff allowed MACTEC to violate the AHA, which placed the worker at increased risk of injury.

**Table C-1. Change Analysis
(continued)**

Normal “Ideal”	Actual	Analysis
All lessons learned are placed in the official lessons learned program	The lessons learned on the previous MACTEC PPE burn event was not entered into the official BJC Lessons Learned Program	The previous MACTEC PPE burn event was repeated.
Safety personnel interject themselves into all aspects of the project that may affect safety	BJC Safety Advocate-4 insulated himself from management decisions that might affect safety	Safety Advocate-4 was not fully engaged in the project and was only partially effective.
The cut-off machine is used in accordance with the manufacturer’s warnings	The manufacturer’s warnings were not reviewed or heeded	The manufacturer’s warning came to fruition.
All job activities at ETTP are discussed at the daily PSS Safety Stand-Up Meeting	The rebar removal with a cut-off machine was not discussed at the daily PSS Safety Stand-Up Meeting	Independent review of work activities might have identified a problem with the selection of the tool.
Radiological surveys support the current posting	The current posting at the K-1302 pad reflects 2001 survey data	Conservative postings place unnecessary radiological requirements on workers.

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Appendix D – Events and Causal Factors Analysis

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Table D-1. Events and Causal Factors Analysis

No.	Direct Cause	Discussion	Related JONs
D1	Sparks impinged on the laborer's right leg, which ignited the PPE.	<ul style="list-style-type: none"> • Due to lack of training, the laborer was directing the sparks from the cut-off machine between his legs. • This action was not in accordance with the manufacturer's safety manual. • After ten cuts, sparks ignited the right leg of his coveralls. 	1 2
No.	Contributing Causes	Discussion	Related JONs
C1	Project execution discipline was lost.	<ul style="list-style-type: none"> • The BJC request that MACTEC personnel wear leather chaps when using the cut-off machine was not formalized. • BJC personnel made an inaccurate determination, and MACTEC accepted it as direction even though it was in conflict with the AHA. • An issue was raised in August 2002 of BJC and SEC RadCon Alliance personnel directing MACTEC employees in an informal manner that was not in accordance with BJC's procedures. 	2
C2	The lessons learned systems were not used properly.	<ul style="list-style-type: none"> • The MACTEC lessons learned write-up for the May 16, 2002, incident was not entered in the BJC Lessons Learned System or the DOE Lessons Learned System. • BJC did not follow up on the May 16, 2002, lessons learned. • MACTEC personnel did not search the lessons learned systems before selection of the cut-off machine or preparation of the prejob brief (POD Meeting). 	1 4
C3	The BJC hot work procedure (BJC-EH-2007) is inadequate.	<ul style="list-style-type: none"> • The BJC Fire Protection Engineering comments were not incorporated in the hot work procedure revision that was made to incorporate the 1999 version of NFPA 51B. • The ASTM standards referenced in the procedure are not the most current versions. • The hot work procedure was not revised to include grinding as hot work per the 1999 version of NFPA 51B. • MACTEC did not follow its AHA because of the inaccurate determination made by BJC. 	1

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

No.	Contributing Causes	Discussion	Related JONs
C4	The MACTEC AHA is not clear.	<ul style="list-style-type: none"> • A task-specific AHA was not developed. AHA 2000-2, Revision 14, includes 48 work activities ranging from “Demolition activities . . .” to “. . . Off-loading rubble at dump site.” • AHA 2000-2 covers 48 items, with numerous subtopics, and it is over 19 pages in length. • The AHA contains multiple references to hot work applicability, which resulted in confusion on when the AHA requires a hot work permit. • The first activity of the MACTEC AHA 2000-2 “Fire” section indicates that a hot work permit is necessary. • Work Activity 33 is less specific and indicates that “A welding/burning/hotwork permit will be obtained prior to beginning torch-cutting.” 	1
C5	There was no review of the anti-c PPE requirements when the contamination and radiological surveys significantly changed.	<ul style="list-style-type: none"> • The K-1302 pad’s radiological posting did not match the radiological surveys performed since 2001. • The posting was based on the original building and associated on-site equipment prior to demolition. • Since demolition and removal of the rubble, the site survey results had been below the detectable limits of the radiological instruments, and no contamination had been found on personnel or the anti-c PPEs. • Re-evaluation of the anti-c controls was never considered. • The PPE requirements follows a pattern familiar at DOE facilities in which anti-c PPE is often overprescribed regardless of the work environment. This is done, in part, in an attempt to reduce the likelihood of exceeding the small contamination levels that require filing costly occurrence reports. DOE has recognized the problem in the past, but no changes to the reporting requirements have occurred. <p data-bbox="695 1749 987 1778">[continued on next page]</p>	1 5

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

No.	Contributing Causes	Discussion	Related JONs
C5		<ul style="list-style-type: none"> • A Defense Program report, <i>Personal Protective Equipment Use in DOE Programs</i>, calls for the establishment of clearer reporting requirements, reporting only incidents with potential human health and safety significance. • The threshold for reporting should be reviewed and tailored to address only contamination that has health significance, thus reducing the number of occurrence reports and potentially reducing the current levels of PPE. • Regardless, the workers continue to be subjected to unwarranted hazards, in this case fire, from multiple layers of PPE. This is obviously contrary to the principles of ISM. 	1 5
C6	The RWP does not recognize abrasive work as hot work.	<ul style="list-style-type: none"> • The RWP for this activity indicates that “fireproof PPE” shall be substituted for hot work applications and not for grinding. 	1 5
C7	MACTEC personnel did not have knowledge of the 1997 welding/cutting fatality at ETPP.	<ul style="list-style-type: none"> • The management and other personnel changes, including multiple subcontractors performing work, have diminished the lessons learned from the 1997 welding/cutting fatality in the K-33 Building at ETPP. 	5
C8	The DOE Facility representative assigned to the Main Plant D&D Project had not performed his regular duties on a full-time basis since January 2003, and DOE Site Office ES&H Staff (subject matter experts) had been assigned to the joint DOE/BJC Safety Management Programs Review of BJC.	<ul style="list-style-type: none"> • DOE-STD-1063-2000, paragraph 4.1.2b, states “Field Element Managers should make assignments so that administrative work does not prevent Facility Representatives from performing their primary function of monitoring the performance of the facilities and operations . . .” • Subject matter experts have been unable to provide their oversight function due to additional assignments outside of their assigned sites. 	6

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

No.	Contributing Causes	Discussion	Related JONs
C9	MACTEC's and BJC's training of its personnel was inadequate.	<ul style="list-style-type: none"> • The training systems could not compensate for the significant changeover in personnel. • The manufacturer's safety manual for the cut-off machine was not on the job site until after the event. • MACTEC and BJC employees did not understand the hazards of the cut-off machine. • The warning label on the cut-off machine was not reviewed. • The MACTEC prejob briefing (POD Meeting) was not adequate to address the activities and hazards associated with the rebar removal job. • Training on tool selection was inadequate. • The tool selection process was based on a process of elimination of the available tools. • BJC Safety Advocate-4 believed it was not his place to recommend a different tool. • BJC STR-5 was not familiar with cut-off machine operation. • Laborer-1 did not operate the cut-off machine in accordance with the manufacturer's safety manual. 	1 3
No.	Root Cause	Discussion	Related JONs
R1	BJC's and MACTEC's work control process was inadequate.	<ul style="list-style-type: none"> • The only task that could be performed on February 18, 2003, was the rebar removal job at the K-1302 pad. • The portable band saw was not available because it was contaminated with fissile material. • The acetylene torch was not available because it had been removed from the site during demobilization. • The cut-off machine had not been used since May 2002. • Laborer-1 had used a cut-off machine on concrete and bar stock at another job. • The manufacturer's warning label on the cut-off machine was not reviewed with Laborer-1, nor was the safety manual for the machine. The warning label on the cut-off machine includes the risk of setting clothing on fire. <p>[continued on next page]</p>	1

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

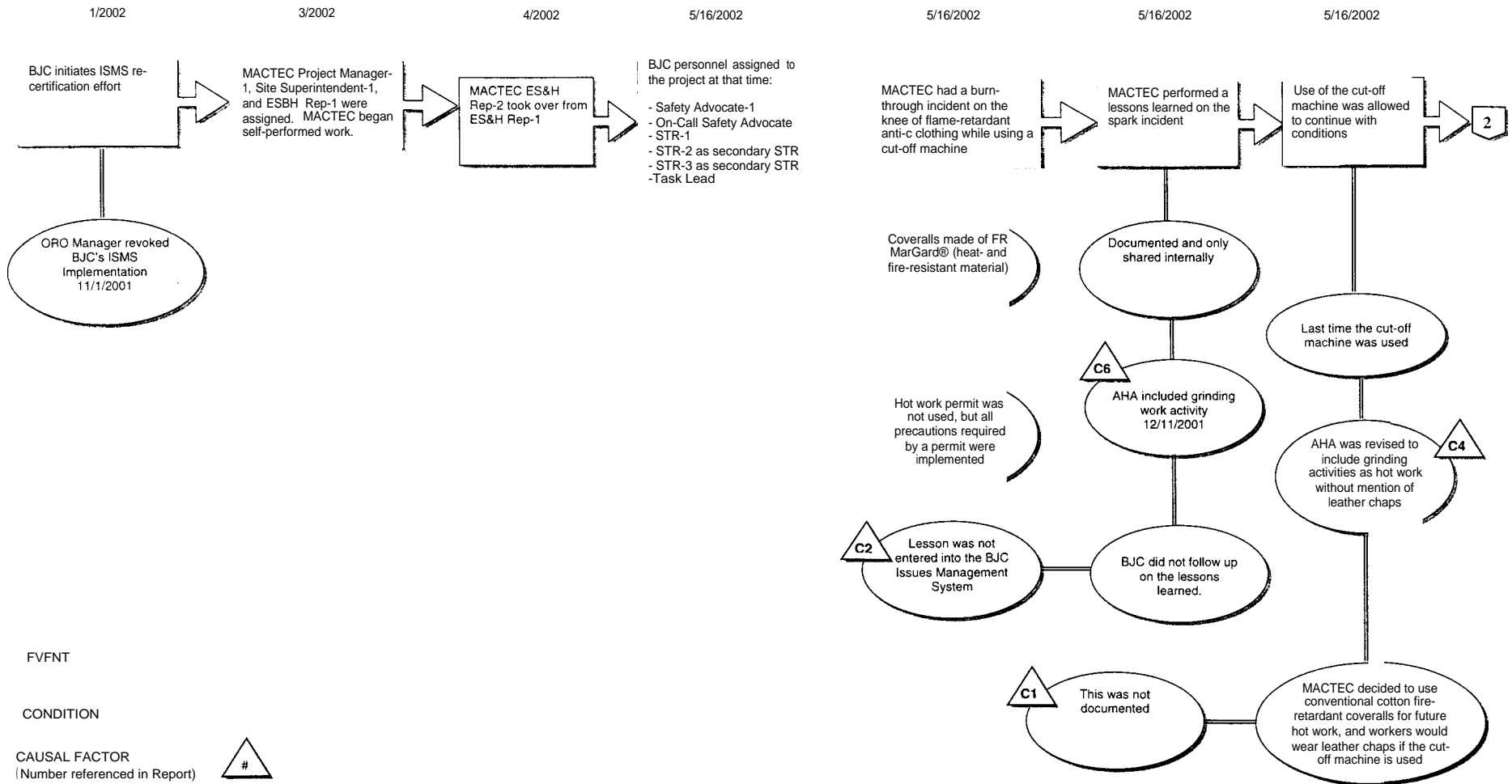
No.	Root Cause	Discussion	Related JONs
R1		<ul style="list-style-type: none"> • No one in attendance at the MACTEC POD Meeting was aware of the previous MACTEC incident with the cut-off machine in May 2002. • The BJC Facility Manager was aware of the fire risk in cut-off machine operation, but he was not informed of its planned use. 	1

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Appendix E – Events and Causal Factors Chart

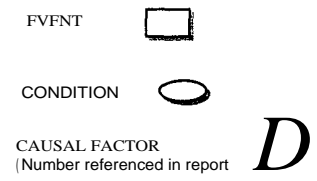
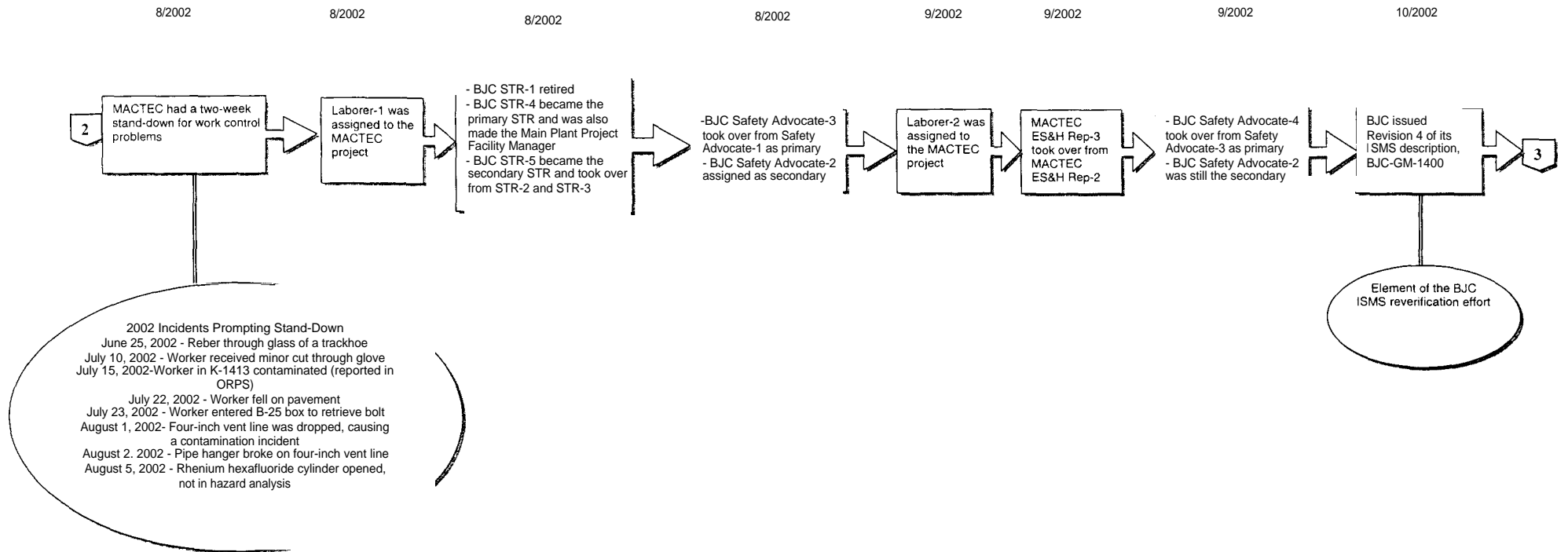
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Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP



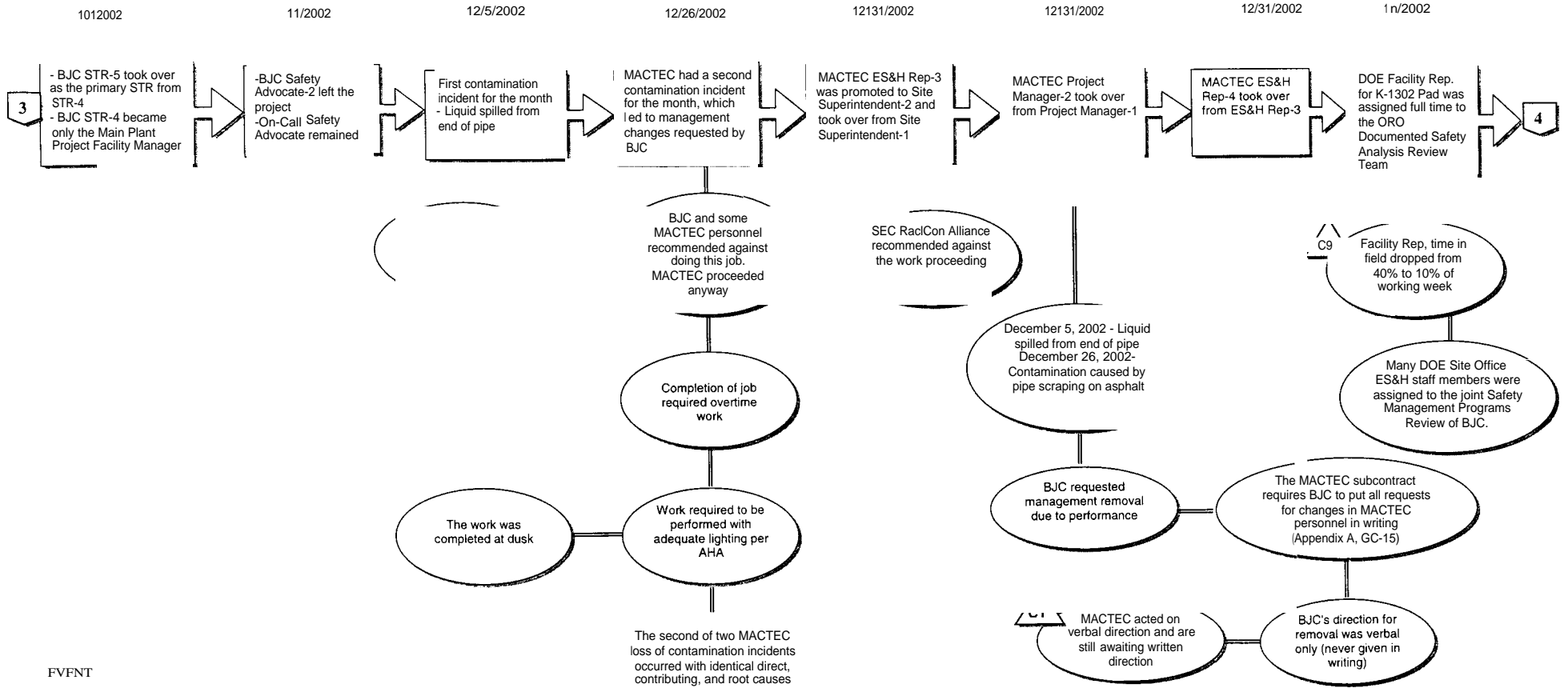
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Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP



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Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP



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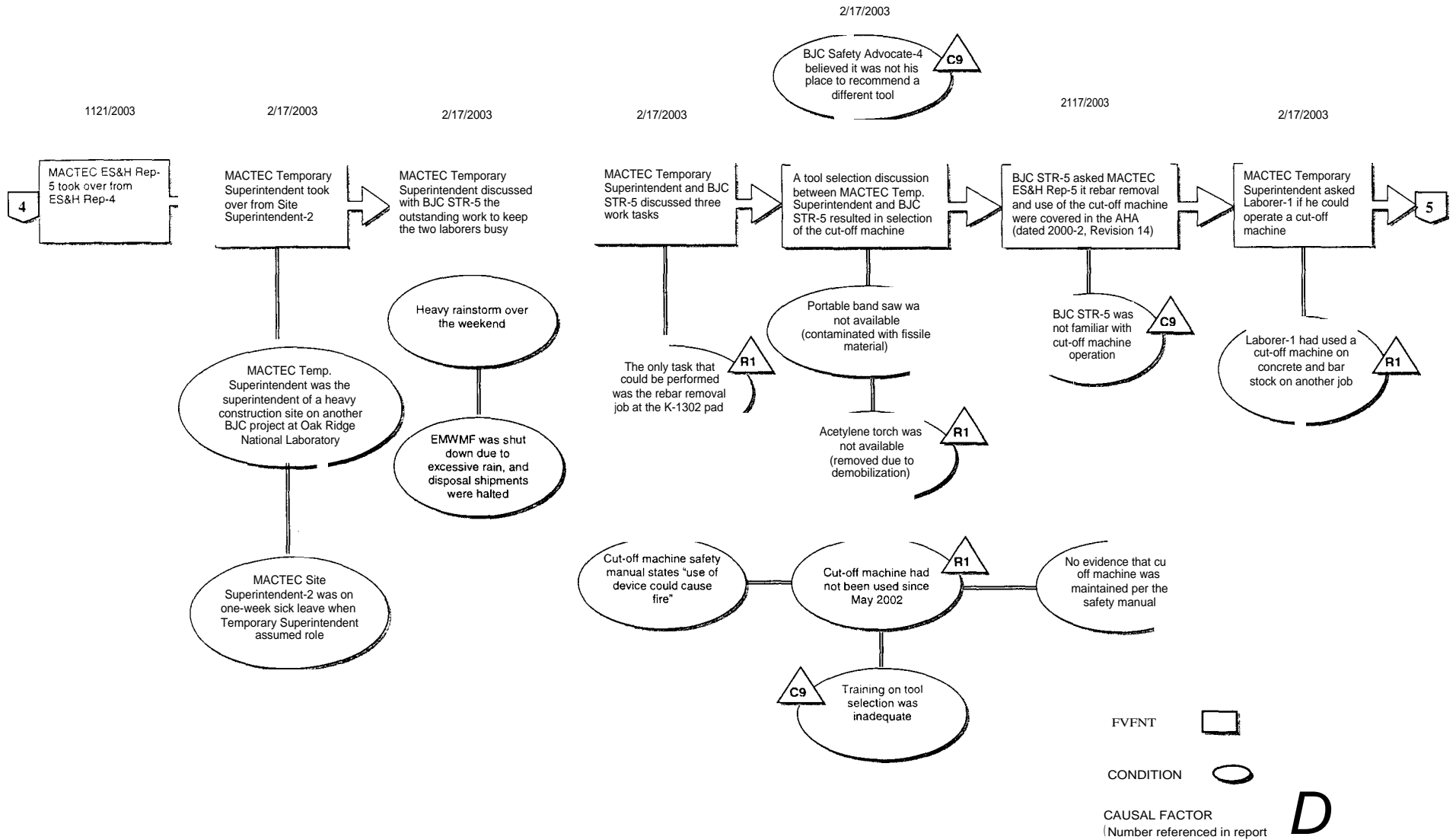
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CAUSAL FACTOR

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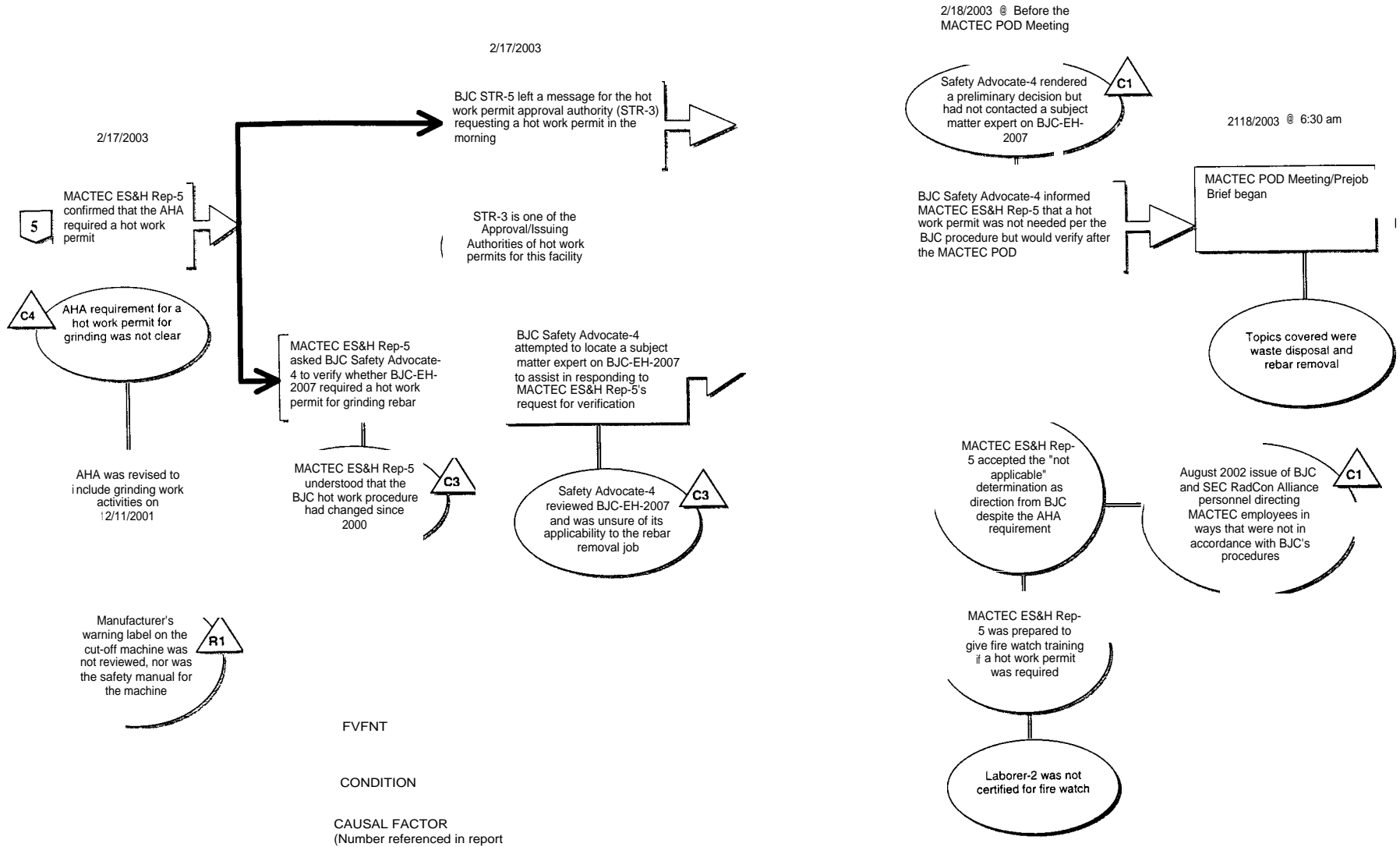
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Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP



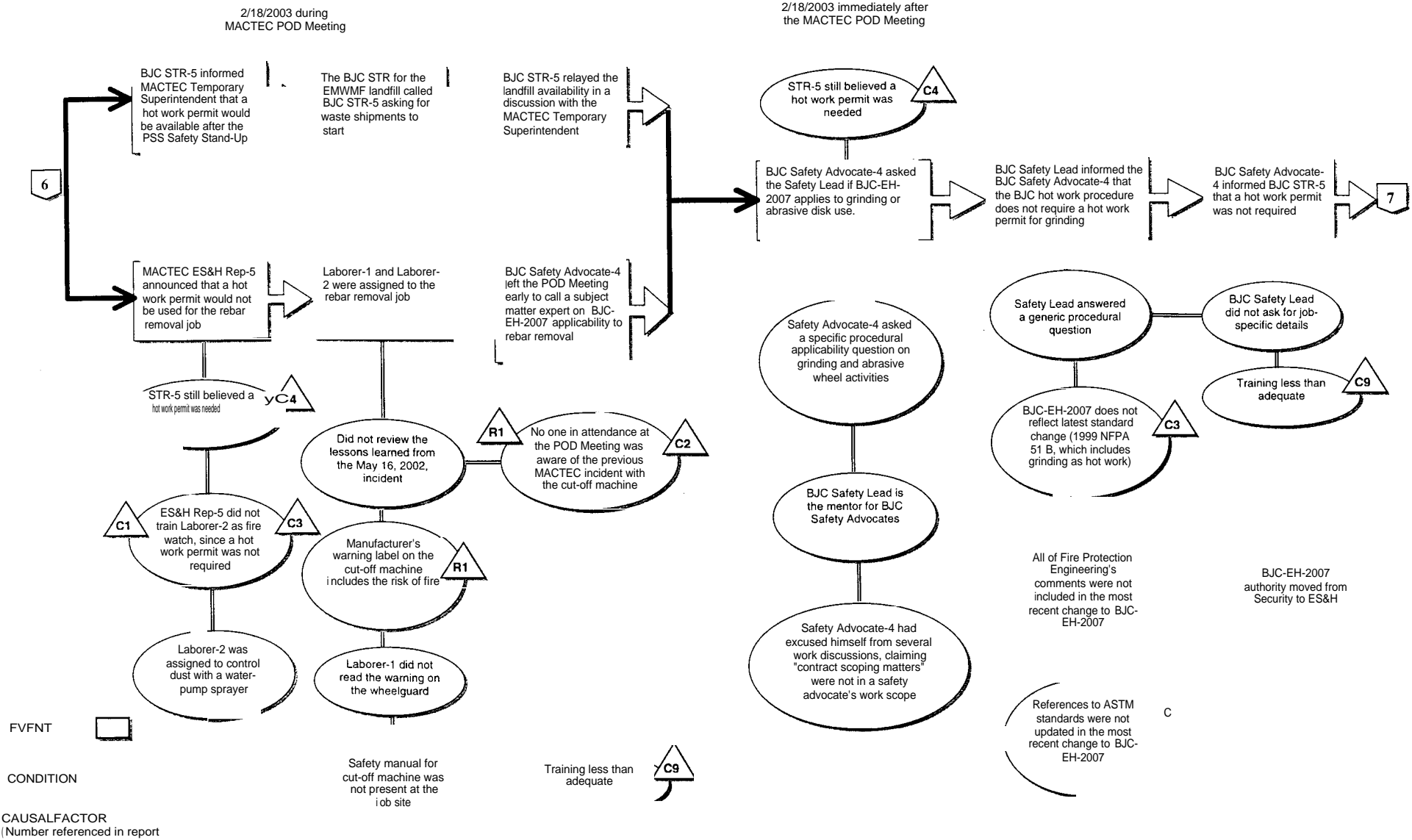
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Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP



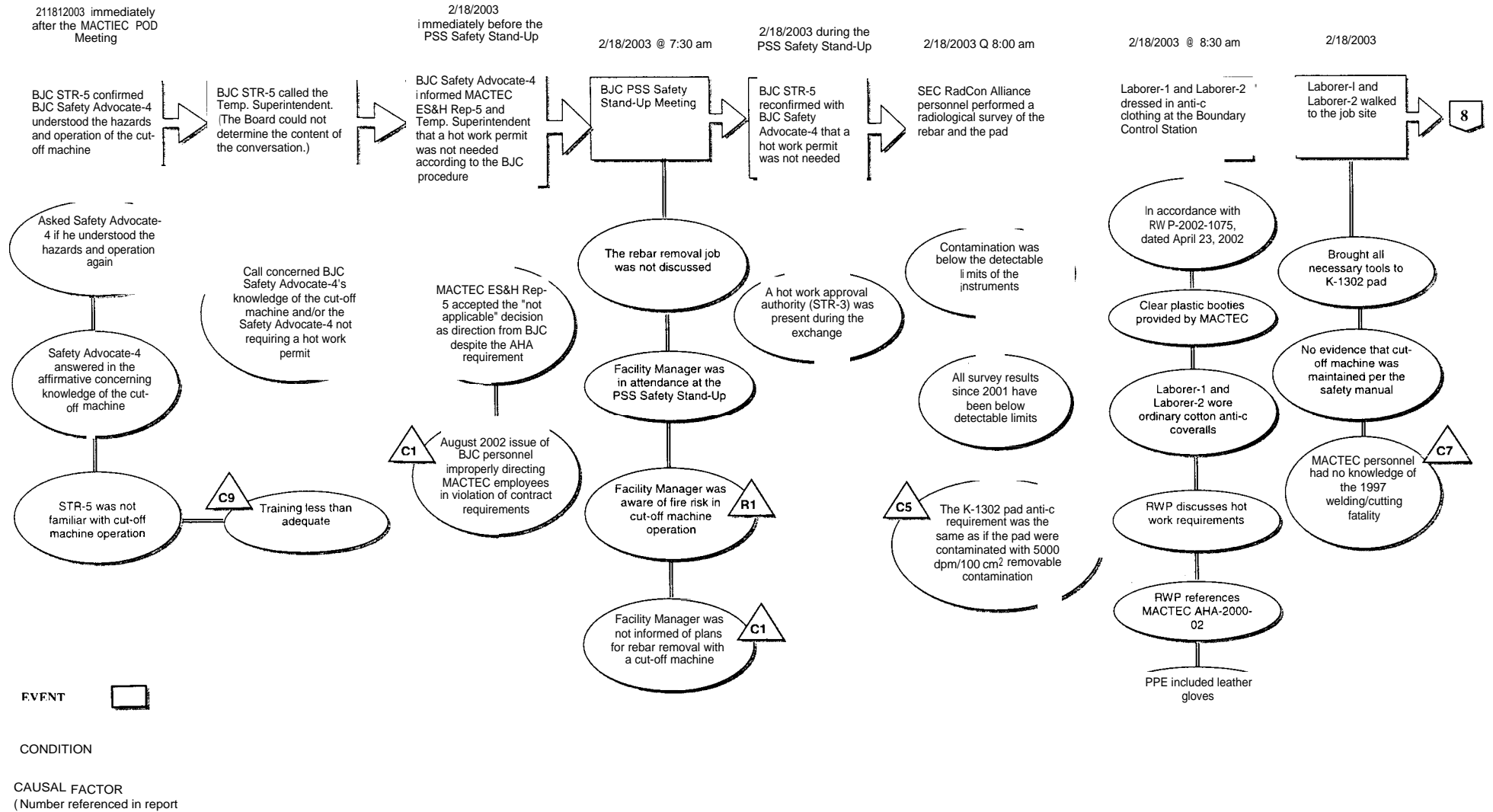
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Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP



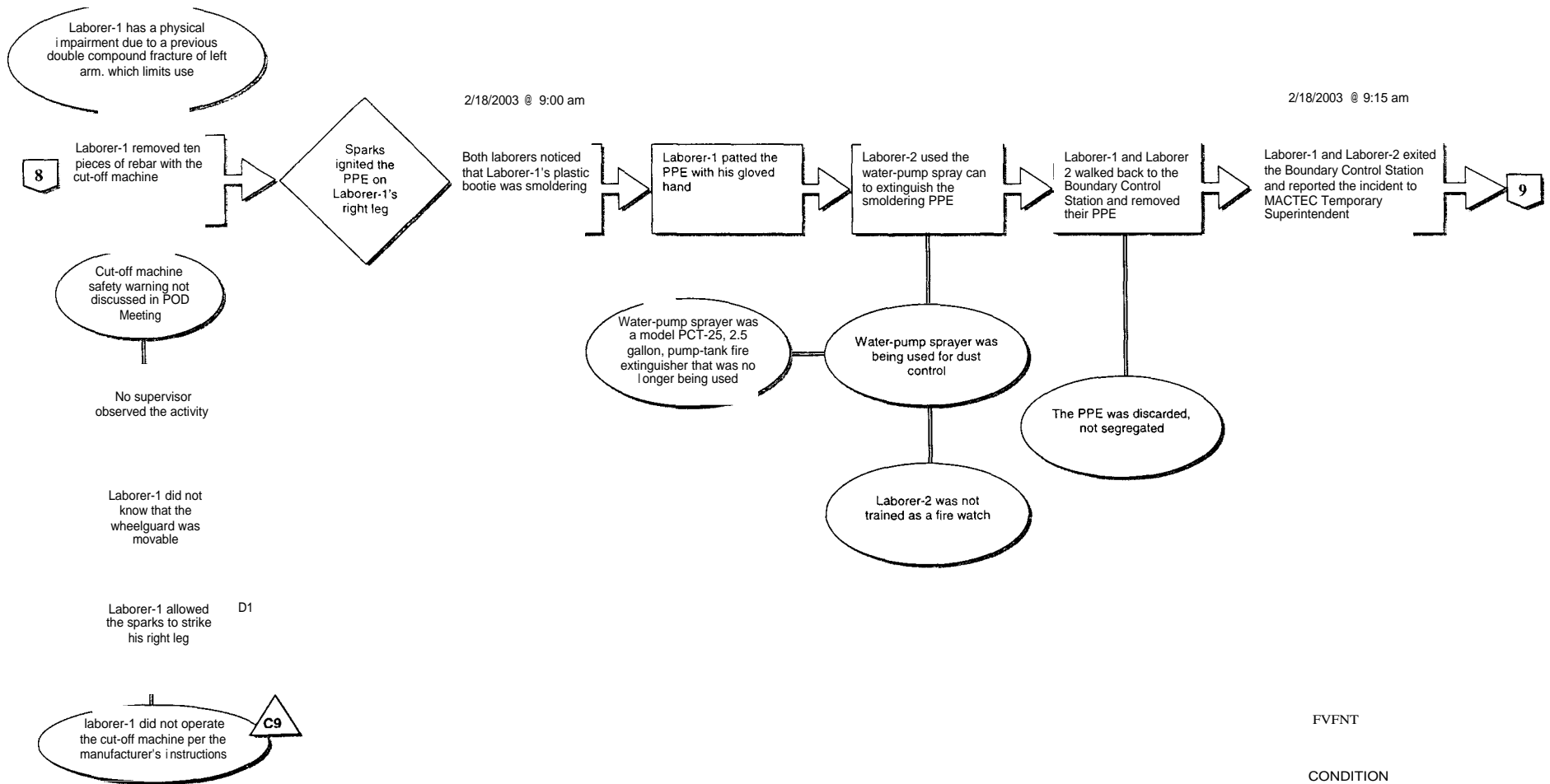
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Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP



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Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP



EVENT

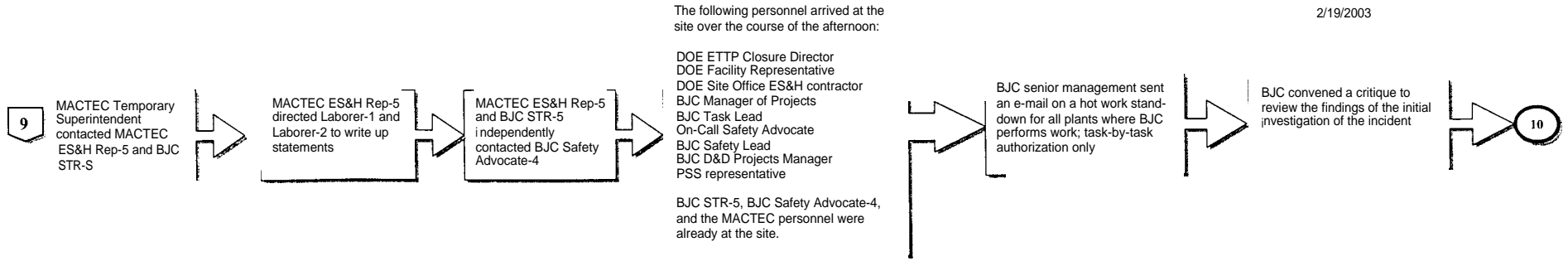
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CAUSALFACTOR
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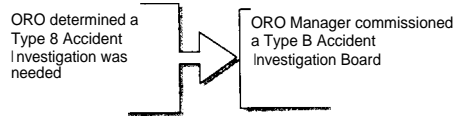
Event and Causal Factors Chart
 Subcontractor PPE Ignition Incident at ETPP

2/18/2003 @ Afternoon



2/19/2003

2/21/2003



FVFN 

CONDITION 

CAUSAL FACTOR
 (Number referenced in report)

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