MAI-2006-23

UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
Metal and Nonmetal Mine Safety and Health

REPORT OF INVESTIGATION

Surface Metal Mine
(Mill)

Fatal Electrical Accident
October 12 2006

United Taconite, LLC
United Plant
Eveleth, St. Louis County, MN
Mine I.D. No. 21-03404

Investigators

George F. Schorr
Supervisory Special Investigator

Alan J. Brandt
Mine Safety and Health Inspector

Amy Lindgren
Mine Safety and Health Specialist

Nicholas W. Damiano
Electrical Engineer

Originating Office
Mine Safety and Health Administration
North Central District
515 West First Street, Room 333
Duluth, MN 55802-1302
Steven M. Richetta, District Manager

OVERVIEW

Andrew D. Reed, maintenance coordinator, age 24, was fatally injured on October 12, 2006, when an electrical short occurred in a ball mill starter circuit. Reed was troubleshooting an electrical problem in the motor ladder start-up sequence for the No. 4 ball mill electrical motors. An air-magnetic circuit breaker that provided over current protection to the circuit failed, resulting in a sustained arc-flash.

The accident occurred because management failed to ensure that the air-magnetic circuit breaker provided over current protection for the electrical circuit. The failure to also provide circuit overload protection for the plant's incoming power feed circuit also contributed to the accident.

GENERAL INFORMATION

United Plant, an iron ore (taconite) milling operation, owned and operated by United Taconite LLC, was located in Eveleth, St. Louis County, Minnesota. The principal operating official was Todd D. Roth, vice president and general manager. The plant normally operated various shifts, 24-hours a day, 7 days a week. Total employment at the plant was 295 persons.

Raw iron ore was shipped to the plant by train from another location. The material was crushed and milled in a multiple step process. Iron was separated from the processed taconite ore by magnetic separation and the iron rich concentrate was processed for shipping by adding a binder, and rolled to form green pellets. The finished heat-hardened pellets were shipped by train to port loading facilities and sold for use in steel manufacturing.

The last regular inspection of this operation was completed on September 8, 2006.

DESCRIPTION OF ACCIDENT

The week prior to the accident, ball mill No. 4 was experiencing random nuisance trips. On October 11, 2006, the day before the accident, the concentrator ball mill production lines were taken offline while repairs were being made to the plant's taconite tailings disposal system. After repairs had been completed, the ball mills were started. The No. 4 ball mill was started on the night shift, ran for approximately 20 minutes, and then shut down automatically. Attempts to restart the No. 4 ball mill were unsuccessful. Bryan D. Sandnas, electronic technician, was called to troubleshoot the motor start-up sequence ladder for the motors used to drive the ball mills. The next day Sandnas arrived at the plant about 4:35 a.m. He tried to diagnose the problem by examining the motor start-up sequence ladder.

About 6:00 a.m., Andrew D. Reed, maintenance coordinator, started his normal work shift. He helped Sandnas diagnose the electrical problem. At approximately 7:00 a.m., Erik N. Maki, electronic technician, arrived to assist Reed and Sandnas.

Before breaking for lunch, Reed and Sandnas thought they had isolated the problem to the circuit that controlled the motor starter conductors. They discussed attempting to start up No. 4 ball mill in test power.

About 12:20 p.m., the crew returned to the motor control room (MCC) and prepared to start up the No. 4 ball mill. Sandnas closed and bolted the No. 4 south and north motor control cabinets and then racked in the motor starter. He called the control room to request that the No. 4 ball mill be started. The control room operator initiated the start-up sequence. Sandnas and Maki were standing apart, but along the east side of the motor control center room, so they could both watch the relays associated with the start-up of No. 4 ball mill. Sandnas was standing by the DHX relay cabinet, adjacent to a door, while Maki stood in front of the No. 4 DC drive cabinet. Russell A. Korpi, lube

technician, passing the motor control room, saw Reed standing near the west wall by the ball mill motor control starter relay cabinets.

When the pre-mill start-up procedures were completed, the start-up of the No. 4 mill was initiated by the control room. As the mill tried to start, Sandnas and Maki initially heard a loud noise and then saw a large ball of fire coming from the opposite side of the MCC room near Reed. Maki attempted to move toward Reed but retreated due to fire and smoke. Maki and Sandnas evacuated the MCC Room and Sandnas then called on his radio, requesting that No. 4 ball mill be shut down.

Plant emergency response personnel and the local fire and emergency medical services were called to the scene. Emergency responders searched for Reed and found him in the MCC room. The victim was pronounced dead at the scene by a St. Louis County medical examiner's deputy coroner. Death was attributed to smoke inhalation.

INVESTIGATION OF THE ACCIDENT

MSHA was notified of the accident on October 12, 2006, at 1:30 p.m., by a telephone call from Kelly R. Campbell., section manager for safety and loss control, to George F. Schorr, supervisory special investigator. An investigation began the same day. An order was issued pursuant to Section 103(k) of the Mine Act to ensure the safety of the miners.

MSHA's accident investigation team conducted a physical inspection of the accident site, interviewed employees, and reviewed conditions and work procedures relevant to the accident. MSHA conducted the investigation with the assistance of mine management, employees, and the miners' representatives.

DISCUSSION

Location of the Accident

The accident occurred in the new side motor control center located on the balling mill floor in the concentrator building. The air-magnetic circuit breaker over-current protective device that failed to clear the fault was located in the new side substation distribution building, part of the plant's electrical power feed substation.

Electrical Equipment

Electrical power entered the mine site at the main substation by means of two 115kV feeds and immediately entered two Allis-Chalmers oil circuit breakers (OCB). Electrical power was then distributed through a 115kV bus that fed five 115kV/4160V transformers. Transformer No. 5, which was involved in the accident, fed the new side substation distribution room (SDR) 4160V bus 50. Electrical power was further distributed to the plant through Allis-Chalmers air-magnetic circuit breakers (ACB).

Electrical power was provided to the concentrator building new side ball mill motor control center (MCC) room by approximately 1000 feet of 750 MCM cables (Appendix B).

As a result of the accident, the MCC room (where the victim was found) and the new side SDR were badly damaged. The 4160 electrical conductors that ran from the SDR to the MCC room also sustained significant damage during the accident.

The MCC room sustained damage to the entire west wall (incoming bus) where the arcing originated. Due to the extent of damage, the origin of the initial fault could not be determined; however, after the inception of initial fault, the fault enveloped all three-phases of the electrical power on the line-side of the ball mill motor starter vacuum contactor in the MCC room.

Damage to the line side of the No. 4 south ball mill motor's starter was the most extensive. The power cables feeding this motor appeared to be burned from the inside out. Damage to these power cables was evident throughout the entire 1000 feet of cable between the SDR and the MCC room. The damage to the wires was indicative to a vast fault current over a period of time. Internal heating of the cables that supplied power to ball mills No. 3 and No. 5 was evident but not excessive, thus supporting No. 4 ball mill line side feed as the origin of the initial fault.

The electrical circuits that supplied power to ball mills Nos. 3, 4, and 5 were protected by an Allis-Chalmers ACB. This breaker was located in the SDR and was found in the closed (on) position after the accident. Electrical power continued to be supplied to the MCC room through the ACB and was only interrupted when the cables feeding Nos. 3, 4, and 5 ball mills melted, causing a physical break in electrical connection.

Approximately 3.5 minutes after the initial fault occurred, the OCB tripped, interrupting electrical power to the entire plant. The OCB was equipped with an under-voltage relay device. The device was designed to open when incoming voltage dropped below a certain percentage of the original line voltage (usually 5 to 10 percent). When the incoming 115kV voltage dropped, the under-voltage relay opened and cut power. The OCB was equipped with an over-current relay; however, this over-current relay was not functional and failed to protect the load side electrical circuit.

Weather Conditions

Weather was not considered a factor in the accident.

Training and Experience

Andrew D. Reed, maintenance coordinator, had 1 year and 4 months of mining experience, all at this operation. He had received training in accordance with 30 CFR, Part 48 and had earned a bachelors degree in electrical engineering. He was experienced in troubleshooting electrical start-up problems.

Bryan D. Sandnas, electronic technician, had 10 years and 9 months of mining experience, all at this operation. He was experienced in troubleshooting electrical start-up problems.

Erik N. Maki, electronic technician, had 11 years and 3 months of mining experience, all at this operation. He was experienced in troubleshooting electrical start-up problems.

ROOT CAUSE ANALYSIS

A root cause analysis was conducted and the following root causes were identified:

Root Cause: Management policies and controls were inadequate. There were no procedures requiring the circuit breakers to be examined and tested periodically to ensure these over-current protective devices functioned properly.

Corrective Action: Management should ensure that all electrical circuits are protected with over-current protective devices and that these devices are maintained and tested in accordance with manufacturer recommendations.

Root Cause: Management failed to recognize the potential hazard of not providing over-current protective devices on all electrical circuits.

Corrective Action: Management should ensure that all electrical circuits are protected with over-current protective devices.

CONCLUSION

The accident occurred because the mine operator failed to ensure that the air-magnetic circuit breaker provided over-current protection for the electrical circuit The severity of this accident was impacted by the mine operator's failure to also provide circuit overload protection for the plant's incoming power feed circuit.

ENFORCEMENT ACTIONS

Order No. 6192195 was issued on October 12, 2006, under provisions of Section 103(k) of the Mine Act:

> A fatal accident occurred at this operation on October 12, 2006, when three miners were attempting to troubleshoot the 4160 volt switch gear of the No. 4 ball mill inside the new side high voltage MCC room at the concentrator. This order is issued to assure the safety of all persons at this operation. It prohibits all activity on the new side ball mill floor. This order also includes the new side main electrical substation control room until MSHA has determined that it is safe to resume mining operations in

these areas. The mine operator shall obtain prior approval from an authorized representative for all actions to recover and/or restore operations in the affected areas.

The order was terminated on October 19, 2006, after the conditions that contributed to the accident no longer existed.

Citation No. 6135226 was issued on January 17, 2007, under provisions of Section 104(a) of the Mine Act for violation of 30 CFR 56.12001:

> A miner was fatally injured at this mine on October 12, 2006, when a sustained arc occurred in the motor control center where the victim was troubleshooting the circuitry for ball mill No. 4. The air-magnetic circuit breaker located in the substation distribution room, which protected the electrical conductors feeding power to ball mill Nos. 3, 4 and 5 from excessive overloads, failed to clear a fault that originated at the line side of the vacuum contactor for ball mill No. 4, located in the motor control center. The failure of this Allis-Chalmers air-magnetic circuit breaker to clear the fault allowed sustained arcing in the motor control center that lasted for more than three minutes. The electrical circuit feeding the motor control center was not provided with sufficient overload protection. The failure of the Allis-Chalmers air-magnetic circuit breaker to protect the circuit against excessive overload resulted in the death of a miner.

Or, in the alternative: § 56.12065 Short circuit and lightning protection

> On October 12, 2006 at about 12:44 p.m., a short circuit occurred in the 4160 volt power lines located in the motor control center. These power lines distributed electrical power to ball mill Nos. 3, 4 and 5. The Allis-Chalmers air-magnetic circuit breaker, located in the substation distribution room, which protected the power lines for ball mill Nos. 3, 4 and 5, failed to operate when a short circuit occurred. This short circuit resulted in sustained arcing that enveloped the motor control center room for more than three minutes, resulting in the death of a miner.

The citation was terminated on January 17, 2007, after a new over-current protection device (General Electric Power-Vac Breaker/5KV at 1200 amps) was installed to protect the electrical circuit that supplied electrical power to ball mills 3, 4, and 5 from excessive overload. In addition to this circuit breaker, an additional level of protection was provided; main breaker (General Electric Power-Vac Breaker rated at 5 KV/400 FLC) that will provide over-current protection to the sub-breaker installed.

Citation No. 6135227 was issued on January 17,2007, under provisions of Section 104(a) of the Mine Act for violation of 30 CFR 56.12001:

A miner was fatally injured at this mine on October 12, 2006, when a sustained arc occurred in the motor control center where the victim was troubleshooting the circuitry for ball mill No. 4. The oil circuit breakers located in the substation, which were used to protect transformer No. 5 and associated power lines from excessive overloads, failed to clear a fault that occurred in the substation distribution room. The failure of these oil circuit breakers to protect transformer No. 5 and associated power lines allowed a sustained fault in the substation distribution room that lasted for more than three minutes. The electrical circuit feeding the substation distribution room, which distributed electrical power to the motor control center room, was not protected with overload protection.

The citation was terminated on January 17, 2007, after a new over-current protection device (Mitsubishi High Voltage SF6 Gas Circuit Breaker rated at 145 KV/3000 amps) was installed to protect the electrical circuit supplying electrical power from the oil filled circuit breaker through transformer No. 5 to the substation distribution room.

Approved By: Date:

Steven M. Richetta
District Manager
North Central District

APPENDIX A

Persons Participating in the Investigation

United Taconite LLC

Terry W. Nanti	area manager - plant

USWA, Local 6860

Brian Lahti	safety coordinator
Larry Roberts	plant safety chair

Jackson Kelly, PLLC

Laura E. Beverage	attorney

Exponent (Failure Analysis Associates)

Brian F. Gsell	manager of electrical practices

St. Louis County

Barry D. Lesar	St. Louis County mine inspector

Mine Safety and Health Administration

George F. Schorr	supervisory special investigator
Alan J. Brandt	mine safety and health inspector
Amy Lindgren	mine safety and health specialist
Nicholas W. Damiano	electrical engineer

APPENDIX B

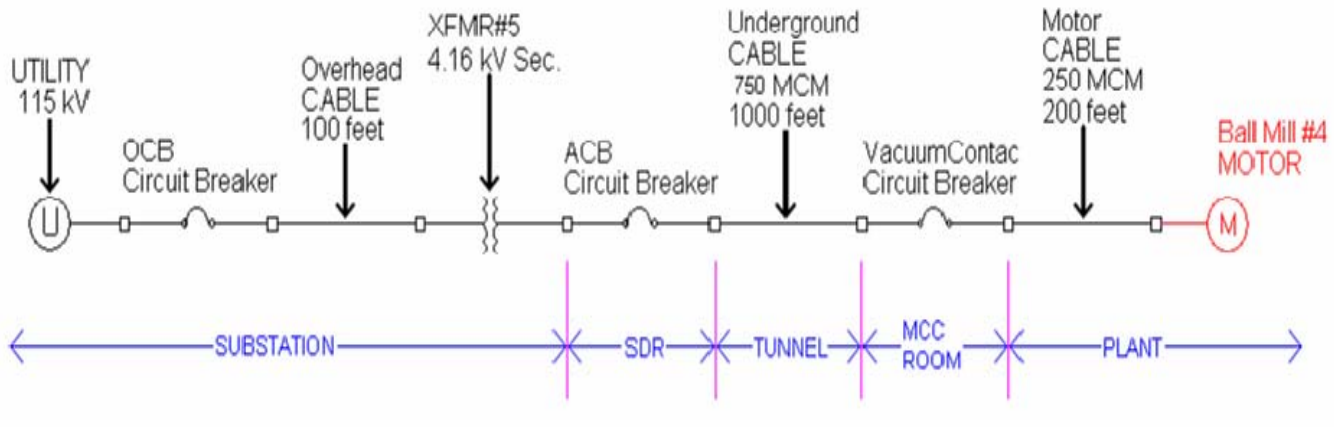

Figure 1: Simple single line diagram of circuits involved in accident

Accident Investigation Data - Victim Information

Event Number: 0 9 9 1 4 1 4

APPENDIX C

U.S. Department of Labor
Mine Safety and Health Administration

Victim Information: 1

1. Name of Injured/Ill Employee:	2. Sex	3. Victim's Age	4. Last Four Digits of SSN:	5. Degree of Injury:
Andrew D. Reed	M	24		01 Fatal

6. Date(MM/DD/YY) and Time(24 Hr.) Of Death:
a. Date: 10/12/2006 b. Time: 12:48

7. Date and Time Started:
a. Date: 10/12/2006 b. Time: 7:00

8. Regular Job Title:
149 Supervisory/Maintenance Coordinator

9. Work Activity when Injured:
020 Maintenance Coordinator

10. Was this work activity part of regular job?
Yes | X | No

11. Experience	Years	Weeks	Days	b. Regular	Years	Weeks	Days	c. This	Years	Weeks	Days	d. Total	Years	Weeks	Days
a. This Work Activity:	1	18	6	Job Title:	1	18	6	Mine:	1	18	6	Mining:	1	18	6

12. What Directly Inflicted Injury or Illness?
045 Electrical flash fire

13. Nature of Injury or Illness:
301 Burn from electrical arc

14. Training Deficiencies:
Hazard: | New/Newly-Employed Experienced Miner: | Annual: | Task:

15. Company of Employment:(If different from production operator)
Operator

Independent Contractor ID: (if applicable)

16. On-site Emergency Medical Treatment:
Not Applicable: X | First-Aid: | CPR: | EMT: | Medical Professional: | None:

17. Part 50 Document Control Number: (form 7000-1)

18. Union Affiliation of Victim: 2605 United Steel Workers of America

Victim Information:

2. Sex	3. Victim's Age	4. Last Four Digits of SSN:	5. Degree of Injury

6. Date(MM/DD/YY) and Time(24 Hr.) Of Death:

7. Date and Time Started

8. Regular Job Title:

9. Work Activity when Injured:

10. Was this work activity part of regular job?
Yes | No

11. Experience:	Years	Weeks	Days	b. Regular	Years	Weeks	Days	c. This	Years	Week	Days	d. Total	Years	Weeks	Days
a. This Work Activity:				Job Title:				Mine:				Mining:			

12. What Directly Inflicted Injury or Illness?

13. Nature of Injury or Illness:

14. Training Deficiencies:
Hazard: | New/Newly-Employed Experienced Miner: | Annual: | Task:

15. Company of Employment: (If different from production operator)

Independent Contractor ID: (if applicable)

16. On-site Emergency Medical Treatment:
Not Applicable: | First-Aid: | CPR: | EMT: | Medical Professional: | None:

17.Part 50 Document Control Number: (form 7000-1)

18. Union Affiliation of Victim:

7. Date and Time Started:

8. Regular Job Title:

9. Work Activity when Injured:

10. Was this work activity part of regular job?
Yes | No

11. Experience:	Years	Weeks	Days	b. Regular	Years	Weeks	Days	c. This	Years	Week	Days	d. Total	Years	Weeks	Days
a. This Work Activity:				Job Title:				Mine:				Mining:			

12. What Directly Inflicted Injury or Illness?

13. Nature of Injury or Illness:

14. Training Deficiencies:
Hazard: | New/Newly-Employed Experienced Miner: | Annual: | Task:

15.Company of Employment:(If different from production operator)

Independent Contractor ID: (if applicable)

16. On-site Emergency Medical Treatment:
Not Applicable: | First-Aid: | CPR: | EMT: | Medical Professional: | None:

17. Part 50 Document Control Number: (form 7000-1)

18. Union Affiliation of Victim: