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

REPORT OF INVESTIGATION

Surface Nonmetal Mine
(Stone)

Fatal Powered Haulage Accident
December 8, 2011

Knife River North Central
43491
Milaca, Mille Lacs County, Minnesota
Mine I.D. No. 21-00462

Investigators

James A. Hines
Mine Safety and Health Inspector

James L. Angel
Mechanical Engineer

Eugene D. Hennen
Mechanical Engineer

Amy Sandelin
Mine Safety and Health Specialist

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

OVERVIEW

Scott A. Armstrong, Crusher Operator, age 41, was killed on December 8, 2011, when a wheel strut axle assembly struck him. The wheel assembly was to be installed on a conveyor to transport it from the mine site. A front-end loader was used to lift the conveyor. The loader bucket suddenly dropped, allowing the frame of the conveyor to strike the wheel assembly. The wheel assembly shifted, striking Armstrong.

The accident occurred due to management's failure to have procedures in place to ensure equipment is taken out of service or properly repaired when defects affecting safety are found. Investigators determined the cold temperatures at the time of the accident affected the performance of the main control valve of the front-end loader's hydraulic system. Other factors contributing to the accident include Armstrong's position near a suspended load, no blocking in place to prevent the fall of the conveyor, and Armstrong not being task trained regarding the installation of the wheel strut axle assembly.

GENERAL INFORMATION

The portable plant, designated as “43491”, a surface stone operation owned and operated by Knife River North Central, is located in Milaca, Mille Lacs County, Minnesota. The principal operating official is Tim Crennen, Regional President. The mine operates one 12-hour shift per day, five days a week, depending on production demands. Total employment is three persons.

The operation is a portable plant operating at the Gardner Pit located in Milaca, Mille Lacs County, Minnesota. The operation mines and mills various types of stone from single bench open pits. The material is crushed and screened in a multiple step process.

The Mine Safety and Health Administration (MSHA) completed the last regular inspection of this mine on November 11, 2010.

DESCRIPTION OF ACCIDENT

On the day of the accident, Scott A. Armstrong (victim); Steven J. Popp, Loader Operator and Team Leader; and Scott K. Killinger, Excavator Operator, reported to work at 6:00 a.m., their normal starting time. Armstrong and Popp went to prepare a conveyor for transportation to another site. Killinger went to work in another area of the pit.

Popp started a front-end loader and began moving the stacker conveyor. About 8:00 a.m., he used the front-end loader to move an electrical box. The machine was shut off until 10:30 a.m., when Popp started it and drove it back to the stacker conveyor.

The conveyor was being lifted to re-position its two wheel strut axle assemblies in preparation for transportation. A chain was fastened to the front-end loader bucket and placed on a lifting arm welded in place to the conveyor frame. As the front-end loader lifted the conveyor, the two wheel assemblies dropped from the conveyor strut, landing on the ground below. The pins used to secure the struts to the conveyor were incorrectly installed prior to lifting of the conveyor. The pins were installed at the bottom of the sleeves used to support the struts and not through the holes in the sleeve, reportedly to gain extra lift height. This allowed the struts to fall out of the sleeves when the conveyor was lifted with the front-end loader.

Popp began reinstallation of the wheel assemblies by lifting the conveyor’s frame high enough so Armstrong could guide and steady a wheel assembly leg into the conveyor strut. Popp attempted to slowly lower the conveyor with the bucket of the front-end loader while Armstrong guided the wheel assembly. Suddenly the loader bucket dropped and the conveyor struck the wheel assembly leg,

propelling it forward striking Armstrong in the head. He immediately collapsed and was unresponsive.

Popp immediately contacted Russell Karsky, Aggregate Supervisor, informing him of the accident. Karsky used his cell phone to contact 911 at 11:01 a.m. The Mille Lacs County Sheriff's department arrived and summoned the coroner to the accident scene. A medical examiner pronounced Armstrong dead at 11:13 a.m. The cause of death was attributed to blunt force injury to the head.

INVESTIGATION OF ACCIDENT

MSHA was notified on December 8, 2011, at 11:05 a.m., by a telephone call from Jeffrey Lambert, Safety Director, to MSHA's National Call Center. The Call Center notified George Schorr, Supervisory Special Investigator, and an investigation began the same day. An order was issued pursuant to Section 103(j) 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 and mine employees.

DISCUSSION

Location of the Accident

The accident occurred in Knife River's Gardner Pit, mid-way between the scale house and the portable plant area. This area, just south of the main pit entry road, is comprised of dry, loose sand and gravel with relatively flat terrain.

Front- End Loader

The front-end loader involved in the accident is a Caterpillar Wheel Loader, Model 988H, manufactured and purchased in 2006. The machine measures approximately 40 feet long, 13 feet wide and 14 feet high. The bucket's maximum raised height is approximately 25 feet. The front-end loader has an operating weight of approximately 110,000 pounds (lbs.), a rated payload of 25,000 lbs., and a maximum tipping load of approximately 76,000 lbs. The machine is powered by a Cat C18 ACERT engine producing approximately 500 horsepower (hp).

The machine utilizes electro-hydraulic bucket lift and tilt controls. The hydraulic power is controlled by electronics that move the actuators. The electro-hydraulic system is composed of the main hydraulic system, hydraulic tank, the pilot system, the implement electronic control system, and the hydraulic fan system. The pilot control actuators are attached to the main control valve.

The hydraulic system is described in Caterpillar's *Systems Operation 988H Wheel Loader Electrohydraulic System Media Number -RENR6217-07 Publication Date -2011/05/01 Date Updated -2011/05/04*. The main hydraulic system consists of the implement pump, pump control valve, main relief valve, main control valve, lift cylinders, and tilt cylinder. The main control valve is equipped with both line relief valves and pilot control actuators. The pilot control actuators are common to both the main hydraulic system and the pilot hydraulic system.

The implement electronic control system consists of the electro-hydraulic control, electronic control module, switches, lift linkage position sensor, and tilt linkage position sensor.

The electro-hydraulic control consists of the control levers, detent coils, and position sensors. The machine is equipped with an optional ride control system. An implement lockout switch is provided to allow the operator or maintenance personnel the ability to disable the bucket controls to prevent accidental operation of the bucket controls while other work is performed in the cab.

As part of the investigation, personnel from Caterpillar, Inc. tested the operation of the front-end loader. Tests were conducted at the mine site and later at Knife River's Highway 10 shop in St Cloud, MN. The tests included temperature measurements of hydraulic fluid, movement (distance and velocity) of the bucket cylinder rods, bucket lift control lever movement, electrical signals from the machine's electronic controls module, solenoid actuator currents, main control valve pilot pressures, pressures in the bucket lift cylinders, and engine speed**.** Analysis of the machine's hydraulic fluid revealed no abnormalities that would have affected the hydraulic operation.

The investigators found abnormal operation of the bucket lift system during the testing. With the hydraulic oil cold, the loader bucket continued to rise after the control lever was released. When the lever was moved to lower the bucket, it suddenly dropped several feet. Additionally, persons having operated the front-end loader in the past reported multiple events where the bucket would suddenly drop.

To determine if the abnormal behavior remained after the hydraulic fluid was warmed, the bucket controls were operated to heat the fluid. Testing was conducted until the temperature of the fluid in the hydraulic tank reached Caterpillar's maximum temperature limit. This method of heating the hydraulic fluid did not eliminate the abnormal behavior. The hydraulic fluid was allowed to cool. The hydraulic fluid was next warmed by operating both the bucket controls and the steering controls. Caterpillar proposed this method of warming the fluid since they considered it would uniformly warm all of the fluid in the hydraulic system. Using this method, the hydraulic fluid was warmed to Caterpillar's

specification for the normal operating temperature of the hydraulic fluid. This method of warming the fluid eliminated the abnormal behavior.

Tests on the Ride Control System did not affect the operation of the bucket lift cylinders. The implement lockout (solenoid hydraulic lockout) that activates a valve to block pilot pressure to the main control valve (a safety feature that prevents inadvertent operation of the bucket controls when general maintenance work is being performed in the operator's compartment) was tested. Locking out of the controls did not affect the abnormal operation of the bucket lift cylinders. This indicated that erroneous signals from the controls did not cause the abnormal operation. No other safety defects were found on the front-end loader.

After the testing, Caterpillar issued *Technical Information Bulletin TIBU6481 "988G/H Uncommanded Implement Lift at Start-Up in Cold Ambient Conditions 10° C (50° F) or Below," dated 31 January 2012*, a Service Magazine article *"An Improved Warm Up Procedure Now Available for All 988G and 988H Wheel Loaders {1000, 5050, 7000}" dated 2012/02/21*, and revised the Operation and Maintenance Manual for warming the hydraulic fluid before use of the machine.

Conveyor and Wheel Assemblies Involved

The stackable truss frame conveyor, Model 36X70 is manufactured by Superior Industries and measures 36 inches in width by 70 feet. It was powered by a 440 volt electric motor and weighed approximately 10,300 lbs. Approximately half of the conveyor's weight was being supported by the front-end loader at the time of the accident. The weight was less than the loader's rated capacity of 25,000 lbs.

The conveyor is designed with a two wheel strut axle assembly. Each of the two wheel strut axle assemblies consist of 6-inch by 6-inch square tubing in the shape of an "L." The long leg of the "L" that slid into a square tube (sleeve) on the side of the conveyor is approximately 64 inches long. The short leg, approximately 18 inches long, is connected to a wheel (11-22.5 tire size). Holes in the long leg of the "L" and in the sleeve allow the conveyor to be positioned at varying heights in 6-inch increments. Pins used to secure the wheel assembly strut within the conveyor sleeve were previously installed at the bottom of the sleeve and not through the holes in the sleeve to gain extra lift height. This configuration allowed the struts to fall out of the sleeves when the conveyor was lifted.

Conveyor Lift and Equipment

A nominal ½-inch diameter chain, approximately 12 feet long with ½-inch hooks on both ends, was used to lift the conveyor. One end of the chain was hooked to a pin welded between two lugs welded to the top inside center of the front-end loader bucket. The other end was hooked to a lifting lug welded to a bar that spanned the top of the conveyor.

The bar was welded to each side frame rail of the conveyor. The lifting lug was centered over the conveyor. The bar was positioned approximately 17 feet 8 inches from the strut sleeve. With the front-end loader positioned so the lifting lug in the bucket was vertically in line with the lifting lug on the conveyor, the closest end of the bucket would have been approximately 11 feet from the sleeve and the victim. The sleeve would have been located to the loader operator's right side. Using the height of the strut assemblies, investigators determined the conveyor sleeve rose at least 6 feet 9 inches above the ground.

Weather Conditions

The weather at the time of the accident was 21 degrees Fahrenheit with 17 to 22 mile an hour winds. The investigators determined the cold temperatures affected the performance of the front-end loader's hydraulic system.

Training and Experience

Scott A. Armstrong (victim) had 9 years of mining experience, all with a crushing crew. A representative of MSHA's Educational Field Services staff conducted an in-depth review of the mine operator's training records. The training records for Armstrong were examined and MSHA determined he did not receive task training regarding lifting/rigging suspended loads in accordance with 30 CFR Part 46.

ROOT CAUSE ANALYSIS

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

Root Cause: Management's policies, procedures, and controls failed to effectively protect Armstrong from the suspended conveyor while he attempted to guide the wheel assembly into the conveyor strut. Suitable blocking or other effective means was not provided. Management did not task train Armstrong regarding the health and safety hazards associated with lifting/rigging a conveyor.

Corrective Action: Management established policies, procedures, and controls to ensure persons are not exposed to suspended loads when lifting conveyor components. Management trained all persons to identify hazards and eliminate them before beginning to lift conveyors.

Root Cause: Management failed to ensure any defects on equipment affecting safety be corrected in a timely manner.

Corrective Action: Management established and implemented policies, procedures, and controls requiring any defects affecting safety be corrected or the equipment removed from service.

CONCLUSION

The accident occurred due to management's failure to have procedures in place to ensure equipment is taken out of service or properly repaired when defects affecting safety are found. Investigators determined the cold temperatures at the time of the accident affected the performance of the main control valve of the front-end loader's hydraulic system. Other factors contributing to the accident include Armstrong's position near a suspended load, no blocking in place to prevent the fall of the conveyor, and Armstrong not task trained regarding the installation of the wheel strut axle assembly.

ENFORCEMENT ACTIONS

Issued to Knife River North Central

Order No. 8664216 -- Issued on December 8, 2011, under the provisions of Section 103(j) of the Mine Act:

> *An accident occurred at this operation on December 8, 2011, at approximately 11:00 a.m. This order is being issued under Section 103(j) of the Federal Mine Safety and Health Act of 1977, to prevent the destruction of evidence which would assist in investigating the cause or causes of the accident. It prohibits all activity at this site until MSHA has determined that it is safe to resume normal mining operations. This order was initially issued orally to Jeffrey Lambert, Safety Director, at 11:37 a.m. and has now been reduced to writing.*

This order was modified to Section 103(k) of the Mine Act when the first Authorized representative arrived at the mine.

This order was terminated on May 14, 2012, after conditions and practices that contributed to the accident no longer existed.

Citation No. 8660812 -- Issued on April 16, 2012, under the provisions of 104(a) of the Mine Act for a violation of 30 CFR Part 56.14100(c):

> *A fatal accident occurred at this operation on December 8, 2011. A miner was attempting to install a set of wheel assemblies on a conveyor to transport it from the mine. A front-end loader was being used to maneuver the conveyor. The bucket was being slowly lowered and suddenly dropped, allowing the frame of the conveyor to strike one of the wheel assemblies. The assembly then shifted, striking the victim. The bucket suddenly dropped due to a safety defect that had been previously identified. The defect made continued operation hazardous to persons but the front-end*

loader was not taken out of service and placed in a designated area posted for that purpose, or a tag or other effective method of marking the defective item used to prohibit further use until the defect was corrected.

Citation No. 8660813 -- Issued on April 16, 2012, under the provisions of 104(a) of the Mine Act for a violation of 30 CFR Part 56.16009:

A fatal accident occurred at this operation on December 8, 2011. A miner was attempting to install a set of wheel assemblies on a conveyor to transport it from the mine. A front-end loader was being used to maneuver the conveyor. The bucket was being slowly lowered and suddenly dropped, allowing the frame of the conveyor to strike one of the wheel assemblies. The assembly then shifted, striking the victim. The miner was struck while working in close proximity to a suspended load.

This citation is a "Rules to Live By" priority standard.

Citation No. 8660814 -- Issued on April 16, 2012, under the provisions of 104(a) of the Mine Act for a violation of 30 CFR Part 46.7(a):

A fatal accident occurred at this operation on December 8, 2011. A miner was attempting to install a set of wheel assemblies on a conveyor to transport it from the mine. A front-end loader was being used to maneuver the conveyor. The bucket was being slowly lowered and suddenly dropped, allowing the frame of the conveyor to strike one of the wheel assemblies. The assembly then shifted, striking the victim. He had not received adequate task training in the installation of the wheel assemblies prior to beginning this task. The mine operator was aware of Part 46 training requirements and the mine operator's Training Plan covered New Task Training. The Federal Mine Safety and Health Act of 1977 states that an untrained miner is a hazard to himself and to others.

This citation is a "Rules to Live By" priority standard.

Approved by: Date: October 5, 2012

Steven M. Richetta
District Manager
North Central District

APPENDIX A

Persons Participating in the Investigation

Knife River North Central

Jeffrey Lambert	Safety Director
John Henry	Aggregate Manager
Russell Karsky	Aggregate Supervisor
Adam Bialke	Aggregate Supervisor
Craig Raske	Aggregate Equipment Manager
Steven Popp	Team Leader/Loader Operator
Joseph Hyatt	Loader Operator
Scott Killinger	Excavator Operator
Jeffrey Bauer	Mechanic
Nichelle Young	Attorney

Caterpillar

Jason D. LaLonde	District Service Representative
Curtis R. Nickolauson	Technical Communicator
Kirk Christopherson	St. Cloud Service Manager
Evan L. Foster	Caterpillar Testing Engineer
Wesley T. Payne	Hydraulics Expert
Aaron Scheele	Caterpillar Equipment Demonstration Operator
Benjamin Kunstleben	Service Technician
Janice Thomas	Caterpillar Attorney

Crane Engineering

David M. Hallman	P.E.
Scott A. Sollars	P.E.

Mille Lacs County Sheriff's Office

Terry L. Boltjes	Officer
Todd H. Hass	Deputy
Bradley R. Barnes	Investigator
John T. Sammis Jr.	Deputy

Midwest Medical Examiner's Office

Michael Madsen, M.D.	Mille Lacs County Assistant Medical Examiner
Teresa M. Corona	Mille Lacs County Death Investigator

APPENDIX A (continued)

Mine Safety and Health Administration

James A. Hines	Mine Safety and Health Inspector
James L. Angel	Mechanical Engineer
Eugene D. Hennen	Mechanical Engineer
Thaddeus J. Sichmeller	Mine Safety and Health Inspector
Amy A. Sandelin	Mine Safety and Health Specialist

APPENDIX B

Accident Investigation Data - Victim Information

Event Number: 6 5 7 4 7 2 1

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. Degree of Injury:
Scott A. Armstrong	*M*	*41*	*01 Fatal*

5. Date(MM/DD/YY) and Time(24 Hr.) Of Death:	6. Date and Time Started:
a. Date: 12/08/2011 b.Time: 11:13	*a. Date: 12/08/2011 b.Time: 6:00*

7. Regular Job Title:	8. Work Activity when Injured:	9. Was this work activity part of regular job?
163 surface miner	*041 Moving equipment*	Yes X No

10. Experience	Years	Weeks	Days		Years	Weeks	Days		Years	Weeks	Days		Years	Weeks	Days
a. This Work Activity:	*9*	*0*	*0*	b. Regular Job Title:	*9*	*0*	*0*	c: This Mine:	*9*	*0*	*0*	d. Total Mining:	*9*	*0*	*0*

11. What Directly Inflicted Injury or Illness?	12. Nature of Injury or Illness:
038 Struck by conveyor's wheel assembly	*390 Blunt force cranio-cerebral injuries*

13. Training Deficiencies

Hazard: | New/Newly-Employed Experienced Miner: | Annual: | Task: X

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

Operator

Independent Contractor ID: (if applicable)

15. On-site Emergency Medical Treatment

Not Applicable: | First-Aid: | CPR: | EMT: | Medical Professional: | None: X

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

17. Union Affiliation of Victim: *9999* *None (No Union Affiliation)*