MAI-2007-04

UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

METAL AND NONMETAL MINE SAFETY AND HEALTH
REPORT OF INVESTIGATION

Surface Nonmetal Mine
(Industrial Sand)

Fatal Machinery Accident
March 23, 2007

Glass Rock Plant
Oglebay Norton Industrial Sands, Inc.
Glenford, Perry County, Ohio
Mine I.D. No. 33-01354

Investigators

Gary L. Belair
Mine Safety and Health Inspector

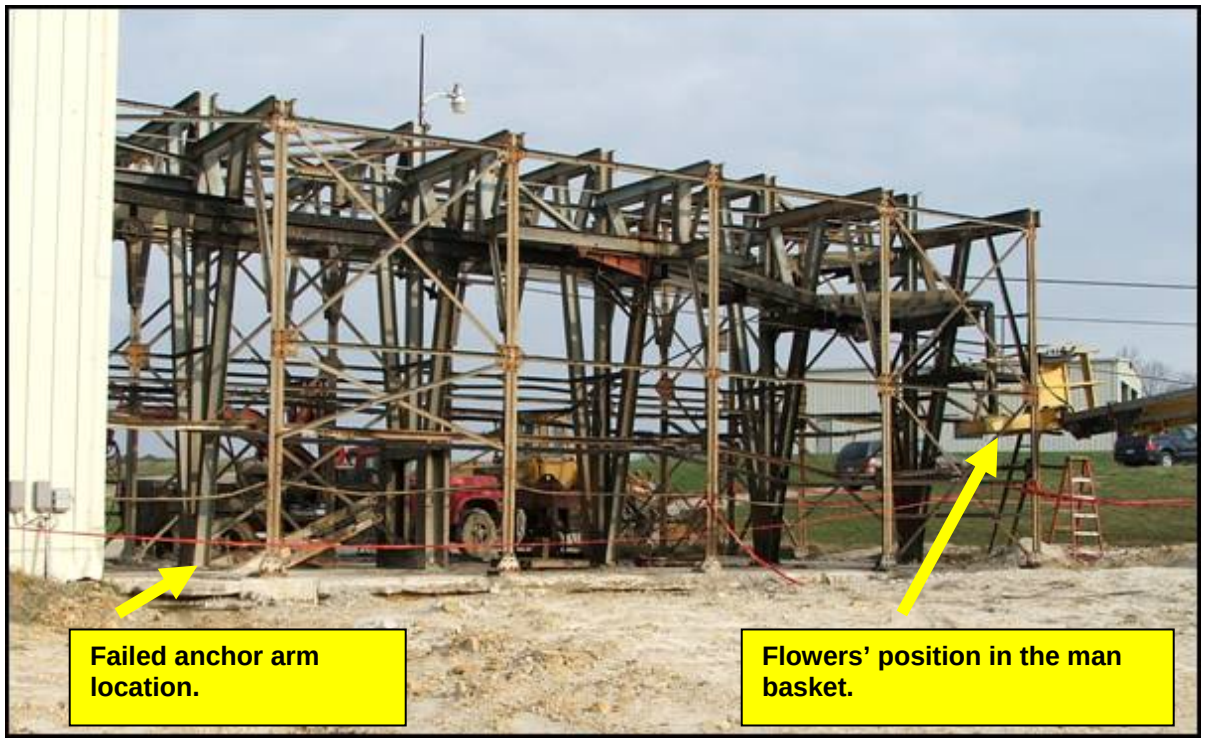
Carol L. Tasillo
Civil Engineer, P.E.

Michael C. Superfesky
Civil Engineer, P.E.

Ronald Medina
Mechanical Engineer

James A. Young
Mine Safety and Health Specialist

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


Failed anchor arm location.
Flowers' position in the man basket.

OVERVIEW

David L. Flowers, tramway maintenance man, age 44, was fatally injured on March 23, 2007, when he was struck by a cable or jacking cylinders while aligning a cable for an aerial tramway. He was in a man basket aligning the load cable with a monocular scope while coworkers monitored two jacking cylinders that pulled the cable toward him. Steel anchor arms securing the cable and jacking cylinders to a ground anchor failed and the cable or jacking cylinders struck him.

The accident occurred because management had not established procedures and policies to ensure that persons could safely tension tram cables. During the tensioning process, excess stress was placed on the anchor arms, causing them to fail. The capacity of the anchor arms was compromised when the end of the arms were cut to provide clearance for the cable grip attached to the arms. The anchor arms were overstretched when a hydraulic power supply, used to operate the jacking cylinders, exerted a force greater than the strength of the anchor arms. The pressure gauge on the hydraulic power supply was inoperable and the relief valve was not set to properly restrict pressure applied to the jacking cylinders.

GENERAL INFORMATION

The Glass Rock Plant, a surface industrial sand operation, owned and operated by Oglebay Norton Industrial Sands, Inc., was located near Glenford, Perry County, Ohio. The principal operating official was Steven A. Bell, general manager. The mine normally operated three, 8-hour shifts per day, and five days per week. Total employment was 43 persons.

Sandstone was blasted from multiple benches and transported to the primary crusher by haul trucks. The crushed material was conveyed to a loading terminal where buckets were filled and then hauled by the aerial tramway to a mill. The material was pulverized, dried, screened, and stored. The finished product was sold for a variety of manufacturing applications.

The last regular inspection at this operation was completed on May 8, 2006.

DESCRIPTION OF THE ACCIDENT

On March 22, 2007, the day before the accident, David L. Flowers (victim), Eric Watkins, haul truck driver; William E. Tullius, tramway operator; and Byron Mitchell, welder, added approximately 66 inches of slack to the cable of the aerial tram at a fixed anchor to prepare the load cable for pulling.

On March 23, 2007, the day of the accident, Flowers reported to work at 5:00 a.m., his normal starting time. Flowers, Tullius, Mitchell, Watkins, and Steven T. Dittoe, haul truck operator, worked in the maintenance shop until it was light enough to work outdoors. About 7:00 a.m., Flowers and Mitchell attached a repair clamp to a section of excessively worn cable while Tullius prepared the jacking cylinders and hydraulic power supply to pull the cable.

Flowers used a come-a-long to hoist the jacking cylinders into position. Tullius and Mitchell monitored the cylinders as the cable was pulled. Flowers observed the cable from the manlift basket. Tullius, Flowers, and Mitchell tightened the pulling grip on the upper end of the jacking cylinders to the cable for each pull. They loosened the holding grip on the lower end of the jacking cylinder and applied hydraulic pressure to retract the cylinders. After each pull, the holding grip on the lower end was tightened, the pulling grip on the upper end was loosened, and the cylinders were retracted. The cable was pulled twice to take up the cable slack. No buckets were resting on the load cable at this time. At 11:30 a.m., Dittoe came to the work site and the third pull was attempted. Two loaded buckets were added and the cable was pulled to re-check the sag.

Flowers was standing in the manlift basket checking for proper cable sag with a monocular scope. After the jacking cylinders pulled approximately 1 foot of cable, Flowers told Tullius the cable wasn't moving. Tullius placed the toggle control valve on the hydraulic power supply in the neutral position, tightened a

leaking hose fitting, and re-engaged the lever. Dittoe saw the cable moving, took a few steps back, turned toward Mitchell, and heard a loud crash. The anchor arms failed and the cylinders, grips, and cable suddenly released towards Flowers and struck him. Dittoe was struck by the tail of the cable. Tullius checked on Flowers and Dittoe and ran to the shop to call for emergency medical assistance.

Dittoe was transported to a local hospital where he was treated for a broken leg. Flowers was pronounced dead at the scene by the Perry County Coroner. The cause of death was attributed to head trauma.

INVESTIGATION OF THE ACCIDENT

The Mine Safety and Health Administration (MSHA) was notified of the accident at 12:25 p.m. EDT on March 23, 2007, by a telephone call from Raymond E. Garey, mechanic crew leader, to MSHA's emergency hotline. Gerald D. Holeman, assistant district manager, was called and an investigation was started that 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 traveled to the mine, 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 representatives of the State of Ohio Division of Mineral Resources Management.

DISCUSSION

Location of the Accident

The accident occurred at the aerial tramway loading terminal (Appendix C, Figure 1). The victim was positioned in a manlift, approximately 7 feet above the ground, under the cable saddle where the loaded buckets left the loading terminal rail and transitioned onto the load cable.

Weather

Rain fell throughout the day of the accident and the temperature was approximately 55 degrees Fahrenheit. Weather was not considered a factor in the accident.

EQUIPMENT

Aerial Tramway

The tramway was built circa 1946 and was relocated in 1973. In 1992, the loading terminal was relocated and the connecting section of the tramway was shortened and the towers were lowered.

The aerial tramway system was divided into three sections: a loading terminal section (800 feet); a center section (4,200 feet); and a discharge terminal section (4,200 feet). The system was comprised of a load, return, and tow cable. The load and return cables were static cables with anchors at the ends of each tramway section. The loaded aerial buckets were conveyed on the static cables by the active tow cable from the loading terminal to the processing mill at the discharge terminal. The buckets had a volume capacity of 36 cubic feet and weighed approximately 3.5 tons when loaded.

The cable involved in the accident was the 800-foot section load cable that began at the loading terminal. This cable was a 1¾-inch diameter, steel, double full lock, coil track rope manufactured by Fatzer AG. It weighed 7.56 pounds per foot and had a minimum breaking strength of 260,140 pounds.

Cable Anchors

The static cable anchors consisted of a double-channel beam, set in a concrete anchor block, buried in the ground. A pinned divider bar served as the connection between the ground anchor beam and the four anchor arms. The other end of the anchor arms were pinned to a cable holding grip that secured the tramway cable to the anchor arm assembly (Appendix C, Figure 2). The four anchor arms were configured as two pairs. The arms were designed using ⅜ inch steel plate, 47½ inches long, and 5 inches wide, with two, 2-1/32 inch diameter pinholes centered 2¾ inches from the ends of the plate. One pair was positioned above the cable and the other pair was positioned below the cable. For clarification and orientation, the two pairs were described as top and bottom. The arms were noted as left and right oriented with respect to the cable running from the loading terminal to Tower 12. The anchor arms were referenced as top-left, top-right, bottom-left, and bottom-right.

Three of the anchor arms failed due to block shear rupture, which allowed the steel to tear between the end of the arm and the pinhole (Appendix B, Photos 1 and 2). The exception was the bottom-left arm where the pin slid out instead of tearing through the pinhole (Appendix B, Photo 2). Based on the physical evidence, the anchor arms released in the sequence of bottom-right, top-right, top-left, then bottom-left. When the first three arms failed, the pin holding the bottom-left arm was able to pivot and slide free.

The end of the anchor arms had been thermally cut to address clearance problems between the anchor arms and the holding grip. This reduced the amount of steel available to resist the pin load and increased the shear stresses in the anchor arm. Investigators determined that three of the arms had been cut twice. The rough surfaces left by the cuts created stress concentrations at notches in the material, further reducing the capacity of the arms.

The connection of the anchor arms to the holding grip were continuous with little space between the connecting plates. The connection of the anchor arms to the divider plate had gaps between the plates causing play and uneven loading in these connections. Additional play was caused by wear and corrosion of the pinholes which allowed 1/16 inch to 7/32 inch clearance between the pin and the pinhole.

The anchor arms were coated with silver paint over red paint or primer. The coating was worn and corrosion was observed across the anchor arms. Deformation of the anchor arms formed a crack pattern in the paint around the pinholes. A similar pattern was engrained in the corrosion indicating that the arms had been previously overloaded.

A section was removed from the bottom-left anchor arm and tested to determine the material properties. The bottom-left anchor arm was selected to preserve the condition of the three anchor arms that sheared since there were no discernible differences between the four anchor arms. Testing showed that the metallurgical composition of the steel met the specifications for AISI-SAE 1522 steel. The yield strength of the steel was 63,200 psi and the ultimate tensile strength was 85,100 psi.

Hydraulic Power Supply and Jacking Cylinders

A hydraulic power supply was used to operate the jacking cylinders for the cable tensioning operation. The power supply consisted of a gasoline motor-driven pump, a control valve, a relief valve, and a pressure gauge. The pump, control valve, and cylinders were rated for a maximum working pressure of 3,000 psi; the hoses connecting the components were rated for 4,000 psi; and the pressure gauge was rated for 5,000 psi. The pressure gauge was not functional. The gauge was positioned, facing away from the controls, such that persons operating the equipment could not read the pressure.

The relief valve was adjustable between 100 psi and 6,000 psi and operated to restrict the maximum operating pressure produced by the hydraulic power supply. The relief valve knob, used for adjusting the pressure, was missing. When tested, the pressure setting was approximately 5,600 psi. The test indicated that the hydraulic power supply was capable of applying up to 5,600 psi on the cylinders at the time of the accident. The cylinders and relief valve were

disassembled and inspected and were found to be in good condition with no indication of any malfunctions.

The two jacking cylinders were manufactured by Hanna Cylinders circa 1973, and were rebuilt by R&M Fluid Power, Inc. in 1988. The cylinders had a 6-inch diameter bore, a 36-inch stroke, and a 2½ inch diameter rod. The cylinders were yoked together in a parallel arrangement so each cylinder attached to an anchor arm pair and acted together to produce the pulling force on a cable being tensioned (Appendix C, Figure 2). Based on the relief valve setting of 5,600 psi, the maximum retraction force created by the two cylinders was approximately 262,000 pounds or 65,500 pounds per anchor arm.

Estimate Failure Load/Pressure

The load required to cause the anchor arms to fail was estimated using empirical equations for block shear rupture (tear) and the material properties acquired from testing. Using these calculations, investigators determined that the first anchor arm failed at an estimated load of 37,000 pounds, equating to a hydraulic pressure on the jacking cylinders of 3,170 psi. If the end of the anchor arm had not been cut, calculations showed that it would fail at approximately 47,000 pounds, equating to a hydraulic pressure on the jacking cylinders of 4,030 psi. An engineering drawing at the mine showed that the maximum pressure on the cylinders was intended to be 2,150 psi, for a cylinder load of 50,000 pounds and a load per anchor arm of 25,000 pounds.

Calculations revealed that the placement of full buckets on the cable during the third pull significantly increased the required tension in the cable and placed a significantly higher load on the anchor arms. Considering the weight of the cable and the catenary geometry, including the cable sag, the cable tension was approximately 4,000 pounds without buckets and about 30,000 pounds with buckets. Another calculation was made to determine the cable elastic elongation (stretch). These calculations indicated that the 84 inches of slack pulled from the cable during the three pulls would create a load approximately equivalent to the intended design capacity of the anchor arms.

Finally, a review of the anchor arm behavior using finite element analyses indicated that regions of high stress were consistent with block shear failure. The analysis showed that the stress concentration on the outside edge of the arm initiated tearing from the end of the anchor arm and progressed towards the pinhole.

Training and Experience

Flowers had 26 years mining experience and had received training in accordance with 30 CFR, Part 46. He had provided on-the-job training to coworkers assisting him in the cable tensioning procedure. He had approximately 11 years experience in cable tensioning work.

Stephen T. Dittoe had 15 years mining experience and had received training in accordance with 30 CFR, Part 46. He had assisted in the load cable tensioning procedure approximately 13 times and in adjusting the tow cable one to two times per year during the last six years. Dittoe's training on cables was by on-the-job instruction.

William E. Tullius had 23 years mining experience and had received training in accordance with 30 CFR, Part 46. Tullius had been tramway operator since April 16, 2001. He had helped Flowers tension cables three times and had received on-the-job instruction.

Byron Mitchell had 27 years mining experience and had received training in accordance with 30 CFR, Part 46. Mitchell had helped tension cables 15 to 20 times. Mitchell's training on cables was by on-the- job instruction.

ROOT CAUSE ANALYSIS

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

Root Cause: Management did not have policies, procedures, and controls in place so persons could safely tension cables on the aerial tram. No assessment of the risk involved in this work assignment was completed. The pressure gauge and relief valve were non-functional on the hydraulic power supply used to complete the task.

Corrective Action: Management should establish policies, procedures, and controls so persons can safely tension cables on the aerial tram. All equipment and tools should be inspected and operating properly. A secondary restraint should be provided to ensure that the cable can not accidentally be released during tensioning. Persons performing the task should be trained regarding safe work procedures before any cables are tensioned.

Root Cause: Management did not ensure that the tramway was adapted to support all loads imposed on the tramway components. The anchor arms used to secure the cable were stressed beyond their yield point. The ends of the anchor arms had been cut to clear the cable grips.

Corrective Action: Management should ensure that component stresses and anchorage loads are analyzed so the tramway can support all loads imposed on its components.

CONCLUSION

The accident occurred because management had not established procedures and policies to ensure that persons could safely tension tram cables. During the tensioning process, excess stress was placed on the anchor arms, causing them to fail. The capacity of the anchor arms was compromised when the end of the arms were cut to provide clearance for the cable grip attached to the arms. The material at the pin connections was reduced, allowing the arms to fail at a lower load than required originally. The anchor arms were overstretched and fractured when the hydraulic power supply, used to operate the jacking cylinders, exerted a force greater than the strength of the anchor arms. The pressure gauge on the hydraulic power supply was not functioning and the relief valve was not set to properly restrict pressure applied to the cylinders.

ENFORCEMENT ACTIONS

Order No. 6169272 was issued on March 23, 2007, under the provisions of Section 103(k) of the Mine Act:

> A fatal accident occurred at this operation on March 23, 2007, when four miners were attempting to tighten a tramway cable using (The Mule) a cable tension jack with hydraulic cylinders. This order is issued to assure the safety of all persons at this operation. It prohibits all activity at the tramway area until MSHA has determined that it is safe to resume normal mining operations in the area. The mine operator shall obtain prior approval from an authorized representative for all actions to recover and/or restore operations to the affected area.

This order was terminated on August 27, 2007. The conditions that contributed to the accident no longer exist.

Citation No. 6196205 was issued July 13, 2007, under the provisions of Section 104(a) of the Mine Act for violation of 56.10002:

> A fatal accident occurred at this mine on March 23, 2007, when a miner was struck by tensioning jacks and/or a cable when the cable anchor arms failed. The victim and coworkers were utilizing hydraulic jacking cylinders to adjust the tension on the wire rope load cable for the aerial tramway. The mine operator failed to assure that this maintenance task was performed according to the recommendations of the cable pulling assembly designer in that: the maximum pressure generated by each jacking cylinder was not

to exceed 2,150 psi, and the load on each cylinder was not to exceed 50,000 pounds.

This citation was terminated on August 23, 2007. The operator had the cable pulling assembly rebuilt and provided training to all miners involved in the cable tensioning process. The training included instruction on the use of the cable pulling assembly, designer specifications for cylinder pressure and load, monitoring pressure gauges, and setting the pressure relief valve. Output force and pump pressure will be monitored remotely to limit exposure to cables that are being tensioned.

Citation No. 6196206 was issued July 13, 2007, under the provisions of Section 104(a) of the Mine Act for violation of 56.14100(b):

> A fatal accident occurred at this mine on March 23, 2007, when a miner was struck by tensioning jacks and/or a cable when the cable anchor arms failed. The victim and three coworkers were utilizing hydraulic jacking cylinders to adjust the tension on the wire rope load cable for the aerial tramway. The pressure gauge provided on the hydraulic power supply used to operate the tensioning jacks was not functioning and the relief valve was not set to properly restrict pressure applied to the cylinders. These defects affected the safety of miners performing this task in that they were unable to monitor and limit the hydraulic pressure during the tensioning process. As a result, excessive output forces were generated, causing the anchor arms to fail.

This citation was terminated on August 14, 2007. The operator redesigned the anchor arms, cable grips, divider bars, and steel pins. The cable pulling assembly was rebuilt, new pressure gauges were installed, and the pressure relief valve was replaced. The hydraulic power supply and jacks were tested. The gauges and pressure relief valve functioned properly. All miners involved in the cable tensioning process were trained and indicated that they understood how to monitor the hydraulic pressure for excessive output forces and to set the pressure relief valve.

Citation No. 6196207 was issued 7/13/2007, under the provisions of Section 104(a) of the Mine Act for violation of 46.7(a):

> A fatal accident occurred at this mine on March 23, 2007, when a miner was struck by tensioning jacks and/or a cable when the cable anchor arms failed. The victim and three coworkers were utilizing hydraulic jacking cylinders to adjust the tension on the wire rope load cable for the aerial tramway. The pressure gauge provided on the hydraulic power supply used to operate the tensioning jacks was not functioning and the relief valve was not set to properly

restrict pressure applied to the cylinders. The miners performing this task had not been trained regarding safe work procedures or health and safety hazards associated with this task.

This citation was terminated on September 10, 2007. The operator developed a task training plan for miners who work with tensioning cables. The maintenance supervisor has been trained to recognize hazards at the aerial tramway by experts from an aerial tramway engineering and construction company. All miners involved in the cable tensioning process have been trained regarding safe work procedures and health and safety hazards associated with cable tensioning. Before any cable tensioning task is performed, the associated risks will be discussed with all miners involved.

Approved by: Date:

Steven M. Richetta
District Manager
North Central District

LIST OF APPENDIXES

APPENDIX A

Persons Participating in the Investigation

Oglebay Norton Industrial Sands, Incorporated

Steven A. Bell	general manager, Ohio and Colorado operations
Wayne C. Dailey	plant manager
Darlene Bray	senior environmental, health and safety manager
Raymond E. Garey	team leader
Timothy L. Adkins	vice president, environmental, health and safety
Byron Mitchell	quarry welder
William E. Tullius	tramway operator
Stephen T. Dittoe	truck driver
Eric Watkins	truck driver
Terry L. Snider	loader operator

Ohio Division of Mineral Resources Management

Jeffrey Hoblick	mine safety coordinator
Jerry Luyster	mine safety specialist

Mine Safety and Health Administration

Gary L. Belair	mine safety and health inspector
Carol L. Tasillo	civil engineer, P.E.
Michael C. Superfesky	civil engineer, P.E.
Ronald Medina	mechanical engineer
James A. Young	mine safety and health specialist

APPENDIX B

Photo 1 – Empty cable anchor arm assembly and failed load cable anchor arms.

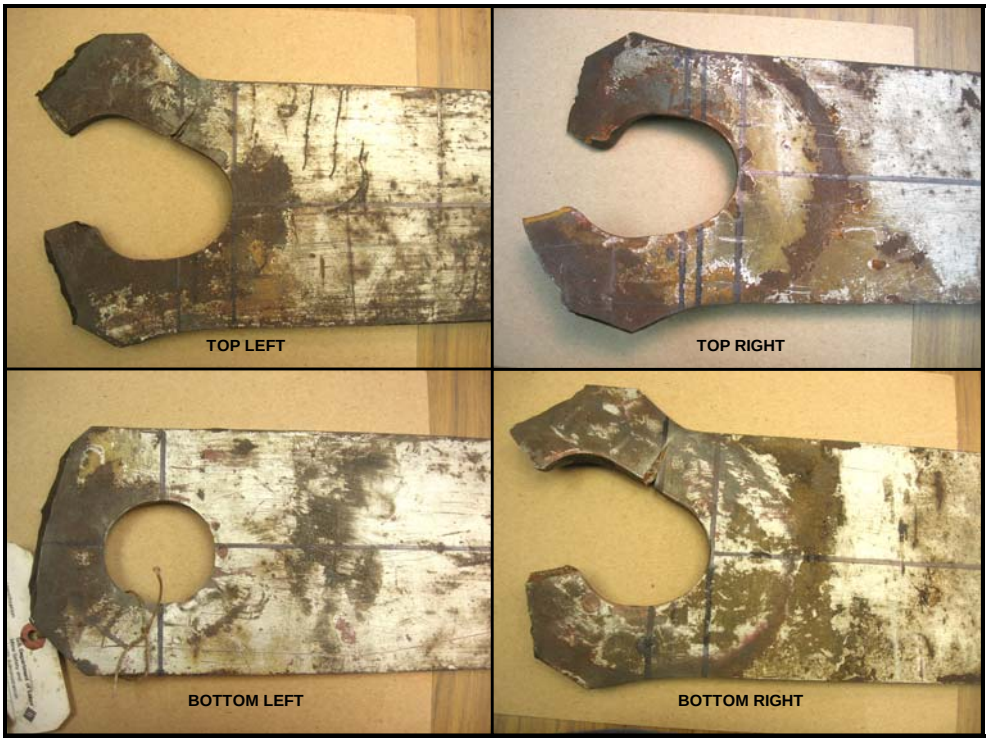


Photo 2 - Anchor arm conditions after pin connection failed.

APPENDIX C

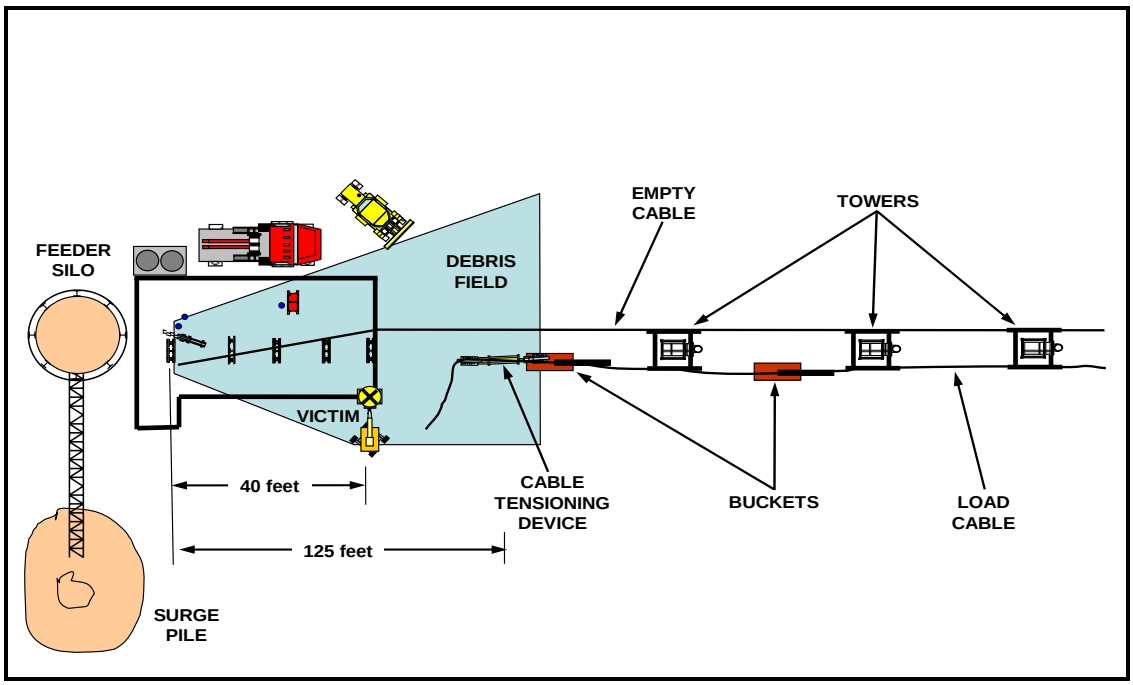


Figure 1 – Overview of the accident scene.

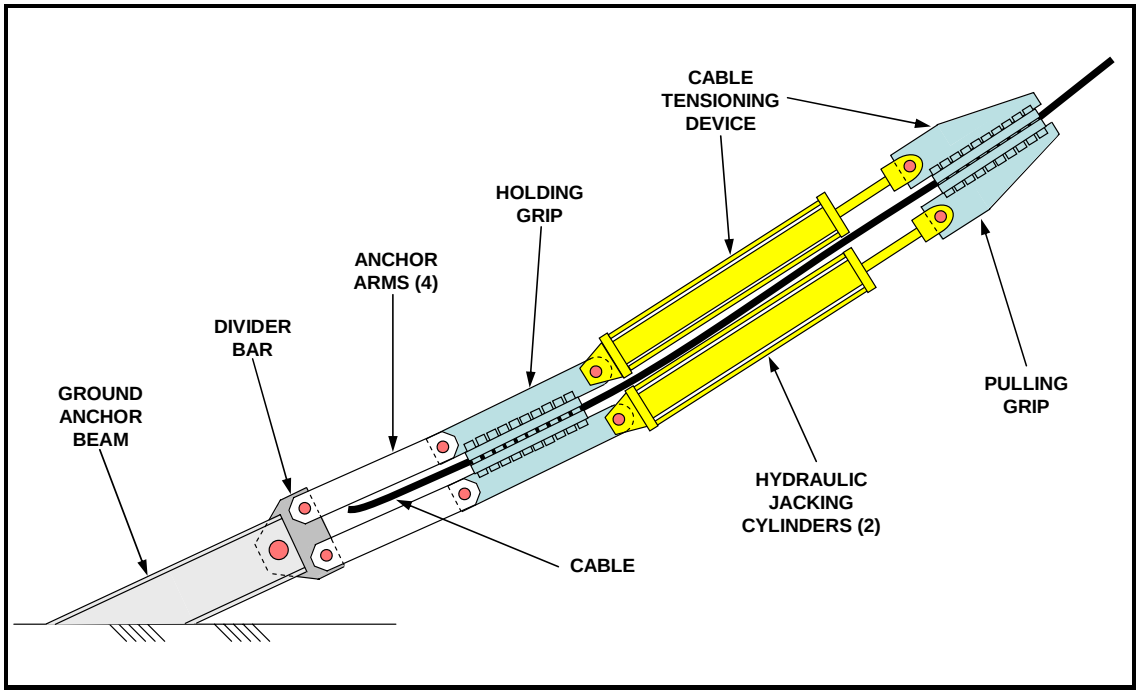


Figure 2 – Illustration of anchor arm assembly and cable tensioning device.

APPENDIX D

Accident Investigation Data - Victim Information
Event Number: 0 9 9 3 7 3 0

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:
David L. Flowers	*M*	*44*		*01 Fatal*

6. Date(MM/DD/YY) and Time(24 Hr.) Of Death: *a. Date: 03/23/2007 b.Time: 11:55*

7. Date and Time Started: *a. Date: 03/23/2007 b.Time: 5:00*

8. Regular Job Title: *104 Tramway Maintenance Man*

9. Work Activity when Injured: *032 Assisting in tensioning wire rope cable*

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

11. Experience	Years	Weeks	Days		Years	Weeks	Days		Years	Weeks	Days		Years	Weeks	Days
a. This Work Activity:	11	3	1	b. Regular Job Title:	11	3	1	c: This Mine:	26	12	4	d. Total Mining:	26	12	4

12. What Directly Inflicted Injury or Illness: *079 Wire rope cable or jack*

13. Nature of Injury or Illness: *390 Blunt trauma to head*

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

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

Independent Contractor ID: (if applicable)

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

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

18. Union Affiliation of Victim: *2582 Glass,Potery,Plast & Allied Wkrs*

Victim Information:

1. Name of Injured/Ill Employee:	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		Years	Weeks	Days		Years	Week	Days		Years	Weeks	Days
a. This Work Activity:				b. Regular Job Title:				c: This Mine:				d. Total 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:

Victim Information:

1. Name of Injured/Ill Employee:	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		Years	Weeks	Days		Years	Week	Days		Years	Weeks	Days
a. This Work Activity:				b. Regular Job Title:				c: This Mine:				d. Total 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: