UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION

Surface of Underground Coal Mine

Fatal Machinery Accident
August 16, 2000

APPENDIX C - Matco Associates, Inc. - Harness Analysis Report

The text portion of the report dated October 6, 2000, by Matco Associates, Inc., entitled Failure Analysis of Two Broken Lanyards From a Safety Harness, is provided on the following pages. Due to the large number of digital images attached to Matco's report, only a selected few have been included in this appendix.

Introduction

Our client submitted one safety harness to which were attached two separate lanyards, each of which had broken during the course of a fatal accident which occurred on August 16, 2000 at the Consol Blacksville Mine in West Virginia. The safety harness was identified as: UVEX Model T201, SN 40123321200. We were requested to analyze the two broken lanyards to determine the condition of the lanyards and the mode of failure.

Infrared Analysis

Infrared spectroscopy was performed on the longer halves of the two broken lanyards using a Nicolet Avatar model fourier transform infrared spectrometer (FTIR) equipped an ASI attenuated total reflectance (ATR) accessory. The two spectra are shown in figures 1 and 2 and were found to be very similar. The fibers of the two lanyards were of the polyamide variety, i.e., a nylon. Polyamide is evident by the strong characteristic bands near 1630 cm-1 and 1530 cm-1. Therefore the lanyard conforms to the material requirements of paragraph 3.2.3.1 of ANSI Z359.1-1992.

Visual Examination

The as received safety harness and attached broken strap lanyards are shown in figure 3. The two reconstructed broken lanyards are shown in figure 4. The reconstruction was based upon comparing the lengths of the broken lanyards.

One of the broken lanyard sections (the top section shown in figure 4) was relatively clean and was reportedly not submersed in the coal washer. One of the lanyards exhibited a tear adjacent to the energy absorber as shown in figures 4 and 5. The identification label attached to the energy absorber is shown in figure 6. The energy absorber and attached lanyards were connected to the safety harness by a snap hook mechanism which was closed but no longer functional and a length of steel wire cable as shown in figure 7.

The identification labels sewn onto the safety harness are shown in figures 8-10. Some damage to the safety harness was observed as shown in figures 11-15. The identification markings stamped into the metal snap hooks on the ends of the lanyards were found to be the same for all three snap hooks. The stamped identification markings are shown in figures 16-22.

Hereafter the lanyard containing the one clean section will be referred to as the first lanyard and the lanyard containing two dirty sections will be referred to as the second lanyard. The clean end of the first lanyard is shown in figures 23 and 24. The snap hook is also shown in these photographs. The other end of this lanyard is shown in figures 25 and 26 where it connects to the fall arrest mechanism. The stitching of the eye terminations was still intact at both ends of this lanyard. The fracture of this lanyard is shown in figures 27-30. Photographs showing the typical condition of this lanyard are shown in figures 31and 32. In general a small amount of abrasion but no other type of damage to the fibers was observed. The observed abrasion damage occurred primarily at the eye termination.

The fracture of the second lanyard is shown in figures 33-36. Approximately 4 1/2 inches from one of the fractures a sharp linear indentation across the width of the lanyard was observed as shown in figures 37 and 38. This feature was only observed on one side of the lanyard. This feature most likely represents the location at which the lanyard was caught by a component of the coal washer prior to failure. The snap hook end of the second lanyard is shown in figures 39 and 40. The other end of the lanyard where it connects to the energy absorber is shown in figures 41 and 42. The stitching of the eye termination was observed to have ruptured at one location as shown in figure 42.

Stereomicroscopic Examination

The lanyards were further examined at moderate magnifications (10x-50x) using an optical stereomicroscope. The abrasion damage to the outer fibers of the clean section of the first lanyard near the snap hook is shown in figure 43. A portion of the fracture is shown in figures 44 and 45. Some of the individual fiber fractures are shown in figures 46-48. Most of the fibers had fractured perpendicular to the columnar axis of the fiber (see figures 46 and 47) although a few fibers exhibited localized swelling at the fracture location. See figure 48. No evidence of fiber degradation was observed.

The coal particulates on the surface of the second lanyard are shown in figure 49. A portion of the fracture is shown in figures 50 and 51. Some of the individual fiber fractures are shown in figures 52-55. Most of the fibers had fractured perpendicular to the columnar axis of the fiber as shown in figure 52. However several fibers were observed to exhibit localized swelling at the fracture location as shown in figures 53-55.

A small bundle of fibers was cut from the fractured end of the clean lanyard for further SEM examination. The location where these fibers were removed is shown in figures 56 and was identified as location no. 3. Two bundles of fibers were cut from one of the fractured ends of the longer section of the second lanyard for further SEM examination. The locations where these fibers were removed are shown in figure 57 and were identified as location no's 1 and 2.

SEM/EDS Examination

The fibers cut from the failed ends of the lanyards were attached to graphite disks using conductive double sided carbon tape and then gold coated for electrical conductivity. The fibers were then examined at higher magnifications using a scanning electron microscope (SEM). The fracture profiles of ten fibers from each sample are shown in figures 58-87. The fracture profiles of the fibers from location no. 1 in the second lanyard are shown in figures 58-67. Half of the individual fibers examined exhibited localized swelling of the fiber adjacent to the fracture. This is characteristic of a high speed tensile break indicating that these fibers were among the last individual fibers to fail for this lanyard. The remaining fibers photographed from this sample exhibited fractures that were nearly perpendicular to the fiber axis and sometimes possessed a small projecting fibril on one side of the fiber circumference. This profile is characteristic of a ductile tensile overload.

The fracture profiles of the fibers from location no. 2 in the second lanyard are shown in figures 68-77. The fibers from this area exhibited fractures that were perpendicular to the fiber axis and sometimes possessed a small fibril on one side of the fiber circumference (see figure 69). These profiles are characteristic of a ductile tensile overload. Two of the fibers photographed (figures 72 and 77) displayed a stepped structure suggesting that the fracture had initiated a two separate locations on opposite sides of the fiber circumference.

The fracture profiles of the fibers from location no. 3 in the first lanyard are shown in figures 78-87. All but one of the fibers from this area exhibited fractures that were perpendicular to the fiber axis and sometimes possessed a small fibril on one side of the fiber circumference. These profiles are characteristic of a ductile tensile overload. One of the fibers (figure 84) exhibited localized swelling of the fiber adjacent to the fracture which is characteristic of a high speed tensile break.

The exterior surfaces of the individual fibers from all three areas examined were found to be somewhat rough in texture. However no evidence of any severe degradation of the fibers was observed.

Conclusion

Visual examination of the fractures for the two lanyards and high magnification examination of individual fibers cut from the two fractures indicated that both lanyards failed as a result of a tensile overload.

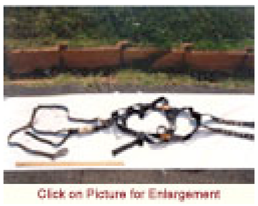

Figure 3 - Photograph showing the as received safety harness and lanyard assembly.

Figure 4 - Photograph showing the reconstruction of the two broken lanyards.

Figure 7 - Photograph showing the connection between the safety harness and the energy absorber.

Figure 37 - Photograph showing a linear indentation in one side of the second lanyard.

Figure 38 - Photograph showing a linear indentation in one side of the second lanyard.

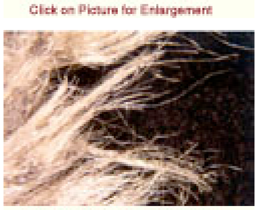

Figure 51 - Photograph at 12x showing the second lanyard fracture.

Figure 57 - **Photograph showing the location of the SEM specimen removal from the second lanyard.**

Figure 58 - **Photograph at 250x showing one of the broken fibers from location no. 1 - second lanyard.**

Figure 69 - **Photograph at 530x showing one of the broken fibers from location no. 2- second lanyard.**