

**UNITED STATES  
DEPARTMENT OF LABOR  
MINE SAFETY AND HEALTH ADMINISTRATION**

**COAL MINE SAFETY AND HEALTH**

**REPORT OF INVESTIGATION**

**Surface Coal Mine**

**Fatal Exploding Vessel Accident  
September 5, 2003**

**No. 2 Surface Mine  
Twin Star Mining, Inc.  
Hurley, Buchanan County, Virginia  
ID No. 44-03658**

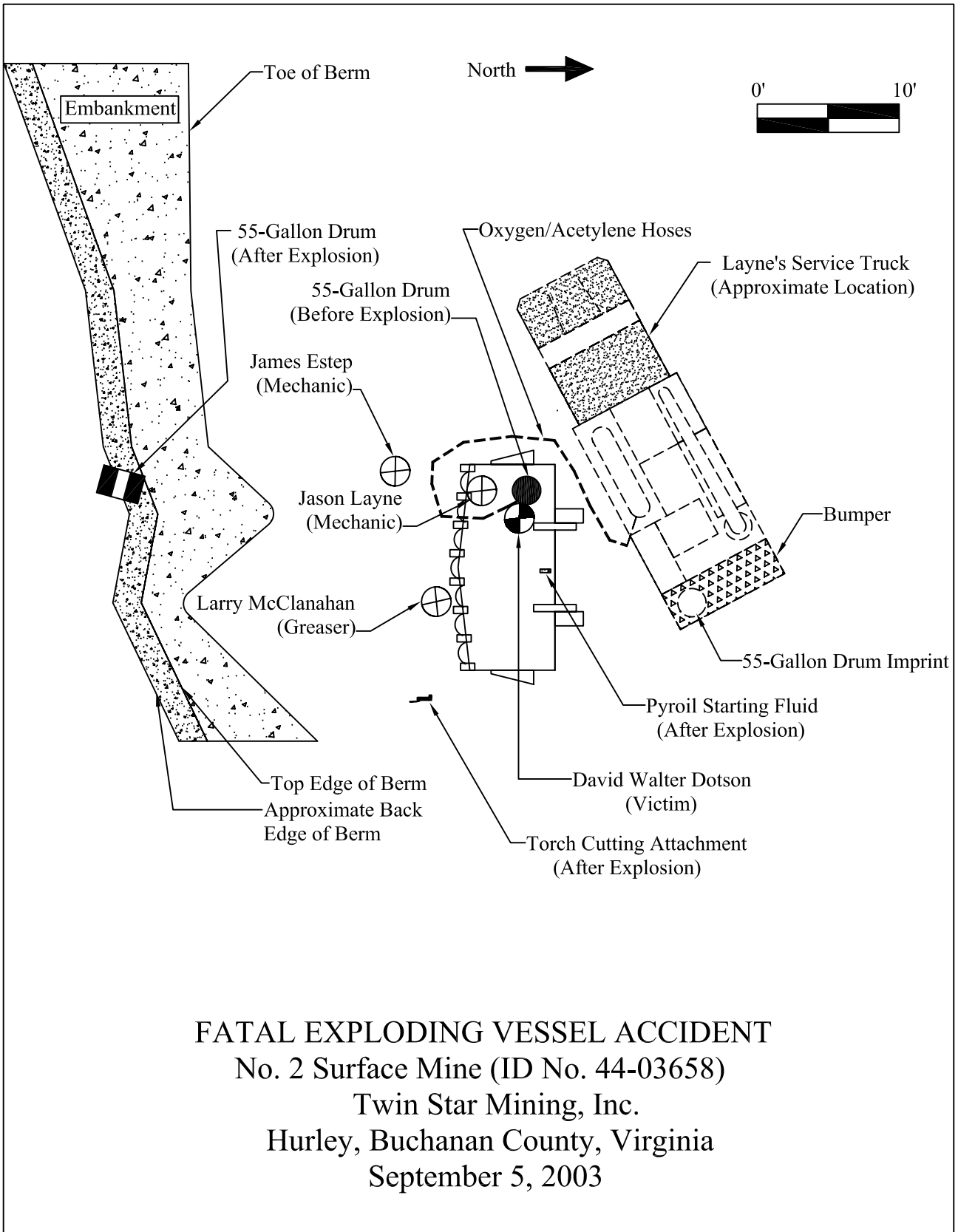
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**FATAL EXPLODING VESSEL ACCIDENT**  
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**Twin Star Mining, Inc.**  
**Hurley, Buchanan County, Virginia**  
**September 5, 2003**

## OVERVIEW

At approximately 8:45 p.m., on Friday, September 5, 2003, a 28-year-old Utility Man with 10 years of mining experience was fatally injured during an exploding vessel accident at Twin Star Mining, Inc.'s No. 2 Surface Mine. The fatally injured miner was holding an unlit oxygen/acetylene torch, through which he was delivering acetylene into an empty 55-gallon antifreeze drum when it prematurely exploded. Earlier in the day, the victim used a trail of starting fluid to ignite a bag filled with acetylene. At the time of the accident, he was intending to demonstrate a larger explosion to a new mine employee. The drum was placed inside an unattached Caterpillar, Model 992-G, front-end loader bucket, which concealed its view and shielded the blast from nearby buildings.

A mechanic, who was standing next to the victim, and two other mine employees, who were approaching the bucket at the time of the explosion, were also injured. The fatally injured victim received massive fatal head injuries when he was struck by debris from the explosion.

The most likely ignition source was static electricity, which was generated by acetylene flowing from the torch tip. An electrostatic discharge likely occurred when the torch tip touched the grounded steel drum.



**Figure 1** – Photograph of the accident site, showing the barrel after it was repositioned inside the front-end loader bucket, at its location prior to the explosion.

## GENERAL INFORMATION

Twin Star Mining, Inc.'s No. 2 Surface Mine is located approximately 1.3 miles North of Hurley in Buchanan County, Virginia, off State Route 711. The mine also extends into Kentucky and West Virginia. All coal is transported to Virginia for processing.

The mine began production in 1974 under the name of Virginia Energy Company, Surface Mine No. 1. Production ceased and the mine was placed in an abandoned status on January 17, 1990. The mine reopened in May, 1994, as Virginia Energy Co., No. 1 Strip. On December 16, 1994, the name was changed to Twin Star Mining, Inc., No. 2 Surface Mine.

The mine employs 53 miners working 2 shifts per day, 5 to 6 days per week. Daily production averages 2000 tons of coal produced with two units of surface equipment. These units are primarily made up of Caterpillar Model 992-G front-end loaders, Caterpillar Model 785 haul trucks, Caterpillar Model D-10 and D-11 bulldozers, and a highwall drill. These units may also be referred to as a "loader spread". The mine extracts coal from the Eagle, Clintwood, Alma, and Pond Creek seams.

The principal officers for the mine at the time of the accident were:

Don Nicewonder .....	President
Kenneth R. Nicewonder .....	Vice President
John Kevin Nicewonder .....	Vice President
Samuel Casey .....	Superintendent/Person at Mine In Charge of Health & Safety

Prior to the accident, the Mine Safety and Health Administration (MSHA) completed the last regular safety and health inspection at this mine on June 16, 2003. The Non-Fatal Days Lost (NFDL) injury incident rate for the mine in 2002 was 3.80 compared to a National NFDL rate of 2.30 for surface mines.

## DESCRIPTION OF ACCIDENT

On September 5, 2003, the evening shift (5:00 p.m. to 3:00 a.m.) for Twin Star Mining, Inc.'s No. 2 Surface Mine began operation under the supervision of Glen Mullins, Evening Shift Foreman. Mullins began his shift on the Kentucky side of the mine, where he supervised the moving of a loader spread from there to the rock crusher. Mullins remained at this location for the next two to three hours. Jason Layne, Mechanic and James Estep, Contract Mechanic, began the shift performing maintenance work on coal haulers. Both went to an area approximately 200 feet south of the maintenance shop to work on a Caterpillar, Model 785 haul truck. The haul truck was located near a newly rebuilt Caterpillar, Model 992 G, front-end loader bucket, which was not mounted to the equipment, approximately 250 feet south of the maintenance shop. One of the coolers on the haul truck was leaking antifreeze into the hydraulic oil. Using Estep's service truck boom, Estep and Layne removed the rock guard from the haul truck in preparation for the repairs.

David Dotson, Utility Man and victim, and Larry McClanahan, Greaser, were greasing and fueling coal loaders on the Kentucky side of the mine. Dotson used his cellular phone to place a food order at a local restaurant (Bertha's Diner). Dotson contacted Bruce Mounts, Haul Truck Operator/EMT, on the CB radio to set up a practical joke concerning McClanahan's tab at Bertha's. Dotson and McClanahan left in separate vehicles to service a water truck, located near the maintenance shop. While en route to the water truck, Mounts called McClanahan on the CB radio and followed through with the joke. When Mounts finished talking with McClanahan, Dotson came back on the radio laughing and told Mounts he had to get out of the truck and do something. Dotson and McClanahan serviced the water truck and prepared to replenish the red antifreeze in the C model trucks. Before loading the red antifreeze in McClanahan's service truck, Dotson asked Layne and Estep if they would need the oil drained from the Caterpillar, Model 785, haul truck. They replied that it would, once the haul truck was in the maintenance shop.

Dotson, McClanahan, and Layne met in the maintenance shop while Estep was retrieving the haul truck. Dotson took an empty plastic bag to the opposite side of Layne's service truck, located just outside the shop door, and filled it with acetylene from a tank located on Layne's truck. When Estep arrived with the haul truck, Layne and McClanahan stood near the shop door and directed Estep into the maintenance shop. Meanwhile, Dotson placed the bag outside the shop, sprayed a trail of starter fluid (approximately 20 feet) to the bag, ignited the trail, and exploded the bag (refer to Appendix E). Layne thought a tire on the haul truck had burst when he heard the explosion. Immediately following the explosion, Dotson reentered the maintenance shop laughing. Estep heard the explosion but did not question the source. At this time, Mullins, the only management person on the shift, was moving a loader spread from the rock crusher, located approximately 0.5 to 0.75 miles from the shop, to the Kentucky side of the mine.

Preparations were made to begin maintenance work on the Caterpillar Model 785 haul truck. The safety cord for the dump bed was fastened so that the coolers could safely be worked on with the bed up. Estep prepared to drain the oil while Dotson and Layne obtained a 55-gallon drum from the maintenance shop and took it outside. The 55-gallon drum was placed on the oversized bumper of Layne's service truck. Layne drove his service truck to the front-end loader bucket. McClanahan walked with Dotson to the front-end loader bucket, while Dotson talked about placing acetylene in the drum and igniting the mixture. Meanwhile, Estep walked to his service truck, which was located between the loader bucket and the maintenance shop. Fearing that he might get in trouble, McClanahan immediately walked back to Estep's service truck and began a conversation with him.

Layne was examining the machining on the back of the front-end loader bucket, as Dotson walked around to the front of the loader bucket. Approximately 5 minutes later, Layne walked to the front of the bucket, where he smelled acetylene and saw Dotson standing next to an empty 55-gallon anti-freeze drum with the tip of an acetylene/oxygen cutting torch in the large hole of the drum lid. The 55-gallon drum was located in the Northwest corner of the front-end loader bucket. Dotson told Layne that he was "going to show the new boy what an acetylene explosion would do." McClanahan had only been employed at the mine for two weeks.

Meanwhile, Mullins drove between Estep's service truck and the shop area while accompanying a loader spread move from the rock crusher to the Kentucky side. He saw Estep and McClanahan conversing at Estep's service truck, but he did not notice Dotson or Layne. McClanahan told Estep that Dotson was going to do something with the drum and acetylene. Estep replied that he did not think they would do that. After he saw Mullins pass, Estep began wondering what was delaying Dotson from returning with the drum.

At approximately 8:45 p.m., Estep and McClanahan began walking toward the front-end loader bucket. As Estep and McClanahan rounded the corner of the loader bucket, to within approximately eight feet of the 55-gallon drum, the acetylene/air mixture in the drum prematurely ignited, causing a loud explosion and a bright flash of light. Dotson was struck by debris and was thrown approximately 6 feet, landing in the loader bucket. Dotson sustained massive head trauma, injuries to his left hand and injuries to his right arm. Layne, standing approximately two feet from the drum, was forced to the ground by the explosion. The explosion damaged the torch assembly, with all parts but the control valves and torch body being disconnected from the oxygen/acetylene hoses. Flames continued to be emitted from the end of the torch body; this along with the heat of the explosion burned Layne's face and eyes as he was struck in the neck by a portion of the torch. Estep's eyes were hit by debris, temporarily impeding his vision and McClanahan was thrown to the ground.

After the explosion, McClanahan used Layne's service truck radio to call for an Emergency Medical Technician (EMT) and other assistance. Layne regained the vision in his right eye and attempted to extinguish the torch, eventually succeeding in the effort. McClanahan attempted to use his caplight to assist Estep in examining Dotson's injuries. Realizing the cap light was insufficient, McClanahan drove Layne's service truck around the bucket and used the vehicle's headlights to provide better lighting for examining Dotson.

Mullins and Bruce Mounts, Haul Truck Operator/EMT, heard the call for assistance. Mullins acknowledged by radio that he wanted Mounts to respond to the accident scene. Mullins then immediately drove to the accident scene. Estep was examining Dotson when Mullins arrived at the accident site. Estep told Mullins to get an oxygen bottle (for first-aid purposes). Mullins left the accident scene traveling towards Mounts. Mullins instructed Mounts to park the haul truck. Mullins picked up Mounts in his company truck to transport him more swiftly. Mullins transported Mounts to the maintenance shop to retrieve the first aid kit and a bottle of medical grade oxygen. Both then traveled to the accident scene.

Shawn Cline, Haul Truck Operator/EMT, also heard the call for assistance and was the first EMT to arrive on the scene. Mounts and Cline performed First Aid and Cardiopulmonary Resuscitation (CPR) on Dotson. Mullins called for an ambulance and drove to the intersection of the mine road and Lower Elk Creek to escort the ambulance service. During this time Mullins instructed Roger Potter, Equipment Operator, to contact MedFlight. Both MedFlight and Knox Creek Fire and Rescue responded to the call. Medical personnel found no signs of life. Knox Creek Fire and Rescue, Inc. transported Dotson to Buchanan General Hospital, located in Grundy, Virginia. Dotson was pronounced dead by Dr. Joseph Segen, Buchanan County Coroner. Layne, Estep and McClanahan were also transported to Buchanan General Hospital. Layne was treated for second-degree burns to his face, arms and upper body, corneal damage and

hearing impairment. Estep and McClanahan were each treated for hearing impairment. All three miners were released following their treatments.

## **INVESTIGATION OF ACCIDENT**

Samuel Casey, Mine Superintendent, notified Frank Linkous, Chief, Virginia Department of Mines, Minerals and Energy (VDMME), of the fatality at approximately 11:00 p.m. on September 5, 2003. Linkous notified James A. Kiser, MSHA-Staff Assistant/Accident Investigation Coordinator at approximately 11:30 p.m. Kiser notified Edward R. Morgan, District Manager and Norman Page, Assistant District Manager. Meanwhile, Jesse Persiani, Work Group Supervisor, was notified of the accident by mine management. Kiser then dispatched Persiani and Harold Musick, Roof Control Specialist, to the mine. An Order was issued pursuant to section 103(k) of the Mine Act to ensure the health and safety of persons in the affected area until the investigation could be completed. Preliminary information was gathered and the accident scene was secured. Officials with Twin Star Mining, Inc.; Virginia Department of Mines, Minerals and Energy and MSHA made arrangements for a joint investigation at the mine. William Crocco, Chief of Accident Investigations at MSHA's Arlington headquarters, was contacted during this time by Kiser with a request for assistance from Technical Support.

The accident investigation team members arrived at the mine at approximately 10:00 a.m. on September 8, 2003. The team consisted of David N. Woodward, Mining Engineer; Russell A. Dresch, Electrical Engineer; Derrick Tjernlund, Fire Protection Engineer; Wade Gardner, Coal Mine Inspector (Surface); Norman G. Page, Assistant District Manager; James W. Poynter, Conference and Litigation Representative and James R. Baker, Educational Field Services Specialist. The accident scene was inspected, photographed, videotaped and measured. A spot inspection was conducted concurrently with the investigation to address any enforcement issues for violations not contributing to the fatality.

MSHA and the VDMME jointly conducted interviews the afternoon of September 8, 2003 at the company's onsite offices. Six people were interviewed: two supervisory employees, three hourly employees and one independent contractor. The 103(k) Order was modified to prohibit any cutting of containers using oxygen/acetylene torches until an appropriate action plan had been approved and implemented. The purpose of the action plan was to prevent similar occurrences.

MSHA received custody of the following items, which were examined and tested at the MSHA Approval and Certification Center (A&CC), located in Triadelphia, West Virginia: the 55-gallon antifreeze drum involved in the accident, liquid from bottom of the drum, white residue from inside drum, the oxygen/acetylene torch assembly, the can of starter fluid, and Dotson's cellular phone.

Due to discrepancies between statements made during initial interviews and physical evidence, several follow-up interviews were conducted. On September 17, 2003, four miners were re-interviewed at the MSHA Grundy Field Office. The witnesses were placed under oath by state authorities during these interviews. Bruce Mounts was interviewed on September 23, 2003, at the mine site. Interviews were concluded on October 14, 2003, at the mine site.



## DISCUSSION

### Human Factors

Practical jokes and horseplay occurred on several occasions prior to the accident. Dotson ordered food from Bertha's Diner at 7:40 p.m. Per McClanahan's earlier request he inquired about the total amount on McClanahan's tab. Dotson contacted Mounts and told him to tell McClanahan he owed 200 dollars to Bertha's Diner and that he could not order anymore food until the tab was paid. Mounts followed through with the joke via the radio. Dotson listened to the joke on the CB radio and then cut in on the radio laughing about the joke. Mounts stated the last time he heard Dotson was following the joke. Mounts stated that no more than ten minutes could have elapsed from the time Dotson spoke to him on the CB radio until he heard the call by McClanahan for help. However, McClanahan stated that this conversation occurred while he was driving his grease truck to the water truck to perform maintenance, at which time Dotson was already at the water truck. This sequence would require at least 30 minutes between the two calls. The 30 minute approximation is based upon the following observations. The last time Mounts heard Dotson was upon Dotson's arrival at the water truck with McClanahan. The truck was greased and fueled taking approximately 10 minutes. Following this a discussion ensued concerning maintenance of the Caterpillar 785 haul truck, the transport of the truck into the shop and preparation of truck (raising bed, safety cord, etc.). This sequence takes approximately 10 minutes minimum. Next the drum was removed from the shop, loaded on Layne's service truck and transported to the loader bucket. Layne spent approximately five minutes behind the bucket and one minute at the drum. Including the time necessary for McClanahan to recover from the explosion and make the call for help this easily provides another 10 minute increment. The total of the previous times being at least 30 minutes.

During testimony, it was established that Dotson had ignited acetylene in plastic bags several times prior to the accident. McClanahan witnessed the explosion of a clear plastic bag, ignited by Dotson, on September 5, 2003. Estep had previously witnessed the explosion of bags "three or four times". Layne had previously witnessed the explosion of "maybe two" bags. Statements were made that Dotson enjoyed playing practical jokes and that "He was all the time cutting up." Statements to this effect were made by Mullins, Estep, McClanahan, and Layne.

Testimony, of both non-management and management personnel, established that management persons were not present during the previously mentioned explosions. Mullins indicated that he was aware of previous horseplay in the form of "goosing" or putting a snake on an individual and that he had seen Dotson spray old filters with starter fluid and burn them. However, Mullins stated that he had not seen Dotson place flammable materials into a container and ignite explosive mixtures, nor had he seen any horseplay that he would deem serious enough for disciplinary action. McClanahan stated that he left Dotson and walked back to Estep's service truck because he was afraid of getting in trouble.

Persons located in the loader bucket would not be visible except to others located between them and the berm, which was approximately 30 feet to the south of the bucket. The rebuilt Caterpillar, Model 992 G, front-end loader bucket measured 14½ feet long, 6¼ feet high, and 6 feet deep and was not connected to any equipment. The back side (connecting side) of the bucket faced north, toward the maintenance shop. The position of the loader bucket and Mullins

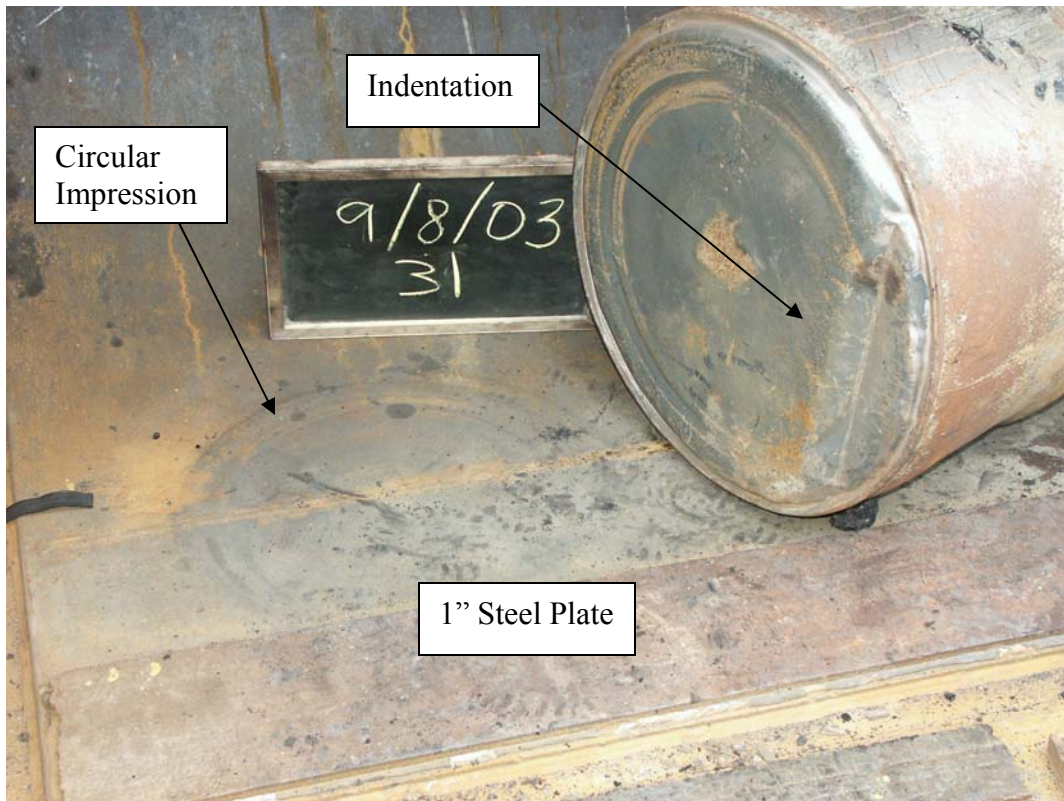
route of travel are consistent with Mullins statement that he did not see Layne or Dotson at the loader bucket.

During interviews, no one would admit to transporting the drum to the accident site. Estep stated that Layne and Dotson exited the shop with the 55-gallon drum. McClanahan stated that he and Dotson walked from the shop to the loader bucket together, that Layne drove the service truck to the loader bucket, and that Dotson was not carrying the 55-gallon drum. When questioned how he traveled from the shop area to the loader bucket, Layne stated “My truck, I was in my truck. I was already out there. We was going to check them bearings.” A ring-shaped impression existed in the dust on the over-sized rear bumper of Layne’s service truck. The size of the ring was identical to the size of the bottom of a 55-gallon drum, indicating that the drum was likely transported to the accident site on the back of the truck bumper. Based upon these observations it is most probable that Layne transported the drum on the oversized rear bumper of his service truck.

The sequence of events immediately prior to the accident was established from several witness statements. Estep stated that he pulled the Caterpillar, Model 785, haul truck into the shop and heard the first explosion. Then he traveled back to his service truck (located approximately halfway between the shop and loader bucket) and brought it to the shop. Following this, he conversed with McClanahan, they both traveled to the loader bucket, and the explosion occurred seconds after their arrival. McClanahan stated that he began his conversation with Estep at Estep’s truck, which was located approximately halfway between the shop and loader bucket. They walked from the truck to the loader bucket and the explosion occurred seconds after their arrival. Mullins stated that he saw Estep and McClanahan at Estep’s truck while it was parked approximately halfway between the shop and loader bucket and that the rockguard was hanging from the truck’s boom at that time. Mullins made these observations while moving a loader spread (set of equipment) through the shop/bucket area. Approximately 6-10 minutes elapsed from the time Mullins passed them until he heard the call for help on the radio. These statements, from three separate witnesses, appear to agree with one another in content and in the timeline.

### **Origin, Flame, and Forces**

The direction of explosive forces extended outward in all directions from the 55-gallon drum, which indicated that the explosion originated inside the drum. Its lid separated from the drum and impacted the top, inner surface of the loader bucket. This was evidenced by a scuff mark on the painted inner surface of the bucket that corresponded to the location of the drum in the bucket. The lid was not found during the investigation and may have traveled down over a steep hillside behind the embankment after ricocheting off the angled inner surface of the bucket. The bottom of the drum was indented, but did not separate from the drum. The indentation in the bottom of the drum conformed to a one-inch thick, flat steel reinforcing plate in the bottom of the bucket (as shown in Figure 2). A circular impression of the drum was also visible on the lower, inner surface of the bucket. During the investigation, these factors were used to position the drum at its location at the time of the accident (as shown in Figure 1) in the northeast corner of the loader bucket.



**Figure 2** – Photograph showing the bottom of drum, the steel plate on the bucket, and the circular impression of the drum on the lower inner surface of the bucket.

Forces of the explosion rebounded off the loader bucket and carried the drum in a southward direction for a distance of 30 feet, depositing it on top of a berm (embankment which aids in preventing vehicles from running off the road, strip bench, etc.). The final location of the drum was evidenced by an impression in the berm and by paint deposited at the location matching the color scheme of the drum. Prior to MSHA’s investigation the drum was retrieved from the coal berm and set in front of the loader bucket, by mine employees. The employees were instructed to do so by the State Trooper investigating the accident.

Layne stated that Dotson was holding the torch with the tip in the hole of the 55-gallon drum at the time of the accident. Dotson’s left middle finger was severed and his right upper arm was fractured during the accident. Layne received burns to the left side of his face but received no injuries to the hands or arms. These injuries are consistent with Layne’s testimony regarding his and Dotson’s activities and locations at the time of the accident.

During the explosion, the oxygen/acetylene combination-cutting torch assembly, manufactured by Victor Equipment Company, Denton, Texas, was broken into at least three pieces: the torch base (lower portion), the cutting attachment (upper portion), and the tip. The base was still connected to the acetylene and oxygen supply hoses, which in turn, were connected to the regulator assemblies on the gas cylinders mounted on the maintenance truck. After the accident, Mullins found the cutting attachment approximately seven feet from the southeast corner of the bucket. The cutting attachment, which was moved prior to the accident investigation team

arriving at the site, consisted of the oxygen cutting lever, oxygen preheat valve, torch head, tip and tip nut (a typical cutting attachment is illustrated in Appendix C). Neither the torch tip nor the tip nut was found during the investigation. Mullins stated that neither the torch tip nor the tip nut were on the torch after the accident.

A nondestructive physical and microscopic examination of the torch cutting attachment was conducted on September 16, 2003, at MSHA's Technical Support facility in Triadelphia, West Virginia. The cutting attachment was stamped as "Listed UL Cutting Attachment 8F39". Looking down at the top of it, the upper portion was twisted approximately 90 degrees counter clockwise from its normal position, indicative of a lateral, off-center impact near the tip. Threads on the tip were stripped, but no impact marks were present. This indicated that these threads were protected from impact by the tip, and that the tip was attached to the cutting attachment at the time of the accident. The impact was likely caused by either the torch being struck by the drum lid or the torch being forced into the front surface of the bucket. Damage to the threads connecting the cutting attachment to the base also consisted of rounded thread tops, indicating that a prying action stripped the attachment from the base. The lateral force that twisted the attachment could have also provided this prying action.

The maximum theoretical explosion pressure from an acetylene-air mixture is 129 pounds per square inch (PSI); and 232 PSI for an acetylene/oxygen mixture. The rate of pressure rise for acetylene can be as much as 25 times faster than methane. For a vessel the size of the drum, pressure rates-of-rise could theoretically exceed 30,000 PSI per second due to the very rapid combustion kinetics of acetylene. Such forces are capable of causing damage consistent with that observed at the accident site.

## **Potential Fuel Sources**

**Acetylene** - Acetylene gas ( $C_2H_2$ ), is inherently unstable and may explode when subjected to heat or a mechanical shock. An explosion hazard exists if acetylene is released in a confined space. Acetylene-air mixtures have a wide flammability range, ignitable at concentrations between 2.5% and 81%. Above 81% concentration, even though true combustion does not take place for acetylene, it can undergo an explosive decomposition reaction. The flash point for acetylene is 32 degrees Fahrenheit ( $^{\circ}F$ ) and the auto ignition temperature is 581 $^{\circ}F$ . The minimum ignition energy for acetylene ranges from approximately 17 micro joules ( $\mu J$ ) in air, down to 0.2 $\mu J$  in pure oxygen. This is an extremely low ignition energy compared to more common gases such as methane with an ignition range from approximately 300  $\mu J$  down to 3  $\mu J$ .

A diagram of a generic oxygen/acetylene cutting torch can be seen in Appendix D. The two gases involved are stored in separate cylinders. Each gas is regulated to a predetermined pressure using regulators. This pressure should be based upon the desired function of the torch and the thickness of the metal being "cut". The torch is also equipped with an oxygen cutting lever. This lever is pressed to activate the release of oxygen. This introduction of higher pressure oxygen allows for the "cutting" process.

During the investigation, the supply valves on the regulators for both the acetylene and oxygen were found in the open position. The oxygen cylinder pressure gauge indicated 1700 pounds per

square inch (PSI), while the regulator pressure gauge indicated 139 PSI. The Acetylene cylinder pressure gauge indicated 200 PSI, while the regulator pressure gauge indicated 11 PSI. Therefore, both oxygen and acetylene could have been delivered to the drum through the torch assembly at the time of the accident. This is consistent with witness statements that Dotson was intentionally releasing acetylene gas into the drum, which provided the primary fuel source for the explosion.

**Antifreeze** - Debris was present in the bottom of the drum that included dirt, leaves, and a small amount of antifreeze. Small white clumps of material were also present on the inner wall surface that appeared to be melted remnants of a thin inner liner. Gas chromatography-mass spectrometry (GC-MS) was used to test samples of liquid residue from the accident drum and from a control sample of antifreeze from a new drum, similar to that involved in the accident and located at the mine site. A 50% antifreeze/50% distilled water mixture, distributed by Poskas Oil and Supply Company of North Tazewell, Virginia, was delivered to the mine in the 55-gallon metal drums. The material safety data sheet (MSDS) for this product indicated that the antifreeze chemical was ethylene glycol. GC-MS testing results matched both the contents of the accident drum and the control sample with a laboratory standard for ethylene glycol. The accident drum sample, although visually “dirty” was clean chemically, and matched the control sample very closely.

The MSDS listed pure Ethylene glycol [C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>] (CAS 107-21-1) as having a closed-cup flash point of 260°F. Its flashpoint was higher when mixed with water. The auto-ignition temperature of ethylene glycol, as listed in the Ignition Handbook Database, would have been 752°F in air, and 775°F in oxygen. Prior to the accident, the drum was stored indoors at room temperature. It was not taken outside until after sunset. Under these conditions, the antifreeze residue in the drum would not have been subjected to sufficient heat to generate flammable vapors. Mine personnel testified that numerous drums of this type are cut on a regular basis with no resulting combustion or explosion. Similar answers were obtained from questioning others throughout the mining industry. Therefore, the original contents of the drum were not likely to have provided fuel for the explosion.

**Starting Fluid** - Cline removed an aerosol can of starting fluid from Dotson’s right front pants pocket while providing first aid. Testimony indicated that Dotson had ignited acetylene in plastic bags on numerous occasions. Just before the accident, he used the can of starting fluid to make a “wick” along the ground to ignite a bag of acetylene from a distance. Witnesses also indicated that Dotson used starting fluid to clean his hands, gauges, and tools.

The aerosol can of starting fluid carried the trade label “PYROIL” and was manufactured by The Valvoline Co., a division of Ashland, Inc. of Lexington, Kentucky. It was listed as Part No. SFR-11. The front of the can carried the signal words “DANGER Extremely Flammable”. The labeled contents of the can included: Heptane (CAS 142-82-5), Diethyl ether (CAS 60-29-7), Hexane (CAS 110-54-3), and Carbon dioxide (CAS 124-38-9). The MSDS for the starting fluid states the content is highly volatile and readily gives off vapors which may travel along the ground or be moved by ventilation; can be ignited by flames, sparks, heaters, smoking, electric motor or static discharge; and can ignite explosively.

GC-MS testing results matched the contents of the aerosol can with that listed on the can label for ether and heptane. There were also some closely related hydrocarbons, including cyclohexane and toluene. These other products may have masked detection of the hexane in the GC-MS. A spiked sample of the accident drum contents was prepared and tested by mixing 10 micro-liters of aerosol contents in 1 milliliter of drum sample (1:100 by volume). Concentrations as low as 1:400 should be detectable in the GC-MS apparatus, based upon this test sample result. However, none of the aerosol contents were detected in the drum sample. It is therefore unlikely that Dotson discharged the aerosol can of starter fluid into the drum prior to the accident.

## **Potential Ignition Sources**

All potential ignition sources were identified and evaluated during the investigation. Potential sources included: smoking materials, cell phones, a striker, chemical reaction of substances with pure oxygen, and static electricity. Of these, the most likely source of ignition energy was the build up of a static electrical charge on the torch caused by the discharging acetylene.

**Static Electricity** - The minimum ignition energies (MIE) for an electric spark to ignite acetylene are 20  $\mu\text{J}$  in air and 0.2  $\mu\text{J}$  in pure oxygen. This makes a gas cloud of acetylene very susceptible to ignition by static electricity. Acetylene is stored by dissolution in liquid acetone within the storage cylinder. As the gas is used, it entrains microscopic droplets of acetone in the gas and transports them to the torch tip. Static charge can build up on the tip due to electron stripping as the droplets exit the tip orifices. The human body can also accumulate a static charge that is 70 times greater than the energy needed to ignite methane. The energy needed to ignite methane is 15 times greater than the energy needed to ignite acetylene. If a torch operator is sufficiently insulated and the tip subsequently contacts a grounded object (in this case the drum was effectively grounded by sitting in the loader bucket), an electrostatic spark could occur with sufficient energy to ignite the acetylene. All conditions necessary for generating an electrostatic spark at the point of origin were present at the time of the accident, making this the most likely ignition source for the explosion.

**Reaction of Acetylene with Pure Oxygen** - Due to the low ignition energies required to ignite acetylene, oxygen/acetylene torches can also be ignited by first turning on the acetylene, and then the oxygen. When the oxygen is adjusted to the proper proportion, the torch will ignite. Such ignitions would be expected to occur at acetylene-oxygen mixtures most favorable for complete combustion. The more complete the combustion of acetylene, the lower the production of soot. Therefore, when high concentrations of acetylene are ignited, black smoke and soot are produced. The inner surfaces of the drum show little to no evidence of blackening from soot. This indicates that a favorable acetylene-oxygen mixture for this type of ignition to occur was present in the drum at the time of the accident. Therefore, ignition of acetylene in this manner could not be ruled out.

**Reaction of Iron and Debris with Pure Oxygen** - When pure pressurized oxygen is directed onto a particle of rust, that particle will incandesce, producing molten material. For a short duration, such particles will reach temperatures capable of igniting acetylene. Also, pressurized oxygen applied to petroleum products (grease, oils, etc.) will combust. Since rust was present on the

inner surface of the drum, rapid oxidization of debris resulting from exposure to pure oxygen could not be ruled out as an ignition source.

**Open Flames** - The U.S. Naval Observatory Astronomical Applications Department lists the sunset time for Grundy, Virginia on September 5, 2003 as 7:52 p.m. and the end of civil twilight as 8:18 p.m. The approximate time of the accident was 8:45 p.m. Layne stated that he was standing next to the drum at the time of the accident and that he did not see flame from the torch. He also indicated that Dotson was not smoking nor was he using a lighter or striker. McClanahan and Estep also stated that, as they approached the bucket, neither saw the torch lit and Estep saw “just the flash of the explosion.” It was therefore unlikely that these potential sources ignited the explosion.

**Cellular Phone** - Dotson was wearing a Motorola Timeport 270c cellular phone at the time of the accident. Mounts stated that a cellular phone was located near Dotson’s left hand when he arrived on the accident scene. The tip of the cellular phone antenna was melted. The manual for this model cellular phone contained the following warning:

**Potentially Explosive Atmospheres**

Turn off your phone prior to entering any area with a potentially explosive atmosphere, unless the phone is a model specifically identified as being “Intrinsically Safe” for use in such areas (for example, Factory Mutual, CSA, or UL Approved). Do not remove, install, or charge batteries in such areas. Sparks in a potentially explosive atmosphere can cause an explosion or fire resulting in bodily injury or even death.

**Note:** The areas with potentially explosive atmospheres referred to above include fueling areas such as below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust, or metal powders, and any other area where you would normally be advised to turn off your vehicle engine. Areas with potentially explosive atmospheres are often but not always posted.

The call history, as displayed by this phone, shows that a call was made to Bertha’s Diner at 7:40 p.m. on the evening of the accident. The call was received by Mrs. Debbie Blankenship. Neither Blankenship nor other persons at the restaurant made a return call to Dotson. The cellular phone shows no incoming calls for September 5, 2003. The cellular phone was tested by A&CC and showed no results of internal ignition and little if any potential to ignite an explosive acetylene mixture. The evidence and testing show it is unlikely that the phone provided the ignition source.

**Mine Safety Program**

Mine safety program documents were reviewed during the investigation. Material Safety Data Sheets (MSDS) for acetylene, Texaco (Shellzone) antifreeze and Pyroil starting fluid were maintained at the mine. Also, the portion of the mine training plan addressing visitors to mine property makes a reference to the prohibition of horseplay. However, no plan provisions existed addressing the mine employees concerning the prohibition of horseplay. Furthermore, no documentation of policy or requirements prohibiting horseplay was found during the investigation. The operator of this mine had not posted a program with respect to the safety regulations and procedures to be followed at the mine. Also, such a program had not been

distributed to each employee. The lack of safety documentation and/or programs creates a safety deficiency per 30 CFR 77.1708.

## **ROOT CAUSE ANALYSIS**

Causal Factor: A safety program, adequate to deter horseplay and misuse of equipment, was not in place.

Corrective Actions: An adequate safety program, which will satisfy the requirements given in 30 CFR 77.1708, will be implemented, posted at the mine site and distributed to each individual mine employee. The program will include adequate stipulations to prohibit horseplay and misuse of equipment. All employees will be trained in the provisions of the new program. The training plan will be revised to assure these provisions are taught during annual refresher, new miner and newly employed experienced miner training.

Causal Factor: The victim introducing acetylene/oxygen into the 55-gallon drum apparently without fear of reprisal on the company's part.

Corrective Actions: The aforementioned safety program should be enforced in a manner that conveys the company's stance concerning the prohibition of horseplay and misuse of equipment.

## **CONCLUSION**

The accident occurred due to the explosion of an acetylene-oxygen-air mixture inside the 55-gallon drum. Forces and heat from the explosion injured four miners, one of whom died from his injuries. Ignition energy was most likely an electrostatic charge that built up on the torch tip from the rapid release of acetylene through the tip orifices. At the time of the accident, the fatally injured miner was using the unlit torch to intentionally fill an empty antifreeze drum with acetylene, and possibly oxygen, to demonstrate an explosion to a new employee. During this process, the torch tip neared the surface of the drum, which was grounded by contact with the front-end loader bucket, permitting an electrostatic arc that prematurely ignited the gas mixture inside the drum. Contributing to the accident was mine management's failure to establish, maintain, and enforce an effective safety program addressing horseplay and other hazards associated with mining activities, such as those related to the use of acetylene.

## **ENFORCEMENT ACTIONS**

A Section 103(k) Order was issued that stated "This mine has experienced a fatal explosive accident on the active surface area; this order is issued to assure the safety of any person in the area until an examination or investigation is made to determine that the area is safe. Only those persons selected from company officials, state officials, miner representatives, and other persons who are deemed by MSHA to have information related to the investigation may enter or remain in the effected area.



A Section 104(a) Citation was issued for a violation of 30 CFR 77.1708, which stated “The operator of this mine had not posted a program with respect to the safety regulations and procedures to be followed at the mine. Also, such a program had not been distributed to each employee. On September 5, 2003, horseplay in the form of misuse of cutting torches, acetylene gas, and compressed oxygen resulted in an explosion at this mine that injured four miners, one of whom died from his injuries. Prior to the fatal accident, smaller acetylene/oxygen explosions and misuse of starting fluid was prevalent at the mine. Safety procedures were not communicated effectively enough to indelibly establish management’s prohibition of horseplay. Adherence to this regulation would have reduced the likelihood of this type of occurrence.”

Approved:

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Edward R. Morgan  
District Manager

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Date

**APPENDIX A**  
**Persons Present During the Investigation**

**TWIN STAR MINING, INC. – MANAGEMENT**

Kenneth Nicewonder ..... Operator  
Samuel Casey ..... Superintendent  
Gerald Mullins ..... Second Shift Foreman

**TWIN STAR MINING, INC.**

Timothy W. Gresham, Esq. .... Attorney  
Charles Justice ..... Safety Consultant

**TWIN STAR MINING, INC. – LABOR**

Larry McClanahan ..... Greaser-Night Shift  
James Estep ..... Contractor/Mechanic-Night Shift  
Jason Layne ..... Mechanic-Night shift  
Danny Rife ..... Mechanic-Day Shift  
Bruce Mounts ..... Haul Truck Driver/EMT  
Shawn Cline ..... Haul Truck Driver/EMT

**VIRGINIA DEPARTMENT OF MINES, MINERALS AND ENERGY**

Frank Linkous ..... Chief, Department of Mines  
Opie McKinney ..... Mine Inspection Supervisor  
Carroll Greene ..... Mine Inspection Supervisor  
Terry Ratliff ..... Coal Mine Inspector  
Joseph Altizer ..... Coal Mine Inspector  
Danny Altizer ..... Coal Mine Inspector  
Bill Messick ..... Coal Mine Inspector

**MSHA DISTRICT 5**

Edward R. Morgan ..... District Manager  
Norman G. Page ..... Assistant District Manager – Inspection Division  
Jesse Persiani ..... Inspection Supervisor  
James W. Poynter ..... Conference and Litigation Representative  
James R. Baker ..... Educational Field Services Specialist  
Russell A. Dresch ..... Electrical Engineer  
Harold Musick ..... Coal Mine Inspector  
Wade Gardner ..... Coal Mine Inspector  
David N. Woodward ..... Mining Engineer

**MSHA APPROVAL AND CERTIFICATION CENTER**

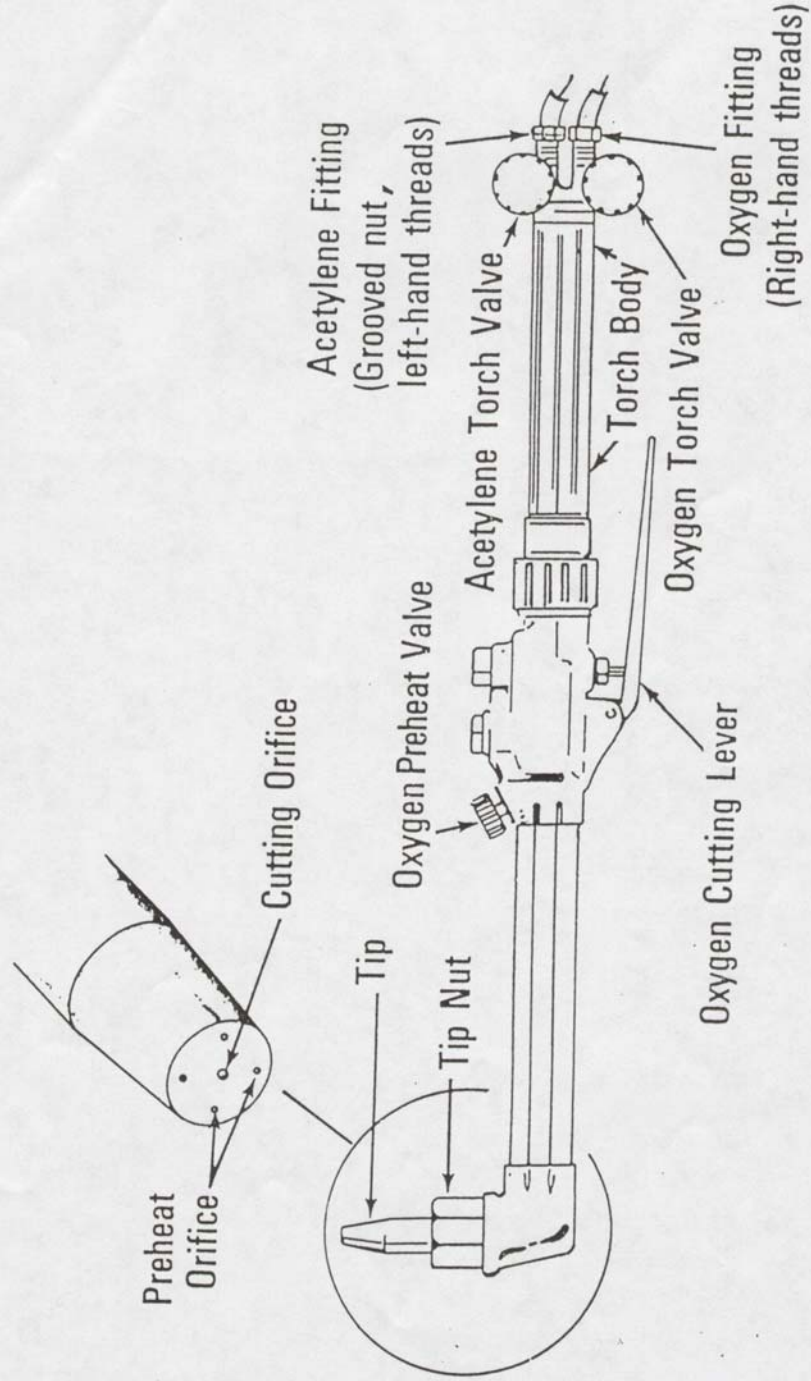
Derrick M. Tjernlund ..... Fire Protection Engineer

**APPENDIX B**  
**Persons Interviewed**

Samuel Casey..... Mine Superintendent  
Gerald Mullins ..... Second Shift Foreman  
Larry McClanahan ..... Greaser-Night Shift  
James Estep..... Contractor/Mechanic-Night Shift  
Jason Layne..... Mechanic-Night shift  
Danny Rife ..... Mechanic-Day Shift  
Bruce Mounts..... Haul Truck Driver/EMT

APPENDIX C  
Typical Torch Body and Cutting Attachment

Parts of a Torch Body  
and Cutting Attachment

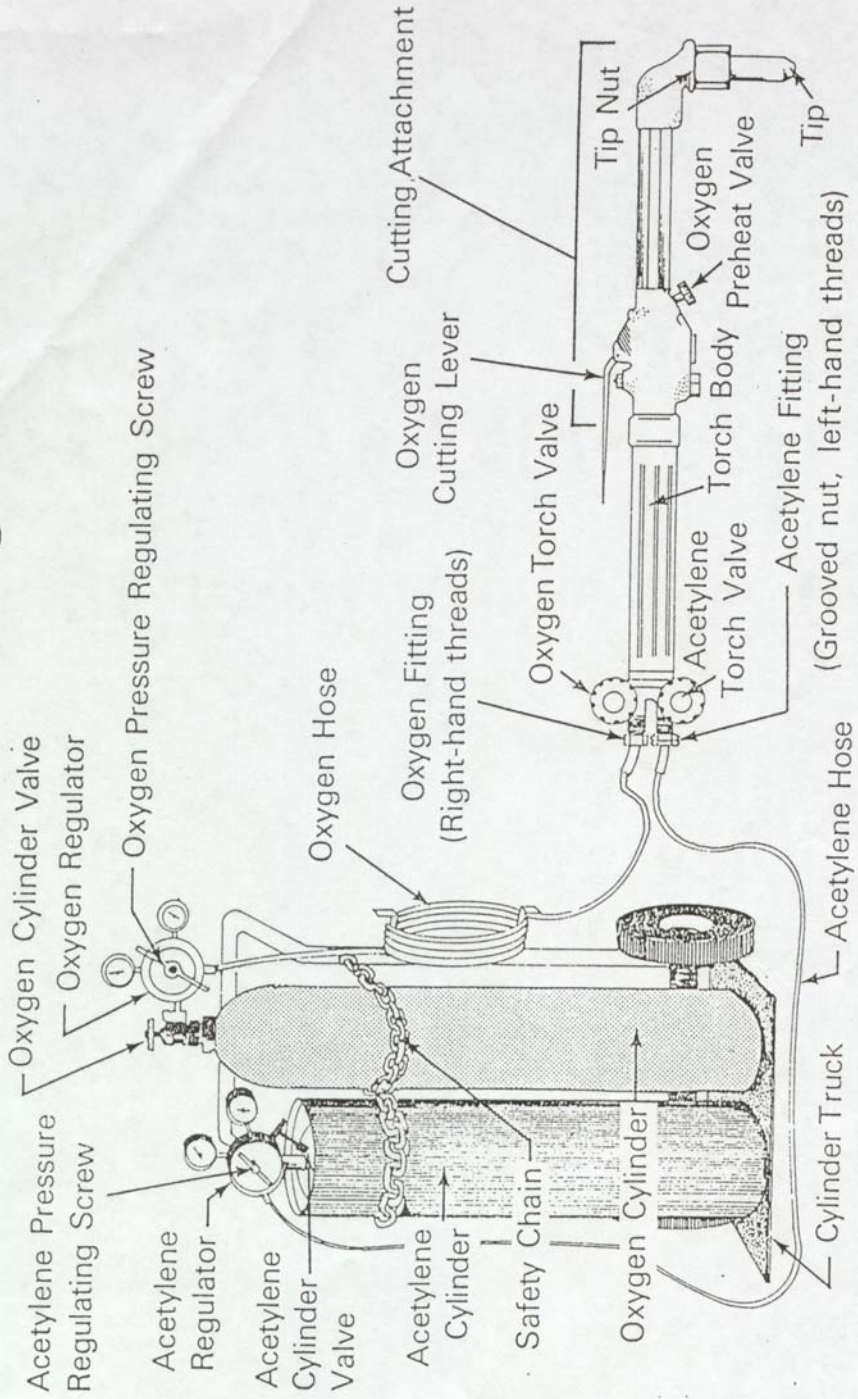


AM I - 233-A

TM 2

**APPENDIX D**  
**Typical Oxyacetylene Cutting Outfit**

# Oxyacetylene Cutting Outfit



TM 1

APPENDIX E

