National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: MAR 0 5 2009

In reply refer to: H-09-1 and -2

Ms. Cynthia Douglass
Acting Deputy Administrator
Pipeline and Hazardous Materials Safety
Administration
1200 New Jersey Avenue, S.E.
East Building, 2nd Floor, PH
Washington, D.C. 20590

The National Transportation Safety Board investigated three accidents that involved highway vehicles transporting bulk quantities of acetylene gas that occurred between July 25 and October 20, 2007, and reviewed reports of a 2008 overturn accident of another vehicle. The vehicles, called mobile acetylene trailers, carried up to 225 cylinders that were connected by a manifold system[1] and filled with acetylene. Two of the accidents occurred as the vehicles overturned on public highways, in East New Orleans, Louisiana, on October 20, 2007, and in Lamar, Colorado, on June 9, 2008. Two of the accidents occurred while the vehicles were being prepared for unloading, in Dallas, Texas, on July 25, 2007, and in The Woodlands, Texas, on August 7, 2007. In the two overturn accidents, cylinders were ejected from the trailers and damaged, releasing acetylene, which ignited. In one unloading accident, the fire on the initial trailer spread to cylinders on an adjacent trailer; in the other, the fire spread to cylinders on adjacent trailers and to nearby buildings and vehicles. The failures of the cylinders on these mobile acetylene trailers and the resultant damage raised concerns about the accident protection provided by these vehicles, the adequacy of the minimum safety standards and procedures applicable to unloading these vehicles, and the adequacy of fire suppression systems at loading and unloading facilities. To address these concerns, the Safety Board conducted a special investigation of mobile acetylene trailers.[2]

In the East New Orleans, Louisiana, accident in which the tractor and mobile acetylene trailer overturned, the cylinders mounted on the trailer were thrown from the vehicle. The postaccident examination of the cylinders recovered from the scene revealed that 32 of the cylinders recovered had their valves broken off during the accident, releasing acetylene that

---

[1] A *manifold system* collects the acetylene gas from multiple cylinders into one pipe or chamber; when the cylinders are filled, the acetylene gas is dispersed from one pipe to multiple cylinders.

[2] For additional information, see National Transportation Safety Board, *Mobile Acetylene Trailer Accidents: Fire During Unloading in Dallas, Texas, July 25, 2007; Fire During Unloading in The Woodlands, Texas, August 7, 2007; and Overturn and Fire in East New Orleans, Louisiana, October 20, 2007*, Hazardous Materials Special Investigation Report NTSB/SIR-09/01 (Washington, DC: NTSB, 2009), which is available on the Safety Board's website at <http://www.ntsb.gov/publictn/2009/SIR0901.pdf>.

ignited. Similarly, in the Lamar, Colorado, accident, about half of the 225 cylinders were thrown from the trailer. The postaccident examination of the cylinders recovered from the scene revealed that 86 of the cylinders had their valves broken off during the accident, resulting in the release and ignition of the residual acetylene. An examination of these cylinders showed that the fire from the cylinders with broken valves caused the fusible plugs of other cylinders to melt, releasing additional acetylene that ignited. Possible ignition sources include the generation of a static charge in the rapidly escaping acetylene and solvent and a spark caused by the steel cylinders striking concrete, rocks or stones, or the road surface.

The Safety Board concludes that the fires in the East New Orleans, Louisiana, and Lamar, Colorado, accidents occurred as a result of the ejection of unsecured cylinders during the rollovers of the mobile acetylene trailers, resulting in damage to many of the cylinder valves and the release of acetylene, which then ignited.

These two accidents demonstrate the high likelihood of an acetylene release and fire when cylinder valves are damaged in rollover accidents. With the extreme flammability of acetylene, undamaged cylinders in proximity to burning cylinders are likely to become involved in a fire. In overturn accidents in which a mobile acetylene trailer rolls onto its side, unprotected or unrestrained cylinders may be ejected from the trailer, as occurred in these two accidents. Ejection of cylinders from a trailer in an accident significantly increases the likelihood of damage to the cylinder valves. In the event that cylinders remain secured to the trailer in an overturn, their valves can be damaged by guard rails and other roadside objects and even contact with the road surface. With the extreme flammability and reactivity of acetylene, undamaged cylinders close to burning acetylene cylinders are also very likely to become involved in a fire.

The cylinders in these two accidents were not adequately secured to the trailers to prevent their ejection during overturn. Current U.S. Department of Transportation regulations for manifolded cylinder systems on trailers, such as mobile acetylene trailers, require only that each cylinder be equipped with an individual shutoff valve that is tightly closed in transit and that the valves and pressure relief devices be protected from damage by framing, a cabinet, or other method. Current Federal regulations do not set sufficient standards for the level of protection that must be provided. To reduce the risks of transporting acetylene, cylinders must remain secured to the trailer during a rollover accident, and the cylinder valves must be protected from impact and damage.

Therefore, the Safety Board concludes that the requirements in the Hazardous Materials Regulations covering mobile acetylene trailers do not sufficiently address (1) the protection of the cylinders, valves, and fittings on the trailers from impact forces that occur during an overturn accident and (2) the secure mounting of the cylinders to the vehicles. The Safety Board believes that the Pipeline and Hazardous Materials Safety Administration (PHMSA) should modify 49 *Code of Federal Regulations* 173.301 to clearly require (1) that cylinders be securely mounted on mobile acetylene trailers and other trailers with manifolded cylinders to reduce the likelihood of cylinders being ejected during an accident and (2) that the cylinder valves, piping, and fittings be protected from multidirectional impact forces that are likely to occur during highway accidents, including rollovers.

The two unloading accidents occurred when the mobile acetylene trailers were connected to piping at loading/unloading plants while the operators were preparing the trailers to be unloaded.

The accident in The Woodlands, Texas, was described in detail by witnesses and recorded by a security camera at the plant. According to the statements of the operators and the video recording, the team had completed connecting their trailer to the plant's discharge arm and had pressurized the trailer manifold by opening all of the cylinders on the trailer. At that point, the team realized that they had not opened the trailer's block valve. They then opened the valve. According to the team's initial statement to emergency responders, when they opened the block valve they heard a loud noise and felt the trailer shake. Opening the block valve allows highly pressurized acetylene to enter a blocked section of piping that contains residual air, which is dangerous because (1) a blocked pipe potentially can cause a reflected shockwave that can initiate a decomposition reaction and (2) pressurized acetylene that mixes with air inside piping can ignite easily with little energy input. The black plume rising from the top of a cylinder seen in the security camera video is an indication that an acetylene decomposition reaction had occurred on the trailer. With this evidence of the decomposition reaction, the black powder found in the fitting between the trailer and the plant piping and in the plant discharge arm was determined to be carbon, which is a byproduct of a decomposition reaction. The Safety Board concludes that the ignition of the acetylene in the accident in The Woodlands, Texas, likely occurred because of the operators' failure to follow Western International Gas & Cylinders, Inc.'s (Western's) standard operating procedures, which resulted in the introduction of high-pressure acetylene into closed piping that contained air, which in turn initiated an acetylene decomposition reaction.

The video recording of the Dallas, Texas, accident did not record the initiation of the accident, and the operator and other witnesses made contradictory observations about the initiation of the accident. In addition, representatives of Western expressed concern that a flame front caused by a failure within the plant's compressor system may have passed through the poorly maintained flash arrestor and started the fire on the accident trailer. Several varying scenarios of the initiation of the accident were considered and discounted during the investigation.

The most likely scenario was the initiation of an acetylene decomposition reaction on the accident trailer. This is supported by witness observations of a black plume over the trailer and the operator's postaccident statement that the trailer's pressure gauges indicated that the pressure in the manifold was 0 pounds per square inch, gauge (psig) after the operator had cycled the valve on the plant's discharge arm, leaving it closed. Because Western's standard operating procedures mandate that 50 psig of pressure be maintained in the manifold between the completion of the leak test and the opening of the discharge arm valve, a pressure reading of 0 psig indicates that the unloading procedures had not been performed correctly. The lack of positive pressure in the manifold likely allowed some air to enter the manifold. In addition, had there been 0 psig acetylene pressure in the manifold when the operator connected the trailer to the plant's discharge arm, the procedures used to mix acetylene and the air in the connection fittings at low pressure would have been ineffective and air could have remained in that area. As the operator began opening the cylinder valves and introduced pressurized acetylene into the manifold, the pressure surge likely hit the closed discharge arm valve and was reflected, generating heat that was sufficient to ignite the acetylene-air mixture in the manifold. The air

was quickly consumed, and a decomposition reaction propagated through the manifold and into the trailer's cylinders through their open valves. The heat from the reaction inside the cylinders melted the cylinders' fusible plugs and released black plumes. Finally, when the released products of decomposition (hydrogen gas and carbon) ignited, the fire heated nearby cylinders, causing their fusible plugs to melt, releasing acetylene gas that then ignited, and fire engulfed the accident trailer. The fire then spread by radiant heat to the three adjacent trailers. Had the manifold pressure been maintained at 50 psig, as required by Western's standard operating procedures, air could not have entered the manifold piping to lower the ignition temperature of the acetylene, and the air between the block valve on the trailer and the plant discharge arm valve would have mixed safely with the acetylene entering from the manifold.

Therefore, the Safety Board concludes that the ignition of the acetylene in the Dallas, Texas, accident likely occurred as a result of the operator's failure to follow Western's standard operating procedures, which resulted in the reduction of the pressure in the manifold to 0 psig, allowing air to enter the manifold and initiating a decomposition reaction when pressurized acetylene was subsequently introduced into the manifold.

Because the Dallas and The Woodlands accidents likely were initiated by the failure of operators to correctly perform Western's detailed unloading procedures, the Safety Board evaluated Western's unloading requirements. Each trailer operator carried a detailed standard operating procedures manual for reference and guidance during loading and unloading. However, in both these accidents, the operators did not perform the unloading procedures correctly or in the proper sequence, which resulted in the acetylene decomposition reactions. In The Woodlands, when the operators realized that they had not performed a required step, they performed the skipped step after they realized their omission. In Dallas, the operator did not recognize that the lack of pressure in the trailer manifold, at a step in the process in which some pressure should be maintained in the manifold, indicated that the unloading procedures had not been performed correctly.

Federal regulations and Compressed Gas Association guidance concerning mobile acetylene trailers focus on design and are silent concerning trailer unloading procedures other than the recommendation that a trained person be in attendance during manual valve operations and when a trailer is being connected or disconnected.

The accidents in Dallas and The Woodlands demonstrate the catastrophic results that can occur when the unloading procedures are not followed exactly. Despite the detailed written unloading procedures Western developed and implemented, the procedures were not sufficient to safeguard against the initiation of a decomposition reaction within the manifold piping and cylinders when simple human errors occurred, as they will from time to time. The complexity of the unloading procedures and the extreme instability of acetylene together created situations having little or no room for human error. The Safety Board, therefore, concludes that because of the instability of acetylene, the current acetylene unloading procedures by themselves are not adequate to ensure safety. The Safety Board believes that PHMSA should require fail-safe equipment that ensures that operators of mobile acetylene trailers can perform unloading procedures only correctly and in sequence.

Therefore, the National Transportation Safety Board makes the following recommendations to the Pipeline and Hazardous Materials Safety Administration:

> Modify 49 *Code of Federal Regulations* 173.301 to clearly require (1) that cylinders be securely mounted on mobile acetylene trailers and other trailers with manifolded cylinders to reduce the likelihood of cylinders being ejected during an accident and (2) that the cylinder valves, piping, and fittings be protected from multidirectional impact forces that are likely to occur during highway accidents, including rollovers. (H-09-1)

> Require fail-safe equipment that ensures that operators of mobile acetylene trailers can perform unloading procedures only correctly and in sequence. (H-09-2)

The Safety Board also issued a safety recommendation to the Compressed Gas Association.

In your response to the recommendations in this letter, please refer to Safety Recommendations H-09-1 and -2. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our Tumbleweed secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Acting Chairman ROSENKER and Members HERSMAN, HIGGINS, SUMWALT, and CHEALANDER concurred in these recommendations. Member HIGGINS filed a concurring statement, which is attached to the hazardous materials special investigation report.

By: Mark V. Rosenker
Acting Chairman