NATIONAL TRANSPORTATION SAFETY BOARD

National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: December 12, 2005

In reply to refer to: R-05-14 through -17

Honorable Joseph H. Boardman
Administrator
Federal Railroad Administration
1120 Vermont Avenue, N.W.
Washington, D.C. 20590

About 2:39 a.m., eastern standard time, on January 6, 2005, northbound Norfolk Southern Railway Company (NS) freight train 192, while traveling about 47 mph through Graniteville, South Carolina, encountered an improperly lined switch that diverted the train from the main line onto an industry track where it struck an unoccupied, parked train (NS train P22). The collision derailed both locomotives and 16 of the 42 freight cars of train 192 as well as the locomotive and 1 of the 2 cars of train P22. Among the derailed cars from train 192 were three tank cars containing chlorine, one of which was breached, releasing chlorine gas. The train engineer and eight other persons died as a result of chlorine gas inhalation. About 554 people complaining of respiratory difficulties were taken to local hospitals. Of these, 75 were admitted for treatment. Because of the chlorine release, about 5,400 people within a 1-mile radius of the derailment site were evacuated for several days. Total damages exceeded $6.9 million.[1]

The National Transportation Safety Board determined that the probable cause of the accident was the failure of the crew of train P22 to return a main line switch to the normal position after the crew completed work at an industry track. Contributing to the failure was the absence of any feature or mechanism that would have reminded crewmembers of the switch position and thus would have prompted them to complete this final critical task before departing the work site. Contributing to the severity of the accident was the puncture of the ninth car in the train, a tank car containing chlorine, which resulted in the release of poisonous chlorine gas.

NS train P22 was a local train working daily out of Aiken, South Carolina. The P22 conductor stated that on January 5, 2005, his crew arrived at the Avondale Mills industry track in Graniteville at about 6:10 p.m. Because the brakeman and conductor had been on duty since 7:00 a.m., they had only 50 minutes to complete their work at the industry and safely secure their train before reaching the maximum 12-hour limit imposed by Federal hours-of-service regulations.

[1] For more information, see National Transportation Safety Board, *Collision of Norfolk Southern Freight Train 192 With Standing Norfolk Southern Local Train P22 With Subsequent Hazardous Materials Release at Graniteville, South Carolina, January 6, 2005*, Railroad Accident Report NTSB/RAR-05/04 (Washington, DC: NTSB, 2005).

The brakeman told investigators he was sure "in his mind" that everything was lined properly when he left the Avondale Mills area at about 7:00 p.m. But he also said he was not "100 percent" sure that he had relined the main line switch before departing. Postaccident inspection revealed that the switch was lined and locked for the industry track, as it had been when train P22 began work at the industry track the day before the accident. The switch showed no evidence of tampering, and no other trains used the track in the area from the time the train P22 crew left until the accident the next morning. The Safety Board therefore concluded that the crew of train P22 failed to reline the main line switch after using it, leading to the subsequent and unexpected diversion of train 192 into an industry track where it struck train P22 and derailed.

The Safety Board's report on the Graniteville accident examines in detail how an experienced train crew could fail to execute a simple action—relining a switch—that they had performed many times before and that, in fact, was a routine part of their jobs.

The Safety Board concluded that the crew of train P22 failed to reline the main line switch for one or more of the following reasons: (1) the task of relining the switch was functionally isolated from other tasks the crew was performing, (2) the crewmembers were rushing to complete their work and secure their train before reaching their hours-of-service limits, (3) the crew had achieved their main objective of switching cars and were focused on the next task of securing their equipment and going off duty, and (4) the switch was not visible to the crew as they worked, leaving them without a visual reminder to reline the switch.

After the accident, the Federal Railroad Administration (FRA) issued Safety Advisory 2005-01, which recommended that railroads review their operating rules and take certain steps to ensure that crews using manually operated switches leave those switches in the proper position when their work is complete. The advisory referenced rules already implemented by the Burlington Northern Santa Fe (BNSF) and the Union Pacific (UP) railroads requiring that crews inform dispatchers of switch positions or inform them that switches had been properly relined before reporting clear of main line track. The FRA also urged the use of a switch position reporting form to be filled out by the conductor before reporting clear of main line track.

In October 2005, the FRA issued Emergency Order 24, "Emergency Order Requiring Special Handling, Instruction and Testing of Railroad Operating Rules Pertaining to Hand-Operated Main Track Switches." While the Safety Board recognizes the timeliness with which the FRA has addressed this safety issue, the Board is concerned about the effectiveness of the emergency order in preventing future accidents. The primary concern of the Board is that the emergency order largely requires what the previous safety advisory had recommended, which has been acknowledged by the FRA to be of questionable effectiveness.

The Safety Board notes that only 2 days after the Graniteville accident, a BNSF freight train was unexpectedly diverted into an industrial siding in California where it struck two loaded cars and derailed. This accident occurred less than 3 months after the BNSF implemented the rule referenced in the FRA advisory, a rule similar to those the FRA is now requiring by its emergency order that all railroads adopt. The Board further notes that the UP had also adopted such a rule before the issuance of the advisory, but this did not prevent the September 15, 2005, collision of a southbound UP freight train with a standing local train in Shepherd, Texas, that resulted in a fatality and several injuries.

At Graniteville, the brakeman whose job it was to reline the switch said that he believed everything was correct when he left the scene, and there is no reason to believe that, even in his haste to return to the terminal, he would knowingly have left the switch improperly lined. While it is possible that a discussion with the dispatcher specifically regarding switches (as required in the emergency order) would have caused him to think through his actions and remember that he had neglected the switch, it is also possible that during such a discussion he would simply have confirmed his belief that he had left the site properly secured. He was certainly aware that when he cleared the track warrants with the dispatcher he was certifying that the main line was ready for use by other trains. He would not likely have done this if he had any doubt about how he had left the track. Finally, under normal conditions, the conductor would have cleared the track warrants with the dispatcher. He likely would have assumed that the brakeman had relined the switch and would have reported it to the dispatcher accordingly, especially if the brakeman had already departed.

Similarly, the use of forms, such as the switch position awareness form, has not been shown to be particularly effective in preventing railroad accidents. For example, some railroads, in order to lessen the chance that a traffic control signal will be missed or misinterpreted by a crew, require that conductors record signal indications as they are encountered en route. But the Safety Board has investigated a number of accidents in which such forms, although required and used, did not prevent crews from missing signals and causing accidents.

The FRA emergency order also requires that railroads provide additional training to employees who operate hand-throw switches. But it is not likely that a railroad employee who is qualified and authorized to operate a hand-operated switch is unaware of the rules requiring that the switch be returned to its proper position after work is complete. It is therefore unclear how additional instruction on rules will improve employee performance. The emergency order also directs that an employee who operates a switch is responsible for returning it to its normal position; however, NS operating rules placed responsibility accordingly, and this did not prevent the Graniteville accident.

The emergency order goes beyond the safety advisory recommendations and current regulations in at least two respects: by directing that job briefings be held at the completion of work and by requiring that a train crewmember who repositions a main line switch in non-signaled territory communicate with the engineer regarding the switch position. The Safety Board welcomes these requirements as worthy additions to existing requirements that could provide an additional layer of safety. The investigation revealed that a comprehensive safety briefing was not held before the work at Graniteville. Had such a briefing been held before and, more importantly, after the work (as required by the postaccident FRA emergency order), the accident may have been avoided.

A significant element of the emergency order is the provision for a civil penalty of up to $27,000 for violations of the order. The penalty may apply to the individual at fault and/or to the company or other corporate entity. The magnitude of this penalty reflects the seriousness with which the FRA views violations of this kind; however, it does not, in the view of the Safety Board, address the cause of the violations. That is, the Board does not believe that employees forget to reline switches because the existing penalties are inadequate. Employees are acutely aware that an improperly lined switch, in addition to being a rule violation that could lead to removal from service, is likely to result in significant property damage or the injury or death of fellow employees or innocent bystanders. A substantial financial penalty is unlikely to be more effective than this sobering prospect in preventing these types of accidents.

Moreover, the Safety Board is concerned that the significant civil penalty may have an unintended impact on safety under some circumstances. That is, an employee who, after leaving a work site, realizes that a switch has been left improperly lined may be made more reluctant than in the past to immediately report the error to train dispatchers. The threat of the severe fine may prompt the employee to attempt a remedy (such as returning later to reline the switch) before the mistake can become known. As happened in the September 2005 fatal collision in Shepherd, Texas, such action on the part of the employee could contribute to an accident that might otherwise have been avoidable.

Clearly, measures beyond added or enhanced operating rules or additional forms, or even severe penalties, are needed to ensure that accidents such as the one at Graniteville do not recur. For example, a conspicuous visual stimulus associated with the switch at Graniteville might have alerted the P22 crew to the position of the main line switch despite any distractions.

When the crew completed securing the train, the head end was about 342 feet from the main line switch. It was dark, and both the engineer and the conductor said the switch banner was not visible at that point. Had the switch banner been conspicuous, it may have been detected by a crewmember who would likely have realized that the switch was not properly lined. And even though the switch position could have been detected as the crew passed along the adjacent road on the way to the terminal, they had no reason to observe it and apparently did not.

A conspicuous visual stimulus could take one of many forms: for example, a steady or flashing strobe light (such as those used on some school buses and traffic signals) of a color that would not be confused with other railroad signals. This would be analogous to the “blue flag” procedures mandated by the FRA to draw particular attention when personnel are working on, under, or between rail cars. The crew would probably have seen a highly conspicuous light before leaving and would have relined the switch. Assuming they had tied down the train out of sight of the switch (and had not traveled past it in leaving) and had therefore left the switch improperly lined despite its conspicuity, a unique flashing strobe or other obvious light might have alerted the train 192 crew to the switch position in time to slow the train.

Alternatively, a device could be installed that would use electronic technology to draw the crew’s attention to an improperly lined switch. Once an employee moved a switch to a non-normal position, the device could monitor the employee’s proximity to the switch. Should the employee leave the vicinity without relining the switch, a notification could be sent to the employee’s pager or cell phone. If the employee failed to respond within a specified time, the system could alert the railroad dispatcher or other designated railroad employee.

While the foregoing examples represent two possible means of capturing an employee’s attention, the Safety Board recognizes that there are likely additional ways by which this objective could be achieved and is issuing a safety recommendation to the FRA to address this issue.

The maximum authorized speed along the NS main line through Graniteville was 49 mph, and according to all available evidence, train 192 did not exceed this speed from the time it left Augusta until it reached Graniteville. However, sight-distance tests demonstrated that the banner indicating the misaligned switch was not identifiable (by investigators who were specifically looking for it) until the train was within about 566 feet of the switch. To the crew of train 192, this distance may have been even less because of the other lights and signals within the train crew's visible range that may have created a perceptual conflict. The Safety Board concluded that at the speed train 192 was traveling as it entered Graniteville, the distance required for the train crew to perceive the banner of the misaligned switch, react to it, and bring the train to a safe stop was greater than the distance available.

The Safety Board was concerned as early as 1974 about the issue of train speeds in areas not under a form of centralized traffic control. As a result of its investigation of a fatal accident in Cotulla, Texas, involving a misaligned switch in non-signaled territory,[2] the Board made the following safety recommendation to the Missouri Pacific Railroad (now part of the UP):

> R-74-22
> Review your operation on main tracks that are not equipped with automatic block signals and take appropriate action to ensure the capability of engineers to stop trains in advance of misaligned switches. This action could include reducing the size or speed of trains, installing automatic block signals or advance-position indicators, or improving the visibility of switch stand targets.

This recommendation was classified "Closed—No Longer Applicable" after the Board was provided with information indicating that the Missouri Pacific Railroad would continue to evaluate territories for the possible installation of automatic block signals or centralized traffic control.

At the time of the Cotulla accident, Interstate Commerce Commission (ICC) Order 29543 was in effect, which established a speed limit of "less than 50 mph" for freight trains operating in non-signaled territory.[3] The Safety Board's investigation of the Cotulla accident revealed that Order 29543 was inadequate in that the maximum allowable speed was established without consideration of factors, such as visibility and stopping distances, that at times may require lower speeds for safe operation. Therefore, the Board made the following safety recommendation to the FRA:

> R-74-26
> Determine and assess the current risks of train accidents involving misaligned switches, collisions, broken rail, and other route obstructions on main track where automatic block signal systems do not exist. Promulgate regulations to replace Interstate Commerce Commission Order 29543. These regulations should detail the major risks and controls assumed, set guidelines for safe operations below the

[2] National Transportation Safety Board, *Collision of Missouri Pacific Railroad Company Freight Train Extra 615 South With a Standing Locomotive, Cotulla, Texas, December 1, 1973*, Railroad Accident Report NTSB/RAR-74/03 (Washington, DC: NTSB, 1974).

[3] This speed limit does not apply along non-signaled track where train movements are governed by a manual block system permanently in effect. See 49 *Code of Federal Regulations* 236.0(c).

maximum operating speed, and assign responsibility to the carrier for safe operations.

When the FRA issued regulations for signal and train control systems in January 1984, the wording of ICC Order 29543 was incorporated, unchanged, into the new regulations. The Safety Board had intended that the new regulations specify circumstances that required that trains be operated below the allowable maximum speed. Because the FRA's actions did not satisfy the Board's intent, Safety Recommendation R-74-26 was classified "Closed—Unacceptable Action."

As acknowledged by the FRA, the frequency and severity of accidents involving misaligned switches in non-signaled territory appear to be increasing. While at least some of the measures the FRA has directed through its emergency order may aid in reducing the number of switching mistakes, they are unlikely to eliminate such mistakes entirely. Additional measures are therefore needed to help ensure that such mistakes, when they do occur, do not result in accidents. The Safety Board is therefore asking that the FRA take regulatory action in regard to train speeds in non-signaled territory.

All fatalities resulting from the accident were caused by inhalation of chlorine gas. During the derailment, the ninth car in the train, a tank car loaded with chlorine, was punctured. Given that both train 192 crewmembers survived the collision (the engineer died later from exposure to the gas), no fatalities or serious injuries would have resulted from this accident had this puncture not occurred. Emergency responders observed that the B-end coupler of the 11th car in the train, a car transporting steel coils, was in contact with the damaged tank jacket near the puncture in the tank shell and was covered with frost. Leaking chlorine, which boils at -29º F at atmospheric pressure, vaporizes rapidly from a liquid to a gas as it escapes through an opening such as a puncture, thereby freezing water vapor in the air and causing frost to form on nearby objects. Metallurgical examination of the damage on the shell around the puncture documented several impression marks on the shell that matched damage found on projecting surfaces of the coupler. The Safety Board therefore concluded that the chlorine gas release that occurred in this accident resulted when the shell of the 9th car on the train was punctured by the coupler of the 11th car.

The punctured tank car was built in 1993, and therefore was required to have both the tank heads and the tank shell constructed of normalized steel. The normalizing heat treatment typically increases the fracture toughness and lowers the ductile-to-brittle transition temperature of steel plate. Thus, for a given composition of steel, normalized steel is less susceptible to catastrophic brittle fractures and requires more energy to fracture than non-normalized steel.

Charpy impact testing showed that the normalized steel in the tank shell of the punctured chlorine car had a fracture toughness that was significantly greater than the fracture toughness of the non-normalized steels of the catastrophically ruptured tank cars involved in the derailment of a Canadian National freight train in Minot, North Dakota, in January 2002.[4] The steel in the Minot tank cars exhibited relatively low fracture toughness, and cracks propagated rapidly

[4] National Transportation Safety Board, *Derailment of Canadian Pacific Railway Freight Train 292-16 and Subsequent Release of Anhydrous Ammonia Near Minot, North Dakota, January 18, 2002*, Railroad Accident Report NTSB/RAR-04/01 (Washington, DC: NTSB, 2004).

around the circumference of each tank. The higher fracture toughness in the Graniteville tank car contributed to the relatively quick arrest of the crack even though there was brittle fracture in its outer portions.

Chlorine tank cars such as the punctured ninth car are tested to a pressure of 500 pounds per square inch, gauge (psig), compared to a test pressure of 300 psig for tank cars used to transport anhydrous ammonia and liquefied petroleum gas. To be rated for the increased operating pressure, the tanks of chlorine tank cars must have greater tank wall thicknesses than tanks of the lower pressure cars. Because of the improved properties of normalized steel and the increased wall thickness, the punctured car was among the strongest tank cars currently in service. The Safety Board therefore concluded that, as shown in the Graniteville accident, even the strongest tank cars in service can be punctured in accidents involving trains operating at moderate speeds.

The Safety Board addressed the improvement of crashworthiness of railroad tank cars in its Minot, North Dakota, accident report. The Board stated in its report:

> Improvements in the crashworthiness of pressure tank cars can be realized through the evaluation of alternative steels and tank car performance standards. The ultimate goal of this effort should be the construction of railroad tank cars that have sufficient impact resistance and that eliminate the risk of catastrophic brittle failures under all operating conditions and in all environments. Achieving such a goal does not necessarily require the construction of a tank car that is puncture–proof; it may only require construction of a car that will remain intact and slowly leak its contents if it is punctured.
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> To address these concerns, the Board recommended that the FRA:
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> R-04-6
> Validate the predictive model the Federal Railroad Administration is developing to quantify the maximum dynamic forces acting on railroad tank cars under accident conditions.
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> R-04-7
> Develop and implement tank car design-specific fracture toughness standards, such as minimum average Charpy value, for steels and other materials of construction for pressure tank cars used for transportation of U.S. Department of Transportation class 2 [gases] hazardous materials, including those in low-temperature service. The performance criteria must apply to the material orientation with the minimum impact resistance and take into account the entire range of operating temperatures of the tank car.

On August 9, 2004, the FRA responded and described the actions being taken to address each recommendation. In response to Safety Recommendation R-04-6, the FRA stated that it has identified ongoing programs at the Volpe National Transportation Systems Center and the University of Illinois at Chicago to evaluate in-train forces associated with train derailments. The FRA said it anticipates that the modeling program will be completed in early 2006. Regarding Safety Recommendation R-04-7, the FRA stated that further research in this area is required and that it may require a "three-year effort" to develop adequate tank car design-specific fracture toughness standards.

On June 22, 2005, in addressing the FRA's response to Safety Recommendation R-04-6, the Safety Board noted that programs to analyze in-train forces have already been identified and that it expects validation of the models to be a standard part of any model development. Based on FRA's response, Safety Recommendation R-04-6 was classified "Open—Acceptable Response." In addressing the FRA's response to Safety Recommendation R-04-7, the Board stated that implementation of tank car design-specific fracture toughness standards, such as Charpy impact value, can be achieved for standard manufacturing processes without waiting for the results of the modeling effort associated with Safety Recommendation R-04-6. The Board added that evaluation and analysis of the dynamics of the Minot accident can provide data about the levels of fracture toughness that may be necessary for pressure tank cars and that data from subsequent accidents in Macdona, Texas, on June 28, 2004, and Graniteville will provide additional information. Based on the FRA's response, Safety Recommendation R-04-7 was classified "Open—Unacceptable Response."

Congress also recognized the significance of the Safety Board's safety recommendations to the FRA by incorporating them into the "Safe, Accountable, Flexible, Efficient Transportation Equity Act," which was signed into law in August 2005. Section 20155 of the act stipulated that the FRA was to validate the predictive model within 1 year of enactment and initiate a rulemaking to implement appropriate design standards for tank cars within 18 months of enactment.

The Macdona and Graniteville accidents, both of which have occurred since the Minot report was issued, resulted in the puncturing of two chlorine tank cars and the death of 12 people from chlorine inhalation. When a liquefied gas such as chlorine, which is poisonous by inhalation, is released, large clouds at lethal concentrations can be generated within minutes. There is often little or no time to alert citizens and to take effective action. Based on Association of American Railroads (AAR) data on tank car shipments in the United States for 2002, chlorine and anhydrous ammonia ranked as, respectively, the fourth and seventh most commonly shipped hazardous materials by tank car. Furthermore, these products routinely travel through communities of varying size, including large metropolitan areas.

It is the belief of the Safety Board that modeling of accident forces and the application of fracture toughness standards as recommended in the Minot report will provide the most effective improvements in the crashworthiness of tank cars. However, at best, it will be several years before a significant percentage of pressure tank cars in service will have been so designed and constructed. Therefore, the most expedient and effective means to reduce the public risk from the release of highly poisonous gases in train accidents is for railroads to implement operational measures that will minimize the vulnerability of tank cars transporting these products.

Supplemental operational measures are already imposed for the transportation of certain high-risk materials. For example, the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration requires that pipeline operators have an integrity management plan for high-consequence areas,[5] which are identified on the basis of population densities and environmentally sensitive areas. The regulations are designed to identify high-risk areas and to develop a process for evaluating the risks within areas identified as high-consequence.

The integrity management plan for pipeline operators describes both preventive and mitigative measures that a pipeline operator must take to protect a high-consequence area. Such measures include implementing enhanced damage prevention practices, better monitoring, shorter inspection intervals, improved system monitoring and detection, and additional personnel training/drills with emergency responders.

For rail transportation of hazardous materials, the AAR since 1990 has published Circular No. OT-55, *Recommended Railroad Operating Practices for Transportation of Hazardous Materials*. This circular contains recommended operating practices for member railroads that include speed restrictions for "key trains"[6] and enhanced track inspection standards for "key routes." Because the train involved in the Graniteville accident was not a key train and the main line track was not on a key route, neither the operational restrictions nor additional inspections applied. Further, even if train 192 had met the definition of a key train, Circular No. OT-55 would not have restricted its speed below that at which it was already operating.

Two research studies have also been conducted that address operational measures to reduce the vulnerability of tank cars transporting hazardous materials. The 1992 FRA report, *Hazardous Materials Car Placement in a Train Consist*,[7] concluded that the rear one-quarter of a train is the most desirable location for cars containing hazardous materials and that reducing the speed and size of trains can reduce the number of cars derailed in an accident. The second study, "Minimizing Derailments of Railcars Carrying Dangerous Commodities Through Effective Marshaling Strategies,"[8] prepared for the Transportation Research Board, reached similar conclusions and provided some additional statistical information to validate those conclusions.

Both these reports address operational measures that may have made a difference in the Graniteville accident. Placement of the three tank cars transporting chlorine near the front of the train and ahead of most of the trailing tonnage increased the probability that the cars would be damaged and would release chlorine in an accident. Had the chlorine cars been placed behind the other loaded cars in the train, the reduction in the trailing tonnage would have reduced the impact forces on the tank cars. A reduction in train speed would also have significantly reduced the

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[5] Under the regulations, a *high-consequence area* may include an urban area with a population greater than 50,000, or a population density of 1,000 people per square mile, or other area (an unincorporated town or village, for example) that contains a concentrated population.

[6] Under the recommended practices, a *key train* includes any train with five tank carloads of poison inhalation hazard (PIH) cargo; or 20 carloads of a combination of PIH, flammable gas, explosives, and environmentally sensitive chemicals; or one or more carloads of high-level radioactive waste. A key train cannot exceed 50 mph.

[7] R. E. Thompson, E. R. Zamejc, and D. R. Ahlbeck, *Hazardous Materials Car Placement in a Train Consist, Vol. 1 (Review and Analysis).* Report DOT/FRA/ORD/18.I. Federal Railroad Administration, U.S. Department of Transportation (Washington, DC: 1992).

[8] F. F. Saccomanno and S. El-Hage, "Minimizing Derailments of Railcars Carrying Dangerous Commodities Through Effective Marshaling Strategies," *Transportation Research Record* 1245. Transportation Research Board, National Research Council (Washington, DC: 1989).

derailment forces on the tank cars. These operational measures, taken individually or collectively, may have been sufficient to prevent the puncture of the tank car and the release of the chlorine.

While the FRA report notes that car placement might be detrimental to train handling and dynamics and that switching cars to change their order in the train might result in exposing these cars to additional dangers, the Safety Board believes that railroads should be able to take these factors into account and still reduce the vulnerability of tank cars transporting chlorine, anhydrous ammonia, and other liquefied gases that are poisonous by inhalation.

In regard to the risks posed by the release of poisonous gases, the Safety Board has found that freight train crews may survive collisions and derailments only to be injured or killed by hazardous materials released in the accident. Although the crew of NS train 192 survived the collision and exited the locomotive unassisted, they could not escape exposure to the chlorine gas. The conductor said that after getting out of the locomotive, he and the engineer were able to walk some distance from the collision site. The two were transported to hospitals. The conductor was treated and released; the engineer died several hours later from inhalation of the toxic gas.

The consequences of this accident are remarkably similar to those of the June 2004 collision of two freight trains in Macdona, Texas. A tank car on the striking train was punctured and released chlorine gas. Once again, the crew of the striking train survived the collision and exited the locomotive unassisted into a chlorine-laden atmosphere. The conductor and engineer had walked about 1,400 feet away from the collision site when the conductor collapsed and died from exposure to chlorine gas. The engineer was hospitalized with severe injuries due to his exposure.

Emergency breathing apparatus is commercially available that would give crewmembers in these circumstances an opportunity to escape a hazardous atmosphere. According to the manufacturers, many of these devices are approved for use to escape certain chemical atmospheres, including chlorine and ammonia, as well as fire and smoke. Emergency escape breathing devices are typically effective for a period of time (5 to 50 minutes) that allow the user to escape and reach a safe location. The devices are used in a variety of industrial settings. They must also be carried on merchant and passenger vessels under the Safety of Life at Sea protocols. The Safety Board concluded that had the engineer of train 192 been wearing appropriate, fully functioning emergency escape breathing apparatus when he walked away from the collision site, he may not have succumbed to the effects of chlorine gas inhalation.

The National Transportation Safety Board therefore makes the following safety recommendations to the Federal Railroad Administration:

> Require that, along main lines in non-signaled territory, railroads install an automatically activated device, independent of the switch banner, that will, visually or electronically, compellingly capture the attention of employees involved with switch operations and clearly convey the status of the switch both in daylight and in darkness. (R-05-14)

> Require railroads, in non-signaled territory and in the absence of switch position indicator lights or other automated systems that provide train crews with advance

notice of switch positions, to operate those trains at speeds that will allow them to be safely stopped in advance of misaligned switches. (R-05-15)

Require railroads to implement operating measures, such as positioning tank cars toward the rear of trains and reducing speeds through populated areas, to minimize impact forces from accidents and reduce the vulnerability of tank cars transporting chlorine, anhydrous ammonia, and other liquefied gases designated as poisonous by inhalation. (R-05-16)

Determine the most effective methods of providing emergency escape breathing apparatus for all crewmembers on freight trains carrying hazardous materials that would pose an inhalation hazard in the event of unintentional release, and then require railroads to provide these breathing apparatus to their crewmembers along with appropriate training. (R-05-17)

Please refer to Safety Recommendations R-05-14 through -17 in your reply. If you need additional information, you may call (202) 314-6177.

Acting Chairman ROSENKER and Members ENGLEMAN CONNERS and HERSMAN concurred in these recommendations.

Original Signed

By: Mark V. Rosenker
Acting Chairman