



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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In reply refer to: R-96-26 through -45

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About 10:40 p.m. on January 6, 1996, Washington Metropolitan Area Transit Authority (WMATA) Metrorail subway train No. T-111, operating on the "Red Line" segment of the Metrorail system, failed to stop as it entered the above-ground Shady Grove passenger station near Gaithersburg, Maryland, the final station on the Red Line. The four-car train ran by the station platform and continued about 470 feet into the Metrorail yard north of the station, where it struck a standing, unoccupied subway train that was awaiting assignment. The T-111 train operator was fatally injured; the train's two passengers were not injured. Total property damages were estimated to be between \$2.1 and \$2.6 million.¹

The Safety Board determined that the probable cause of this accident was the failure of WMATA management and its board of directors (1) to fully understand and address the design features and incompatibilities of the automatic train control system before establishing automatic train operation as the standard operating mode at all times and in all weather conditions, (2) to permit operating department employees, particularly Operations Control Center (OCC) controllers and supervisors, to use their own experience, knowledge, and judgment to make decisions involving the safety of Metrorail operations, and (3) to effectively promulgate and enforce a prohibition against placing standby trains at terminal stations on the same track as incoming trains. Contributing to the severity of the injuries to the train operator was the disproportionate amount of crush sustained by the lead cars of the colliding trains.

Postaccident testing revealed no defect or failure in train T-111's braking system or its slip/slide wheel protection feature. Safety Board stopping distance tests conducted with a train that was identical to train T-111 and that was known to have no mechanical defects confirmed that the accident train demonstrated the braking performance that would have been expected

¹For more detailed information, read Railroad Accident Report—Collision of Washington Metropolitan Area Transit Authority Train T-111 with Standing Train at Shady Grove Passenger Station near Gaithersburg, Maryland, January 6, 1996 (NTSB/RAR-96/04).

given the capability of the equipment, the speed of the train, and the low-adhesion condition of the rails.

According to WMATA documents, the design specifications for the H-1 slip/slide control unit on Metrorail cars called for a minimum braking efficiency of 80 percent of the braking rate that available track adhesion would support at all adhesion levels above 5 percent. For Metrorail cars, the available deceleration rate at 5 percent adhesion is 1.1 mph/sec. To meet the specifications, then, the slip/slide control unit must be capable of achieving a minimum deceleration rate of 0.88 mph/sec (80 percent of 1.1 mph/sec) at 5 percent adhesion.

WMATA acceptance test documents confirmed that the slip/slide system in the series 2000 and 3000 cars met the specified 0.88 mph/sec deceleration rate; however, this rate is incompatible with the design assumptions of the Metrorail ATC system. According to documentation provided by WMATA, the Metrorail block design is safe so long as the effective brake rate of the train is equal to or greater than 75 percent of the B2 full service brake rate of 2.2 mph/sec. Because the H-1 slip/slide control units cannot always achieve this minimum deceleration rate (1.65 mph/sec at 75 mph), they cannot be expected always to guarantee safe stops.

While train T-111 was servicing the Rockville station, it lost the performance level 3 that it had been assigned when it entered the station. Once its doors were closed and the train was ready to depart, it should have regained performance level 3 and been assigned an automatic train supervision (ATS) speed of 59 mph. But because the train had overrun the station and its lead car was outside the station track circuit, the correct performance level was not received, and the train defaulted to the *highest* performance level, with its top speed limited only by the maximum automatic train protection (ATP) speed (75 mph) for the route segment between Rockville and Shady Grove.

WMATA has relied upon performance levels and the ATS subsystem to provide speed reductions in poor weather and to keep speeds below the ATP limit. The ATS subsystem, however, is a non-fail-safe subsystem. Had it been fail-safe in design, the ATS subsystem of train T-111 would have defaulted to the safest state when the train failed to receive an ATS speed transmission before leaving the Rockville station, and the accident probably would not have occurred.

This investigation revealed that WMATA did not follow the rule-change procedures established by the *Metrorail Safety Rules and Procedures Handbook* (MSRPH) when it used the November 17, 1995, Notice to OCC controllers to change rule 3.85 and eliminate manual train operation during inclement weather. Because the rule-change procedures were circumvented, the normal checks and balances that should have been in place were absent. Thus, the policy change did not receive the scrutiny from various operational perspectives that may have helped ensure that the decision was well thought out and that all its ramifications were considered.

The MSRPH states that train operators will not operate rail vehicles at a speed higher than the *maximum authorized speed*. Although Safety Board investigators were able to identify only one WMATA document that specifically referred to 59 mph as the maximum authorized

speed, many at Metrorail regarded this as the maximum allowable speed across the Metrorail system. On probably no other question during this accident investigation, however, did WMATA officials and employees evidence more confusion and provide more contradictory testimony.

The Safety Board concluded that WMATA management, prior to the accident, did not have a well-thought-out, firmly established maximum authorized speed policy that was understood and followed by all operating department employees. Furthermore, WMATA management failed to revisit the issue of maximum authorized speed in the context of its decision to curtail manual train operation on the Metrorail system, which created confusion among those employees, including OCC controllers and train operators, who have primary responsibility for ensuring system safety.

WMATA management recognized that positioning a gap train on the same track as incoming trains presented an unnecessary risk and had given "verbal" instructions that gap trains were to be placed on the track opposite that of arriving trains. But as shown by this accident, which would not have occurred if the gap train had been located on the adjacent track, these oral instructions were totally inadequate. The Safety Board concluded that if WMATA management had initially issued written, rather than oral, instructions regarding the safe placement of gap trains and had ensured that this policy was known and followed, the gap train at Shady Grove would probably not have been located where it was on the night of the accident, and the collision would not have occurred.

The Safety Board determined that WMATA did not have a recurrent formal training program for OCC controllers. While controllers were required to pass an annual rules test, they were not provided with any review or other preparation for taking the test. Additionally, WMATA had no program to ensure that controllers remained familiar with the physical characteristics of the route segments over which they had responsibility. The Safety Board is concerned that without recurrent training on operating rules, safety instructions, policies, and diagnostic procedures, physical characteristics of the Metrorail system, and emergency notification procedures, OCC controllers are not properly prepared to carry out their safety-critical function.

The Safety Board is concerned that OCC personnel did not see this accident developing as soon as train T-111 was directed to service the Rockville station. The controllers apparently were not able to diagnose the problem as one that required more than adherence to standard operating procedures. Perhaps more disturbingly, evidence suggests that if they had, in fact, diagnosed the full extent of the problem, they would have been prevented from taking the proper action because no authorized procedures had been developed, and the rigid management controls within the OCC and WMATA required certain decisions to be approved by executive management. The Safety Board therefore concluded that OCC controllers, and, to a degree, their immediate supervisors, had responsibility for day-to-day train operations, but they lacked the authority and the systematic procedures necessary to effectively carry out that responsibility. In the view of the Safety Board, such conditions are not consistent with the requirements of an effective central control operation.

Evidence gathered from this accident investigation indicates that WMATA management relies heavily on oral instructions to convey safety-related information. For example, the instructions regarding placement of the gap train at the Shady Grove yard were oral instructions. Even the important November 17, 1995, notice prohibiting routine manual train operation began as an oral instruction from the general superintendent for rail transportation, who stated that he did not recall asking the OCC supervisor to put the new guidance in writing. Metrorail management apparently considered oral instructions to be perfectly adequate, even when those instructions involved a policy change that actually constituted a change to an operating rule.

An over-reliance on oral instructions was not the only deficiency the Safety Board noted in Metrorail procedures for disseminating information. WMATA managers told Safety Board investigators that Metrorail had no formal procedures to ensure that train operators, terminal supervisors, OCC supervisors and controllers, or other operating personnel actually received memoranda or notices meant for them. The Safety Board is concerned that the Metrorail practice of posting memoranda or notices on bulletin boards or placing them in mailboxes gives no assurance that employees will actually receive the information, and it leaves no documentary record that employees have read and understood important safety-related guidance.

The combination of the November 17, 1995, Notice to OCC Personnel and the November 20, 1995, WMATA memorandum, subject: Manual Train Operation, completely eliminated routine manual train operation across the Metrorail system. This left train operators with no opportunity to develop or maintain proficiency in operating trains manually in revenue service. The Safety Board is concerned that, without regular practice in manual train operation, train operators will not be able to develop and maintain self-confidence and attain the level of proficiency needed to ensure safe operations under non-ATC conditions.

The highly computerized Metrorail ATC system is designed to bring trains to a stop at the appropriate station marker. Nonetheless, Metrorail experiences an average of 400 to 450 station or platform overruns each year. The Safety Board is concerned that this large number of station overruns indicates the presence of an uncorrected deficiency in that part of the Metrorail ATC system that is designed to detect a train's location in relation to a station platform. As shown by this accident, under certain circumstances, a platform overrun of only one car can have serious safety implications.

Even though both train T-111 and the gap train consisted of Breda 3000-series railcars, car 3252, the lead car of train T-111, sustained damage that was vastly disproportionate to that sustained by the lead car of the gap train. By the time car 3252 came to rest, it had telescoped approximately 21 feet over the body of 3191, and its occupant volume had been severely compromised. This accident could have happened during a weekday rush hour to a train carrying hundreds of commuters. Many of those passengers who would have been occupying the front portion of the first car would probably have received fatal injuries, and scores more throughout the train could have been injured seriously. The Safety Board concluded that the design of Metrorail cars may make them susceptible to telescoping in collisions that involve a failure of the attachments securing the end underframe to the side sills.

Postaccident toxicological tests of the operator revealed the presence of codeine (and its metabolite), an analgesic and ingredient in Tylenol 3, in sufficient quantity to indicate a therapeutic use of the medication. The tests also detected four ingredients commonly found combined in over-the-counter cold medications. The WMATA medical office advised the train operator to use Tylenol 3 cautiously at the time the train operator was working as a station manager. This suggests that WMATA appreciates the potential hazards associated with use by employees, while they are at work, of pain medications containing codeine. However, the fact that there was no evidence that the medical office followed up on its advice after the train operator transferred to rail service suggests that more needs to be done. In fact, this investigation revealed that WMATA does not have an education program for employees in safety-critical positions that deals with the use and effects of medications.

Train T-111 was not equipped with an event monitor/recorder. In fact, no highly automated rapid transit system in the United States equips its trains with devices that monitor and record all vital train systems and system events; this despite the fact that the data provided by such devices could help those agencies enhance the efficiency and cost-effectiveness of their operations by providing engineering, signal, maintenance, operations, and training departments with vital information about the way their systems and their operators are performing. Such data can also be invaluable in the event of an accident. Because train T-111 was not equipped with such an event recorder, Safety Board investigators had to gather, interpret, and interpolate information from a number of sources before they could reconstruct the accident sequence and evaluate the electronic, mechanical, and human performance factors that led to the collision. Although the lack of an event recorder did not affect the outcome of this investigation, the Safety Board believes that the absence of event monitors/recorders on rapid transit trains represents a potentially serious obstacle to investigators attempting to determine the cause of accidents on rail systems responsible for moving millions of passengers daily.

As a result of its 1982 investigation of the only previous Metrorail fatal accident,² the Safety Board recommended that WMATA maintain the carborne monitors on existing Metrorail cars and require their installation on cars presently on order....” The Safety Board acknowledges WMATA’s efforts since that time to foster development of advanced-technology carborne monitors and to facilitate their eventual installation on Metrorail cars. The Safety Board is concerned, however, that this process has been underway for 14 years and that Metrorail trains still are not equipped with carborne recorders/monitors that capture even a minimal amount of information. Had Metrorail cars been so equipped, WMATA management may have been able to precisely pinpoint the cause of the increase in wheel flats that led to the November 1995 policy change, and perhaps that change would not have been made.

When the OCC reported the accident to the Montgomery County Emergency Communication Center, the caller identified the location of the accident by the street address for the Shady Grove station. According to the responding incident commander, this caused some firefighters to respond to the Shady Grove station rather than to the accident site some 500 feet beyond the station. Also, the caller did not provide the emergency service dispatcher with the

²Railroad Accident Report—*Derailment of Washington Metropolitan Area Transit Authority Train No. 410 at Smithsonian Interlocking, January 13, 1982* (NTSB/RAR-82-06).

status of third-rail power or specify the best access points to the accident site, both of which are required by Metrorail standard operating procedures.

Immediately after the accident, the OCC Red Line button controller attempted repeatedly to deenergize that section of third rail in the accident area that could be controlled remotely from the OCC. These attempts failed when circuit breaker 33 did not respond to trip commands from the Red Line command console. This was not a unique incident; WMATA engineers told Safety Board investigators that various circuit breakers have failed to respond to remote trip commands before and that the source of the problem has never been identified. Because third-rail power was not taken down immediately, passenger evacuation and firefighters' efforts to search the lead car of train T-111 for passengers were delayed.

As soon as it became obvious that the circuit breaker could not be tripped from the OCC, an OCC controller or other WMATA official could have directed Metrorail or rescue personnel at the accident scene to bring down third-rail power locally by using a nearby emergency trip switch. Instead, WMATA management decided to leave this section of third rail energized in order to accommodate trains en route into the Shady Grove station. Even after the OCC became aware that passengers, an injured train operator, and firefighters were at the accident scene, the OCC controller permitted two more trains to proceed into the Shady Grove station.

The fact that a portion of the energized third rail lay in the interlocking posed special problems for firefighters because they had no schematic diagrams of the third-rail circuit. Sections of third rail that lie within interlockings have gaps that make it difficult to determine visually how the sections of third rail are interconnected. In this case, firefighters had difficulty judging how many warning strobe alarm devices (WSADs) were needed and how they should be placed to effectively monitor third-rail power in the accident area.

Firefighters and their commanders at the scene did not attempt to establish a direct communications link with the OCC to determine the status of the third rail. Instead, firefighters communicated with Metrorail personnel at the scene, who relayed these communications to the yard tower or to the OCC by radio. This created confusion; for example, Metrorail personnel at the scene called the tower on several occasions and asked that the third rail in the accident area be deenergized, even though third-rail power in the area where the accident occurred is controlled by the OCC and not by the yard tower.

When Montgomery County rescue personnel arrived on the scene, they were equipped with only one WSAD. Although two more WSADs arrived sometime later, because this accident occurred near an interlocking, a minimum of four WSADs would have been required, one on each independently controlled section of third rail, to ensure that rescue personnel would have been warned of third-rail reenergization in the accident area.

Therefore, the National Transportation Safety Board recommends that the Washington Metropolitan Area Transit Authority:

Analyze the braking performance under low-adhesion conditions of all railcar series in the Metrorail fleet. Take the measures necessary to ensure compatibility

between the cars' braking performance and the automatic train control system block design. (R-96-26)

Discontinue the use of the non-vital and non-fail-safe automatic train supervision (ATS) subsystem to perform safety-critical functions, and make it impossible for trains to default to a higher speed when a lower speed is required to ensure safe operation. (R-96-27)

Establish management controls to ensure that changes to Metrorail operating policy are properly evaluated before adoption and that any such changes that may constitute a change in operating rules are (1) made in compliance with formal rule-change procedures, and (2) fully coordinated with all appropriate Washington Metropolitan Area Transit Authority technical and administrative branches and divisions. (R-96-28)

Establish, document, and enforce a maximum authorized speed for every route segment on the Metrorail system. Ensure that these speeds are made known to all Metrorail personnel who hold safety-sensitive positions. (R-96-29)

Develop a formal operating rule that governs the placement of standby gap trains at Metrorail terminals or other locations. This rule should clearly state that gap trains will not be stored on the inbound track. (R-96-30)

Develop and implement a formal, comprehensive, recurrent training and qualification program for Operations Control Center controllers that includes, at a minimum, decisionmaking, instruction and testing on Washington Metropolitan Area Transit Authority rules, policies, operational procedures, emergency procedures, emergency preparedness and notification (including the minimum information to be provided to emergency dispatchers); Metrorail signal and control systems; and the physical characteristics of the Metrorail system, to include requirements that controllers be qualified on the physical characteristics of the route segments for which they are responsible. (R-96-31)

Develop and implement procedures for Operations Control Center controllers that (1) provide for active monitoring of both the automated control system and revenue train operation, (2) permit standardized interventions at the onset of recognition of potential automated system failures as well as direct hazards to individual trains, and (3) include unambiguous, clear guidelines for recognizing emergency operating situations requiring the stopping of trains. (R-96-32)

Discontinue the practice of using oral instructions to convey standard operating procedures or to notify Metrorail personnel of new or revised rules, policies, or operating practices. (R-96-33)

Develop and implement procedures to ensure that Metrorail operations personnel receive all bulletins, special orders, memoranda, or notices related to their

responsibilities. These procedures should include a mechanism by which these personnel must sign or initial a document to signify that they have received, read, and understood any guidance intended for them. (R-96-34)

Implement policies and procedures that provide a means for train operators to develop and maintain proficiency in manual train operation. (R-96-35)

Conduct a detailed investigation and analysis to determine the cause of the approximately 400 station or platform overruns experienced across the Metrorail system each year, and take the measures necessary to improve train stopping accuracy and to eliminate station overruns. (R-96-36)

Undertake, with the assistance of qualified engineering support, a comprehensive evaluation of the design and design specifications of all series of Metrorail cars with respect to resisting carbody telescoping and providing better passenger protection, and make the necessary modifications, such as incorporating underframe bracing or similar features, to improve the crashworthiness of cars in the current and/or future Metrorail fleet. (R-96-37)

Establish and administer a comprehensive educational program to alert employees to the potential adverse effects on performance that may arise from the use of prescribed and over-the-counter medications. (R-96-38)

Finalize the specifications for a new advanced-technology carborne monitoring system and, once that is complete, retrofit existing Metrorail cars with the monitors/recorders during rehabilitation and require that all new Metrorail cars be equipped with the devices. (R-96-39)

Coordinate with emergency service providers in all jurisdictions served by the Metrorail system to determine what information should be provided during an initial emergency notification, and amend the *Metrorail Safety Rules and Procedures Handbook* or standard operating procedures as needed to reflect these requirements. (R-96-40)

Amend Washington Metropolitan Area Transit Authority standard operating procedures to require that in Metrorail emergencies in which rescue workers must be summoned to the scene or in which the possibility of passenger evacuation exists, all train traffic be diverted from that location as soon as possible and all third-rail circuits in the emergency area, including those on adjacent tracks, be deenergized as soon as trains have left the vicinity. (R-96-41)

Develop a mechanism to provide emergency rescue personnel responding to an accident anywhere on the Metrorail system with easily accessible information about third-rail circuitry. Such a mechanism could include or consist of posting schematics or third-rail circuit diagrams on all blue light boxes and fences adjacent to interlockings. (R-96-42)

Implement a program of regularly scheduled operational testing of systems used to remotely trip third-rail circuit breakers from Operations Control Center command consoles. (R-96-43)

Increase the frequency of command and control exercises conducted jointly between the Washington Metropolitan Area Transit Authority and the emergency rescue services of all jurisdictions served by the Metrorail system. (R-96-44)

Coordinate with and assist fire and rescue service providers of all jurisdictions served by the Metrorail system in the procurement and distribution of sufficient quantities of warning strobe and alarm devices (WSADs) or similar protective devices to ensure that all rescue stations that may respond to a Metrorail accident are equipped to monitor the status of third-rail power in an accident area that includes one or more interlockings. (R-96-45)

The Safety Board also issued Safety Recommendation R-96-46 to the Federal Transit Administration; R-96-47 to the American Public Transit Association; R-96-48 to the Montgomery County Fire and Rescue Commission, and R-96-49 to all jurisdictions providing primary or secondary response to Metrorail accidents or incidents.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations R-96-26 through -45 in your reply. If you need additional information, you may call (202) 314-6439.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: 
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Chairman