NIOSH

FACE

Fatality Assessment and Control Evaluation Program

Division of Safety Research • 1095 Willowdale Road • Morgantown, West Virginia 26505 • Phone: (304)285-5916

FACE Report Number: 2001-02 **December 14, 2001**

State Department of Transportation Highway Maintenance Worker Dies After Being Struck by a Car While Installing Reflectors on a Guardrail

SUMMARY

On October 30, 2000, a 47-year-old male State Department of Transportation (DOT) maintenance worker (the victim) died after he was struck by a car that intruded into a work zone where he and a coworker were installing reflectors on a guardrail located along the median of an interstate highway. Shortly before the incident, the victim and his coworker placed "WORK AREA AHEAD" signs 1,000 feet in advance of their work area on both the south and north shoulders of the westbound lanes. After placing the signs, they drove west and parked their work truck on the north shoulder across the road and west of the section of guardrail they planned to work on. They walked across the traffic lanes and then turned and walked eastward on the shoulder facing oncoming traffic. They walked approximately 650 feet to an area where they began their work installing reflectors. They walked westward working their way back toward their work truck, stopping every 12.5 feet to install reflectors on the guardrail. Both workers were working from the traffic side of the guardrail when the victim's coworker looked up, saw a car approaching in the left lane headed toward them, and yelled a warning to the victim. The coworker was able to lift one leg over the guardrail and get out of the car's travel path before the car struck the guardrail and then the victim. The impact threw the victim over the guardrail and down a ravine into the 200-foot-wide median separating the eastbound and westbound traffic lanes. The driver involved in the incident did not stop. When stopped by police later that day, he said he had fallen asleep before the impact. The coworker was not injured and ran across the highway to his work truck and radioed his employer for help. The employer called 911. The coworker ran back to help the victim but, finding him unresponsive, went back up to the highway to wait for emergency medical services (EMS) personnel. EMS personnel responded within 20 minutes,

Incident Site

Fatality Assessment and Control Evaluation (FACE) Project

The National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR), performs Fatality Assessment and Control Evaluation (FACE) investigations when notified by participating states (North Carolina, Pennsylvania, South Carolina, Tennessee, and Virginia); by the Wage and Hour Division, Department of Labor; or when a request for technical assistance is received from NIOSH-funded state-level FACE programs in Alaska, California, Iowa, Kentucky, Massachusetts, Minnesota, Nebraska, New Jersey, New York, Ohio, Oklahoma, Texas, Washington, West Virginia, and Wisconsin. The goal of these evaluations is to prevent fatal work injuries in the future by studying the work environment, the worker, the task the worker was performing, the tools the worker was using, the energy exchange resulting in fatal injury, and the role of management in controlling how these factors interact. The FACE program does not seek to determine fault or place blame on companies or individual workers. For further information visit the FACE website at **www.cdc.gov/niosh/face/faceweb.html** or call toll free 1-800-35-NIOSH.

checked the victim and determined that he had sustained fatal injuries. They called the coroner who pronounced the victim dead at the scene.

NIOSH investigators concluded that, to help prevent similar occurrences, employers should, at a minimum

- ***adopt policies that require workers to work on the median side of the guardrail whenever it is safe to do so***
- ***periodically monitor and evaluate employee conformance with safe operating procedures and provide retraining as necessary when the procedures are not followed***
- ***establish a formal process for scheduling highway maintenance tasks, including installing reflectors, that identifies the need for consideration of appropriate crew size, traffic control devices, and safe work practices for the tasks to be performed.***

Additionally,

- ***Federal, State and local highway transportation and enforcement agencies should continue their efforts in educating the public regarding work zone safety issues and safe navigation through work zones.***

INTRODUCTION

On October 30, 2000, a 47-year-old male State Department of Transportation (DOT) maintenance worker (the victim) died after he was struck by a car that intruded into a work zone. The victim and a coworker were installing reflectors on a guardrail along a heavily traveled 4-lane divided interstate highway. The NIOSH Division of Safety Research (DSR) learned of the fatality through a news wire service on October 31, 2000. On November 30, 2000, a DSR occupational safety and health specialist traveled to the incident site to conduct an investigation. The incident was reviewed with personnel from the state police department. A police officer drove the investigator through the area where the incident occurred. The following day, the DSR investigator met with three representatives of the employer who were conducting an internal investigation of the incident. The police report, death certificate, and photographs taken shortly after the incident were reviewed. Information reported in this investigation was obtained through police interviews and official police reports, and from interviews with employer representatives. The victim's co-worker was interviewed by employer representatives, but was not available for interview by the DSR investigator.

The victim's employer was a State DOT that had been in existence for more than 80 years and employed 12,000 workers, 8,000 of whom had field duties. There were 43 DOT employees working in the county where the victim was working and 39 of them had maintenance duties similar to the victim's duties. The employer employed a full time safety manager with statewide responsibility and had a labor/management safety committee. There was a training /safety coordinator in each of the 11 districts within the state. A safety awareness day and three formal safety meetings were provided by the employer during the past

year. The employer had a comprehensive written safety program and had a job safety analysis (JSA) written for maintenance operations, including general shoulder work. Extensive training was provided to employees through manuals, classroom, on-the-job training, and training videos. The victim had 6 years experience with this employer and had attended employer mandated safety training regularly. Over the past 30 years, the employer has experienced 65 work-related fatalities.

INVESTIGATION

The incident occurred along the shoulder-side of a guardrail on an interstate highway. The four-lane highway was divided by a wooded and sloped median strip approximately 200 feet wide. The interstate was built in the early 1970s, and had been upgraded several times over the years. Guardrails had been installed along selected sections of the interstate highway when it was built. Reflectors (technically termed butterfly delineators because of their shape), used to guide drivers, were being installed on the guardrails on the day of the fatal incident. The weather was sunny, windy, dry, and cold but above freezing. In the area where the incident occurred, the highway was level and straight and the roadway and shoulder were blacktopped. Rumble strips were present along each shoulder. These strips provide a warning (rumble sound and vibration as the tires of the vehicle pass over them) to motorists who drift from the traffic lane onto the shoulder that they need to correct their travel path. The area under the guardrails was gravel and extended approximately 2 feet from the paved shoulder to the grass median. The posted speed limit was 65 miles per hour.

On the day of the incident, the victim and coworker arrived at work at 7:30 a.m. They normally worked with a minimum road crew of four but on the day of the incident one crew member had been assigned other tasks and another was attending a safety conference. According to the safety coordinator, it was accepted practice for a two-man maintenance crew to do "fill in" tasks such as installing reflectors on guardrails or removing animal carcasses from highways, when other work was not available. The two-man crew traveled in a truck assigned to them to four locations along the highway where they picked up deer carcasses. At approximately 9:45 a.m., they arrived at a location on the interstate highway where they planned to install reflectors on a section of guardrail extending along the south shoulder of the road. They set up "WORK AREA AHEAD" signs on each shoulder of the westbound lanes approximately 1,000 feet in advance of their work area. After placing the signs on both the north and south shoulders, they drove the work truck west, to the end of their work area. The victim was assigned a 15,000 pound gross vehicular weight (GVW) truck on the day of the incident and, according to the safety coordinator, had standard operating procedures been followed, the workers would have parked their work truck with its lights flashing in advance of their work area on the south shoulder where it would have offered a measure of protection from oncoming motorists and served to alert motorists of work being done in the area.

Evidence suggests that the men parked their work truck on a flat space along the north shoulder of the interstate. The truck's front- and rear-mounted amber lights were turned on, 4-way hazard lights were flashing, and a blizzard light (strobe) mounted on the back of the cab was flashing. They crossed the two lanes of westbound traffic and then walked east (facing traffic) along the south shoulder of the interstate to an area about 650 feet east of their parked truck. They then worked their way back toward the truck moving west as they installed reflectors along the guardrail.

Both crew members were wearing the personal protective equipment required by their employer and recommended in the Manual on Uniform Traffic Control Devices (MUTCD).[1] The victim was wearing an orange hard hat, orange and yellow vest, orange T-shirt, a fluorescent orange sweatshirt, blue jeans and work boots. It was the crew's first day working in this section of the interstate, but they had performed this task many times in the past. Their usual duties included repairing roadways, plowing snow, grading roads, and mowing.

Both workers were standing on the traffic side of the guardrail. They had installed several reflectors, one every 12.5 feet, and had worked about 40 minutes at the site when the incident occurred. They were starting to install a reflector when the victim's coworker, who was standing near the victim, facing and watching traffic, looked up and saw a car approximately 1,000 feet away in the lane nearest them, headed toward them. According to the police report the vehicle speed was estimated at 60 miles per hour. The coworker yelled a warning to the victim, who was standing next to him, but with his back to the traffic installing a reflector on the guardrail. The coworker who gave the warning had just enough time to lift one leg over the guardrail as the car traveled over rumble strips on the shoulder, struck the guardrail, and skidded approximately 35 feet along the guardrail striking the victim (Photo 1). The impact threw the victim over the guardrail and down a slope into the wooded, 200- foot-wide median strip where he came to rest in a ravine approximately 50 feet from the guardrail.

Photo 1. *Guardrail on the South Shoulder of the Westbound Lane.* Note: The guardrail is marked POI to designate where the apparent point of impact with the victim took place.

The driver of the car drove back onto the highway without stopping and continued traveling west. The figure shows the layout of the incident scene.

The coworker ran across to the north shoulder, where the work truck was parked, to radio his employer for help. The employer called 911. The coworker ran back across the highway and down the ravine of the median to assist his coworker. He called the coworker's name and when he did not get a response, went back up to the highway to wait for emergency personnel. Police and emergency medical services (EMS) responded within 20 minutes, evaluated the victim's condition and determined that he had sustained fatal injuries. They called for a truck equipped with a truck- mounted attenuator (TMA) and a lighted arrow signal, and parked it in the left traffic lane to direct traffic into the right lane to protect emergency personnel working in the area (Photo 2). Emergency responders called the coroner who pronounced the victim dead at the scene at 11:40 a.m. According to the coroner's report the victim died at the time of impact, 10:25 a.m.

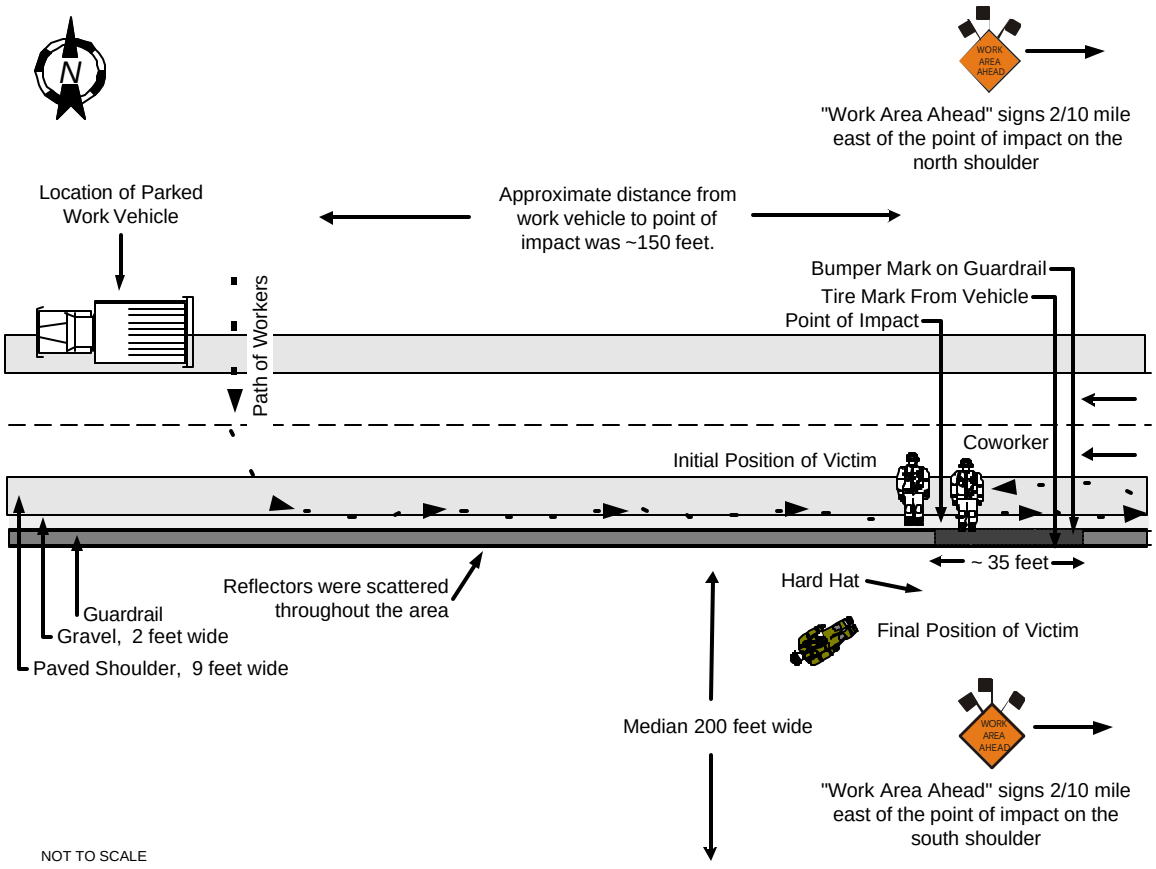


Figure. Aerial View of Incident Site.

Photo 2. *Incident Site*. Note: Photograph 2 shows the "Work Area Ahead" sign with 3 orange flags, that the crew had placed along the both the north and south shoulders of the highway. The photograph also shows the rumble strip along the paved shoulder and the yellow line marking the edge of the roadway. These strips are designed to alert motorists who drift off the roadway of the need to correct their travel path. The truck shown in the photograph was not at the site prior to the fatal incident. The truck has a truck-mounted attenuator (TMA) which is designed to attenuate or absorb an impact. It has a lighted arrow directing traffic to the north lane. It was parked in the south lane after the fatal incident and during the investigation when the south lane was closed to traffic. A truck with a TMA, when positioned correctly, increases worker visibility and protection.

Later that day, the driver was stopped by police and taken before a district judge and arraigned. According to his statement to police, the driver reported that he had fallen asleep and had driven off the road, hitting the guardrail. Without stopping his vehicle, he drove on for about 5 minutes and then pulled over to check the damage on the car. Realizing he may have hit a person, he panicked and drove north toward the home of a friend in another state. The police report indicated that the driver was driving while not properly licensed.

CAUSE OF DEATH

The coroner's report stated the cause of death was multiple blunt trauma to head, chest and abdomen.

RECOMMENDATIONS /DISCUSSION

Recommendation #1: Employers should adopt policies that require workers to work on the median side of the guardrail whenever it is safe to do so.

The employer's policy should include a method for evaluating the conditions on the median side of the guardrails for safe footing. Wherever the evaluation indicates it is safe to do so, work should be performed from the median side of the guardrail, where the guardrail provides some protection against being struck by oncoming cars.

Recommendation #2: Employers should periodically monitor and evaluate employee conformance with safe operating procedures and provide retraining as necessary when the procedures are not followed.

Employers should ensure that supervisors periodically monitor and evaluate employee compliance with safe operating procedures in order to correct unsafe practices, and provide retraining as necessary. The employer's standard procedure for this type of slow-moving work adjacent to a roadway directs workers to position their work vehicle on the shoulder in advance of their work area with its yellow lights flashing and rotating (see Appendix 1). When there is a two-man crew, as the work progresses, workers periodically return to the vehicle and reposition it, always keeping the vehicle in advance of their work area on the vehicle approach side, between themselves and oncoming traffic. When there is a larger crew, one member remains in the truck driving it forward and following behind the work as the work progresses. A correctly positioned truck, equipped with flashing lights, provides a warning to approaching drivers that work is being done in the area, in addition to serving as a barrier between workers and vehicular traffic.

Recommendation #3: Employers should establish a formal process for scheduling highway maintenance tasks, including installing reflectors, that identifies the need for consideration of appropriate crew size, traffic control devices, and safe work practices for the tasks to be performed.

Highway maintenance activities, such as installing reflectors and clearing debris, were typically fit into the workday as time allowed. Assessments of the hazards for specific jobs, necessary traffic control devices, and other safety measures were done at each site by assigned staff. A more formal process of scheduling maintenance tasks should be established in order to ensure that crew size is

appropriate to complete the tasks; necessary traffic control devices are identified and available; other measures that should be taken to ensure the safety of workers are considered and utilized; and employees are briefed on site-specific hazards and necessary safety measures prior to work.

Employers should make evaluating the need for supplemental traffic-control devices for specific sites part of their formal scheduling and preparation for highway maintenance work. For example, in areas where the shoulder is too narrow to provide sufficient room for the shadow vehicle to follow workers working along the shoulder, closing the lane adjacent to the shoulder and setting up proper channelizing devices to divert traffic away from the shoulder may be needed. Use of an additional more specific sign may be needed to supplement the "WORK AREA AHEAD" signs, such as a "SHOULDER WORK" sign.

For protecting work operations along the shoulder of interstate highways where high density, fast moving traffic is expected, shadow vehicles should always be used and they should be equipped with a truck-mounted attenuator (TMA). A TMA is a cushion attached to the rear of the protective vehicle and is designed to absorb a rear impact. The MUTCD references the American Association of State Highway Transportation Officials (AASHTO) Roadside Design Guide, Chapter 9,[2] for guidance on use of impact attenuators. The placement must allow for a buffer distance between the vehicle and the worker. This distance is typically a compromise between anticipated roll-ahead post-collision movement of the protective vehicle and excessive space that would permit traffic to move into the buffer zone. Table 9.3 from the Roadside Design Guide is provided in Appendix 2. Supervisors should consult this table and inform workers of the appropriate buffer distances required for their work situations. Whenever a protective vehicle is occupied by an operator, the vehicle should be equipped with a TMA and the operator should be properly restrained.

Another example showing a greater level of protection for workers can be found in the MUTCD diagram 6H-4, Short-Duration or Mobile Operation on Shoulder (TA-4) shown in Appendix 3. This traffic control plan shows the work zone bordered by vehicles on each end. Workers do their work in a designated space between the vehicles. A shadow vehicle with a TMA is placed on the vehicle approach side of the work zone and a work truck is placed just beyond the work area. The workers and trucks move ahead as the work moves. Although the MUTCD diagram TA-4 was designed for two way traffic, the concept behind this traffic plan could be used on interstate highways to provide a greater level of protection for workers. The second truck would provide a visual reminder and barrier and would help keep motorists from moving onto the shoulder where work was being performed. Advance warning signs would still need to be placed in accordance with the MUTCD for interstate highway traffic.

Along with formal scheduling for maintenance tasks, employers may find it useful to have their supervisors complete a pre-maintenance task checklist with their maintenance workers before they go to their highway work sites in order to ensure that all safety issues have been reviewed and addressed.

Additional information regarding work zone safety issues can be found in a Centers for Disease Control and Prevention (CDC) publication No. 2001-128 entitled "Building Safer Highway Work

Zones: Measures to Prevent Worker Injuries from Vehicles and Equipment" which is available through the NIOSH Education and Information Division by calling 1-800-356-4674. [3]

Recommendation #4: Federal, State and local highway transportation and enforcement agencies should continue their efforts in educating the public regarding work zone safety issues and safe navigation through work zones

Discussion: A continual effort aimed at educating the public regarding work zone safety issues (e.g., standard signage, protective apparel colors, importance of obeying postings) is needed to remind the public how to move safely through highway work zones. This type of education can be offered through public service announcements on radio, televison, and newspapers, as well as through driver education courses and through inclusion in driver training manuals.

REFERENCES

1. ATSSA [2001]. Manual on uniform traffic control devices (MUTCD), millennium edition, part VI. Fredicksburg, VA: American Traffic Safety Services Association.

2. AASHTO [1996]. Roadside design guide, second edition. Washington DC: American Association of State Highway Transportation Officials.

3. NIOSH [2001]. Building safer highway work zones: Measures to prevent worker injuries from vehicles and equipment. Cincinnati, OH: U.S. Department of Heath and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2001-128.

INVESTIGATOR INFORMATION

This investigation was conducted by Doloris N. Higgins, Occupational Safety and Health Specialist, Fatality Assessment and Control Evaluation Team, Surveillance and Field Investigations Branch, Division of Safety Research.

APPENDIX 1

Employer's Figure 6: Traffic control for slow moving or moving short-term operation - adjacent to any roadway.

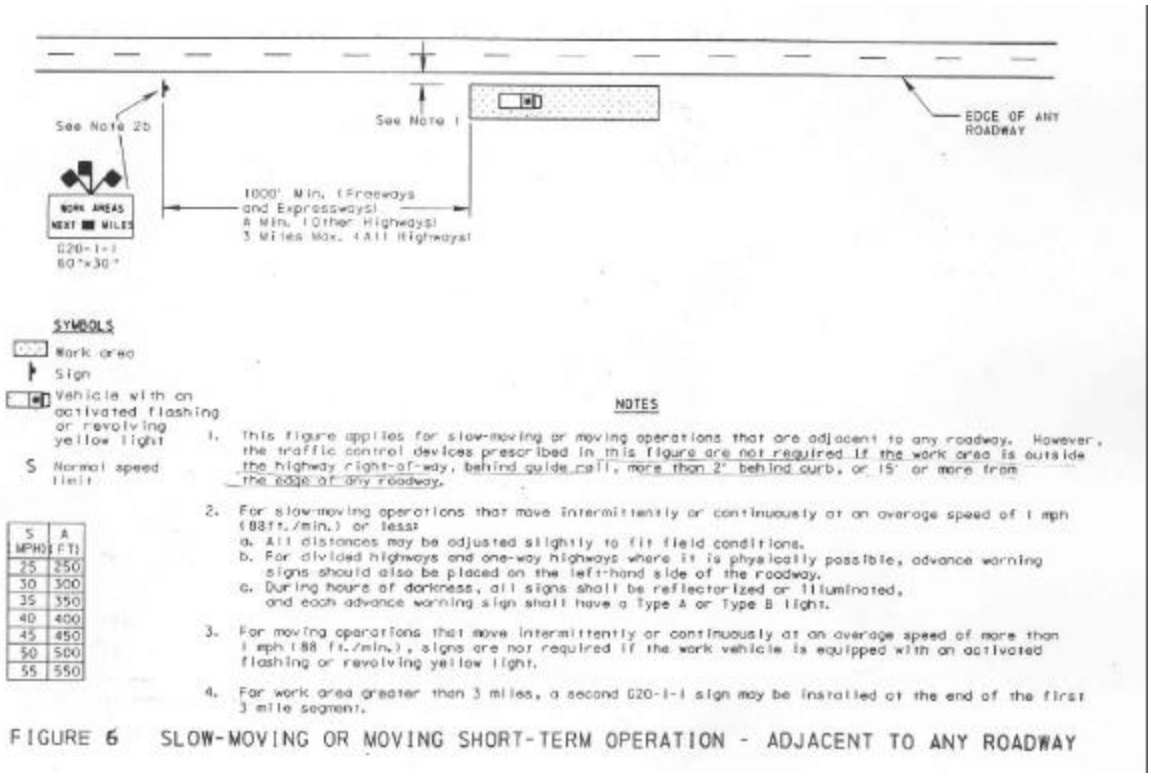


FIGURE 6 SLOW-MOVING OR MOVING SHORT-TERM OPERATION - ADJACENT TO ANY ROADWAY

APPENDIX 2
Examples of a Guideline for Spacing for Shadow Vehicles

For Shadow Vehicles Weighing 10,000 kg or More

Operating Speed/Speed Limit (km/h)[1]	Recommended Spacing (m)[2]	
	Stationary Operation	Moving Operation[3]
Greater than 90	45	52.5
70 - 90	30	45
Less than 70	22.5	30

For Shadow Vehicles Weighing Less than 10,000 kg but Greater than 4500 kg[4]

Operating Speed/Speed Limit (km/h)[1]	Recommended Spacing (m)[2]	
	Stationary Operation	Moving Operation[3]
Greater than 90	52.5	67.5
70 - 90	37.5	52.5
Less than 70	30	30

[1]Should use operating speed if higher than posted speed limit.
[2]Recommended spacing is distance between front of shadow vehicle and beginning of work area which is the first worker/operation/vehicle to be protected.
[3]Distances are appropriate for vehicle speeds up to 25 km/h.
[4]All Department CONSTRUCTION projects should refer to Section 619-1.02N of the Standard Specifications. Shadow Vehicles shall weigh 8000 kg to 9000 kg on all Department construction projects.

GENERAL NOTES:
1. The heaviest shadow vehicle should be used to optimize protection of our employees. Because roll-ahead is minimized with heavier shadow vehicles, they can be placed closer to the work space to minimize the risk of vehicles cutting in ahead of the shadow vehicles.

2. The spacing distance is good with or without a TMA. A vehicle equipped with a TMA may move less than a truck not equipped with a TMA. However, the recommended spacing is conservative enough to allow the same spacing for a TMA versus a vehicle without a TMA.

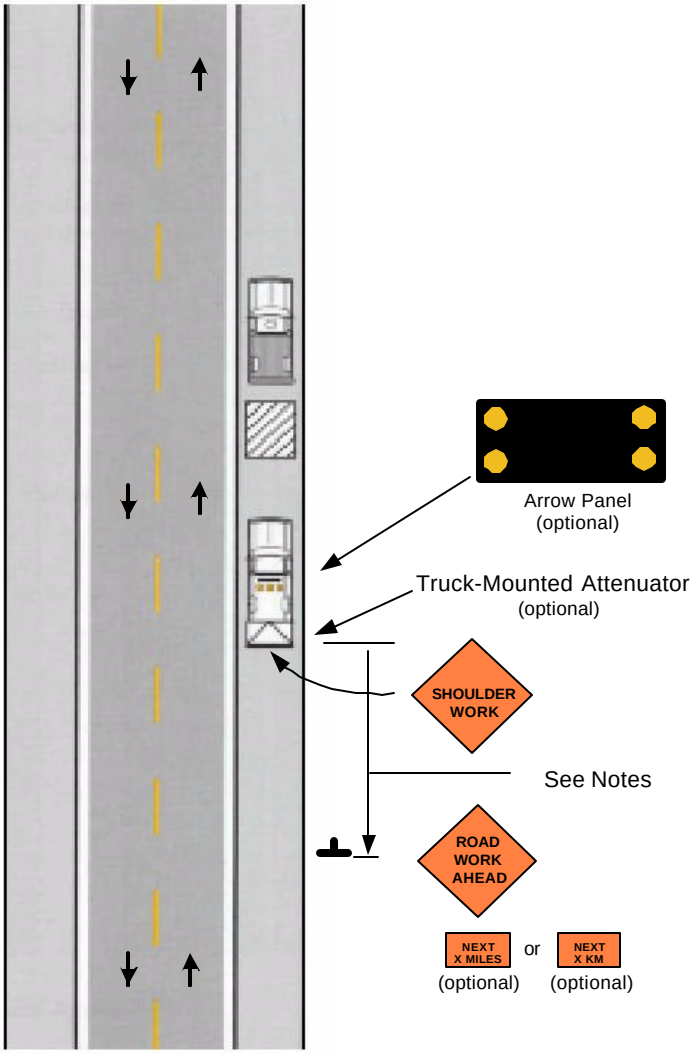
3. Distances are intended as guidelines. However, engineering judgement should be used to alter distance to take into effect traffic conditions, vehicle mix, sight distance, other site conditions, etc.

Source: Roadside Design Guide, second Edition. American Association of State Highway and Transportation Officials (AASHTO), Washington DC, 1996.

APPENDIX 3

MUTCD Traffic control plan for mobile operation on the shoulder.[1]

Figure 6H-4. Short-Duration or Mobile Operation on Shoulder (TA-4)



Typical Application 4

Notes for Figure 6H4

Guidance:
1. In those situations where multiple work locations within a limited distance make it practical to place stationary signs, the distance between the advance warning sign and the work sign should not exceed 8km (5 mi).
2. In those situations where the distance between the advance signs and the work is 3.2 km (2 mi) to 8km (5 mi), a Supplemental Distance plaque should be used with the ROAD WORK AHEAD sign.

Options:
3. The ROAD WORK NEXT XX KM (MILES) sign may be used instead of the ROAD WORK AHEAD sign if the work locations occur over a distance of more than 3.2 km (2 mi).
4. Warning signs may be omitted when the work vehicle displays rotating lights or strobe lights if the distance between work locations is 1.6 km (1 mi) or more, and if the work vehicle travels at motor vehicle traffic speeds between locations.

Standard:
5. Although vehicle warning signs can be used to supplement the rotating lights or strobe lights, they shall not be used instead of rotating lights or strobe lights.
6. If an arrow panel is used for an operation on the shoulder, the caution mode shall be used.

_____ *Date:* _____

Doloris N. Higgins, Safety and Occupational Health Specialist
Fatality Assessment and Control Evaluation Team
Trauma Investigations Section
Surveillance and Field Investigations Branch
Division of Safety Research

_____ *Date:* _____

Virgil J. Casini, Team Leader
Fatality Assessment and Control Evaluation Team
Trauma Investigations Section
Surveillance and Field Investigations Branch
Division of Safety Research

_____ *Date:* _____

Robert Koedam, Chief
Trauma Investigations Section
Surveillance and Field Investigations Branch
Division of Safety Research

_____ *Date:* _____

Dawn N. Castillo, Chief
Surveillance and Field Investigations Branch
Division of Safety Research

_____ *Date:* _____

Tim Pizatella, Deputy Director
Division of Safety Research