

## WORKZONE Injury Prevention Measures



### Work zone layout

*Road builders and maintainers can:*

- Assign a traffic control supervisor who is knowledgeable in traffic control principles overall responsibility for the safety of the work zone setup.
- Carefully review the TCP and, during contract negotiations, negotiate with the contracting agency as to revisions to the TCP that are needed to ensure worker safety.
  - Ensure that the work zone is set up in accordance with the Millennium Edition of the MUTCD.
  - Evaluate the effectiveness of the temporary traffic control setup by having the project supervisor walk or ride the job looking for evidence of near misses (e.g., skid marks, damaged barricades).
  - Include employees in the walk- or drive-through as a training tool, and to emphasize that safety is a continuous priority.
  - Authorize the traffic control supervisor to temporarily halt work until unsafe conditions related to temporary traffic control have been eliminated.
- Document work zone setup and changes throughout the course of the project. Retain these records in a "job file" as a reference for future jobs.
- Where provided for in contract documents, increase the size of the lateral buffer zone to reduce worker exposure to passing motorists.
- To the extent practical, keep the length of the work zone appropriate to the work in progress so that motorists do not increase speed after passing through a long stretch with no sign of work activity.

*Contracting agencies can:*

- Establish a streamlined process for reviewing and approving changes in the work zone setup that are necessitated by safety concerns.
- Close the road completely and reroute traffic where feasible.
- Provide alternative transportation modes and alternative routes for road users.
- On interstate and similar roadway systems, minimize worker exposure to traffic hazards by forcing traffic moving in both directions onto one side of the road and completely closing off the workspace.
- Specify the use of temporary pavement markings to laterally move the traffic lane away from the workspace on projects lasting less than 2 weeks.
- For night work, specify:
  - Increased taper length

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- Installation of low-level transitional lighting in advance warning areas and termination areas to ease motorists' adjustment to changing lighting conditions.

### *Road builders and maintainers and contracting agencies can*

- Cooperate to design and implement TCPs in accordance with safety management principles that call for a hierarchical approach to prevention of worker injuries:
  - Reduce worker exposure to injury to the extent possible. For highway construction, possible strategies to reduce exposure to injury from traffic vehicles include rerouting all traffic to one side of a multi-lane highway, or complete road closure.
  - Where worker exposure to traffic cannot be completely eliminated, use positive protective barriers to shield workers from intrusions by traffic vehicles. Examples applicable to highway work zones are truck-mounted attenuators (TMAs) and temporary traffic barriers.
  - Where installation of temporary traffic barriers is impractical or creates a greater hazard, install channelizing devices such as traffic cones and barrels to delineate the work zone. Keep in mind that channelizing devices supplement the use of temporary traffic barriers but are a less effective physical barrier to prevent vehicles intruding into the work zone.
  - Consider additional measures such as sensors, handheld radios, and intrusion alarms, but do not rely on them as a primary protection against injury.

### *Policy makers (Federal, state, and local) can:*

- Revise OSHA regulations for the construction industry (29 CFR 1926, Subpart G - Signs, Signals, and Barricades) to require adherence to the Millennium Edition of the MUTCD in place of the 1971 version that is currently specified [FHWA 2000; CFR]. This change would make OSHA regulations consistent with Federal Department of Transportation policy, which will require state departments of transportation to adhere to the more protective version of the MUTCD by January 17, 2003.
- Where Federal agencies have overlapping responsibilities for work zone safety, collaborate to ensure that regulations are consistent and comprehensive enough to ensure worker safety.
- Collaborate with contractors, labor, and the research community to develop tables of recommended widths for lateral buffer spaces under varying traffic speeds and volumes.

## **Use of temporary traffic control devices**

### *Road builders and maintainers can:*

- Use temporary traffic control devices, such as signage, warning devices, paddles, and concrete barriers, in a consistent manner throughout the work zone.

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- Set up temporary traffic control within a reasonable time prior to construction so that motorists do not become complacent and ignore warning signs and devices when work begins.
- Provide flaggers with devices that increase their visibility to passing motorists and construction vehicles. One example that has been field-tested and shown to be effective is the flashing slow/stop paddle, which consists of a standard paddle with a strobe light mounted on its face [Stout et al. 1993].
- Keep channelizing devices clean and properly maintained to preserve their reflective intensity and visibility.
- Ensure that all traffic control devices are operating properly and in place at all times. Missing traffic control devices create the potential for motorists to inadvertently enter the workspace or exit the highway in the wrong place.
- For night work:
  - Reduce spacing between channelizing devices to compensate for reduced driver visibility.
  - Ensure arrow panels are set at nighttime levels; daytime settings used at night produce blinding light.
  - Increase the size of traffic control devices, reflective material, and lettering to improve driver recognition.

### *Contracting agencies can:*

- To better delineate highway exits in work zones, consider specifying a different color for channelizing devices and signs intended to guide motorists off the exit ramp.
- Create positive separation between the traveling public and workers by specifying:
  - Use of temporary traffic barriers whenever possible. Paint barriers a color that contrasts with the background. Reflectors, lights, or light tubes can be installed on barriers to further enhance delineation.
  - Use of truck-mounted attenuators (TMAs) for a wider range of work zone safety applications. TMAs can be placed on the upstream, lateral, or downstream sides of traffic flow to physically isolate the workspace. They may be particularly useful in moving work zones, where they can move forward as work progresses to protect workers from being struck from behind by traffic vehicles.

### *Policy makers (Federal, state, and local) can:*

- In cooperation with contractors, labor, and manufacturers, develop a consensus standard for the use of temporary traffic barriers and TMAs as positive separators.
- Require consistency in traffic control devices within a single work zone area. Move toward uniformity in the type and placement of traffic control devices within local jurisdictions, at the state level, and nationally.

## **Motorist education and speed enforcement**

### *Road builders and maintainers and contracting agencies can:*

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- Give motorists plenty of advance warning of upcoming work zones.
- Ensure that motorists have real-time information in signage and in traveler's advisory radio broadcasts.
- Install warning signs that provide estimated time of delay and other road closure information so that drivers have sufficient opportunity to exit and take a different route.
- Use a combination of traffic queue detection equipment and dynamic message signs to vary messages as traffic conditions change.
- Keep warning sign messages simple and brief.
- Cover or take down warning signs when workers are not present.
- Remove channelizing devices when they are no longer needed.

### *Contracting agencies can:*

- Follow the MUTCD recommendation that reduced speed zoning should be avoided as much as practical. However, in highly vulnerable situations which threaten worker safety, consider reducing speed through regulatory speed zoning, use of police, funneling, lane reduction, flashing lights, or flaggers. Speed reductions should be applied incrementally to maintain uniform traffic flow. Normal speed limits should be restored when work is no longer in progress, when workers are no longer at the job site, or when hazards have been removed or protected.
- Use an advance media campaign to advise the public of upcoming road work.

### *Policy makers (Federal, state, and local) can:*

- Educate the public about work zone safety issues (e.g., standard signage, apparel colors, and importance of obeying reduced postings) through public service announcements, driver education courses, and driver training manuals.
- Educate the public about human factors related to safe navigation of work zones (e.g., decision sight distance, reaction time, and stopping distance) through public service announcements, driver education courses, and driver training manuals.

### *Policy makers (Federal, state, and local), law enforcement, and others can work together to:*

- Implement and evaluate alternative speed control measures in the work zone:
  - Videotape speeding motorists to provide an incentive to slow down through the work zone.
  - Use radar-gun technology to advise motorists when they are exceeding work zone speed limits. Explore the extension of this technology to automatic issuance of speeding tickets.
  - Increase fines for motorists exceeding work zone speed limits, and increase penalties for motorists convicted of driving through the work zone under the influence of drugs or alcohol.
  - Use pace vehicles to pull into lanes and slow traffic.
  - Increase presence of law enforcement at the beginning of the work zone.
  - Use a variety of speed control methods throughout the course of a project so that motorists do not learn how to anticipate and avoid speed controls.

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- Follow through on speed control measures through ticketing and fining violators.
- Use a law enforcement officer who is trained in work zone traffic control as a flagger in work zones where speed control is needed.
- Ensure that officers are trained in work-zone traffic control procedures and know the MUTCD.
- Ensure that officers working temporary traffic control are adequately protected from work zone hazards.

### **A New Jersey cooperative program enlists law enforcement personnel to improve worker safety:**

Parsippany, New Jersey is a model of collaborative efforts to improve highway work zone safety. This program has not only reduced work-site accidents and injuries, but has also reduced motorist collisions and fatalities in work zones. Police officers receive three to four days of OSHA training on the job risks associated with roadway construction, and are then authorized to warn employers of safety hazards on the job site. If hazards are not corrected after the second warning, police notify OSHA. Cooperators in this effort are the New Jersey State Police, international and local Laborers' Union, the Utilities and Transportation Contractors' Association, Rutgers University, local and county police, and the New Jersey Department of Labor.

### **A Wisconsin program places law enforcement personnel among highway workers as a speed control measure:**

Beginning in the spring of 1999, a new program in Racine County, Wisconsin, placed deputy sheriffs in plainclothes among highway construction workers in an effort to control speeding through work zones. Deputies, wearing orange work vests and equipped with handheld laser speed detectors and portable radios, identify speeding or erratic vehicles and notify law enforcement personnel positioned after the work zone if a stop or arrest is warranted. Racine County Sheriff Bill McReynolds stated that while the presence of law enforcement vehicles is a partial deterrent, the possible presence of officers among construction workers might cause motorists to exercise greater caution driving through the work zone [National Public Radio 1999].

## **Flaggers**

*Road builders and maintainers can:*

- Train all flaggers consistent with their level of responsibility and work zone conditions. Flaggers should know the traffic flow, the work zone setup, and proper placement of channelizing devices.
- Assign each flagger responsibility for monitoring operations in his or her immediate work area. Authorize flaggers to recommend to the traffic control supervisor that operations be temporarily halted, and the hazard corrected when they see a hazard threatening the safe movement of traffic through the work zone. Authorize flaggers to halt operations in the event a hazard arises, and the traffic control supervisor is not in the immediate area.

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- Train flaggers to maintain sufficient distance from other highway workers, so that they can be identified by passing motorists.
- In the event multiple flaggers are required, ensure they have the appropriate sight distance or two-way radios to communicate effectively.
- Avoid using flaggers whenever possible. Use alternative traffic management systems such as lane shifts, portable traffic signals, or remote signaling devices operated by workers away from the flow of traffic.
  - **Use alternatives to flaggers when traffic control is required under hazardous conditions such as high traffic speeds, inclement weather, night work, and other conditions which limit visibility.**

### *Policy makers can:*

- Develop flagger training program(s) that provide core competencies and are flexible enough to address varying work situations. The current OSHA 500 course in construction can serve as a model. Flaggers who successfully complete the program(s) could be issued documentation that could be carried from employer to employer and state to state.
- Add requirements for protection of flaggers to the OSHA construction standard.

## **High-visibility apparel**

### *Road builders and maintainers can:*

- Require all workers on foot to wear high-visibility safety apparel.
- Inspect high-visibility clothing regularly to ensure that color has not faded and that retroreflective properties have not been lost.
- So that workers do not blend into the background, consider seasonal variations in landscape and foliage when choosing colors for worker apparel.
- Consider using fluorescent garments with retroreflective material when working under poor lighting conditions.
- Consider increasing visibility by using high-visibility arm bands and hats, and vests with strobes.

### *Contracting agencies can:*

- Require fluorescent and retroreflective materials on head gear and on flaggers' gloves.

### *Policy makers (Federal, state, and local) can:*

- Change the MUTCD to require that all workers wear high-visibility safety apparel.
- Periodically evaluate visibility requirements in the MUTCD and OSHA regulations in light of changes in technology and consensus standards.
- Because visibility will be affected by background colors and available light, develop guidelines and mandates that specify retroreflective or fluorescent material, rather than prescribe a specific color. {Note: research suggests that the most effective choices for

fluorescent colors are red-orange, fluorescent yellow-green, or a combination of these [Turner et al. 1997].}

- Incorporate criteria for selection and use of high-visibility clothing into 29 CFR 1926 Subpart E- Personal Protective and Life Saving Equipment, or incorporate them into the MUTCD for reference in Subpart E.

*Manufacturers can:*

- Design high-visibility apparel that is effective 24 hours a day and during any weather condition.
- Create high-visibility apparel with one design on the front and a different design on the back. If a worker's back is to the driver, the driver knows that the worker cannot see him.
- Manufacture apparel to ensure visibility of the wearer from 360 degrees.

**An ANSI consensus standard provides guidance on high-visibility safety apparel:**

A new voluntary consensus standard, ANSI/ISEA 107-1999, American National Standard for High-Visibility Safety Apparel, provides guidance for use of high-visibility safety apparel to protect workers exposed to hazards of low visibility, including highway construction workers. The standard specifies minimum amounts of retroreflective materials, colors, and placement of materials for high-visibility worker apparel. It also defines three garment classes based on the surface area of background and retroreflective material used to make the garment. Specifications in the standard are intended to make the wearer of the apparel conspicuous under any light conditions by day, and under illumination of vehicle headlights in the dark.

Though not considered a part of ANSI/ISEA 107-1999, Appendix B provides the following conspicuity criteria for selection of apparel:

**Class 1** - For use in situations which permit the worker's full attention to approaching traffic, with ample separation of workers and vehicles, and traffic speeds not exceeding 25 mph. Specifies a minimum of 0.14 m<sup>2</sup> fluorescent background material and 0.10 m<sup>2</sup> retroreflective material.

**Class 2** - For use in inclement weather conditions, for work on or near roadways with higher traffic levels, or for traffic speeds above 25 mph. Class 2 apparel is appropriate for use in situations where worker attention is diverted from approaching traffic, or where separation of workers and traffic is less than ample. Specifies a minimum of 0.50 m<sup>2</sup> fluorescent background material and 0.13 m<sup>2</sup> retroreflective material.

**Class 3** - For use in settings where workers and vehicle operators have high task loads, where workers are exposed to traffic speeds above 50 mph, and where workers are exposed to a wide range of weather conditions. Class 3 apparel is recommended for all highway construction personnel. Specifies a minimum of 0.8 m<sup>2</sup> fluorescent background material and 0.2 m<sup>2</sup> retroreflective material.

**Note:** Performance of Class 3 apparel, suggested for use by all highway construction personnel, exceeds the 1,000-foot distance visibility recommendation in the MUTCD. The

new ANSI/ISEA standard states that the worker should be conspicuous through the full range of body motions and be identifiable as a person. Appendix B further suggests that workers needing Class 3 apparel should be conspicuous from a minimum distance of 1,280 feet [ANSI/ISEA 1999].

### **Illumination of the work zone**

*Road builders and maintainers can:*

- When installing lighting within a work zone, ensure proper illumination for the work space, while controlling glare so as not to blind workers and passing motorists:
  - Lower the height of lighting equipment to reduce glare for motorists.
  - Consider using glare-free light balloons and glare screens.

*Policy makers (Federal, state and local) can:*

- Develop a comprehensive consensus standard for illumination of work zones. The standard could include:
  - Minimum lighting levels needed for each work task
  - Types of light sources recommended for both portable lighting and equipment-mounted lighting
  - Minimum area to be illuminated around each type of equipment
  - Recommendations for placement of both portable lighting and equipment-mounted lighting.

*Manufacturers can:*

- Work with policy makers, contracting agencies, contractors, and labor to develop standards for illuminating highway work zones.

### **Research into work zone illumination needs:**

Illumination guidelines for nighttime highway work are now being developed by researchers at the University of Florida. Preliminary recommendations from this research defined three categories of highway construction and specified lighting levels needed for each:

**Category I:** General illumination requirement for the work space (5 foot-candles)

Recommended for large-scale visual tasks with comparatively low need for accuracy

**Category II:** Provides for general illumination of tasks and around equipment (10 foot-candles)

Recommended for work done on and around construction equipment such as paving and milling which require somewhat greater accuracy and where workers are located near



machinery

**Category III:** Specified for small scale visual tasks requiring high accuracy, such as repairing cracks or pot holes (20 foot-candles)

Also recommended for situations requiring extreme caution and attention, such as flagging and signaling

The preliminary illumination recommendations also cover light sources, lighting system configurations (temporary, portable, and equipment-mounted), steps for designing a lighting system, and the importance of maintenance and backup of the system. The final product of the research will be illumination guidelines for nighttime highway work that specify design requirements for work zone lighting, taking into account visibility requirements of motorists passing through the work zone. The research is funded through the National Cooperative Highway Research Program [Transportation Research Board 1996].

### **Developing internal traffic control plans**

A temporary traffic control plan (TCP) describes how a specific work zone is to be set up to ensure the safety of the motoring public traveling through the work zone; however, construction equipment and vehicles within the work space are not addressed by TCPs [Graham and Migletz 1994] . In contrast to a TCP, an internal traffic control plan (ITCP) is a tool that project managers can use to coordinate the flow of construction vehicles, equipment, and workers operating in close proximity within the activity area, so that the safety of workers can be ensured.

*Road builders and maintainers can:*

- Develop an internal traffic control plan (ITCP) once the temporary traffic control plan has been established. As the ITCP is developed, consider how the work space fits within the overall work zone and make sure that the ITCP is placed in the context of a temporary traffic control plan.
- Develop internal traffic control plans for all medium, large, and multi-contractor jobs. For small recurrent operations such as filling potholes, routine maintenance, and mowing, a checklist could be used in place of a complete ITCP.
- Develop schematic diagrams depicting the movement of construction workers and vehicles within the workspace. Sample diagrams have been developed for paving, trenching, and dirt-spread operations [Graham and Migletz 1997]. These diagrams provide an idea of how a typical ITCP diagram might look but must be modified to assure compatibility with the overall TCP and to address site-specific conditions.

### **Management elements that may be addressed in an ITCP:**

- Chain of command
- On-site equipment and personnel
- Contact information, including company personnel, other on-site contractors, the contracting agency, and emergency response services

- The location, timetable, and scope of the project
- An operations communication plan that includes the following:
- A plan for orienting independent truck drivers and subcontractors to the workspace and the ITCP
- Methods of communication regarding changes in the ITCP
- A means for workers on foot to talk with equipment operators, truck drivers, and the people in charge of controlling or coordinating the flow of vehicles and equipment entering and leaving the workspace and the movement of heavy equipment within the work space A means for grader operators, dozer operators, truck drivers and scraper operators to communicate with each other and with the prime and subcontractors

#### **Safety elements that may be addressed in an ITCP:**

- Identification of ITCP coordinator assigned to the project
- A description of the role and authority of the ITCP coordinator
- A description of the role employees have in implementing the ITCP, and in recognizing, reporting and eliminating safety hazards
- A continuous process for reviewing incidents, close calls, and potential hazards involving workers and equipment within the workspace and for elimination of reported hazards
- A description of how the ITCP fits within the temporary traffic control plan

#### **Hazard assessment and control elements that may be addressed in an ITCP:**

- Schematic diagrams depicting the movement of construction workers and vehicles within the workspace (see ITCP diagram elements)
- A checklist of site-specific hazards with a description of how these hazards will be minimized: what procedures, safety equipment, and control strategies will be used?
- A reporting system for all close-calls and incidents related to the internal traffic control plan (to encourage reporting, consider using an anonymous reporting system)
- A plan for safely handling intermittent traffic stoppages, e.g., for equipment turnaround
- Anticipated traffic volume and speed, as well as speed limit for operation within the workspace
- Specifications for lighting in the workspace

#### **Elements of an ITCP Diagram:**

- Standard symbols for pieces of equipment and project personnel that will be on site
- Overview of how the activity area fits within the temporary traffic control plan
- Location of proximate traffic control devices
- Delineated areas around specific pieces of equipment and operations where workers on foot are prohibited (e.g., swing radius of an excavator, blind areas of a dump truck)
- Locations for storing and servicing materials and equipment

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- Location of parking for visitors and workers
- Size and location of lateral buffer zones
- Description of internal signage and all internal traffic control devices

### *Contracting agencies can:*

- Assist contractors in the development of ITCPs and in reviewing compatibility of ITCPs with the project TCP.

### *Policy makers (Federal, state, and local) can:*

- Establish guidelines for developing ITCPs.
- Develop sample ITCPs for selected road construction operations.

## **Implementing internal traffic control plans**

### *Road builders and maintainers can:*

- Train workers in the implementation of the ITCP for each project.
- Place a trained ITCP coordinator at each job site. By being at the job site, the coordinator is able to respond immediately to hazardous situations. The employer should authorize the coordinator to make adaptive changes and/or halt operations as needed to ensure worker safety.
- Evaluate the effectiveness of the ITCP throughout the project, noting changes required as the project evolves. Retain schematic drawings and other documents in the "job file" for use in developing future ITCPs.
- At entrances to the activity area, distribute site-specific safety materials, including a copy of the ITCP and safety guidelines for workers on foot, to all drivers and visitors coming into the activity area. Other means of communicating this information include toolbox safety meetings, faxing the ITCP to other employers who will be on site, and distributing the ITCP to truck drivers at the loading facility.

### *Contracting agencies can:*

- Ensure agency staff understand the ITCP for each project so that they can comply with the ITCP when they travel to a work site during inspections.

## **Accountability and coordination at the work site**

### *Road builders and maintainers can:*

- Avoid assigning collateral duties that distract safety personnel from focusing on their safety responsibilities.
- Make supervisors accountable for daily documentation of hazards and how hazards were mitigated.

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- Maintain lines of communication between the individuals responsible for different aspects of work zone safety.

### *Contracting agencies can:*

- Require contractors and subcontractors to prepare site-specific hazard assessments that include identification of hazards and description of how hazards will be eliminated or controlled.
  - For each project, use hazard assessments to guide identification of immediate worker training needs.
- Adopt a project-wide communication program in which each contractor informs all other contractors of hazards related to their work. This allows each contractor the opportunity to ensure that employees are aware of hazards resulting from work being done by others at the site.
- Require an on-site senior project supervisor with final authority and overall responsibility for safety on the project.
- Conduct a pre-construction meeting among contractors to coordinate project activities, discuss potential hazards and how hazards will be eliminated, or minimized.

## **Equipment operation and maintenance**

### *Road builders and maintainers can:*

- Make sure that each equipment and vehicle operator has a valid driver's license.
- Allow equipment to be operated or repaired only by persons who have been trained and authorized to work with that piece of equipment. Assign responsibility for each piece of equipment to an individual worker.
- Designate a supervisor to be responsible for daily pre-shift equipment checks and for verifying that any problems are corrected. Although equipment may be inspected by various people, the supervisor must be responsible for ensuring that inspections are performed daily, that necessary repairs are made, that scheduled maintenance is performed, and that records of all inspections and repairs are maintained.
- Ensure that workers are paid for the time they spend performing equipment safety checks.
- When repairs are made on site, require that the operator's controls are made inoperable so that the equipment cannot be moved by another worker while repairs are being made.
- Require equipment operators to set parking brakes when leaving equipment unattended. When equipment is parked on an incline, chock wheels in addition to setting parking brakes. Chocks should be of sufficient size and configuration to immobilize the equipment.
- Require employees to report equipment problems to the designated competent person and give employees the authority to shut down unsafe equipment without repercussion.
- Develop pictorial checklists to make equipment inspections easier.
- Keep operator manuals in the equipment cab.

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- Ensure ready access to repair manuals by maintenance personnel at all work locations.
- Contact the equipment manufacturer to obtain operator and repair manuals when purchasing used equipment.
- For night work, install light strips on trucks to better delineate vehicles and equipment. Drivers must turn off this additional lighting before leaving the work area.
- Use equipment with rollover protective structures (ROPS). Purchase and have installed retrofit ROPS and seat belts for older equipment.
- Train equipment operators in safe work practices to prevent equipment rollovers:
  - Maintain proper tire pressure
  - Know material density and surface stability
  - Use spotters with two-way radio communication
  - Train operators to use seat belts and to remain belted in the event of a rollover
  - Use edge guards on trailers to prevent rollovers
  - Use spotters during loading and unloading of equipment from transport trailers
  - Install full-width loading ramps on transport trailers.

### *Contracting agencies can:*

- Specify use of high conspicuity tape to delineate height and width of construction vehicles and equipment. Existing Federal standards that apply to tractor-trailers provide a model for placement, pattern, color, and reflectivity of tape at the sides and rear of the trailer [49 CFR 393.13].
- For night work, specify installation of low-level lighting on trucks and equipment so that operators can see workers on foot in the vicinity.

### *Policy makers (Federal, state, and local) can:*

- Require the highway construction industry to comply with a standard similar in purpose to the general industry lockout/tagout standard (29 CFR 1910.147).

### *Manufacturers can:*

- Make operator and repair manuals for equipment available on manufacturers' Websites or through an on-line clearinghouse.

## **Safe equipment operation around workers on foot**

### *Road builders and maintainers can:*

- Separate workers on foot from equipment as much as possible:
  - Schedule work tasks to keep workers on foot out of areas where heavy equipment is in use.
  - Channelize dump trucks leaving the work space and keep workers on foot out of that channel. Use flexible, colored poles (as used for snowplow markers) or temporary pavement marking inside the work space to mark pedestrian-free

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areas or flow-of-traffic lines. These delineators should be installed so that the public will not notice or respond to them, but the workers will recognize them as guideposts.

- Train subcontractors, crews, operators, and truck drivers to understand any symbols, markers, and colors used to separate workers on foot from equipment within the workspace.
- Design the workspace to eliminate or decrease backing and blind spots; when feasible pull trucks in and let the operation catch up to them.
- Train workers on foot and equipment operators in appropriate communication methods (e.g., using hand signals and maintaining visual contact) to be used when workers on foot are required to be in the same area as equipment.
- Train equipment operators never to move equipment without making positive visual contact with any workers on foot near the equipment.

### **Training and certification**

#### *Road builders and maintainers can:*

- Implement performance-based training that evaluates trainees' core and specialized knowledge and demonstrated ability to perform the tasks for which they were trained.
- Create an industry-wide campaign to promote training and to publicize available training programs.
- Since all workers, including equipment operators and supervisors, are likely to be on foot around operating vehicles and equipment, train all workers to recognize and avoid the hazards of working on foot around equipment.
- Train all workers in hazards and adaptations for work at night and in other low-visibility conditions.
- Hold daily toolbox meetings at the job site to discuss and report hazards and close-calls, and to discuss safety considerations for performing the day's tasks.
- Train workers on the specifics of the ITCP for each new construction project.
- Review ITCP with workers whenever it is modified.

#### *Policy makers (Federal, state, and local) can:*

- Promulgate an OSHA regulation mandating training of all construction workers whose actions affect work zone safety. The current MUTCD recommends but does not require that all such persons, from upper-level management through field personnel, receive training appropriate for the job decisions each is required to make.
- Develop training programs that provide workers with an understanding of safety hazards and methods of hazard reduction in highway and street construction.
- Begin to develop a national certification process for equipment operators.
  - Preparation for certification could involve a 2- to 4-year qualification period that includes classroom and on-the-job training and experience.
  - Certification would be a function of the operator's qualifications, demonstrated knowledge, and proficiency.

- The certification process should provide for maintaining and renewing certification on a periodic basis.

#### **A national third-party crane certification program:**

The National Commission for the Certification of Crane Operators (NCCCO) is a nonprofit corporation that was founded in 1995 to develop effective performance standards for safe crane operation to assist all segments of general industry and construction. The NCCCO is strictly a credentialing organization—the Commission does not offer training programs, since that would compromise its objective measurement of a candidate's knowledge and skills. What the NCCCO does provide is a comprehensive and independent means of assessing crane operator knowledge and skills through administration of a core and several specialty written examinations. On February 26, 1999, the OSHA and the NCCCO signed an agreement officially recognizing the NCCCO national crane operator certification program as meeting OSHA requirements for crane operator proficiency. As a result, when compliance safety and health officers perform inspections or make accident investigations, they will recognize NCCCO certification as verification that crane operators have met the training requirements of the OSHA standards.

#### **An OSHA standard with specifications for performance-based training:**

The OSHA standard for powered industrial truck training provides a model for performance-based training. The standard stipulates that training shall consist of a combination of formal instruction, demonstrations by the trainer, practical exercises performed by the trainee, and evaluation of the operator's performance in the workplace. Also specified in the standard are situations in which refresher training must be conducted, including the following: unsafe operation has been observed; the operator has been involved in an accident or "near-miss" incident; the operator is being assigned to drive a different type of truck; or workplace conditions have changed such that the safe operation of the vehicle may be affected. At a minimum, the standard requires that operator competence be reevaluated at least once every 3 years. In contrast with the crane operator certification program discussed above, the OSHA standard requires the operator to be certified by the employer; certification through a third party is not allowed [29 CFR 1910.178(l)]. Note: The requirements applicable to construction work under 29 CFR 1926.602(d) reference those set forth in 29 CFR 1910.178(l).

### **Changes in the contracting process**

*Contracting agencies can:*

- Level the playing field among all potential contractors by requiring a written safety program in bid specifications. Contractors may risk losing jobs when they bid higher to account for costs of training, maintenance, and other safety program elements.
- Level the playing field among all potential contractors by specifying appropriate protective technologies (e.g., TMA, concrete barricades) as individual bid line items when preparing bid specifications, instead of using generic contract language that simply specifies contractors must comply with Federal and state safety regulations.

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- In bid specifications, stipulate that all workers on foot be equipped with high-visibility safety apparel.
- In planning new construction and rehabilitation, specify durable surfacing materials that will need to be replaced less frequently.
- Pre-qualify all contractors and subcontractors to ensure that they have good safety records. Periodically reevaluate the pre-qualified list of contractors.
- Through contract language, specify that the traffic control supervisor must have overall responsibility for temporary traffic control.
- In bid specifications, include provisions for the contractor to set up an adequate workspace for safe operations (e.g., sufficient lateral buffer space and room for equipment to maneuver).
- Require demonstrated understanding and ability to implement the TCP as an acceptance criterion for awarding contracts. Do not award contracts based solely on a low bid criterion.
- Use the quality and completeness of the TCP and the ITCP as acceptance criteria for awarding contracts.

*Policy makers (Federal, state, and local) can:*

- Develop model safety specifications for contracting agencies to use when developing contract documents. During the bidding process, contractors would then be able to assign costs for implementing better safety practices.
- Create forums for dialogue among all entities involved in highway construction.

### **Laboratory and field research needs**

*Policy makers (Federal, state, and local), contracting agencies, road builders and maintainers, labor, and the research community can work together to:*

- Develop prototype internal traffic control plans for a broad range of highway construction tasks and evaluate their effectiveness through field studies.
- Determine the optimum dimensions and spacing for channelizing devices.
- Determine the optimum lateral buffer zone distance and recalculate the maximum travel speed outside the workspace based on this distance.
- Determine optimum spacing between the truck-mounted attenuator (TMA) and the vehicle in front of it; develop interventions to deter motorists from driving in front of the TMA in order to get around it.
- Evaluate driver recognition and comprehension of different channelizing devices under various lighting and weather conditions.
- Evaluate the reliability of intrusion alarms for alerting workers of traffic vehicles that have penetrated the workspace.
- Evaluate the effectiveness of law enforcement officers or vehicles stationed in the advance warning area as a means of reducing crashes and worker injuries.
- Evaluate risk to law enforcement personnel who are used in work zone advance warning areas. Evaluate effectiveness and applicability of phosphorescent, fluorescent, and retroreflective materials, including the patterns used when they are applied to a garment.



## WORKZONE Injury Prevention Measures

- Evaluate the effectiveness and applicability to work zones of:
  - Sensing devices that sound an alarm when an object is near the vehicle
  - Parabolic mirrors on construction equipment—similar mirrors are now in use on school buses
  - Individual vibrating alarms that can be triggered from any place on the site, giving a worker 8-10 seconds notice of approaching vehicles
  - Transmitters worn by workers which will send a signal/alarm to approach construction equipment [Hoffner 1997]
  - Tapes that sound an alarm when a person or vehicle crosses them
  - Closed-circuit television cameras, mirrors, and devices that stop a vehicle nearing a collision.
- Evaluate ways of reducing glare caused by work zone illumination:
  - Evaluate polarized windshield glass or polarized material over windows as a means of limiting glare.
  - Assess warning lights and strobe lights used on emergency vehicles and traffic control devices to determine need for glare reduction.
- Conduct research to better understand physiological and psychosocial effects of night work, extended shifts, rotating shifts, and irregular work schedules on worker safety.
- Conduct research to determine the most effective means of delivering training to highway construction workers.
- Measure light levels and test the effectiveness of mirrors and video cameras under nighttime construction conditions.
- Conduct hazard surveillance research to determine levels of worker exposure to specific types of machinery in highway construction zones.

### **Data and record keeping**

*Policy makers (Federal, state, and local) can:*

- Modify existing injury and fatality data systems to allow more detailed analysis of exposure to injury risk for highway construction workers in work zones:
  - In highway crash data systems, distinguish between injuries to workers and injuries to motorists.
  - Continually analyze work zone crash data so that high-risk work zones can be quickly identified, and hazards eliminated.
  - Accurately identify work zones where crashes are occurring by recording a unique identifier (e.g., DOT project code) on documents such as police crash reports.
  - Consider adding time of injury and type of equipment information to the OSHA 200 logs or other data collection forms.
  - Collect information on type of road construction: new, rehabilitation, or maintenance, as well as information on type of work schedule (i.e., regular or compressed work schedules, overtime work, or night work).

## WORKZONE Injury Prevention Measures

- To produce better state-level data on highway work zone injuries and better estimates of worker exposure, coordinate data collection and analysis between state departments of health and transportation. Consider developing injury rates per mile of highway built or maintained.
- Assess work zone-related worker injuries and fatalities on an annual basis and report results through Web and print media.

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