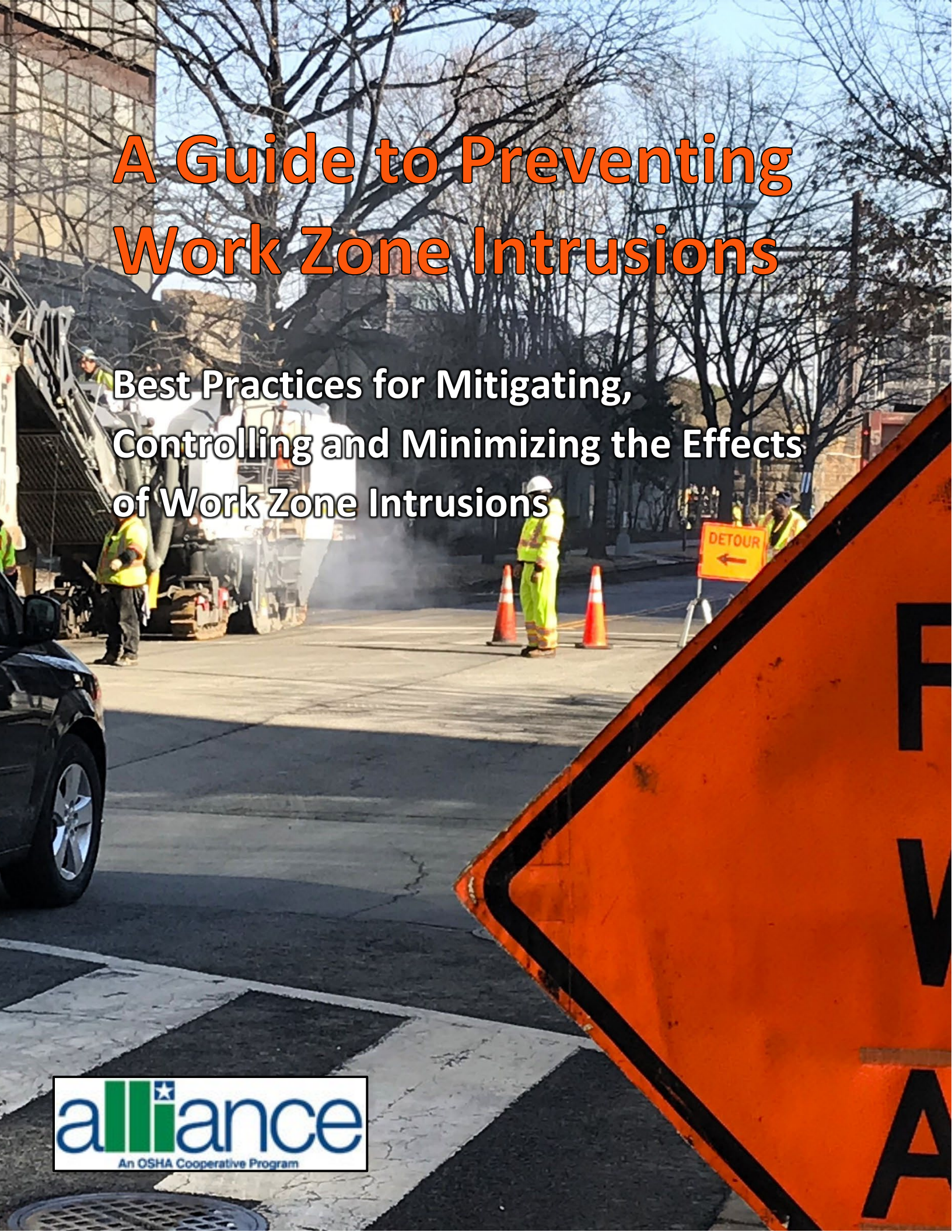
A Guide to Preventing Work Zone Intrusions

Best Practices for Mitigating, Controlling and Minimizing the Effects of Work Zone Intrusions



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Overview

Members of the OSHA Roadway Work Zone Alliance (Alliance) prepared this work zone prevention intrusion guide. It is based on work initiated by the American Road & Transportation Builders Association's (ARTBA) Safety Forum. It is intended to be used as a template for industry organizations to build their own document with company- or organization-specific information and images. Organizations should consider state and local agency policies to ensure their version aligns with these recommendations.

The document is intended for general informational purposes only, and is not a substitute for advice from a qualified professional. It is the employer's responsibility to comply with regulations set forth in federal, state, and local workplace safety standards, including the Occupational Safety and Health Act. In providing this advisory document, the Alliance and its members do not assume the employer's duty to provide its workers with a safe and healthful workplace and are not responsible for the actions or employer-related compliance with this or any other standard.

The OSHA Roadway Work Zone Alliance members include:

ARTBA American Road & Transportation Builders Association

LIUNA TRAINING & EDUCATION FUND

NAPA NATIONAL ASPHALT PAVEMENT ASSOCIATION

International Union of Operating Engineers

LABORERS' HEALTH & SAFETY FUND OF NORTH AMERICA

The Associated General Contractors of Alaska — Skill, Responsibility, Integrity

ISEA INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION

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National Institute for Occupational Safety and Health NIOSH

Through the Alliance between OSHA's National Office and Roadway Work Zone Partners (listed above), this *Guide for Preventing Work Zone Intrusions* was developed for informational purposes only. It does not necessarily reflect the official views of OSHA, the U.S. Department of Labor, or the National Institute for Occupational Safety and Health.

Mention of trade names, commercial products, or organizations does not imply endorsement by the U.S. Government.

Introduction

Vehicle intrusion incidents occur when a vehicle enters the work area. Work zone intrusions are a significant cause of worker deaths and injuries in the roadway and transportation construction industry. According to the Bureau of Labor Statistics (BLS), on average, 60 industry workers are killed annually from being struck by vehicles and equipment in roadway construction zones. While intrusions may be due to driver recklessness, inattention, distraction, or impairment, they may also result from improper temporary traffic control. Controls should not rely on the motorists' assessment of a situation and may need to go beyond the plans and specifications outlined in the Manual on Uniform Traffic Control Devices (MUTCD). This guidance document provides a set of coordinated transportation management strategies and describes how they might be used to manage the work zone during roadway construction projects. Transportation management strategies for a work zone include temporary traffic control measures and devices, safe work practices, training, planning and coordination, and worker protection.

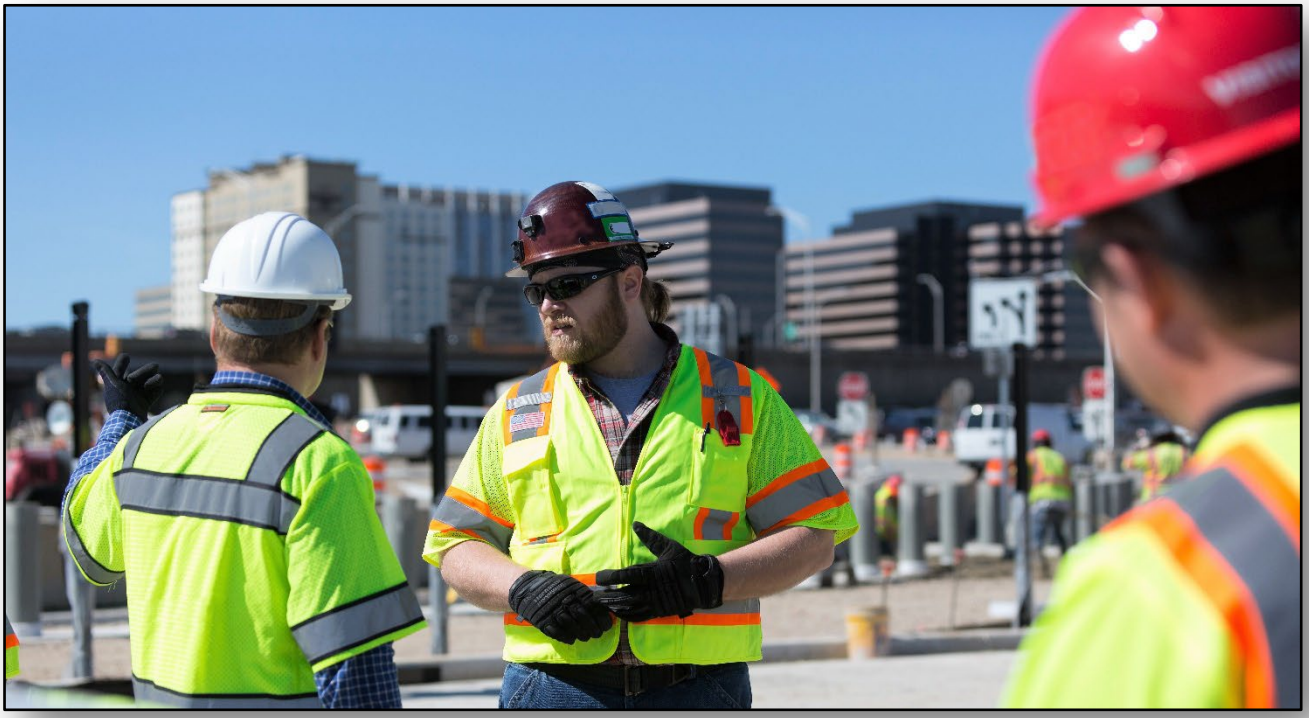
Part 1: Model Practices

Leadership and Management

Effective leadership ensures employees have the training and resources available to mitigate anticipated safety challenges on the job site through management's clear, demonstrated commitment to the

allocation of resources for the implementation of best practices, accountability, training, and personal protective equipment use. Specifically:

- Traffic Control Supervisors should be trained and have certifications in control of traffic as required by the jurisdiction in which they are working. Project managers and engineers should also be trained in work zone traffic control design.
- All management, supervisors, and traffic control personnel associated with construction operations where workers are exposed to traffic should be trained and/or have third-party certification in one or more of the following areas: traffic management and design, temporary traffic control set up and removal, and/or project management safety.
- Company executives should engage with their subcontractors and other site contractors to coordinate safety practices, including temporary traffic control and adequate worker training.
- Site managers should meet with state and local law enforcement agencies to request additional visibility and enforcement presence. Representatives from these agencies should be invited to project safety meetings.
- Additionally, local company management should meet with state associations and local departments of transportation (DOTs) regarding additional safety strategies for improving work zone safety such as temporary concrete barriers or mobile barriers, utilizing rumble strips, deploying law enforcement officers, or setting-up detour routes or road closures.
- At the start-up of a new project, consider sharing information with major trucking companies and state trucking associations and request they communicate with truck drivers about planned work zones and possibly seek alternate routes if available. In some situations, large commercial carriers may need to be re-routed and agencies that issue oversize permits must be notified.



Risk Assessment (Job Hazard Analysis—JHA) / Reduction of Risk

Job Hazard Analysis (JHA)

A JHA identifies the required steps in a particular job or task, the known and anticipated hazards associated with each step, and the controls that will be used to eliminate or mitigate each hazard. The JHA is included in the work plan.

Work Plan

Work Plans must be established for each operation to proactively identify potential exposures to occupational safety or health hazards, assess and prioritize the risks associated with those hazards, and identify the controls necessary to eliminate or mitigate those hazards. Start each shift with a safety meeting to review the operations and associated work plans and identify and control potential hazards and risks, allowing specific and evolving concerns to be addressed frequently. Workers should be trained to recognize potential hazards and have the authority to report hazards and initiate control methods.

Work Zone Risk Assessment

Assess the work site on an ongoing basis including the hazards and changing conditions in the work zone. Everyone on the site must understand the locations within the project work zone where intrusions may occur. The assessment should include:

- Safety processes to be used on-site.
- Specific work zone training for site workers.
- Hazards and risks relevant to the work area and the applicable risk reduction methods.
- Past/potential incidents, injuries and near misses.
- Safety equipment.
- Proper personal protective equipment (PPE) including high visibility clothing.
- A daily meeting between the project supervisor and the project team traffic control supervisor to discuss special concerns, ramp closures, and set up and break down times for the next shift's closure.
- Truck ingress and egress.
- Dedicated spotters who are trained to watch for possible intrusions and report unsafe conditions. Note: Spotters and flaggers are two distinct jobs with different tasks. They should not be combined into one simultaneous role. A flagger is a person who provides temporary traffic control whose attention is focused on motorists and roadway traffic.

Huddles for Safety, Quality, Production, Environmental, and Code of Conduct

Conduct a daily (or more frequent) gathering during which a foreman or crew lead person identifies the hazards and challenges associated with planned tasks. Discuss precautions that will be taken to avoid potential hazards and challenges using the project work plan and associated JHAs.

Other Risk Reduction Methods

At the beginning of each shift, and as conditions change, conduct a brief safety gathering with the onsite crew to discuss the work plan, safety controls, daily goals, and work strategies. These meetings may include briefings on the following site conditions:

- Adjustments to engineering controls such as temporary concrete barriers or mobile barrier devices.
- Variable speed options (where available and appropriate) to temporarily lower the speed of the traveling public.
- Portable rumble strips to alert the traveling public.
- Detours to reroute traffic.
- Law Enforcement.
- Durable copies of traffic control plans (external and internal); provide these to field staff as a reference so they are able to ensure the traffic control installation is compliant with the contract documents, addresses the identified risks, and recognize additional means, methods or processes that may provide intrusion protection.
- Before start-up or during maintenance work, check that all equipment in the work zone is parked in a manner that protects workers from errant vehicles.
- When necessary, temporary traffic control plans should be updated to reflect information learned from these meetings.

Specialized Worker Training

- Train workers to mount and dismount vehicles and equipment on the side away from traffic.
- Provide flaggers, equipment operators, and other crew members with aerosol-type warning horns and/or high-decibel whistles to warn crew members of immediate hazards.
- Train quality assurance (QA) and quality control (QC) personnel as flaggers so they can flag for each other while performing short-term work adjacent to traffic.
- Train all company drivers and hired haulers to stop and sound their truck's air horn when they hear the warning horn.
- Create a process for workers to identify near-misses, correct observed deficiencies, and comply with the safety plan and procedures.

Safe Work Best Practices

- As much as possible, minimize time spent working directly adjacent to traffic.
- Enter and exit equipment on the side away from traffic.
- When traveling on foot in the work zone, deliberately maximize your distance from traffic.
- Never walk down the middle of the lane or within the width of the lane if other options are available.
- Walk on a nearby sidewalk if possible.
- If traffic is on both sides of the closure, walk closest to the side facing oncoming traffic.
- If someone needs to work directly adjacent to traffic, utilize a spotter to watch oncoming traffic. Consider taking an additional lane as a buffer.
- Conduct all breaks, meetings, or idle time in a safe area away from traffic. Ensure a means of safe passage to a safe area away from traffic.
- When maintenance needs to be performed on equipment, move equipment off the roadway and away from traffic or behind protective devices, (i.e., barrier wall).

- In an emergency, if vehicles or equipment cannot be moved off the roadway, position another vehicle with an attenuator directly behind it or close the lane. Contact emergency responders for assistance.
- Use additional channelizing devices whenever possible to tightly close the radius at crossovers, side streets, and driveway entrances.
- Ensure that flaggers position themselves properly on the shoulder or in the safest possible location that is visible to the motoring public for at least 500 ft. (distances may vary depending on speed and other state and local standards).
- Set-up/Take-down Temporary Traffic Control. Ensure temporary traffic control devices provide continuous worker protection throughout the set-up/take-down process.

Technology

There is an expanding array of technological advances for use in the construction maintenance of traffic (MOT) environment. This guide references some of these devices to provide guidance and raise awareness of technological solutions. Research is recommended to ensure implementation of the newest proven methods for protecting employees working next to traffic. Technology should be evaluated on a case-by-case basis.

(See Appendix B for a list of products for consideration.)

One Lane-Two Way Traffic Control

Automated Flagger Assistance Device (AFAD)

AFADs are remote-operated traffic control devices enabling flaggers to be positioned out of the traffic lane(s) and are used to control traffic in advance or within a work zone. These devices are designed to be remotely operated and reduce the number of flaggers required for a project.

When implemented, AFAD operators are only required to be flagger certified according to the MUTCD. An AFAD must be remotely operated by an operator who has been trained and understands the operating procedures of the AFAD in use. When the AFAD is in operation, the operator shall not leave the AFAD unattended for any reason.

Prioritize and use of AFADs in accordance with the policies of the local road authority having jurisdiction over the project. AFADs can reduce risk to employees by reducing their direct exposure to traffic and the potential for an incident.

Portable Traffic Signals

Portable Traffic Signals are independently powered, portable traffic signaling equipment that can be remotely controlled and used to manage traffic as a temporary traffic control in a roadway work zone.

Personal Protective Equipment (PPE)

There are many options to consider when selecting PPE for specific tasks. Below are the items that have been determined to be effective when working next to live traffic. Use the PPE meets local agency requirements and conforms to appropriate American National Standards Institute (ANSI) standards.

Head Protection

When setting or picking up closures, employees are exposed to excess wind while on moving vehicles and being passed by high-speed traffic. Safety or climbing helmets provide head protection and are not as easily dislodged. Industrial hard hats are also available with a chin strap. Employers should contact their PPE provider to discuss options. Select head protection that conforms to ANSI/ISEA Z89.1-2014 (R2019) - the American National Standard for Industrial Head Protection, or the most recent edition of this standard.

High Visibility Clothing

Provide and wear high-visibility clothing that meets U.S. Federal Highway Administration (FHWA) and the U.S. Occupational Safety and Health Administration (OSHA) requirements. Both agencies use the ANSI/ISEA 107 standard as the basis for their requirements. For roadway construction, ANSI/ISEA 107 requires "Type R" Class 2 apparel. For improved nighttime visibility, Class 3, which includes garments with sleeves, is necessary. While the Department of Transportation requires the use of high visibility clothing that conforms to ANSI/ISEA 107-2015, the most recent version is ANSI/ISEA 107-2020. It is always recommended protective and safety equipment conforms to the most recent edition of any American National Standard.

Wearable Lighting

Wearable lighting consists of devices worn by workers during low-light and nighttime operations. Generally, the high visibility garments required for use by workers are augmented by a strobe light wrapped around the hardhat and powered by a battery strapped to the worker. The lights flash around to alert the drivers of the presence of the worker in the night.

Examples:

Halo Light

Halo lights are best used in low-light situations and for people who are walking around inside a soft closure. This adds some additional lighting for completing tasks but is mainly for illuminating the body and making personnel more visible.

Personal Headlamps

Personal headlamps are best used for those working in specific areas or dedicated work that requires spotlighting. These aid in providing lighting while completing a specific task, but also can help make the employee more visible to others.

Vehicle Recommendations

Camera Installation in Work Vehicles

It's best to have multiple cameras installed and well-maintained on the vehicles when completing MOT work to provide visibility at multiple angles.

- **Rear-Facing**: Captures any incidents from the rear. It also captures the actions of the employees on the cone setting operation. This comes in handy for incident investigations, verifying injury claims that were not witnessed, and performance training and review.
- **Forward-Facing**: Captures the driver's actions and any incidents/issues in front of the vehicle. This can be used for incident investigations and to verify any complaint that may be made regarding a driver's actions.
- **Cab-Facing:** This will also capture the driver's action when behind the wheel. This will help reduce the use of handheld devices while driving. It can be used in incident investigations to verify the driver was performing their job function appropriately.
  The use of multiple camaras will assist operators to identify the location of workers who may be laboring near the equipment, especially in blind areas to the rear, passenger side, and immediately in front of the vehicle.

Work Vehicles

All work vehicles entering and exiting traffic must be outfitted with revolving or flashing lights/beacons to improve the communication between construction vehicles and the public. Vehicles should also be equipped with retroreflective tape/sheeting to make them more visible to traffic and alert motorist to their presence. Organizations should be aware of local standards and regulations to ensure lighting is compliant.

Equipment Considerations to Prevent Work Zone Intrusions

- Crash attenuators
- Proper lighting for nighttime operations

- Retroreflective tape and sheeting on tools, vehicles, and other equipment
- Temporary rumble strips
- Speed feedback signage
- Portable, changeable message signs
- Well-maintained and properly deployed channelizing devices
- Positive protective barriers
    - Mobile barriers
    - Movable barriers
    - Concrete, plastic, and steel barriers

Pre-Construction Public Communications

Campaigns can be an effective means to alert the public about construction in an area, encouraging motorists and other roadway users to use alternative routes, plan for delays, and pay attention to the additional hazards associated with roadway construction zones. Public communications may include:

- Billboards
- Radio and TV advertising
- State and local 511 or other public information systems
- Signs promoting worker presence, increased penalties for speeding in work zones, and other warnings
- Use of *law* enforcement/off-duty police presence

Part 2: Model State DOT Practices

There are specific tools and funding mechanisms that state agencies can use to ensure adequate temporary traffic control devices are used to protect workers. For an overview of model state practices addressing work zone intrusion prevention, refer to this table identifying specific tools (e.g., full road closure, general public awareness, innovative use of law enforcement, etc.) by state.

Eligibility of Construction and Highway Safety Equipment Acquisition Costs as a Direct Charge

In a memorandum dated September 8, 2017, FHWA affirmed that if a division administrator determines that the cost of equipment is reasonable and necessary for a federal-aid project(s) and the state provides adequate assurances of a federal highway or transportation interest, the cost of equipment acquisition may be approved as a direct charge. Such an allowance is helpful for equipment such as mobile and movable barriers that can be used for many years, beyond the duration of any single project. (See Appendix A.)

Safety Contingencies

The Infrastructure Investment and Jobs Act (IIJA) also known as the Bipartisan Infrastructure Law (BIL) provided an opportunity for state transportation agencies to create work zone safety contingency funds to pay for additional safety needs on a project that were not anticipated when the project began. Contingency funds are not intended for contract extras or quantity overruns. Change orders are typically used as a mechanism to address unforeseen conditions that arise during construction. Unfortunately, when unexpected traffic safety concerns are identified during the project, the time required for processing and approving a change order may impede efforts to address the safety problems quickly and efficiently. Safety contingency funds can be used to address those needs in a more expedited manner. (See ARTBA/NAPA Work Zone Safety Contingency Fund Q&A)

FHWA Subparts J & K

23 CFR 630.1012 (FHWA's Subpart J) explains payment procedures for transportation management plans as they apply to payment for work zone temporary traffic control items:

§ 630.1012 Project-level procedures.
(c) The Plans, Specifications, and Estimates (PS&Es) shall include either a transportation management plan (TMP) or provisions for contractors to develop a TMP at the most appropriate project phase as applicable to the State's chosen contracting methodology for the project. A contractor developed TMP shall be subject to the approval of the State and shall not be implemented before it is approved by the State.

(d) The PS&Es shall include appropriate pay item provisions for implementing the TMP, either through method or performance-based specifications.
(1) For method-based specifications individual pay items, lump sum payment, or a combination thereof may be used.
(2) For performance-based specifications, applicable performance criteria and standards may be used (e.g., safety performance criteria such as number of crashes within the work zone; mobility performance criteria such as travel time through the work zone, delay, queue length, traffic volume; incident response and clearance criteria; work duration criteria).

23 CFR 630.1102 (Subpart K) further defines the role of the DOT with an overview of the regulation requirements. It explains a primary purpose behind the regulation of temporary traffic control treatments includes "*contract pay items to ensure the availability of funds for these provisions*."

Section 630.1108(f) provides a detailed explanation of how payments should be made for various forms of temporary traffic control:

(f) Payment for Traffic Control. Consistent with the requirements of 23 CFR 630.1012, Project-level Procedures, project plans, specifications, and estimates (PS&Es) shall include appropriate pay item provisions for implementing the project TMP, which includes a Temporary Traffic Control (TTC) plan, either through method or performance-based specifications. Pay item provisions include, but are not limited to, the following:

(1) Payment for work zone traffic control features and operations ***shall not be incidental to the contract*** or included in the payment for other items of work not related to traffic control and safety; *(emphasis added).*

(2) As a minimum, separate pay items shall be provided for major categories of traffic control devices, safety features, and work zone safety activities, including but not limited to positive protection devices, and uniformed law enforcement activities when funded through the project;

(3) For method-based specifications, the specifications and other PS&E documents should provide sufficient details such that the quantity and types of devices and the overall effort required to implement and maintain the TMP can be determined;

(4) For method-based specifications, unit price pay items, lump sum pay items, or a combination thereof may be used;

(5) Lump sum payment should be limited to items for which an estimate of the actual quantity required is provided in the PS&E or for items where the actual quantity required is dependent upon the contractor's choice of work scheduling and methodology;

(6) For Lump Sum items, a contingency provision should be included such that additional payment is provided if the quantity or nature of the required work changes, either an increase or decrease, due to circumstances beyond the control of the contractor;

(7) Unit price payment should be provided for those items over which the contractor has little or no control over the quantity, and no firm estimate of quantities is provided in the PS&Es, but over which the highway agency has control of the actual quantity to be required during the project;

(8) Specifications should clearly indicate how placement, movement/ relocation, and maintenance of traffic control devices and safety features will be compensated; and

(9) The specifications should include provisions to require and enforce contractor compliance with the contract provisions relative to implementation and maintenance of the project TMP and related traffic control items. Enforcement provisions may include remedies such as liquidated damages, work suspensions, or withholding payment for noncompliance.

Pictured above in a Mobile Barrier, a temporary positive protection device designed to guard both workers and other roadway users from construction operations.

Appendix A

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **INFORMATION**: Eligibility of Construction and Highway Safety Equipment Acquisition Costs as a Direct Charge

Date: September 8, 2017

In Reply Refer To:
HIF-1/HSA-1

From: Thomas D. Everett
Associate Administrator for Infrastructure

Elizabeth Alicandri
Associate Administrator for Safety

To: Directors of Field Services
Division Administrators

Purpose

The purpose of this memorandum is to provide guidance to the Federal-aid division offices concerning the eligibility of construction and highway safety equipment acquisition costs as a participating direct charge to a single Federal-aid project when certain conditions are met.

Background

The FHWA's policy for participation in costs associated with equipment acquisition is based on the Uniform Administrative Requirements, Cost Principles and Audit Requirement for Federal Awards in 2 CFR Part 200. States may request participation in such costs through: a) an approved indirect cost rate plan or b) on a project basis through an approved depreciation rate (amortized cost) analysis based on costs that are necessary, reasonable, and allocable to a specific Federal-aid project. Federal-aid funds will participate only in the portion of the amortized cost directly attributable to the time the equipment is used on a specific Federal-aid project.

The FHWA expects that States will continue to follow this general policy. However, the Division Administrator may approve the direct charge to an eligible Federal-aid program funding source for the up-front acquisition cost of equipment if a State's request for prior written consent [2 CFR 200.439(b)(1)] provides sufficient documentation supporting a Federal highway or transportation interest. This direct cost option provides additional flexibility to the States for costs that benefit the Federal-aid highway program.

Guidance

As defined in 2 CFR 200.33, equipment means the tangible personal property (including information technology systems) having a useful life of more than 1 year and a per-unit acquisition cost that equals or exceeds the lesser of the capitalization level established by the non-Federal entity for financial statement purposes, or $5,000. Under these regulations, capital expenditures for equipment used in a Federal grant are generally unallowable as a direct charge to the Federal grant program except with the prior written approval of the Federal awarding agency.

If a State requests to charge the full cost of equipment acquisitions as a direct charge to a single project rather than allocating the amortized acquisition costs over the useful life of the equipment, it must provide FHWA with adequate assurances that there is a Federal highway or transportation interest in doing so. These assurances include:

- A certification that the equipment will be used on an authorized Federal-aid project within 3 months.
- A certification that the equipment will be used for its intended purpose over the useful life of the equipment. The certification must include a discussion on the expected useful life of the equipment and the annual number and types of projects that would benefit from the use of this equipment.
- A certification that the contracting agency has in place sound internal controls for documenting and monitoring its efficient use on eligible activities. The Division Administrator may require a report from the State documenting the use of the equipment as part of its monitoring program.
- A certification that the equipment will be maintained and not lie idle for extended periods of time making it inefficient as a direct cost activity.
- Evidence that adequate internal controls are in place and reasonable assurances that Federal-aid funds are not participating in unallowable costs.

The State must also provide documentation concerning compliance with FHWA's construction contracting requirements related to equipment, including but not limited to:

- Use of publicly owned equipment (23 CFR 635.106),
- Material or product selection requirements (23 CFR 635.411), and
- Buy America requirements[1] (23 U.S.C. 313 and 23 CFR 635.410).

If the Division Administrator determines that the State's request is eligible and approves the request, the approval must be provided by the Division Administrator in writing and may not be delegated. If direct cost participation is not supported, States may continue to perform an amortization of purchase costs as is normally done for equipment and assign the allocable costs to the projects, utilizing an approved equipment usage rate.

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[1] The Buy America provisions of 23 U.S.C. 313 apply to any obligation of funds under Title 23, and therefore FHWA's Buy America requirements apply to all Federal-aid projects, not just highway construction projects.

If direct cost participation is approved, a separate Federal-aid project must be established for the sole purpose of acquiring equipment. The contracting agency must certify that the equipment will be used in accordance with the eligibility criteria for the applicable Federal-aid funding.

National Highway Performance Program and Surface Transportation Block Grant Program Projects

The FHWA participates in the costs of construction as defined in 23 U.S.C. 101. This includes all costs incidental to the construction or reconstruction of a highway on Federal-aid projects. The costs of equipment used in highway construction, or equipment used by the State to administer the Federal-aid project, are eligible project costs. However, the equipment must be necessary for the implementation of a Federal-aid project. Examples of equipment that may meet eligibility criteria as a direct charge under certain conditions include the acquisition of equipment used to construct the project or equipment used by the contracting agency to administer the project. National Highway Performance Program and Surface Transportation Block Grant Program funds cannot participate in unallowable costs, such as routine maintenance or law enforcement that is typically performed with State funds (or projects where there is no Federal highway or transportation interest).

Highway Safety Improvement Program (HSIP) Projects

In certain circumstances, the FHWA Division Administrator may approve HSIP funding for the direct charge of equipment as a highway safety improvement project, provided the activity is consistent with the State strategic highway safety plan (SHSP), and: (i) corrects or improves a hazardous road location or feature; or (ii) addresses a highway safety problem [23 U.S.C. 148(a)(4)].

The specific HSIP eligibility criteria are clarified in the HSIP Eligibility Guidance, dated February 26, 2016. One of the basic foundations of the HSIP is the direct linkage between the data-driven priorities established in the SHSP and the identification, development, and implementation of HSIP projects, specifically listed in 23 U.S.C. 148(a)(4)(B). The purpose of the linkage is to ensure that the limited HSIP funds are used effectively to achieve a significant reduction in traffic fatalities and serious injuries on all public roads.

After the initial purchase of the equipment using HSIP funds, the State may use the equipment for its intended safety purpose on any public road (including local roads) for any project (e.g. Federal-aid or non-Federal-aid, capital improvement or maintenance, etc.).

Summary

In summary, if the Division Administrator determines that the cost of equipment is reasonable and necessary for a Federal-aid project(s) and the State provides adequate

assurances of a Federal highway or transportation interest as described above, the cost of equipment acquisition may be approved as a direct charge. Otherwise, States may continue to perform an amortization of purchase costs as is normally done for construction equipment.

If you have any questions about this policy, please contact Gerald Yakowenko, Team Leader, Office of Program Administration (202-366-1562) or Karen Scurry, Office of Safety (609-637-4207).

Appendix B – Work Zone Intrusion Prevention Devices

There are several technologies, both in use today and experimental, that provide additional protection to mitigate the impact of vehicle intrusions in work zones. These include positive protection devices, worker warning systems, and driver warning systems.[1] Provided below are summary descriptions of technologies that are being used in work zones and technologies that are under research and development. The reader is directed to the original source document (See footnote 1) for further details.

1. **Positive Protection Devices**
    a. **Autonomous Truck-Mounted Attenuators:** Automated equipment with truck-mounted attenuators are highly automated vehicles meant to operate in the work zone without a human operator. For example, there are automated vehicles that follow behind a lead vehicle. These automated trailing vehicles are used as an unmanned mobile crash barrier, absorbing the impact of traffic which enters the work zone during slow-moving highway operations such as line painting or sweeping. (Example: ATMA from Kratos Defense.)
    b. **Mobile Barriers:** A mobile barrier is a mechanical system that serves as a barrier between passing vehicles and the work zone. Mobile barriers are easy to set up and remove in and around short-term work zones during peak traffic hours. Mobile barriers are useful during the daytime and nighttime as some of the barriers have a lighting system and a dynamic message sign attached. A crash attenuator may be attached to provide a cushion for the impact of vehicles at the rear end of the truck. (Example: MBT from Mobile Barriers)
    c. **Automated Flagger Assistance Device:** An automated flagger assistance device (AFAD) is a mobile unit with signal lights or stop/slow signs to alert vehicles to stop or proceed and a mechanical gate system that provides an alert to drivers. Audio systems, while not a standard feature, can be installed to provide audio feedback in case a vehicle moves forward during a stop sign. The AFAD is a mechanically operated temporary traffic control device set up around work zones and is operated automatically with the programmed setup for the duration of stops and movements. (Example: SQ2 from Horizon Signal)

2. N**etworked Systems for Workers**: A class of technologies that directly support the safety of workers through various devices connected to a central communication system or stand-alone system unit and placed on work zone channelizing devices or worn by the workers as a personal wearable safety device.
    a. Work Zone Intrusion Technology (WZIT), including equipment-mounted sensors, are a category of intrusion alert systems that utilize a single technology or multiple technologies such as radar (scanned radar), high precision differential GPS system, accelerometers, gyroscopes, and magnetometers, for position and orientation sensing to detect vehicle intrusions. (Example: AWARE System from CRH.)
    b. Cone/barrel-mounted sensors use sensors embedded in the devices and generally are impact-activated work zone intrusion devices. The intrusion devices are mounted on a

[1] Gambatese, Louis, Nnaji, Guide to Alternative Technologies for Preventing and Mitigating Vehicle Intrusions into Highway Work Zones (2022), Transportation Research Board, ISBN 978-0-309-68706-5 | DOI 10.17226/26625

cone/barrel and generally are activated when a vehicle hits the cone/barrel during the intrusion impact. (Example: SonoBlaster from Transpo Industries.)

c. Networked cone or barrel system with sensors is a class of technologies that refers to systems in which channelizing devices like cones and barrels are equipped with sensors and wireless technologies to detect intrusions and provide warnings to workers. The Intellicone system, a portable site alarm (PSA) powered by motion sensitive and communications-based technologies, is an example of such a system. The device utilizes General Packet Radio Service/Global System for Mobile (GPRS/GSM) communications and GPS sensors. (Example: Intellicone from Highway Resource Solutions.)
d. Pneumatic WZIT systems utilize pneumatic tubes connected to a transmitter, and the tube activates its alert mechanisms, such as an alarm siren or a strobe light. The tubes are placed parallel to the road shoulder at the entry point to the work zone. The alert mechanisms are activated when a vehicle passes over the pneumatic tube. (Example: Worker Alert System from Astro Optics.)
e. Bluetooth enabled WZIT system contains a network of Bluetooth zones that function as an intrusion alert system. Several devices utilize the Bluetooth low-energy (BLE) based proximity sensing and alert system, which uses adaptive signal processing (ASP) methods to communicate between the Bluetooth zones. This application not only extends to detect close proximity sensing, but the automated collection of information enables sharing e-notices to drivers and diverting traffic flow. (Example WorkzoneAlert App.)
f. Computer vision and ranging is a class of technologies that utilizes computer vision and ranging with the use of cameras, Internet of Things (IoT), and LiDAR to provide real-time auditory or visual feedback to workers in the work zone. The computer vision and ranging generally utilizes artificial intelligence and machine learning to continuously learn about the environment, keep track of the objects within the range, learn about the physical attributes, assess the danger or threat, and provide real-time feedback to the user. (Example SmartCone from SmartCone Technologies.)
g. Smartwatches are electronic watches with the capability to connect to a wireless system through Bluetooth and Wi-Fi systems and enable the user to read messages and get alerts or warnings through flashing lights or vibration. An application of the smartwatch integrated with a network of Bluetooth zones was seen in a long-term work zone configuration. The vehicles were equipped with a Bluetooth signal emitter chip where there were Bluetooth receiver chips along the work zone boundary. When the Bluetooth emitter-enabled vehicle came close to the receiving Bluetooth zones, a message alert and a vibration was sent to workers wearing the smartwatches. This communication enabled a timely alert of a threat and a head start for the workers to respond in the situation.

3. **Driver Warning Systems:** This is a class of technologies that provide vehicle drivers with early notification about an upcoming work zone.
    a. Dynamic message signs (DMSs) have been employed in highway work zones in the United States as a temporary traffic control (TTC) device for many years. DMS use has proven to be effective in decreasing mean vehicle speed before the work zone. Speed reductions are achieved through numerous changes in the message, such as a graphical images or sequential messages displayed instead of a text-based message, radar attached to the message sign that allows notifying the drivers of their speeds, and a change in the rate of flashes per minute to socially influence the vehicle drivers.

b. Queue warning systems (QWSs) alert vehicle drivers to an impending traffic queue by transmitting electronic messages to portable changeable message signs and providing a warning to vehicle drivers at the upstream location of the construction zone. Another feature is that it alerts vehicle drivers to slow down owing to traffic ahead or to take a detour to save time before reaching the starting location of the traffic queue. When networked with a cone/barrel mounted WZIT device, the system could be used for work zone intrusion prevention and mitigation.
c. An unmanned aerial system (UAS) is a completely mechanical aircraft system consisting of three system components: (1) an autonomous or human-operated control system that is usually on the ground or a ship, but may be on another airborne platform; (2) an unmanned aerial vehicle (UAV); and (3) a command and control (C2) system, which sometimes is referred to as a communication, command, and control (C3) system to communicate with the remote user. UAVs and a camera system provide real-time traffic monitoring with high temporal and spatial resolution that helps to dynamically manage the work zone by interacting real-time with changeable message boards, driver mobile phones, a traffic management center, or a law enforcement agency.

Other Products

Pi-Lit: (pi-lit.com)
Pi-Lit offers several products that help make road work more visible. Sequential lighting solutions (smart lights), cloud-based products and traditional lighting solutions.

SAWS: (sawsinc.net)
SAWS is an early warning system designed to help minimize incidents in construction zones by using traffic radar sensors. This system helps alert drivers in the construction zones to stop, yield or be aware of approaching dangers.

iCone: (iconeproducts.com)
iCone products can provide real-time information on traffic patterns, strike alerts on attenuators or other devices and serves as a warning device to travelers who use online navigation systems.

Ver-Mac Video System: (ver-mac.com)
- High-definition camera with integrated Wi-Fi and GPS
- Mounts to the windshield
- Powered from the vehicle battery with an auxiliary and a plug-in adapter.
- Automatically downloads videos when the camera is in Wi-Fi range of the base station.
- Multiple cameras on one server