ADVANCED WORK ZONE TRAINING

Revised: September 2010

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Advanced Work Zone Course Overview

- Safety and mobility policy
- Fundamental principles of work zones
- Traffic Control Standards
- Use of the engineering policy guide for work zones
- Components of a temporary traffic control zone
- Types of operations
- Type of acceptable devices
- Crashworthiness standards
- Quality requirements of devices
- Special applications
- Speed limit requirements
- Documentation and inspections

Advanced Work Zone Course Objectives

- Discuss work zone safety and mobility policy
- Identify the different components that make up a temporary traffic control zone
- Describe each step involved in temporary traffic control zone operations
- Apply temporary traffic control devices in accordance to the EPG and MUTCD
- Recognize temporary traffic control device quality requirements
- Apply traffic control plans to site conditions, through inspecting, monitoring traffic controls, and changing traffic control devices indicated by traffic incidents
- Access the legal consequences of action or inaction relative to work zone traffic control and identify risk management procedures

Introduction

On any given day, the Missouri Department of Transportation (MoDOT) has at least 100 work zones on the highway system. This number increases threefold in the summer months. MoDOT is committed to providing safe and efficient movement of both motorized and non-motorized traffic through or around temporary traffic control work zones and providing protection for workers and equipment located within those work zones. MoDOT focuses its resources to emphasize roadway visibility in temporary traffic control work zones and traffic flow through those work zones. While work zone traffic accident statistics have been on a steady decline since 2002, there is still a need to reduce the number of accidents in work zone. In 2009 Missouri experienced:

- 2,085 work zone crashes
- 645 work zone injuries
- 12 work zone fatalities

The desired end-results of MoDOT's efforts is to reduce work zone incidents and travel time while providing safer work zones with minimal impact on the traveling public. (MoDOT has continued to see a steady decline in the amount of work zone fatalities, injuries, and crashes every year since 2002).

To better educate those responsible for designing and managing temporary traffic control in work zone safety considerations, MoDOT has created this course, "Advanced Work Zone Training" (AWZT). The course is the third part of a curriculum pertaining to work zones. Upon completion of the course, the participants will be certified as a "Work Zone Specialist" (WZS). MoDOT will have a WZS involved in every aspect of the traffic control plan from preliminary to post-construction work.

The WZS' actions directly impact the mobility and safety of a work zone. The WZS is responsible for knowing applicable standards, guidelines, interpreting plans, specifications, coordinating temporary traffic control requirements, meeting the requirements of the contract or field operation guidelines, and supervising traffic control personnel.

The AWZT consists of four (4) parts including three (3) learning sessions and a project. The subjects will range from reviewing MoDOT's work zone policies, traffic control devices, basic plan reading, work zone inspections, tort liability, etc. The class will be broken into groups which will work on a three-phase project ending in a presentation. Each portion of the project utilizes the information and tools the participants will learn through the class. Each participant's comprehension of the course material will be tested at the end of class. **NOTE: This class is federally mandated and was implemented in October 2007.**

Module 1: Work Zone Policy

Work Zone Safety and Mobility Policy

MoDOT is committed to providing safe and efficient movement of both motorized and non-motorized traffic through or around temporary traffic control zones and protecting workers and equipment located within those areas. As such, MoDOT focuses on the visibility of temporary traffic control devices and traffic flow through work zones located on the state highway system. Our staff's and partners' attention to improved work zone visibility and mobility, from the preliminary planning stages through the end of all work, results in safer work zones with minimal impact on the traveler - a benefit to all.

Goals

Compliance with the guidelines enables MoDOT and its partners to meet the following work zone goals:

1. Provide an environment conducive to roadway user and worker safety.
   - Work toward zero work zone fatalities
   - Reduce crashes in all types of work zones
2. Minimize impact of work zones on roadway user
   - Limit traffic delays to 15 minutes or less
   - Provide customers real-time work zone information

Guidelines

The two purposes for establishing a temporary traffic control zone while working within the highway right of way are:

1. To provide for the safe and efficient movement of both motorized and non-motorized traffic through or around the workspace
2. To provide protection for workers and equipment located within the workspace.

Work in or adjacent to the highway does violate traffic expectations and is performed in vulnerable conditions. However, a properly designed and executed temporary traffic control plan will enable the temporary traffic control zone to provide the above noted functions in the most effective manner possible.

Each person whose actions affect temporary traffic control zone safety, from the upper-level management through field workers, should receive training appropriate to the job decisions each individual is required to make.

Fundamental Principles

Motorized and non-motorized traffic and worker safety is an integral and high-priority element of every incident management, maintenance, permit, and utility operation. Consideration of the following principles should enhance the safety performance of the temporary traffic control zone.

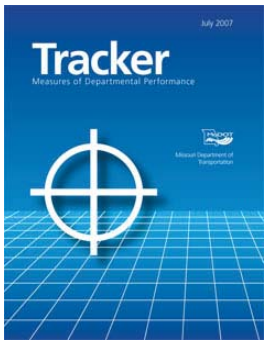
- Prepare a temporary traffic control plan and communicate it to all responsible parties prior to occupying the site
- Provide those whose actions affect the temporary traffic control zone with training appropriate to their level of responsibility
- Employ the same basic safety principles used to design permanent roadways
- Avoid frequent or abrupt geometric changes
- Minimize delay and disruption
- Schedule and coordinate operations according to MoDOT Work Zone Guidelines
- Provide adequate warning, delineation and channelization in advance of and through the affected area
- Provide positive guidance
- Provide for safe operation of work
- Encourage use of alternative routes
- Assume drivers will only reduce their speeds if they clearly perceive a need to do so
- Provide for reasonably safe passage of bicyclists and pedestrians
- Provide recovery areas where practical
- Coordinate operations with those having jurisdiction over any affected cross-streets, railroads or transit facilities
- Ensure continuation of emergency services
- Communicate with and provide reasonable accommodations for adjoining property owners
- Ensure temporary traffic control devices used are effective, in good working order and reasonably consistent with the traffic control plan
- Monitor performance of the temporary traffic control and modify as needed
- Inspect and maintain temporary traffic control devices
- Remove, cover or turn, and turn off all unnecessary temporary traffic control devices
- Maintain a record of any crashes or incidents
- Store unused equipment and material in such a manner as to reduce the probability of being hit
- Involve the media to assist in information dissemination

Responsibilities

MoDOT employee's (field operation forces, construction inspectors, design personnel, district and Central Office staff); contractors; permittees; law enforcement personnel; product vendors; manufacturers; and suppliers play a vital role in ensuring work zones are safe and efficient. Examples of these responsibilities include:

- Conduct analyses to identify work zone impacts to traffic flow and safety
- Identify strategies to minimize impact and maximize awareness of work zones
- Use innovative contracting and bidding options to reduce construction time
- Set appropriate work zone speed limits
- Incorporate innovative technologies to improve traffic flow through work zones
- Coordinate lane closures to maximize traffic capacity and minimize disruption
- Designate a trained person at the project/work level who has the primary responsibility, and sufficient authority, to implement the transportation management plan (TMP) and other safety and mobility aspects of the project/work
- Verify all personnel are trained in traffic control to a level commensurate with their responsibilities
- Ensure work zones are maintained in a neat, orderly, and effective manner
- Improve traffic control measures, as needed, to address field conditions pertaining to traffic flow, visibility and workers and motorist safety
- Perform quality assurance reviews of work zones to promote consistency and ensure compliance with policies and guidelines
- Identify successes and areas of improvement and share that information with appropriate personnel

Measurements



An important factor in evaluating the department's performance in temporary traffic control design, deployment, operation, and maintenance are the measurements of our work zones affect on mobility and safety. These measures track how well the department meets its customer expectations of work zones on state highways.

MoDOT reports quarterly on its ability to provide safe, effective, and efficient work zones via three (3) Tracker measures. These measures relate to the department's tangible results of Uninterrupted Traffic Flow, Roadway Visibility, and Safe Transportation System are:

- "Percent of Work Zones Meeting Expectations for Traffic Flow"
- "Percent of Work Zones Meeting Expectations for Visibility," and
- "Number of Fatalities and Injuries in Work Zones"

NOTE: For additional guidance on work zones, refer to MoDOT's Work Zone Safety and Mobility Policy.

Module 2: Work Zone Standards

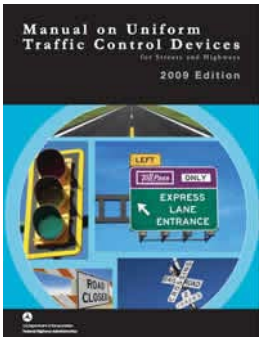
Traffic Control Plan

A traffic control plan describes temporary traffic control measures to be used for facilitating the movement of traffic through a temporary traffic control zone. It plays a vital role in providing continuity of safe and efficient traffic flow when a work zone or an incident area temporarily disrupts normal traffic flow.

Several temporary traffic control plans, referred to as typical applications, are included in this manual. These plans are also referenced in 616.1 Preparation of Traffic Control Plan (TCP) and depict the most common applications of temporary traffic control devices used in highway-related operations.

There are two (2) sources of information regarding temporary traffic control requirements for work on Missouri's state highway system. They include the Federal Highway Administration's Manual on Uniform Traffic Control Devices (MUTCD) and MoDOT's Engineering Policy Guide (EPG). Key factors to designing a temporary traffic control plan should, provide positive guidance, be sensitive to the road user's needs, and minimize congestion and delays.

Manual on Uniform Traffic Control Devices (MUTCD)



Part 6 of the MUTCD sets forth minimum temporary traffic control standards to be implemented on the nation's highways. MoDOT elects to use this document as the standard for all permit or utility work on our state highways to provide an easy reference manual to those performing this type of work in multiple states. This allows parties some flexibility in choosing to use certain devices and equipment in their work zones and the physical and design aspects of those items as long as they comply with the MUTCD, including crashworthiness requirements, and the fundamental principles and responsibilities noted in Module 1.

MoDOT Engineering Policy Guide (EPG)

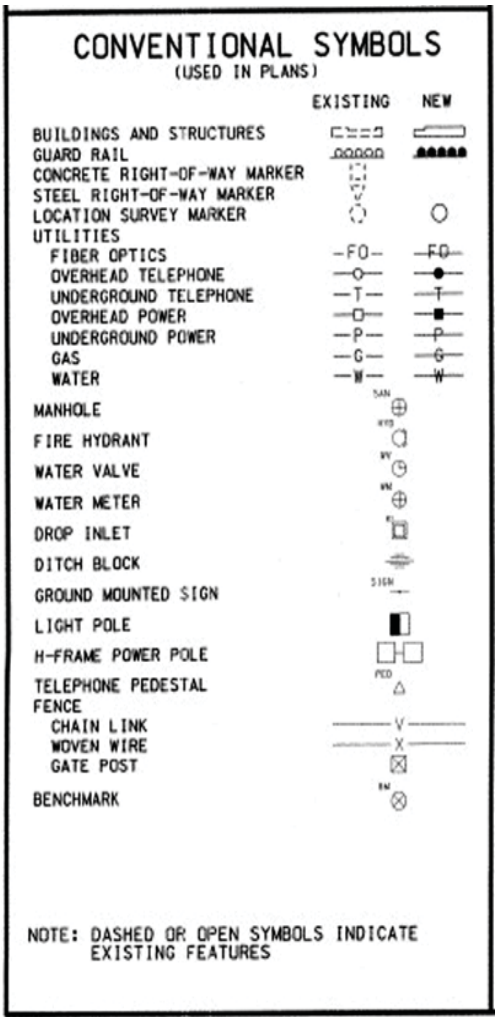
MoDOT's EPG provides guidance on the implementation of temporary traffic control measures by MoDOT's field personnel. The guidelines are based on the standards provided in Part 6 of the MUTCD, but incorporate certain MUTCD allowances and department recommendations to improve work zone safety and mobility. The temporary traffic control set-ups shown in the EPG are typical and may, as field operations require, be adjusted per those guidelines. The EPG applies to all operations performed by MoDOT staff on the state highway system.

Link: **wwwi/intranet/tr/ttc/opt_fo_manual.htm**

Module 3: Basic Plan Reading

A Traffic Control Plan (TCP) is a set of drawings and notes detailing the temporary signing, striping, and other traffic control devices to be set up on a specific project. These plans are consistent with the complexity of the project. A TCP can be very simple such as a Typical Application or very complex, depending on how much a particular job might impact the road user. It is the WZS responsibility to interpret the TCP, implement it in the field and adjust it for field conditions by the safest possible manner.

Parts of a Typical Traffic Control Plan



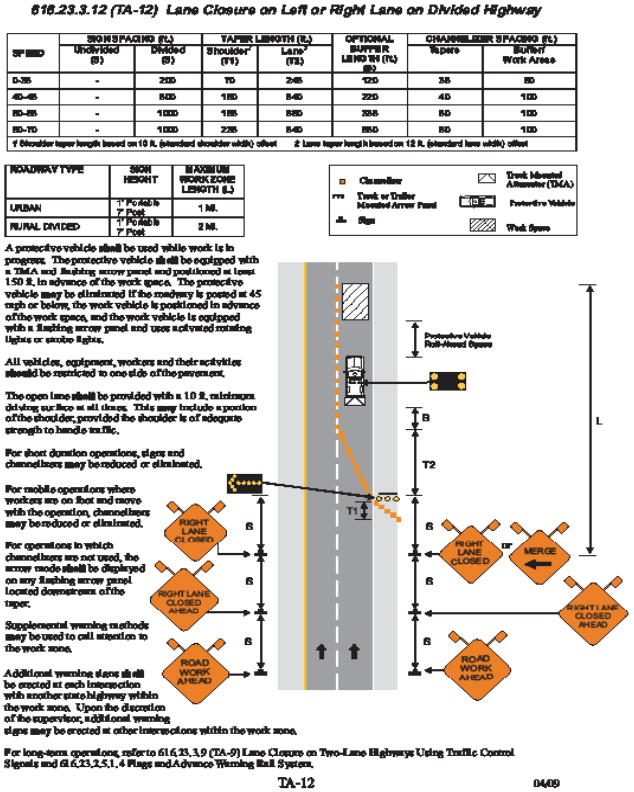
- **Title Sheet** – This the very first sheet in a set of plans. The title sheet contains the legend of symbols used in that set of plans. The title sheet also contains an index of the plan sheets. The index is important for finding the appropriate information whether it be traffic control, drainage, bridges, etc. The title sheet is also where you will find the name and signature of the engineer of record.
- **Title Block**- This is where you find project-specific information including the route, county, project number, and the contract number.
- **North Arrow**- There is a North arrow on every plan sheet. The North arrow helps you orient the plan by identifying which way the plan lies in relation to the direction, North.
- **Legend**- The legend is where you'll find the symbols used on the plan sheets and their meaning.
- **Match Lines**- Match lines identify where separate drawings may be connected to form a single drawing when the drawing extends over multiple pages.
- **Break Lines**- Break lines are used to indicate an area where geometric conditions do not change or areas of insignificance.
- **Station**- Stationing is the conventional way of identifying distances along the roadway, (usually along the centerline) marking each 100' interval in a 0 + 00 format. Look for equations, which are used occasionally to call out breaks in the stationing, which will need to be accounted for when determining the correct distance between two (2) points (stations) along the roadway. Permanent field markings may be in place on some roadways.
- **Graphic Scale**- Because plan sizes often change, a graphic scale is provided to estimate distances.

Typical Applications contain the most common temporary traffic control plans needed for work accomplished within highway right of ways. These typical applications feature information on and a schematic of how the temporary traffic control zone is set up. ***Current Typical Applications can be found on the main page of the EPG/TCFO article 616.23. Here the Typical Applications (pdf format) can be viewed and or printed.***

Supervisors should exercise discretion in the application of these guidelines and typical applications, as deviations may be necessary due to conditions and requirements of a particular site or jurisdiction. Many variables, such as work location, work duration, work type, time of day, weather conditions, road type, geometrics, vertical and horizontal alignment, intersections, interchanges, traffic volumes, traffic mix and traffic speed affect the needs of each zone. Therefore, it may be necessary to modify, enhance or combine typical applications to provide adequate temporary traffic control for a particular situation. If a situation is encountered where none of the typical applications provided can be easily adapted for use, consult the appropriate engineering staff or their designee for assistance to develop a temporary traffic control plan specific to the field condition.

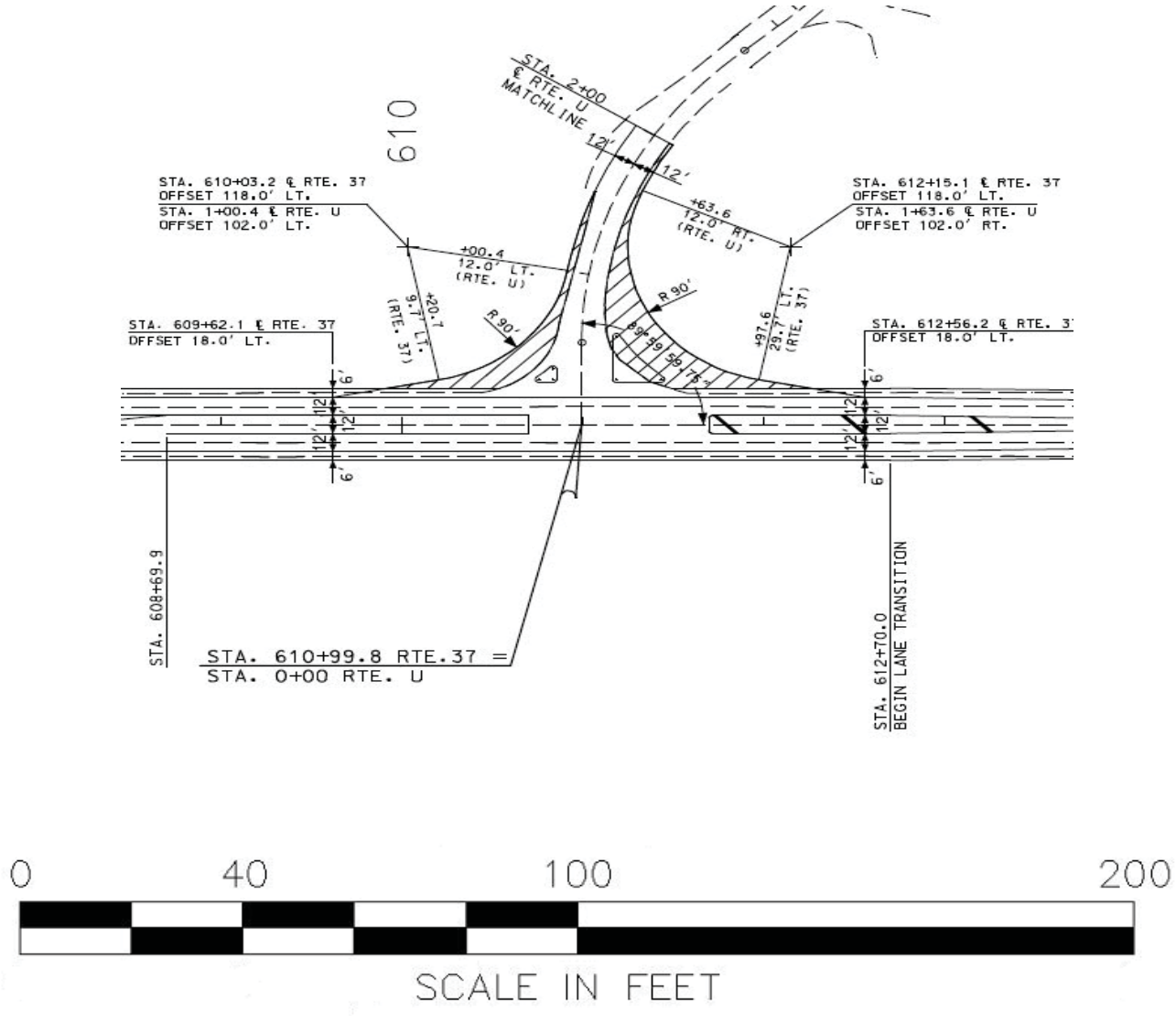
Key Terms

May – permitted
Should – strongly recommended
Shall – mandatory



Golden Rules of Plan Reading: ***"READ THE NOTES"***

When reading a plan, it is important to read the notes. They may contain important information, details, exceptions and clarifications. Designers use notes to be specific about a particular item.



Transportation Management Plan

The Transportation Management Plan (TMP) consists of strategies to manage the work zone impacts of a project. The TMP may include only a Traffic Control Plan (TCP) on non-significant projects. For projects that have been determined to have a significant impact on the driving public the TMP should include TCP, Transportation Operations (TO), and Public Information (PI) components.

Transportation Operations (TO)

The TO component of the TMP identifies strategies that will be used to mitigate impacts of the work zone on the operation and management of the transportation system within the work zone impact area. Typical TO strategies may include, but are not limited to demand management, corridor/network management, safety management and enforcement, and work zone traffic management. The scope of the TO component will be determined by the project characteristics and the transportation operations and safety strategies. Some examples of TO are capacity, detours, ingress/egress, emergency vehicles, traffic generators, law enforcement, and motorist assist.

Public Information (PI)

The PI component of the TMP communicates strategies to inform affected road users (e.g., the general public, area residents, businesses, and appropriate public and transportation association entities) about the project, the expected work zone impacts of and the changing conditions on the project. The scope of the PI component is determined by the project characteristics and the public information and outreach strategies identified through the use of the traffic management strategy matrix. Public information should be provided through methods best suited for the project and may include, but are not limited to, information on the project characteristics, expected impacts, closure details, commuter alternatives and other traveler information strategies. Some examples of PI are direct mailing, radio, web site, public discussions, news releases, and Portable Changeable Message Signs.

The TMP should be developed and implemented in sustained consultation with all stakeholders (e.g., other transportation agencies, railroad agencies/operators, transit providers, freight movers, utility suppliers, police, fire, emergency medical services, schools, business communities and regional transportation management centers, etc.).

Traffic Management Strategy Matrix

To facilitate the development and continual improvement of the TMP, a traffic management strategy matrix has been developed and should be used throughout all phases of a project, from the preliminary development stage to final construction of a project. The traffic management strategy matrix addresses key components and identifies corresponding strategies to manage the work zone impacts of a project. Thereby assisting in developing the TMP components. Link to the strategy matrix **http://wwwi/intranet/tr/ttc/programs.htm**

General Public Information

In addition to the work zone specific Public Information activities, MoDOT provides general work zone information to the public through various outlets including publication of a statewide work zone map and work zone driving safety tips, posting of current work zone locations and conditions to the Internet, promotion of Work Zone Safety Awareness Week, and advertisement of work zone safety-related messages via radio, television, and billboards. Through these efforts, MoDOT positively influences work zone safety and mobility, by helping motorists access information they need to plan their trips and become more work zone conscious.

Module 4: Highway Type and Capacities

Traffic Capacity (Hourly Volume Restrictions)

In planning work on highways, it's important to consider traffic volume. Traffic volumes help determine time of work with minimum disruption to traffic and allows you to gauge the measures necessary to inform the traveling public or mitigate traffic backups when that work can't be done in those specific time frames. The following are traffic capacities for typical highways.

Interstates and Freeways

Interstates and freeways are high-volume multiple-lane routes divided by medians. These routes carry the largest volumes of traffic, and depending on the number of lanes, can affect thousands of vehicles per hour. By using the appropriate work zone guidelines on these roadways, the biggest work zone improvements can be made. The Highway Capacity Manual provides traffic-capacity information for urban freeway work zones. This information may also be used for rural freeways and interstates.
The most common interstate and freeway work zone situation in Missouri is where one of two (2) lanes are closed in a direction.
Where there are three (3) lanes in one direction and one is closed, or where there are four (4) lanes with one or two (2) lanes closed, the open-lane capacity is approximately 1,450 vehicles per hour per lane. Strategies to reduce effects on the motoring public should be considered when traffic volumes approach 75 percent of the restricted capacity, or 1,100 vehicles per hour per open-lane.

Roadway Capacities

Work zones limit the amount of traffic that can travel a roadway because of reduced speed limits, closed lanes and additional driver distractions. The following guidelines address these issues with different types of state routes to improve conditions while ensuring safety is the top priority.

The following table shows various open-lane and closed-lane scenarios with the expected vehicle capacities.

Interstate & Freeway Lane Conditions		Capacity Restrictions		Cautionary Zone	
Total number of lanes	Number of open lanes	Vehicles per hour per lane	Total capacity in open lanes	Vehicles per hour per lane	Total capacity in open lanes
3	1	960	960	750	750
2	1	1240	1240	1000	1000
5	2	1320	2640	1000	2000
4	2	1420	2840	1100	2200
3	2	1430	2860	1100	2200
4	3	1480	4440	1100	3300

Multi-Lane Roadways

Undivided multi-lane roadways also have more than one lane per direction. However, because most do not have medians, they must be treated differently than interstates and freeways. The work-zone capacity of multi-lane roadways is approximately 1,000 vehicles per hour per open lane. Strategies to reduce effects on the motoring public should be considered when volumes approach 80 percent, or 800 vehicles per hour per open lane.

Divided multi-lane roadways that are in rural settings with limited access points should be treated like interstates, while such facilities in urban settings with numerous access points should be treated like undivided multi-lane roadways.

Two-Lane Roadways

Work zones for two-lane roadways need to be reviewed on a case-by-case basis. Although these routes have the lowest traffic volumes, they do not have medians and may have narrower shoulders and more curves than higher-volume routes. Strategies to reduce effects on the motoring public should be considered when volumes from both directions approach 600 vehicles per hour.

The capacities provided above are estimates and may be adjusted based on past experience, lane widths, truck volume, geometrics, lane usage, etc.

Traffic capacity numbers for a roadway are available in the Traffic Management System (TMS).

Type of Highway

Considerations are to be made as to the type of highway where the temporary traffic control is to be used. There are three (3) types of highways to consider.

- **Urban** - Area within the limits of incorporated towns and cities where the posted speed is 60 mph or less.
- **Rural Divided -** Highway with physical separation of traffic in opposite directions. Area generally characterized by lower volumes, higher speeds and fewer turning conflicts and conflicts with pedestrians. Includes unincorporated areas designated by community boards.
- **Rural Undivided -** Highway with no physical separation of traffic in opposite directions. Area generally characterized by lower volumes, higher speeds and fewer turning conflicts and conflicts with pedestrians. Includes unincorporated areas designated by community boards.

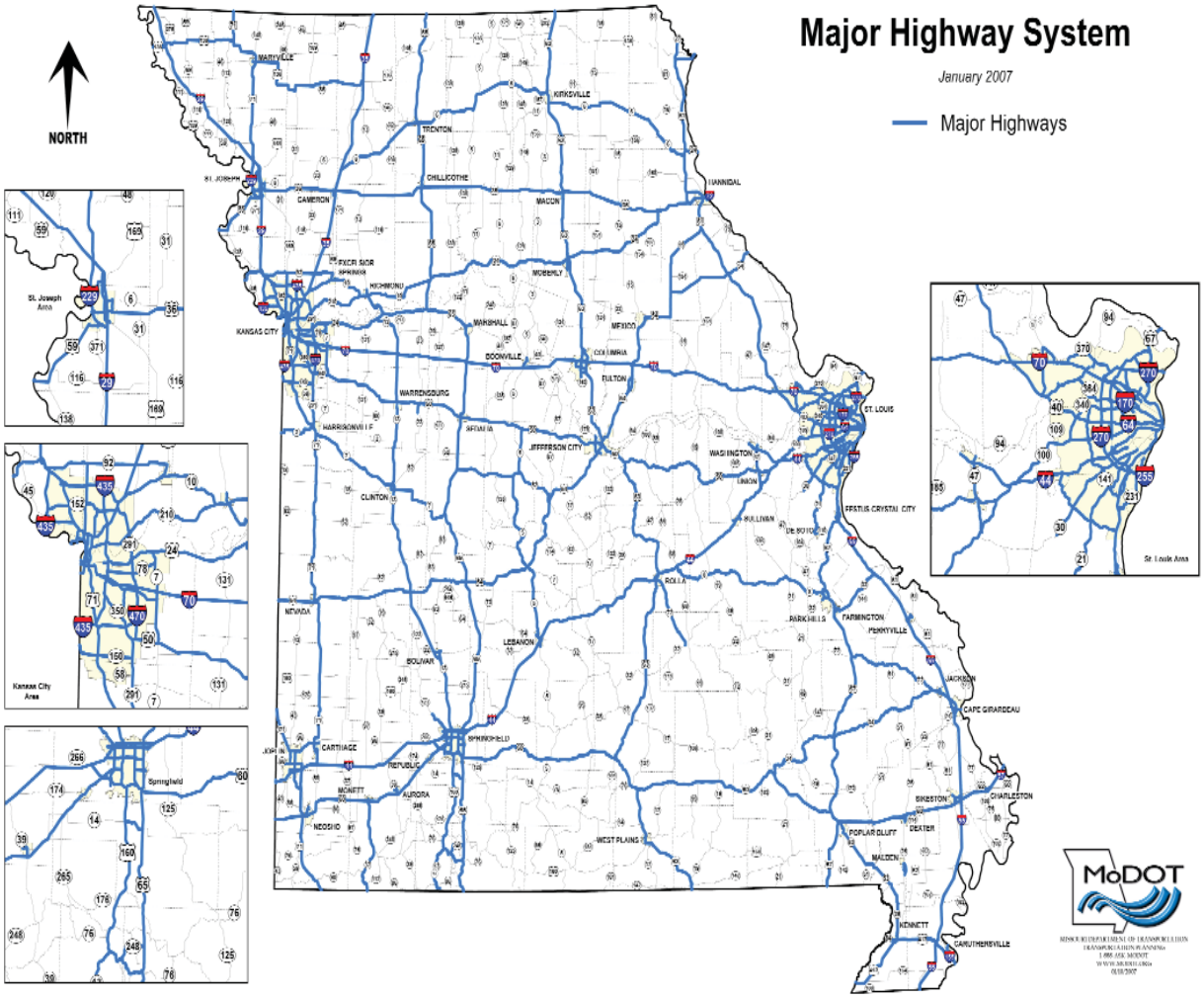
Major and Minor Road Definitions

Major Highway - consists of all routes functionally classified as principal arterials. The principal arterial system provides for statewide or interstate movement of traffic. The major highway system in Missouri totals 5,402 centerline miles or 17 percent of the total state highway miles. The major highways carry 76 percent of the total vehicle miles traveled in the state.

Minor Highway – consists of all routes functionally classified as minor arterials, collectors or outer roads. These routes mainly serve local transportation needs and include highways commonly referred to as lettered routes, such as Route A, Route C, and Route DD. The public sometimes refers to these routes as farm-to-market roads. The minor highways total 27,000 centerline miles or 83 percent of the total state highway miles and carry about 24 percent of the total vehicle miles traveled in the state.

Major highway system map that details routes considered being Major Roads.

Consult District for specific route classifications. Major highway system map can be found online through the ***EPG in Article " Brighter Roads Better Future"*** which is linked on the main EPG page in the navigation box.



Travel Time Information

To help alleviate driver frustration with delays through maintenance and construction work zones, Portable Changeable Message Signs (PCMS) or Dynamic Message Signs (DMS) are to be used to inform motorists of travel times. The following provides guidance on their usage.

- On interstate and other major roadway or bridge projects, near real-time travel time will be provided for work zones subject to traffic delays of 15 minutes or more due to work activity. Delay time will be calculated by the following equation:

Delay Time = T_{wz} - T_p
Where T_{wz} = Time to travel through WZ
T_p = Time to travel through area at posted WZ speed limit

- Travel times will be determined and messages update, as needed, at regular intervals and as conditions change. Possible methods to estimate travel times include: 1) driving the limits of the work zone, 2) establishing times based on predetermined queuing lengths, 3) monitoring travel times of vehicles traveling through the work zone, or 4) automated means.
- Distance to end of work zone, in miles, with estimated travel times, in five-minute increments, will be displayed on a properly delineated PCMS or DMS board. These boards will be located in advance of any potential traffic queue. Additional boards may be used as needed. The recommended display for these messages is:

Work Zone Ends 10 Miles	15-20 Minutes Travel

- Unless travel time is provided through automated means, PCMS and DMS units will display the following recommended messages when workers are not present and traffic delay can be expected.

Work Zone Ends 10 Miles	Expect Delays

- PCMS and DMS units may display meaningful messages when workers are not present, no traffic delay can be expected, and travel time is not provided through automated means.
- It is recommended that the units be capable of being remotely updated via cell phone or other means to make the information more time relevant.

Module 5: Special Considerations

Worker Considerations

Of equal importance to the safety of the motorized and non-motorized traffic navigating the temporary traffic control zone is the safety of the worker involved in activities within the zone. Therefore, it is important to comply with the following minimum requirements.

- Train field employees involved in the planning, set-up, operation, maintenance or removal of temporary traffic control to the level of their responsibility (for MoDOT employees, this typically requires the completion of both the *Flagger Training* and *Work Zone Technician* courses)
- Require workers to wear the appropriate safety apparel while in the temporary traffic control zone (for MoDOT employees, refer to *Safety Policies, Rules & Regulations Employee Handbook*)
- Inspect and operate vehicles and equipment within the temporary traffic control zone appropriately (for MoDOT employees, refer to *Safety Policies, Rules & Regulations Employee Handbook*)
- Use physical barriers instead of channelizers to separate traffic from the activity area
- Use protective vehicles and truck-mounted attenuators within the temporary traffic control zone to provide protection from errant vehicles
- Close the road to traffic temporarily where traffic volumes are low and an adequate alternate route exists
- Request assistance of law enforcement officials in patrolling the temporary traffic control zone
- Provide adequate lighting to perform work activities within and guide traffic through the temporary traffic control zone
- Heighten awareness of the temporary traffic control zone through the use of supplemental warning methods
- Ensure workers are visible to equipment operators
- Ensure signal person and equipment operator understand hand signals

Flagger Control

The role of the flagger in temporary traffic control is an important one. It is the flagger's responsibility to assess the safety and efficiency of traffic operations within the temporary traffic control zone and manage the movement of traffic through the proper assignment of right of way and/or by controlling traffic speed. Guidelines for performing this vital function are set forth in the *Flagger Training* course materials. It is good practice for flaggers to review these guidelines on a regular basis to ensure they perform their duties effectively.

Except when performed under emergency conditions, workers engaged in flagging operations on the state highway system shall have successfully completed a recognized flagger training course. For MoDOT employees, this requires the successful completion of the *Flagger Training* course or an approved substitute.

Clothing (MoDOT policy only - not contractor guidelines)

- Class II apparel, hi-vis vest for daytime operations
- Class III apparel, hi-vis vest (Class II) with pants (Class E) worn during nighttime operations
- Clothing shall be in accordance with MoDOT's *Safety Policies, Rules and Regulations Safety Handbook*
- All PPE (Personal Protective Equipment) worn during nighttime operations shall be retroreflective
- A neat appearance helps gain respect and makes your job more effective

Daytime

All MoDOT employees, salaried and wage, working on or near the right of way during daytime operations, and/or where there is a routine exposure to traffic and/or equipment shall properly wear a minimum of a MoDOT approved Class II Safety vest or shirt, which meets or exceeds the ANSI/ISEA 107-2004, American National Standard for High Visibility Safety Apparel.

Pedestrian/Bicyclist Consideration

Work zones should continue to accommodate the road users who were using a roadway before construction began. Work zones present additional workload not only to drivers of passenger vehicles and heavy trucks, but also to pedestrians, bicyclists, and motorcyclists. In addition to providing well-designed facilities for these other road users, agencies should notify drivers of the presence of these people and vehicles and design the work zone so drivers can see and avoid these users. Accommodation of pedestrians, bicyclists, motorcyclists, and heavy-truck drivers should be planned before work begins. In addition, regular inspection of conditions for these road users should be performed in order to ensure that these users are being accommodated safely.

Roadway articles in work zones open to public travel should be free from surface irregularities and construction debris. Uneven and cluttered surfaces can cause motorcyclists or bicyclists to fall and may present tripping hazards to pedestrians. Hazards include pavement edges, large or deep ruts, metal plates, drainage grates, expansion joints, and pavement or other surfaces with low skid resistance. The travel path should be continuous and hard. Vehicle detectors and pedestrian push buttons on existing roadways should continue to be accessible, or other options provided, during the project.

Additional strategies beyond those briefly discussed in this article are covered in other volumes of the NCHRP Report 500 series:

- Pedestrians (Volume 10)
- Bicycles (forthcoming)
- Motorcycles (Volume 18)
- Disabled (Volume 13)

Pedestrian Considerations

The MUTCD should be consulted for information on accommodating pedestrians in work zones and on reducing pedestrian-vehicle conflicts.

Careful consideration should also be given to the needs of pedestrians with disabilities, especially when there is evidence that the regular users of this area include pedestrians with special needs. The level of accessibility of existing pedestrian facilities should be maintained during the work period to the extent practical. The MUTCD provides guidance on providing accessible facilities in work zones, including consideration of pedestrians with either visual or mobility disabilities. The changes made to a pedestrian's path, due to work zones, will interrupt the routine of a person with visual disabilities whose route goes through the affected area. Visually impaired pedestrians need clear guidance though the work zone, and this can be provided through detectable barriers and edges on channelizing devices, guide rails, audible warning devices, or even audible spoken messages activated by push buttons.

Bicyclist Considerations

Consideration should be given to the needs of bicyclists as work zones are being designed, set up, and as work is being performed. Pavement edge drop-offs or longitudinal joints can present hazards to bicyclists, as can surface debris and low-traction areas.

Warning signs increase driver awareness of bicycles in work zones. Standard MUTCD bicycle warning signs should be used to alert drivers to the presence of bicyclists.

Where existing bicycle or pedestrian facilities or pathways will be affected by roadwork, the needs of bicycles and pedestrians are to be addressed in the Traffic Control Plan (TCP). Use the following guidelines if temporary pedestrian facilities are needed:

- Pedestrians must not be led into direct conflicts with worksite vehicles, equipment or operations.
- Pedestrians must not be led into direct conflicts with mainline traffic moving through or around the worksite.
- Pedestrians must be provided with a safe, accessible and convenient path replicating as nearly as possible the most desirable characteristics of existing sidewalks or footpaths.
- Part VI of the MUTCD contains additional information on handling pedestrians in work zones.
- Separate pedestrian movements from the activity area and motorized traffic (in some cases it may be necessary to use a physical barrier instead of channelizers to provide this separation)
- Provide a clearly delineated and usable travel path that nearly replicates the existing path
- Provide advance notification of sidewalk closures to discourage unsafe pedestrian movements
- Avoid accessing activity area across pedestrian paths

Human Factors

Human factors are concerned with the design, development, evaluation and operation of traffic control devices so the driver can navigate through work zones as safely and efficiently as possible. Communication between roadway users and the road itself is essential. Developing an effective temporary traffic control plan can help reduce the problems associated with human error.

Human factors are integrated into every aspect of the transportation system:

- Geometry: How much turn at a certain speed can a human tolerate?
- Signs: How far can a human eye see?
- Speed Limit: How fast can we travel comfortably at a certain degree in radius of a roadway?

Human factors are increasingly important for temporary traffic control. In work zones we are giving drivers new information and violating their expectation of a “normal” driving experience.

Human Traits affecting Behavior

Drivers are affected by the following traits:

- Visual Capability
  - Age of driver
  - Eyesight
  - Night vision
- Driver Perception and Response Time
- Physical Issues with Aging
- Information Handling

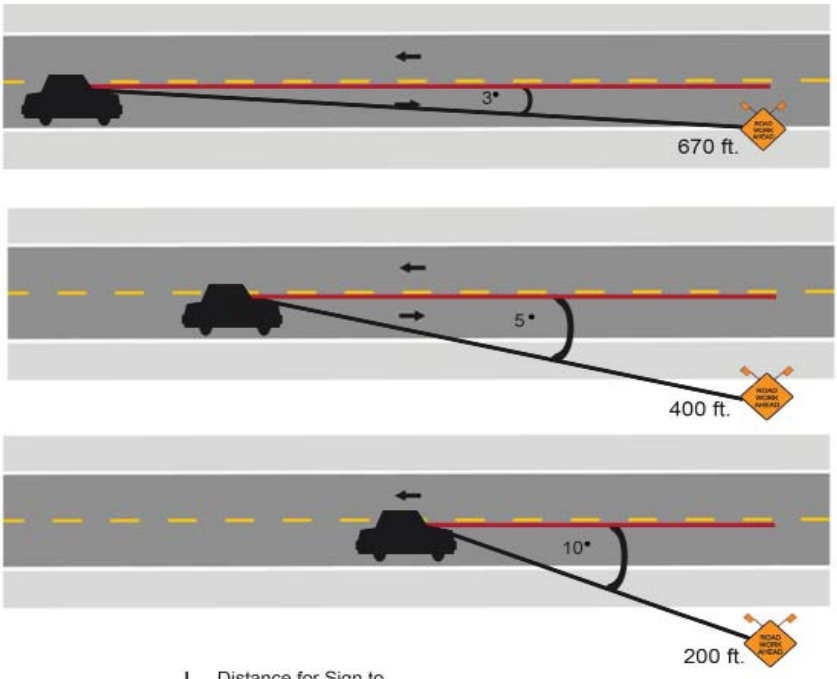
There are many other human traits we take into consideration when we plan, design, and operate work zones, but these are the core qualities on which to focus.

Visual Capability

Roughly 90% of the information we receive as human beings is visual, and the same applies for drivers. Driver must digest the information given in all conditions while in motion. This includes a need for advanced visual techniques, including depth perception, 3-dimensional analysis, and speed recognition.

Adding to the complexities of the task are distractions inside and outside of the driver's vehicle, and clutter on the roadway – which can either be literal trash or the clutter of too many signs.

Visual Acuity / Cones of Vision



Perceptual Cone of Vision	Distance for Sign to Appear in Visual Cone	
	Right Lane	Left Lane
3°	670 ft.	900 ft.
5°	400 ft.	540 ft.
10°	200 ft.	270 ft.

The cone of vision shows how people take in information. The drivers' ability to understand what they are seeing is reduced the farther the object is removed from the center of their sight.

- Color vision is best at about 3 degrees from center, which can be estimated by making a circle with your forefingers and your thumbs at arms length
- Between 3 and 6 degrees, color is not as readily obvious, but the information can typically be seen clearly
- Outside of 6 degrees, the visual field is hard to see, and it is seen without clear detail
- Satisfactory vision is still possible inside 20 degrees
- Peripheral vision is typically around 120 – 150 degrees (At this angle, very little detail, if any, can be seen)

The ability to read information placed "not straight ahead" is very important to consider when signs are posted on wide roadways. Of course, our heads and eyes are not fixed; we constantly scan ahead for information. However, the most effective placement of devices is within the 10-20 degree Cone of Vision.

The Need for Light

As we age, our need for light increases significantly. At the same time, it is more difficult for all drivers to see well at night – especially with glare.

An older driver will see only 80% as well as a younger driver during the day. However, that same driver will see just 34% as well at night (compared to the young driver during the day). It is very important to consider the light conditions of temporary traffic control zones when designing and managing those areas.

Consideration must be given to all light and weather consideration. For example, a sign that has enough contrast during the day to be read might not be acceptable at night.

All Drivers are Not the Same

There are limits to people's ability to gather and process information and to make appropriate responses in work zones. It is important to consider the wide range of the population using the roadway system.

At any given time there are young, old, fatigued, impaired and distracted drivers traveling through your work zones. Not everyone comes to the task with the same knowledge and abilities.

Older Drivers

An additional concern when discussing the range of drivers is the aging of the U.S. population. The average age continues to increase, and the number of older drivers (70+) on the roadways is expected to grow greatly in the next few years. A sub-set of this group is older women, who historically have not driven as they age, but will in the future.

Though motorists older than 70 drive less frequently than other age groups, they already account for more than their share of fatalities. In fact, the only group more dangerous than senior citizens is teen-agers. Senior drivers have special trouble judging speed and distances, which are two important skills needed to navigate through the complex situations in many work zones.

Impairment

Beyond the obvious impairment of alcohol and other drugs, drivers often will be impaired by fatigue and distractions, ranging from cell phones and CD players to kids in the back seat.

The Driving Task

In general, people handle information needed for driving in three (3) steps.

1. Gather information from various sources
2. Use the information to make decision based on experience, knowledge, and skills
3. Perform the action

The time to complete this task is called Perception Reaction Time (PRT). A typical PRT is around 2.5 seconds, though it can increase in complex situations (like work zones).

A lot can happen in 2.5 seconds, illustrated by the chart below. At 70 mph, a driver travels over 250 feet!

Speed (mph)	Traveled in 2.5 sec
30	110 ft
40	147 ft
55	202 ft
60	220 ft
65	239 ft
70	257 ft

Information Overload

Too much information at one time makes the driver confused about which information is needed. The driver simply doesn't have enough time to read and digest the information presented. Similarly, multiple signs on one sign array confuse the driver of which signs has the appropriate information for the particular situation. Too many signs in close proximity pose a similar problem.

In a work zone the driver needs more time controlling the vehicle, steering, and braking, giving him less time to read, process, and react to the information on the signs. In this situation, the potential for information overloading increases. Too much unnecessary information can cause information overloading.

Provide Positive Guidance

It is important to provide road users with the appropriate information at the right time in order for them to be able gather the information, process it and make the desired decision.

Give drivers only one option – the right one – by showing them very clearly the desired path. This path can be shown to the driver through signing, pavement marking, and channelizing devices.

Module 6: Nighttime Work Zones

With increased volumes of traffic on the highway system, nighttime road construction has become a strategy that MoDOT uses to minimize traffic delays. When working at night there are several challenges that require attention. First, nighttime work brings a reduction in visibility for workers and drivers. Second, nighttime work may negatively impact the surrounding community with excessive noise and light. Third, construction personnel and the drivers are more likely to suffer fatigue during the night rather than during the day. These challenges make it imperative that a safe work zone and lighting plan is designed to address nighttime challenges.

The decision to work at night should be based on several factors including:

- Traffic Characteristics
- Construction Schedule
- Impact to Communities and Businesses
- Other Items

Nighttime hours shall be defined as one-half hour before sunset to one-half hour after sunrise.

Safety apparel shall be worn per the manufacturer's design. Safety Apparel with zipper and/or hook and loop(Velcro) closures should be fastened in the front and on the sides, to meet the visibility requirements of the ANSI/ISEA 107-2004 Standard. The apparel should be worn properly and snug as to reduce issues associated with loose or baggy clothing.

Retroreflective clothing shall be visible for at least 1000 ft. during nighttime flagging and shall identify the wearer as a person.

Nighttime Apparel Requirements

All employees, salaried and wage, working on or near the right of way during nighttime hours, and/or where there is a routine exposure to traffic and/or equipment shall properly wear MoDOT approved Class III Safety Apparel (Class II or Class III top and Class E pants), which meets or exceeds the ANSI/ISEA 107-2004, American National Standard for High Visibility Safety Apparel.

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Advantages and Disadvantages of Nighttime Work Zones Include:

Typical Advantages

- Reduced traffic congestion due to low volumes
- Less involvement with business activity
- Allows for restoration of normal traffic patterns during the day
- Less traffic is exposed to hazards related to driving through the work zone
- Workers are exposed to fewer passing vehicles
- Road user costs may be lower
- Work periods may be longer
- Traffic control options may be more feasible

- Nighttime work may allow for better productivity, easier material delivery, and reduced equipment costs
- Air pollution and fuel consumption is reduced
- Lower nighttime temperatures, during the normal construction season, improves working conditions and makes for better material handling

Typical Disadvantages

- Reduced visibility
- Greater probability for fatigued and impaired drivers
- Impact to surrounding communities
- Unit construction costs are generally higher
- Nighttime traffic speeds will tend to be higher because drivers are less likely to expect to encounter work zones
- A greater proportion of the vehicles encountered at night will include alcohol or drug - impaired drivers
- Local residents may experience noise and light pollution, as well as vibration disturbances, during night construction
- Reduced construction season

Work Zone Lighting

Work zone lighting consists of two (2) components, work area lighting and overhead lighting, as described in Sec 616 of the specifications. Work zone lighting is specified on the plans and included as a pay item when work is required at night or when lighting needs to be present during non-working hours (i.e. lighting gore areas, crossovers, etc.).

Typical work zone lighting may include dirigible lighting, portable light towers, balloon lighting, lights attached to equipment or post-mounted lights. In some cases, existing lighting or ambient lighting may meet lighting level requirements and negate the need for including work zone lighting as a pay item.

When stationary operations exceed 15 consecutive days, such as a bridge replacement, interchange or intersection work that occurs at night, temporary fixed lighting is considered in lieu of work zone lighting. Temporary fixed lighting is also be considered for islands, temporary bypasses, crossovers and connections and areas of potential conflict, such as temporary ramps, intersections and one-lane, two-way traffic operations that are in place for more than 15 consecutive days. These conditions may require lighting even though the work may not be conducted at night. This type of lighting, while more difficult to design and install, provides more uniform light distribution thereby enabling the motorist to better navigate the work zone at night. If temporary fixed lighting is chosen, it must be designed, shown in the plans and a 901 pay item for “Temporary Lighting” included. Temporary fixed lighting generally includes wood poles, luminaries and power supplies.

When nighttime work is being performed, lighting should be used to illuminate the work area, equipment crossings, and other areas. The amount and location of light provided is based on the type and detail of work being performed and the degree of difficulty in navigating the work zone. Minimum required intensity for flagging operation activity is 0.6 foot-candles. Work area lighting provides a minimum maintained intensity of 5 footcandles (54 lux).

Glare

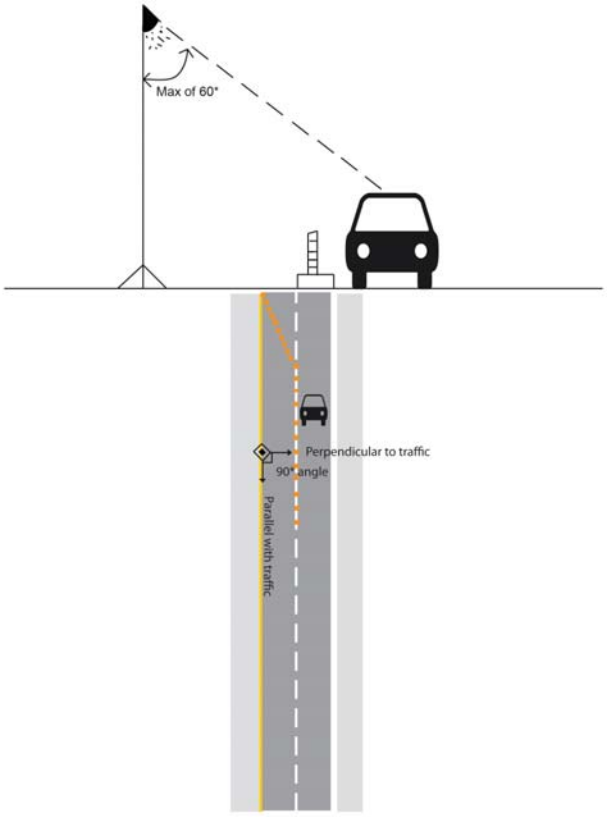
Lighting shall not produce a disabling glare to approaching motorists, flaggers, or workers. Factors impacting glare are:

- Distance between driver and luminaires
- Height of luminaires
- Direction the luminaires are aimed

To minimize glare:

- Locate luminaires so that axis of candlepower is located away from the line of sight of motorists
- Luminaires should be aimed so the center of the beam axis is no greater than 60 degrees above vertical plane
- Tower-mounted luminaires should be aimed either perpendicular or parallel to the roadway

The following diagram illustrates how to minimize glare for tower mounted angles.



Lighting Devices

There are two purposes for providing lighting devices in temporary traffic control zones.

The first purpose is to illuminate a portion of the roadway in order to safely and effectively perform work activities or to highlight areas requiring increased driver attention. This is accomplished through work and area lighting, respectively. The second purpose is to supplement other temporary traffic control devices or to identify work vehicles and equipment. This is accomplished through warning and fleet lighting, respectively.

Work lighting enhances worker safety and quality of the work performed during nighttime operations by illuminating the work area to a level at which workers can adequately see what they are doing. A minimum intensity of five (5) foot-candles is recommended to satisfy this objective. Typically, this lighting is provided by an array of vehicle- or equipment-mounted floodlights, an array of floodlights on a portable lighting unit, or an internally illuminated balloon. Lighting shall be positioned so that it does not cause glare for motorists, spill onto adjacent properties, create shadows within the workspace or become a safety concern.

Area lighting illuminates specific areas significant to traffic guidance within the temporary traffic control zone during nighttime hours. Lighting of this nature is required at flagger stations and may be considered at gore areas, transitions, ingress and egress areas, equipment crossings, intersections, and temporary signals. A minimum intensity of 0.6 foot-candles in the specific area is recommended for this type of lighting. Typically, this lighting is provided by a single light on a portable lighting unit or mounted on a temporary pole. As with work lighting, lighting shall be positioned such that it does not cause glare for motorists, spill onto adjacent properties, create shadows or become a safety concern. Flagger stations in operation at night are required to be lit.

Warning lights are an option available to increase the target value of other temporary traffic control devices. Typically, a single self-contained unit that emits a yellow light is used for this type of lighting.

There are three (3) types of warning lights: A, B and C.

Warning lights are available that provide two (2) types or all three (3) types in a single unit. Ensure proper mode is selected when implementing this style of warning light.

Type A (Low Intensity Flashing). These flashing lights may be used on drum-like channelizers to warn of an unexpected, isolated hazard. This device is not used in shifts, tapers or long runs of channelizing devices.

Type A are low-intensity, flashing light units capable of being visible from a distance of 3000 ft. on a clear night. These units may be used during nighttime hours to warn motorists they are approaching or proceeding through a potentially hazardous area. Their use is limited to supplementing other traffic control devices throughout the temporary traffic control zone. They are not be used for delineation.

Type B (High Intensity Flashing). These flashing lights may be used on advanced warning signs when geometrics, traffic volumes or other conditions warrant increased visibility.

Type B are high-intensity, flashing light units capable of being visible from a distance of 1000 ft. on a sunny day with the sun directly on or behind the device. These units may be used during both daytime and nighttime hours to warn motorists they are approaching a potentially hazardous area. Their use is limited to supplementing signs in the advance warning area and other temporary traffic control devices at point locations throughout the temporary traffic control zone. They are not be used for delineation.

Type C (Steady-Burn). These steady burn lights may be used on drum-like channelizers to delineate traffic in shifts, tapers or long runs or on direction indicator barricades in merging tapers in the work area at night at the designer's discretion.

Type C are steady-burn light units capable of being visible from a distance of 3000 ft. on a clear night. These units may be used during nighttime hours to delineate the intended path. Their use is limited to supplementing a traffic control device in a lane taper; one-lane, two-way taper; diversion, curve, and similar conditions. Note: When used to help delineate curves, light units shall only be placed on the outside of the curve.

Warning lights shall be mounted at a minimum of 30 in., measured from the base of the host device to the bottom of the unit, exclusive of any housing. In addition, lights should be installed so they do not hinder the functionality of the device they supplement or become a hazard themselves. Ensure warning lights meet crashworthy requirements.

Fleet lighting increases the visibility of work or incident response vehicles and equipment while in the temporary traffic control zone. All work vehicles and equipment shall be equipped with an acceptable warning light system. These lights shall be activated whenever a vehicle or piece of equipment is engaged in a work zone or incident response operation within the temporary traffic control zone. An exception to this requirement is those vehicles and pieces of equipment located within a workspace delineated by channelizers or protected by temporary traffic barrier. For this situation, activation of the lights is not required. Standard hazard warning lights may be used as a supplement to, but not as a replacement for fleet lighting.

Traffic Control

Nighttime work does not require changes in traffic control setup or in the design of the devices. However, enhancements to traffic control may be considered and flashing arrow panels and changeable message signs shall be dimmed when working at night. Traffic control enhancements include tighter channelizer spacing, larger devices, addition of warning lights, longer transition areas, etc.

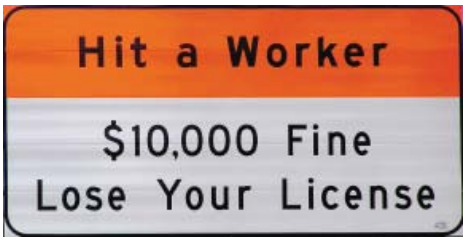
Module 7: Speed Limits

MoDOT has the authority to set speed limits on the state highway system. This power extends to establishing speed limits in temporary traffic control zones, where the speed limit may be reduced from the normal speed limit for safety purposes.

A reduced speed limit should be carefully considered before it is imposed, as motorists will only reduce their speed if they perceive a need to do so. Any decision to reduce the speed limit based on an arbitrary, 'across the board', or other inappropriate rationale may result in non-compliance with the reduced speed limit by motorists and a false sense of security for workers.

Should a reduced speed limit be deemed appropriate, table 616.23.2.7.2 Maximum Speed Reductions or Minimum Speeds in the EPG shows the recommended maximum speed reductions or the minimum speed that may be imposed in temporary traffic control zones.

Fine Signs



In an attempt to improve work zone safety, the legislature passed a bill in 2001 and amended it in 2006, to provide for increased fines for speeding or speeding and passing in properly posted temporary traffic control zones when workers are present. The required posting is accomplished though the installation of fine signs.

The new law increases the fines for killing or injuring a highway worker, including motorist assist employees, up to $10,000 with the possibility of the motorist losing his or her license. Other changes with the new law includes:

- Changing the definition of a work zone to include work related to incident removal
- Repeals a previous sign covering/uncovering provision, which states that informational signs in work zones must remain unveiled
- Increases the fine to $300 for the second offense for passing in a work zone on a two-lane highway when workers or equipment are present and/or when an appropriate sign is visible
- Creates the crimes of endangerment of a highway worker and aggravated endangerment of a highway worker

1. Exceeds the posted speed limit by 15 mph or more;
2. Passes another vehicle in a work zone and such offense results in the death or injury of a highway worker;
3. Fails to stop for a work zone flagman or fails to obey traffic control signals erected in the work zone;
4. Physically assaults or attempts to assault a highway worker with a motor vehicle or other instrument;

5. Intentionally strikes or moves barrels, barriers, signs, or other devices erected to control the flow of traffic for a reason other than avoidance of an obstacle, an emergency or to protect the health and safety of another person; or
6. Commits various offenses in which points may be assessed.

    - If a motorist endangers a highway worker without causing the worker injury or death, the motorist shall be subject to a fine of not more than $1,000 and shall have four (4) points assessed against his or her driver's license
    - If a person commits the offense of aggravated endangerment of a highway worker, the offender shall be subject to a fine up to $5,000 where a highway worker is injured; and up to $10,000 if a highway worker is killed (the offender will also have 12 points assessed against his or her license, which is an automatic one-year suspension of the driver's license)
    - A person commits the offense of aggravated endangerment of a highway worker if, as a result of one of the traffic violations under endangerment of a highway worker, a highway worker is injured or killed

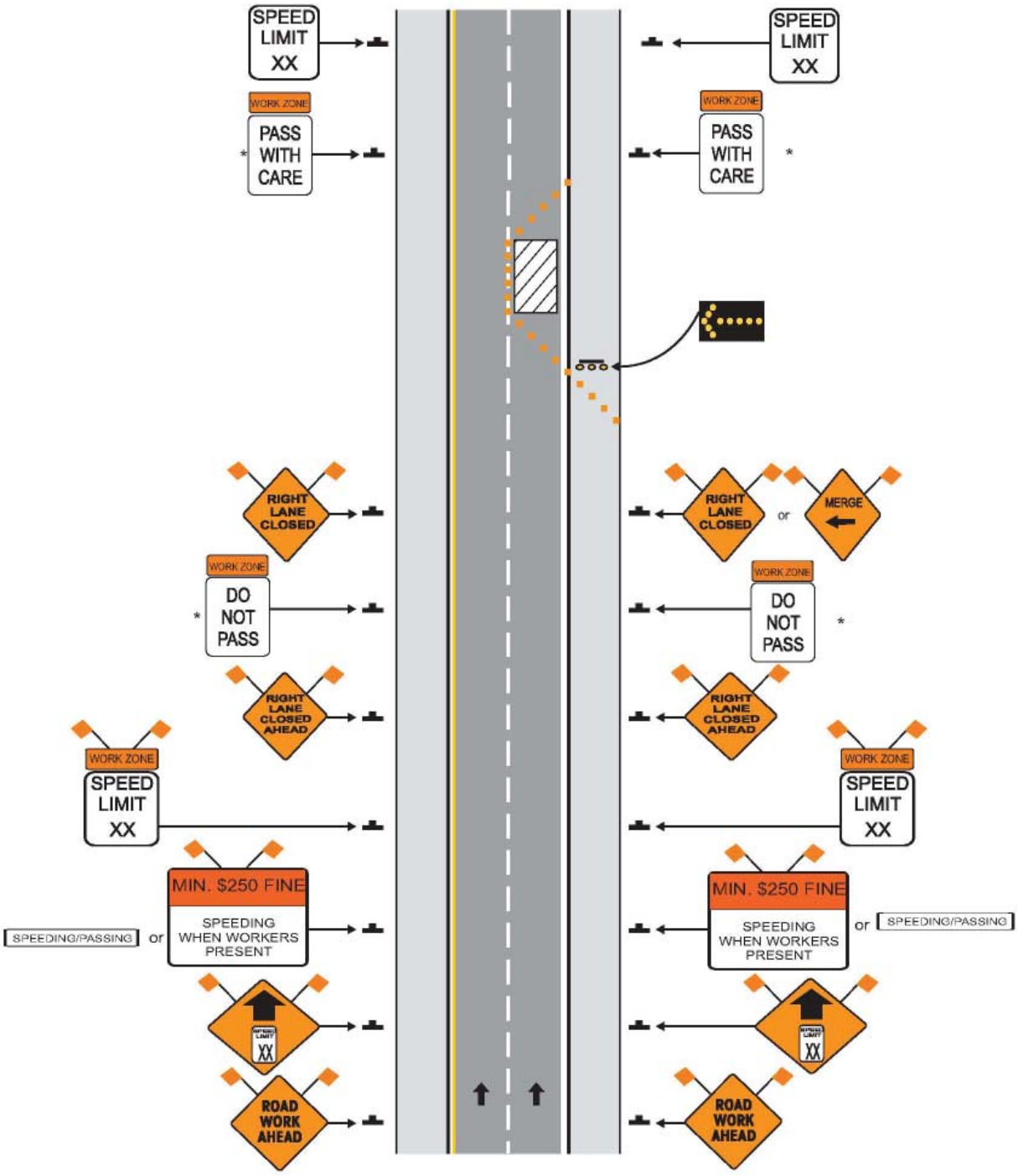
Fine signs provide the motorist with information on the amount of fine and for what action the fine will be assessed. As with other regulatory signs, these signs are most effective if they are properly applied and enforced.

The implementation of the speeding portion of this provision may be considered when all four (4) of the following criteria are met or where, upon the judgment of the supervisor, there is a need to control speed through the temporary traffic control zone.

- Work duration longer than 4 hours
- Reduced speed limit in effect
- Normal posted speed is greater than or equal to 60 mph
- Workers on roadway without barrier protection

The implementation of the passing portion of this provision may be considered when, in addition to meeting the previous criteria or judgment, there is a lane drop on a multilane highway consisting of a maximum of two (2) lanes in the affected direction.

When fine signs are used, their location, as well as other signing requirements, shall conform to the following illustration.



*Signs not used when only speeding portion of provision is invoked.

Law Enforcement

The use of law enforcement in an active or passive capacity will be identified initially at the planning stage, but needs to be continually re-evaluated throughout the duration of the maintenance or construction project. Typical situations where law enforcement may be beneficial are speed enforcement, temporary flagging situations, incident management, complex traffic control setups, mobile operations, and changes in traffic control setups.

The presence of law enforcement within the work zone may have a positive or negative impact on traffic flow and safety within a work zone, depending on the placement of the law enforcement officials and how law enforcement officials ticket violators. Law enforcement officials and their vehicles should be located as not to be a hazard to the driving public nor themselves. They should be asked to pull violators over at a pre-designated area, such as beyond the end of the work zone, at a location that will have minimal impact.

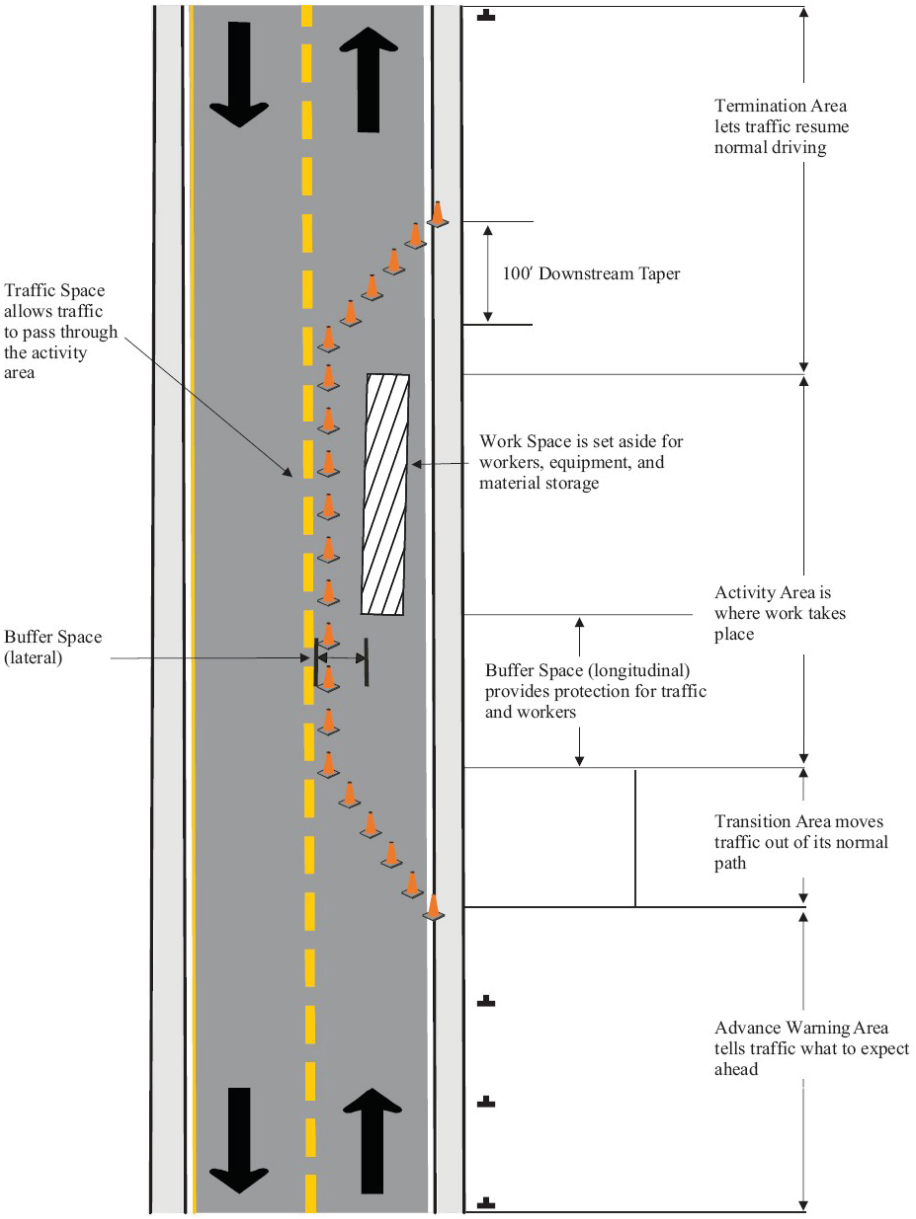
When law enforcement is present, you need to continually evaluate the effectiveness of their presence. For example, if their presence starts backing up traffic to where motorists may be placed in an unsafe situation, such as just over a hill or around a curve where inadequate sight distance is provided for approaching vehicles to stop, the law enforcement official should be asked to move to another location where they are not restricting traffic flow or you can ask them to leave the area when such conditions develop.

Module 8: Temporary Traffic Control Zone

A temporary traffic control zone is a article of highway where traffic conditions are changed due to a work zone or an incident area through the use of temporary traffic control devices, law enforcement, or other authorized officials. It extends from the first warning sign or rotating/strobe lights on a vehicle to the last temporary traffic control device. The zone may either be stationary or move as work progresses.

A temporary traffic control zone consists of four (4) basic components: advance warning, transition, activity and termination.

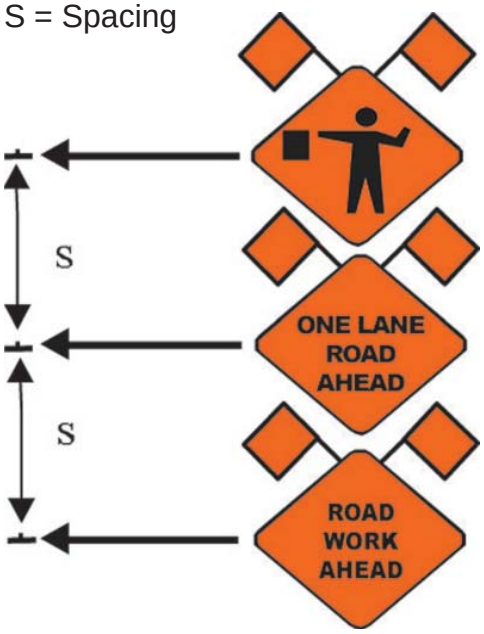
These areas are illustrated in the following figure.



Advance Warning Area

The advance warning area is where traffic is informed of an upcoming temporary traffic control zone. It may vary from a single sign or rotating/strobe lights on a vehicle to a series of signs depending on the duration, location, and type of work.

S = Spacing



The advance warning area contains warning signs with appropriate legends, regulatory signs, such as speed reduction signing, changeable message signs and other warning devices. The signs or other warning devices are positioned to give the driver sufficient time to react to the conditions. Warning devices are not to be placed too far in advance, as the warning message will lose effectiveness. Suggested advance sign spacing information is available.

In some cases on high volume routes, traffic backups due to the work activity may extend past the normal advance warning area. In this case, additional signing may be required to warn drivers before they reach the backup. For longer-term activities, alternate route signing and interactive devices or changeable message signs may be considered. Computer programs are available to aid in estimating back ups and delays due to work zones.

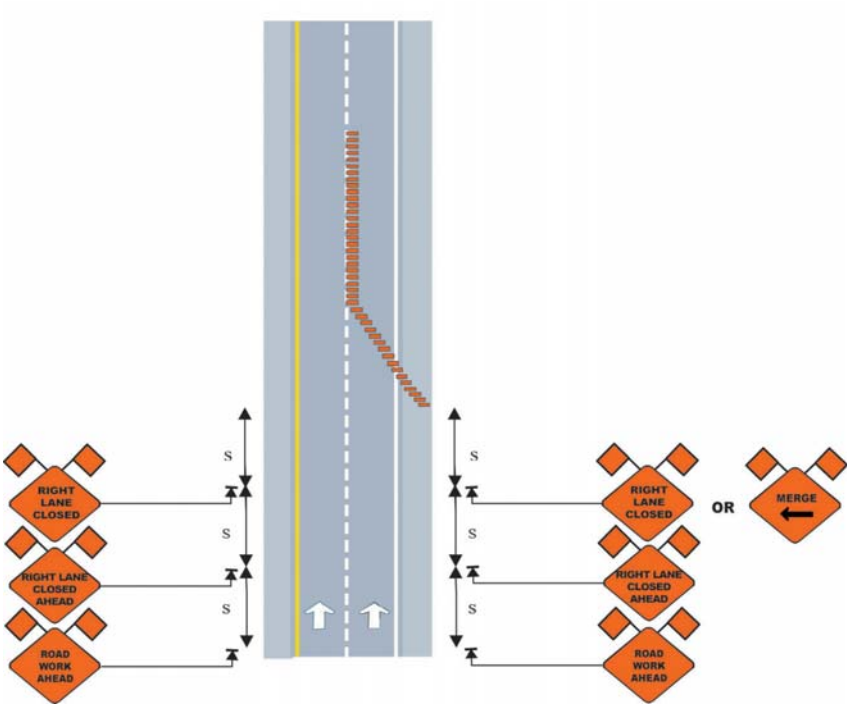
In some cases, particularly in urban areas, the advance warning area may extend through an intersection or interchange. ***Special considerations such as additional advance signs or adjustments to sign spacing may be needed to assure all approaching drivers are informed of the conditions.***

Recommended sign spacing in this area is shown in the following table.

Table 616.23.2.2.2 Sign Spacing

Speed Limit (mph)	Spacing[1] (ft.)	
	Undivided Highway	Divided Highway
0-35	200	200
40-45	350	500
50-55	500	1000
60-70	1000	1000
[1] Sign spacing may be adjusted, normally by increasing it, to accommodate field conditions and visibility.		

Note: Sign spacing may be adjusted *nominally* for field conditions, such as sight distance, sign location, curves, etc.



Tips to Calculate Distances

Pavement markings are a great way to measure distances between channelizers. Mile markers and delineators also are a great way to calculate distances for signs.

- A pavement dash is 10 feet long with a 30 foot space between markings
- Delineators are spaced 1/10 of a mile apart (approximately 500 feet)
- Interstate mile markers are spaced 2/10 of a mile apart (approximately 1000 feet)
- The odometer on your vehicle is another useful tool to measure distances when laying out a work zone

Transition Area

When redirection of the driver's normal path is required, traffic must be channelized from the normal path to a new path. Transition areas usually involve strategic use of tapers, channelizing devices, signing, pavement marking and other traffic control devices.

There are three (3) types of tapers: shoulder, lane and one-lane, two-way.

- The ***shoulder taper*** is used to close the shoulder where it is part of the activity area or when improved shoulders might be mistaken for a driving lane
- The ***lane taper*** is used to close a driving lane by forcing traffic to merge
- The **one-lane, two-way taper** is used to close one lane of a two-lane, undivided highway where the remaining lane is used alternately by traffic in each direction. The taper should have a length of 100 ft. (5 channelizers at 20 ft. spacing). In addition to the channelizers, a flagger, STOP or YIELD sign, pilot car or temporary traffic signal controls traffic through this.

Recommended taper length and channelizer spacing for shoulder and lane tapers in the transition area are shown in the following table.

Speed Limit (mph)	Taper Length [1] (ft.)		Channelizer Spacing [4] (ft.)
	Shoulder[2]	Lane[3]	
0-35	70	245	35[5]
40-45	150	540	40[5]
50-55	185	660	50[6]
60-70	235	840	60[6]

[1] Taper lengths may be adjusted to accommodate crossroads, curves, intersections, ramps, or other geometric features.
[2] Based on 10 ft. shoulder width.
[3] Based on 12 ft. land width.
[4] Channelizer spacing may be reduced to discourage traffic encroachment.
[5] Spacing reduced to ½ at intersections.
[6] Spacing may be reduced to ½ at intersections.

Note: Taper lengths may be adjusted whenever they are located close to a crossroad, curve, intersection, ramp or other geometric feature. Whenever tapers are used near interchange ramps, crossroads, curves or other influencing factors, it may be desirable to adjust the length of tapers. Longer tapers are not necessarily better than shorter tapers (particularly in urban areas characterized by short block lengths, driveways, etc.), because extended tapers may encourage motorists to delay lane changing. ***The real test of taper length involves observing motorists after the traffic control plan has been implemented.***

Type of Taper

Taper Length. The length of taper used to close a lane (L) is determined by the speed of traffic (posted speed prior to construction) and the width of the lane to be closed (lateral distance traffic is shifted). Taper lengths and formulas are available in the EPG.

Merging Tapers. Merging tapers are used to close a lane or combine traffic lanes on multilane facilities. It is important to provide full-length tapers (L) where practical. For long-term operations, lane line markings are removed through the merging taper and temporary edge lines are to be provided to guide drivers through the taper and the work area.

Shifting Tapers. Shifting tapers are used to laterally shift a lane or lanes of traffic where merging is not required. Shifting tapers typically have a length of L, although where space is limited, shifting tapers may be reduced to 1/2 L. Where 1/2 L shifting tapers are used, REVERSE CURVE or REVERSE TURN signs, along with any required advisory speed plaques, are to be posted prior to the shift. For long-term operations, conflicting pavement markings are removed and temporary markings are provided to guide drivers through the tapers and work area. For short-term operations where it is not practical to modify pavement markings, a device spacing of 10 ft. is used.

Shoulder Tapers. It is important to close shoulders prior to shoulder work or through lane closures. This helps prevent drivers from entering the work zone on the shoulder and helps prevent collisions with flashing arrow panels and other traffic control devices. Shoulder tapers typically have a length of 1/3 L.

One-Lane, Two-Way Tapers. Where one lane of a two-lane two-way roadway is closed, a short taper of 100 ft. with a device spacing of 20 ft. is used to guide drivers into and out of the one-lane two-way article. For long-term operations, centerline markings are removed and temporary edgeline markings are provided to guide drivers through the tapers and the work area.

Two-Way Center Turn Lane Tapers. A taper length of 1/2 L is used to close a center turn lane. Where space is limited, a shorter taper may be used.

Activity Area

The activity area is the area of the roadway where the work takes place. It is composed of the workspace, traffic space and buffer space.

- The ***workspace*** is the area closed to traffic and set aside for workers, equipment, materials and a protective vehicle, if one is used upstream (this area is usually delineated by channelizers or temporary barriers to exclude vehicles and pedestrians)
- The ***traffic space*** is the area in which traffic is routed through the activity area
- The ***roll-ahead space*** (when a protective vehicle is added to the activity area) is located in front of the protective vehicle and is free of workers, materials, equipment and tools (this space allows for the protective vehicle to move or "roll" upon impact by an errant vehicle without entering the workspace and striking workers, materials or equipment and tools)
- The ***buffer space*** provides a recovery space for an errant vehicle (buffer spaces may be placed longitudinally or laterally with respect to the direction of traffic flow)

Longitudinal buffer spaces are to be used whenever practicable. Lateral buffer spaces may be considered based on the type of work.

Lateral buffer spaces are to be used when practical between the traffic space and fixed objects or pavement drop-offs. Guidelines for the length of longitudinal buffer spaces are given below:

Recommended longitudinal buffer length in the activity area is shown in the following table.

Recommended Length of Longitudinal Buffer Spaces

Speed Limit (mph)	Buffer Length (ft.)
0-35	120
40-45	220
50-55	335
60-70	550

Termination Area is where traffic is returned to its normal path. This area extends from the downstream end of the activity area to the last temporary traffic control device. This area may include a downstream taper or a sign informing traffic it may return to normal operations (e.g. END ROAD WORK or Speed Limit). When a downstream taper is used, the recommended length is 100 ft. (5 channelizers at 20 ft. spacing) per lane.

Module 9: Work Zone Operations

Work Zone Length

While it is important to grab the motorist's attention as they approach the temporary traffic control zone, it is just as important to maintain their attention as they travel through the work zone. To accomplish this, the work zone length, including any areas of inactivity within this length, should be kept to a minimum.

The work zone length is defined as the distance from the last sign in the advance warning area to the last temporary traffic control device in the same direction or to the last sign in the advance warning area in the opposing direction, whichever is longest.

The recommended maximum work zone length is shown in the following table.

Table 616.23.2.7.1 Maximum Work Zone Lengths

Highway Type	Work Zone Length
Urban	1 mile
Rural Divided	2 miles
Rural Undivided	3 miles

Work duration is a major factor in determining the number and types of devices used in temporary traffic control zones. The duration of a temporary traffic control zone is defined relative to the length of time an operation occupies a location. There are six (6) categories of work duration: long-term stationary, intermediate-term stationary, short-term stationary, short duration, mobile and emergency.

Duration of Work

- ***Long-term Stationary*** – planned work occupying a location more than three (3) days
- ***Intermediate-term Stationary*** – planned work occupying a location more than one (1) daylight period up to three (3) days, or night time work lasting more than 30 minutes
- ***Short-term Stationary*** – planned daytime work occupying a location more than 30 minutes and less than twelve (12) hours
- **Short duration** – planned day time or night time work occupying a location up to 30 minutes
- ***Mobile*** – planned work moving intermittently or continuously
- ***Emergency*** – Work involving the initial response to and repair/removal of response priority 1 items according to *MoDOT's Incident Response Plan Manual*

Long-term Stationary operations include planned work ***occupying a location more than three (3) days***. Post-mounted signs, larger channelizers and barricades, temporary traffic barriers, temporary pavement markings, work lighting, area lighting, warning lighting and temporary traffic signals are devices generally incorporated into the temporary traffic control plan for these operations. In addition to providing a greater margin of safety, these types of devices provide superior operational characteristics - an important consideration during nighttime hours and periods when workers are not present.

Intermediate-term Stationary operations include planned daytime work occupying a location for more than one daylight period up to three (3) days or planned nighttime work occupying a location more than 30 minutes. ***Nighttime work - work beginning one-half hour before sunset and ends one-half hour after sunrise.***

In these operations the same procedures and devices used in long-term stationary operations may be desirable. However, their use should be carefully considered, as they may not be feasible or practical to deploy. The increased time to place and remove these devices in some cases could significantly lengthen the project, thus increasing exposure time.

Short-term Stationary operations include planned ***daytime work occupying a location for more than 30 minutes, but less than twelve hours.*** This type encompasses the majority of work zone activities undertaken on the state highway system. In these operations, procedures and devices are usually simplified when compared to intermediate and long-term stationary operations because workers are present to maintain and monitor the temporary traffic control zone, the zone is only set up during daylight hours and it is only in place for a relatively short period of time. Portable signs, flashing arrow panels, channelizers, fleet lighting, protective vehicles and truck-mounted attenuators are devices generally incorporated into the temporary traffic control plan for these operations.

Short duration operations include planned daytime or nighttime work occupying a location up to 30 minutes.

These operations might involve different types of temporary traffic control devices since it often takes longer to set up and remove the temporary traffic control than it does to perform the actual work. Vehicle-mounted signs, truck-mounted flashing arrow panels, fleet lighting, protective vehicles, channelizer cones and truck-mounted attenuators are typical devices considered for use in these types of operations.

Mobile operations include planned work that moves intermittently or continuously.

These operations often involve frequent, short stops for activities where workers are on foot. ***These stops can only last up to 15 minutes in duration***. Typical work activities include litter cleanup and pothole patching.

Due to the similarity of these activities to short duration operations, the same procedures and devices considered for use in short duration operations are also desirable for use in these types of mobile operations. When non-mobile devices like portable signs are used, they should be moved periodically to keep them near the operation.

Mobile operations also include work activities in which workers and equipment move along the roadway without stopping. Typical work activities include mowing, snow removal, spraying, sweeping and long-line striping.

Therefore, total mobility of the temporary traffic control zone is important and devices should be chosen accordingly. In some continuously moving operations, a work vehicle equipped with fleet lighting may be sufficient. In others, a protective vehicle equipped with fleet lighting, a truck-mounted attenuator, a flashing arrow panel and a sign may be needed. ***Where work proceeds at unusually slow speeds, less than five (5) miles per hour, it may be desirable to place warning signs along the roadway and move them periodically as work progresses.***

Emergency operations include unplanned work occupying a location up to 15 minutes. Within MoDOT, these operations consist of the initial response to and repair/ removal of safety concerns as defined by Response Priority 1 items (refer to the MoDOT's Incident Response Plan).

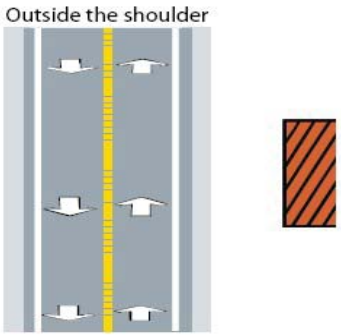
In these operations, it is usually more advantageous, from a safety standpoint, to remove or provide warning of the risk in a timely manner with limited temporary traffic control than it is to set up a temporary traffic control zone for short duration operations. The decision to reduce the temporary traffic control shall be at the discretion of the supervisor. However, work activities shall still be performed with the safety of the motorist and worker in mind. A vehicle-mounted sign, truck-mounted flashing arrow panel and fleet lighting are devices generally incorporated into the temporary traffic control plan for these operations. A protective vehicle and truck-mounted attenuator should be considered as additional safety measures.

Location of Work

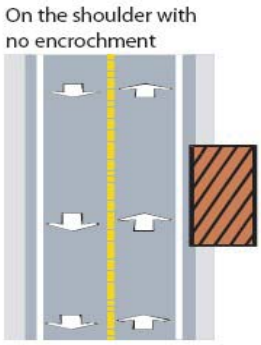
In addition to work duration, work location is also a major factor in determining the temporary traffic control needed for a temporary traffic control zone. As a general rule, the closer the work activity is to traffic, the greater the need for and number of temporary traffic control devices. Typically, the degree of temporary traffic control is based on three (3) locations: work beyond shoulder, work on shoulder and work within the traveled way.

Work outside the shoulder includes any work performed between the edge of the shoulder, the edge of the travel way where no shoulder exists, to the right of way line or within any unimproved median.

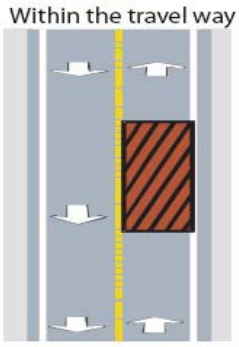
Work performed in this area typically requires a minimal amount of temporary traffic control, such as signs and fleet lighting, or even none at all. The amount and type of temporary traffic control depends on the lateral displacement of the work activity and the location and movement of any work vehicle or equipment relative to the edge of the shoulder, or travel way where no shoulder exists.



Work on shoulder includes any work performed on the shoulder that does not significantly encroach upon the adjacent driving lane. Where no shoulder exists, this also includes any work performed adjacent to the roadway that encroaches, but not significantly, upon the adjacent driving lane. ***A significant encroachment means 10 ft. of driving surface cannot be maintained for traffic.***



Work within the travel way includes any operation requiring a lane closure. Due to the location of the operation, more temporary traffic control devices are required to ensure the safety of both the motorist and the worker.



Module 10: Temporary Traffic Control Devices

Temporary traffic control devices are the medium through which traffic is informed of and guided through a temporary traffic control zone or otherwise protected from an unsafe condition. The most common devices include signs, portable changeable message signs, flashing arrow panels, channelizers, barricades, temporary traffic barriers, pavement markings, lighting devices, temporary traffic signals, crash cushions, protective vehicles and truck-mounted attenuators.

Crashworthy Devices and NCHRP 350 Reports

The purpose of Manual for Assessing Safety Hardware (MASH) is to present uniform guidelines for the crash testing of both permanent and temporary highway safety features and recommended evaluation criteria to assess test results. Guidelines are also presented for the in-service evaluation of safety features. These guidelines and criteria, which have evolved over the past 40 years, incorporate current technology and the collective judgment and expertise of professionals in the field of roadside safety design. They provide: (1) a basis on which researchers and user agencies can compare the impact performance merits of candidate safety features, (2) guidance for developers of new safety features, and (3) a basis on which user agencies can formulate performance specifications for safety features. MASH is an update to and supersedes NCHRP Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features, for the purposes of evaluating new safety hardware devices. MASH does not supersede any guidelines for the design of roadside safety hardware, which are contained within the AASHTO Roadside Design Guide.

FHWA (Federal Highway Administration) will formally adopt MASH as our crash test standard during the next revision of 23 CFR 625.4 “Standards, Policies, and Standard Specifications.” It will also be included in the FHWA Policy & Guidance Center. However, MASH will not be mandated as a design standard for safety hardware. The Roadside Design Guide fulfills that function.

- All highway safety hardware accepted prior to adoption of *MASH* using criteria contained in *NCHRP Report 350* may remain in place and may continue to be manufactured and installed.
- Highway safety hardware accepted using *NCHRP Report 350* criteria is not required to be retested using *MASH* criteria.
- If highway safety hardware that has been accepted by FHWA using criteria contained in *NCHRP Report 350* fails testing using *MASH* criteria, AASHTO and FHWA will jointly review the test results and determine a course of action.

- Upon adoption of *MASH* by AASHTO, any new highway safety hardware not previously evaluated shall utilize *MASH* for evaluation and testing.
- Highway safety hardware installed on new construction and reconstruction projects shall be those accepted under *NCHRP Report 350* or *MASH.*
- Agencies are encouraged to upgrade existing highway safety hardware that has not been accepted under *NCHRP Report 350* or *MASH:*
    - o during reconstruction projects,
    - o during 3R projects (changes to the roadway that may change the safety design), or
    - o when the system is damaged beyond repair.

In 1998, MoDOT adopted and implemented Test Level 3 criteria for temporary traffic control devices used on Missouri State Highway system.

NCHRP 350 prescribes four (4) categories of temporary traffic control devices. These categories, defined as 1 through 4, are discussed below.

Category 1 – Lightweight devices, including cones, trim-line and drum-like channelizers, and tubular markers, with or without fixed lights. Past testing and performance indicate these devices did not cause an appreciable change in speed or intrude into the passenger compartment of the impacting vehicle. FHWA suggests states accept Category 1 devices based on self-certification by the contractor, manufacturer, and vendor. Hence, MoDOT specifications require the contractor, manufacturer or vendor to furnish a manufacturer's certification of crashworthiness, per NCHRP 350 Evaluation Criteria, for these devices.

Category 2 – Traffic control devices, including, Types I, II, and III barricades, vertical panels, directional indicator barricades, and portable sign supports, with or without lights. These devices must be successfully crash tested to at least NCHRP 350, Test Level 3. For Category 2 devices, this requires crashing a compact vehicle traveling at 62 mph into the device at 0 and 90 degrees. MoDOT specifications require the contractor, manufacturer, or vendor to furnish the FHWA acceptance letter and a certification letter stating the device being furnished is of the same physical and chemical properties of that tested. The FHWA acceptance letter shall indicate the device and appurtenances comply with the crash test requirements of NCRHP 350, Test Level 3 (TL-3).

Category 3 – Rigid devices, including truck-mounted attenuators, barriers (temporary and permanent), impact attenuators, crashworthy end terminals, and breakaway sign supports. These devices must be successfully crash tested to at least NCHRP 350, Test Level 3. For Category 3 devices, this requires crashing a 3/4 ton pick-up truck at 62 mph into the device at 0 degrees (20 degrees for longitudinal barriers). Portable 3-loop concrete barriers and post-mounted sign support assemblies do not require certification of crashworthiness as MoDOT prescribes the design of these devices in its specifications. For other Category 3 devices, MoDOT specifications require the contractor, manufacturer, or vendor to furnish the FHWA acceptance letter indicating the device and appurtenances comply with the crash test requirements of NCRHP 350, Test Level 3.

Category 4 – Trailer-mounted equipment including lighting units, arrow panels, temporary traffic signals, and changeable messages signs. Currently, Category 4 devices do not need to meet any crashworthy requirements. However, these devices shall be properly located and delineated or shielded from traffic, where feasible. In addition, it is important to remove these devices when not needed as they do pose a safety concern.

Note: In addition to the certification requirements noted above, the contractor, manufacturer, or vendor must certify the devices are constructed and installed according to MoDOT standard specifications and plans. Modifications may make devices non-compliant. Modifications must be approved by appropriate MoDOT staff prior to being implemented.

In order for these devices to perform the functions noted previously, they must command the public's respect. This means the correct devices are installed according to the traffic control plan and they function as intended. ***Furthermore, the devices are maintained throughout the life of the operation and removed when no longer needed. Devices that are damaged or have lost their functionality should be replaced or, when acceptable, repaired.***

It may become necessary to ballast some of these devices to inhibit their movement due to natural and vehicle-induced wind in the field. This is particularly the case for portable sign supports and channelizers. ***Ballast shall be selected and installed such that the ballast itself does not become a hazard if impacted by a vehicle. When in doubt on ballasting, consult the device's manufacturer for their recommendation.***

Refer to ATSSA's Quality Standards for Work Zone Traffic Control Devices for guidelines regarding acceptability of devices.

Signs

Temporary traffic control signs convey, in words and symbols, both general and specific messages used by motorized and non-motorized traffic to navigate the temporary traffic control zone safely and efficiently.

Work zone warning signs are typically 48 in. x 48 in., diamond-shaped, black on orange signs with MoDOT fluorescent orange sheeting. Retroreflective sheeting is required for nighttime activities.

Therefore, it is important all permanent and temporary signs not applicable to conditions present in the temporary traffic control zone be removed, covered, or turned away from the roadway so they are not visible to traffic.

To ensure maximum visibility, existing signs and other physical features (trees, sidewalks, billboards, commercial signs, etc.) must be considered when locating work zone signs.

Sign Design

Details, descriptions, and ordering information for signs used for temporary traffic control are specified in 616.2 Work Zone Signing and Applications, in the preceding EPG.

These signs may have a rigid or flexible substrate. However, the two (2) sign materials are not necessarily interchangeable. Each should be used on a sign support for which the sign system (i.e. the sign and support) has been designed. This is especially true when trying to meet crashworthiness requirements.

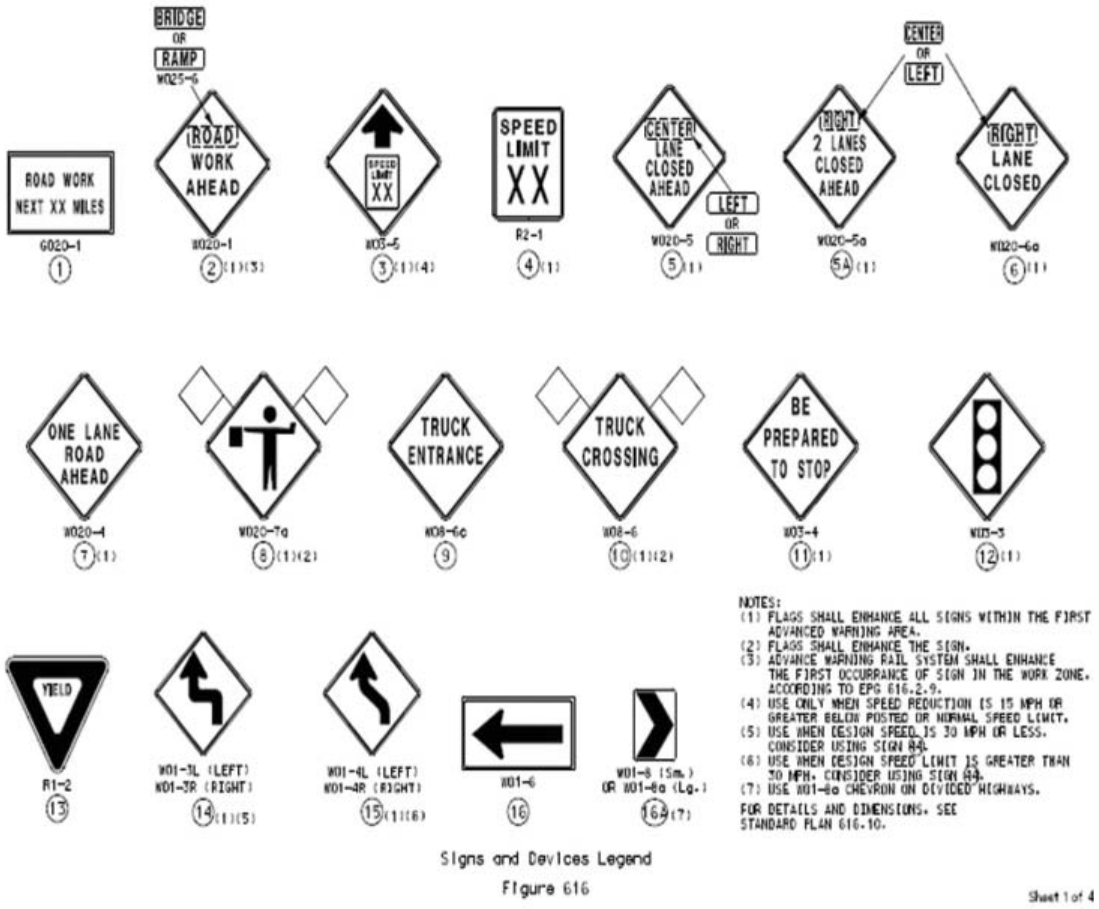
Flashing warning lights may be used and flags shall be used to supplement these signs provided they do not block the sign face.

Work zone regulatory signs are identical to permanent regulatory signs with MoDOT Type 3 sheeting. Work zone guide signs are generally rectangular in shape and have a black legend on orange background with MoDOT fluorescent orange sheeting; but may come in different sizes, shapes, colors and sheeting depending on the type and purpose of the signing. Sometimes a plate or plaque is affixed to a work zone sign or mounted below it to customize the sign. For additional discussion on enhancements, refer to 616.2.9 Flags and Advance Warning Rail System.

Sign and Device Legend

Additional signs within the work zone may be enhanced with flags at the district's discretion, although such practice should be infrequent. The sign and device legend can be found in the EPG article 616 Temporary Traffic Control within the work zone figures quick link box. Using the example above the first set of advanced warning signs shall be flagged. Additional flagging requirements can be found in the device legend.

Sign and device legend below page 1 of 4 (Example)



Identify the sign to be used and follow the key along with notes to determine supplemental warning requirements.

Example:

Sign #2 (Road Work Ahead) will follow notes 1 and 3.
Flags required in first advanced warning area.
Advanced warning rail enhancement required if used under conditions set in EPG 616.2.9 (long term stationary).

Sign #8 (Flagger Symbol) will follow notes 1 and 2.
Flags required in the first advanced warning area. Flags shall enhance the sign (shall have flags installed at all times regardless of location).

Supplemental Warning Methods

It may, on occasion, be desirable to enhance the target value of certain temporary traffic control devices or the entire zone. ***The purpose of this is to increase awareness of the temporary traffic control zone or specific conditions within it.***

Typical methods for accomplishing this objective include supplementing the prescribed devices with other devices, adding devices to the zone, or changing the characteristics of a device itself. Examples of possible enhancements are as follows:

- Cones by signs or at flagger stations
- Increased sign height
- Additional signs
- More or increased levels of retroreflectivity
- Speed trailers
- Warning lights on devices
- Light bars on vehicles
- Area lighting
- Law enforcement
- Portable changeable message signs
- Press releases
- Pavement markings

Flags and Advance Warning Rail System

All signs within the first advance warning area shall be enhanced with flags. Flagger Ahead (WO20-7a) and TRUCK CROSSING (WO8-6) shall have flags regardless of the location within the work zone.

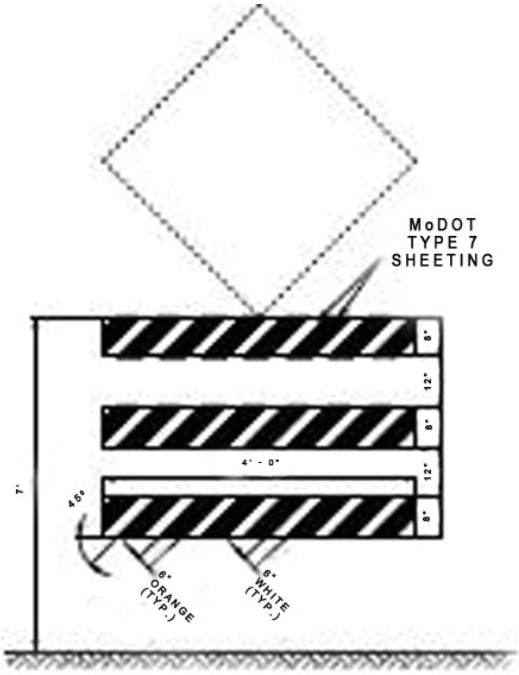
The Advance Warning Rail System (AWRS) shall consist of three (3) barricade rails used to enhance the target value of certain signs on long-term stationary operations. The AWRS is only installed on the first occurrence of the ROAD/BRIDGE WORK AHEAD (WO20-1) signs on the mainline roadway.

The following are, but are not limited to, ways to install the AWRS:

1. The three (3) barricade rails may be attached to U-channel, wood or PSST posts, according to the minimum sign area (sign and rails) as located in ***Table B of Standard Plan 616.10.***

2. A crashworthy skid-mounted sign and rail assembly.

3. The sign and three-rail system may be mounted as separate crashworthy devices. The rail system shall be located directly in front of the sign with 7 ft. to 10 ft. separating the two (2) devices.



ADVANCED WARNING RAIL SYSTEM

MAXIMUM WEIGHT OF SIGN MUST NOT EXCEED 25 LBS.

THE SIGN AND RAIL SYSTEM MAY BE MOUNTED AS TWO SEPARATE CRASHWORTHY DEVICES. THE RAIL SYSTEM SHALL BE LOCATED DIRECTLY IN FRONT OF THE SIGN WITH 7 TO 10 FEET SEPARATING THE TWO DEVICES.

WHERE MARKING IS NOT PROVIDED ONT HE BACKSIDE. STRIPS OF 3" WIDE MODOT TYPE 7 ORANGE SHEETING MAY BE APPLIED TO THE ENDS OF EACH RAIL TO HELP DELINEATE THE DEVICE.

Sign Classification

Temporary signs are classified into one of three (3) types:

- Regulatory
- Warning
- Guide

Regulatory signs give notice of traffic laws or regulations and indicate applicability of legal requirements that would not be readily apparent.

These signs are generally rectangular in shape and have a black legend on white background. Noteworthy exceptions to this rule are the STOP, YIELD, DO NOT ENTER and WRONG WAY signs.

Warning Signs give notice of situations or conditions that might not be readily apparent. These signs are generally diamond-shaped and, when used in a temporary traffic control zone, have a black legend or symbol on an orange background.

Guide signs indicate route designations, destinations, directions, distances, services, points of interest or other geographical, recreational or cultural information. These signs come in different shapes and colors depending on the type and purpose of the signing. However, special guide signs relating to the conditions of the temporary traffic control zone (e.g. RAMP OPEN, DETOUR, ROAD WORK NEXT XX MILES, etc.) are typically rectangular in shape and have a black legend on an orange background.

Sign Installation

Signs used for temporary traffic control are placed on the right side of an undivided highway and on both sides of divided highways unless otherwise specified. Where space exists, signs may also be placed on the left side of multi-lane, undivided highways. Signs should not be located where they will conflict with the movement of non-motorized traffic or where visibility of them will be limited by field conditions.

Signs shall be:

- Reasonably plumb to the pavement
- Safely and neatly ballasted
- Clearly visible and legible/distinguishable to approaching traffic during the day and, if applicable, during the night

Recommended sign spacing is shown in Table 616.23.2.2.2, Sign Spacing.

Signs may be supported in one of four (4) methods: on a portable support, break-away post, vehicle or traffic barrier.

Signs may be supported in one of four (4) methods:

- Portable support
- Break-away post
- Vehicle
- Traffic barrier

Sign Height

Sign mounting requirements can be found in the EPG article 616.2 Work Zone Signing and Applications or in Standard Plan 903.03

The following table shows typical sign heights:

Type of Roadway	Sign Height
Urban	1’ Portable 7’ Post
Rural Divided	1’ Portable 7’ Post
Rural Undivided	1’ Portable 5’ Post

Signs may be installed per the following table:

Drawing 616.10

Type	Sign Support	Sign Substrate	Minimum Mounting Height (3)	Usage Liminations	Comments
Post	Perforated Square Steel Tube U-Channel Wood	Rigid	5' Rural Undivided Highways 7' Rural Divided Highways 7' Urban Highways	None	Posts shall be free of any bracing and extend no further above the sign except as needed for warning light attachment. See standard plan 903.03 for post installation details. Galvanization of posts will not be required.
Type 1 Portable	Skid Fold-up Stand	Rigid	5' Rural Undivided Highways 7' Rural Divided Highways 7' Urban Highways	Permitted only where post mounting is not feasible	Systems shall comply with crash test requirements of NCHRP 350 Test Level 3 and may be placed adjacent to or within the roadway provided a minimum lateal clearance of 3 feet. Measured horizontally from the edge of the sign to the edge of designated traveled way, is maintained.
Type 2 Portable	Easel Fold-up Stand Self-driving Post Type III Moveable Barricade Skid	Flexible Rigid	12" (4)	Permitted only for installation up to 3 days (5). Where signs are obscured by other objects (i.e. traffic control devices. Parked vehicles, barrier, vegetation, etc.) or installed on multiland undivided facilities or multiland divided facilities with 3 or more lanes in one direction. Mounting heights shall be as specified for post-mounted signs	Systems shall comply with crash test requirements of NCHRP 350 Test Level 3 and may be placed adjacent to or within roadway provided a minimum lateral clearance of 3 feet. Measured horizontally from the edge of the sign to the edge of the designated traveled way, is maintained.
Barrier	Concrete Traffic Barrier Guardrail	Flexible Rigid	5' Rural Undivided Highways 7' Rural Divided Highways 7' Urban Highways	Permitted only where longitudinal barrier is present.	System shall provide positive connection to the barrier and minimize potential for vehicle snagging.
Vehicle	Pavement Marking Equipment Pilot Car Protective Vehicle	Flexible Rigid	48"	Permitted only in pilot car or moving operations.	
(3)	Measured from the bottom of the sign to the near edge of the pavement.				
(4)	Mounting heights for critical regulatory and guide signs (e.g., stop, yield, do not enter, wrong way, one way, and gore exit) shall be as specified for post-mounted signs.				

Portable signs are temporary traffic control signs affixed to a portable support such as a self-driving post, easel, fold- up sign stand, barricade, etc. These signs are to be constructed of either a rigid or flexible substrate, as required, to meet crashworthiness requirements.

A minimum mounting height of one ft., measured vertically from the bottom of the sign to the near edge of the pavement, is recommended. However, higher mounting heights should be considered on higher volume highways, on multi-lane highways, in urban settings, and where the sign is located in line with other traffic control devices to increase the visibility of the sign.

Mounting heights for regulatory and guide signs are as specified for post-mounted signs. Portable signs may be located adjacent to or within the roadway itself. ***However, a minimum lateral clearance of three (3) ft.,*** measured horizontally from the edge of the sign to the edge of the designated traveled way, is recommended.

Signs mounted in this manner may be left in place for up to three (3) days. An exception to this duration is any crosswalk/sidewalk closure, any road closure, Horizontal Arrow, Double-Headed Horizontal Arrow, Chevron, DETOUR (within arrow) or Gore Exit sign. These signs may be left in place for over three (3) days.

When not in use, consideration should be given to removing portable signs from the temporary traffic control zone to discourage theft and limit potential hazards within the right of way.

Break-Away Post-Mounted Signs are temporary traffic control signs affixed to a breakaway support such as perforated square steel tube, U-channel, wood, etc. These signs are constructed of a rigid substrate.

A minimum mounting height of seven (7) ft., measured vertically from the bottom of the sign to the near edge of the pavement, is recommended for urban highways and rural divided highways.

A minimum mounting height of five (5) ft., measured vertically from the bottom of the sign to the near edge of the pavement, is recommended for rural undivided highways. If a supplemental sign is mounted below another sign, the mounting height of the supplemental sign may be one ft. less than the heights specified.

A minimum lateral clearance of two (2) ft., measured horizontally from the edge of the sign to the edge of the roadway, is recommended for installations on roadways with ***curbed articles.***

A minimum lateral clearance of six (6) ft., measured horizontally from the edge of the sign to the edge of the traveled way, is recommended for installations on roadways ***without curbed articles.***

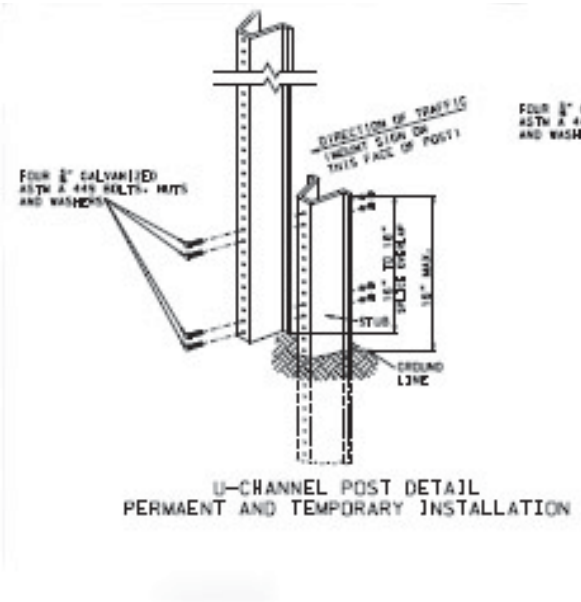
U-Channel Post

When mounting signs using U-channel post, use of full length post is acceptable. However use of the optional splice is acceptable as well. There are two (2) options available when using the splice installation.

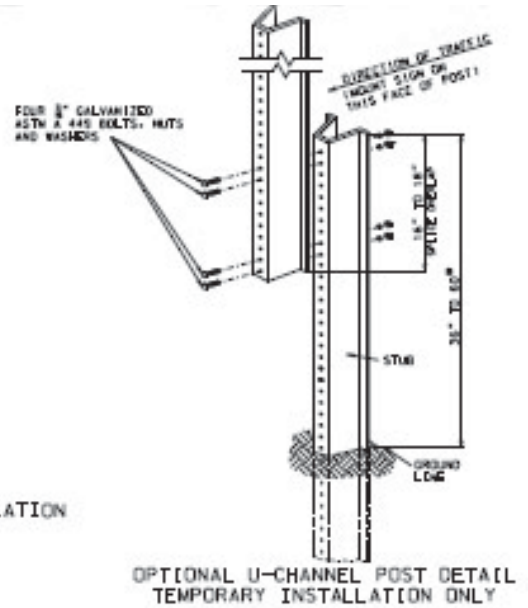
Mounting guidance can be found in the EPG article 616.2 Work Zone Sign Applications. ***Use standard plan 903.03 Drawing 903.03BG for sign mounting guidance.***

- **Permanent and Temporary Installation**
  - 18” from the ground line to the top of the stub
  - Splice overlap shall be positioned entirely between the ground line and 16” to 18” above the ground line

- **Temporary Installation**
  - 36” to 60” from the ground line to the top of the stub
  - Overlap shall be between 16” and 18”
- Splices shall have four (4) sign grade bolts installed at the top 2 bolt holes of the stub and the bottom 2 bolt holes of the overlap sign post
- Stub shall face traffic
- If a plaque is used, neither the sign or the plaque shall be positioned within the splice



U-CHANNEL POST DETAIL
PERMAENT AND TEMPORARY INSTALLATION



OPTIONAL U-CHANNEL POST DETAIL
TEMPORARY INSTALLATION ONLY

Vehicle-mounted signs, when allowed in 616 Temp. Traffic Control are temporary traffic control signs affixed to a protective vehicle or pilot car at a ***recommended minimum height of (4) four feet (48 inches),*** measured vertically from the bottom of the sign to the pavement surface.

Barrier-mounted signs are temporary traffic control signs affixed to the top portion of a temporary or permanent traffic barrier. The method of attachment to the barrier must assure a positive connection and minimize potential for vehicle snagging. ***Mounting heights for regulatory and guide signs are as specified for post-mounted signs.***

Signs in Narrow Medians

In order to accommodate narrow medians, it may be necessary to reduce the sign size; clip the sign corners or edges; or possibly both.

Where signs are installed in narrow medians, the size of signs may need to be reduced to provide sufficient lateral clearance. It is important to retain the diamond shape of warning signs as much as possible. It is not acceptable to use rectangular shapes in lieu of diamond shapes, but the corners of the diamond shaped signs may be clipped to reduce sign width. It is preferable to use 36 in. warning signs rather than to cut the corners of 48 in. signs. Refer to Figure 616.2.4 in the EPG, which provides guidelines for signs in narrow medians.Any other sign sizes or shapes used that are not shown in the standard plans are shown in the plans with a layout including lettering size and series.

Portable Changeable Message Signs

Portable changeable message signs are temporary traffic control devices with the flexibility to display a variety of messages. These messages provide pertinent traffic operation and guidance information to the motorist. They serve as a supplement to, not as a replacement for or a repeat of, static temporary traffic control signing. In temporary traffic control applications, these units are generally mounted on a trailer.

Some typical situations where portable changeable message sign use may be beneficial to temporary traffic control are as follows:

- Where the speed of traffic is expected to drop substantially
- Where significant queuing and delay are expected
- Where adverse environmental conditions exist
- Where there are changes in alignment or surface conditions
- Where there is a ramp, lane, or roadway closure
- Where a crash or incident has occurred
- Where traffic patterns change

Messages should consist of a ***maximum of two (2) phases***. Typically, these phases consist of ***three (3) lines of eight (8) characters***. Techniques such as fading, exploding, dissolving, moving, or scrolling text shall not be used. The entire message cycle ***should be readable to traffic at least twice while traveling at the posted speed***.

Messages should be programmed prior to deployment of the unit to the field. Consideration of the following guidelines will assist in designing a message.

- Each phase should convey a single thought
- If the message can be displayed in one phase, the top line should present the problem, the center should present the location or distance ahead, and the bottom line should present the recommended driver action
- The message should be as brief as possible
- When a message is longer than two (2) phases, additional portable changeable message signs should be used
- When abbreviations are used, they should be easily understood

Signs should be located to provide traffic with ample warning of any conditions ahead or actions they may need to perform.

It is preferable to locate signs off to the right of any usable portion of the roadway. Where field conditions do not allow for this placement, the signs may be located on the outside shoulder of the roadway or within the median where field conditions do not allow for deployment on the outside shoulder.

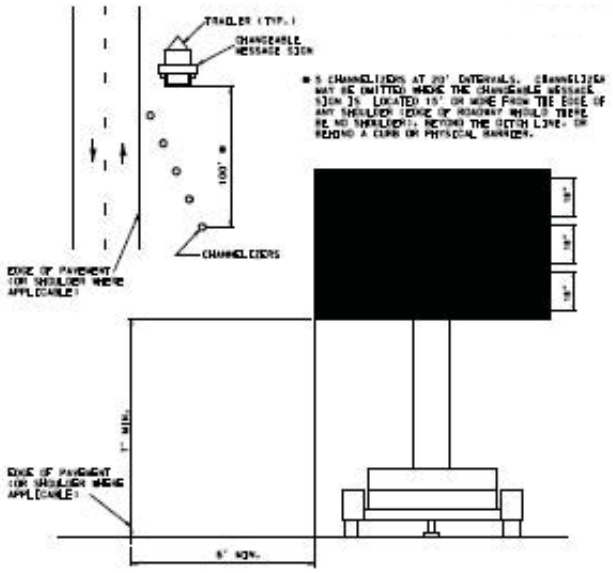
A minimum lateral clearance of three (3) ft., measured horizontally from the edge of the sign to edge of the traveled way, is recommended.

If multiple signs are used, the signs should be located on the same side of the road and separated according to the sign spacing chart.

A minimum mounting height of seven (7) ft., measured vertically from the bottom of the sign to the roadway, is recommended.

When deployed, the sign shall be sighted and aligned with approaching traffic to ensure visibility of the message.

Five (5) channelizers should be used to delineate each sign. hese channelizers should be positioned on the upstream end of the unit to form a taper leading up to traffic side of the unit. The recommended length of this taper is 100 ft. For a sign located in the median, the sign should be delineated from both directions.



CHANGEABLE MESSAGE SIGN

Channelizers may be omitted where the CMS is located 15’ or more from the edge of any shoulder (edge of roadway where there is no shoulder), beyond the ditch line, or behind a curb or physical barrier.

Information can be found in Article 616 in the EPG within Standard Plan 616.10 drawing 616.10A

The following are examples of pertinent messages which may be displayed on PCMS:

1. Road paving ahead
2. Road under repair
3. Concrete repairs ahead
4. Bridge under repair
5. Drainage work ahead
6. Workers on roadway
7. Use left/right lane
8. Work zone ends xx miles
9. xx minutes travel
10. Expect delays
11. Crash ahead
12. All lanes blocked
13. Crash at xxx mm
14. Delay of xx hour(s) possible

The following table contains the most common abbreviations used in PCMS messages:

Word	Abbreviation	Word	Abbreviation
Alternate	ALT	Minor	MNR
Avenue	AVE	Normal	NORM
Boulevard	BLVD	North	N
Cannot	CANT	Northbound	NB
Center	CNTR	Parking	PKING
Do Not	DON'T	Right	RHT
East	E	Road	RD
Eastbound	EB	Service	SERV
Emergency	EMER	Shoulder	SHLDR
Entrance	ENT	Slippery	SLIP
Enter	ENT	South	S
Expressway	EXPWY	Southbound	SB
Freeway	FRWY	Speed	SPD
Hazardous Material	HAZMAT	Street	ST
High-Occupancy Vehicle	HOV	Temporary	TEMP
Hour(s)	HR	Traffic	TRAF
Information	INFO	Vehicle	VEH
It Is	ITS	Warning	WARN
Junction	JCT	West	W
Lane	LN	Westbound	WB
Left	LFT	Will Not	WONT
Maintenance	MAINT	Miles	MI
Major	MAJ		

Abbreviations in the following table may be used only when the prompt word either precedes or follows the abbreviation.

Word	Abbreviation	Prompt
Access	ACCS	Road
Ahead	AHD	Fog*
Blocked	BLKD	Lane*
Bridge	BRDG	(name)*
Condition	COND	Traffic*
Congestion	CONG	Traffic*
Construction	CONST	Ahead
Downtown	DWNTWN	Traffic*
Exit	EX, EXT	Next*
Express	EXP	Lane
Hazardous	HAZ	Driving
Interstate	I	(route number)
Local	LOC	Traffic
Lower	LWR	Level
Major	MAJ	Crash
Oversized	OVRSZ	Load
Prepare	PREP	To Stop
Pavement	PVMT	Wet*
Roadwork	RD WK	Ahead
Route	RT	Best*
Turnpike	TRNPK	(name)*
Township	TWNSHP	Limits
Upper	UPR	Level
*Prompt word goes before abbreviation		

Abbreviations in the following table should not be used as they may cause confusion.

Abbreviations	Intended Word	Common Misinterpretation
ACC	Accident	Access (Road)
B4	Before	None
CLRS	Clears	Color
DLY	Delay	Daily
FDR	Feeder	Federal
L	Left	Lane (Merge)
LT	Light (Traffic)	Left
PARK	Parking	Park
POLL	Pollution (Index)	Poll
RED	Reduce	Red
STAD	Stadium	Standard
WRNG	Warning	Wrong

A complete list of acceptable abbreviation can be found in Part 1 of the MUTCD.

Flashing Arrow Panels

Flashing arrow panels are temporary traffic control devices with a matrix of elements capable of flashing displays. The devices are intended to provide additional warning and directional information to assist in traffic movement through or around a temporary traffic control zone. These units may be either trailer- or truck-mounted. However, truck- mounted units are preferred in mobile operations.

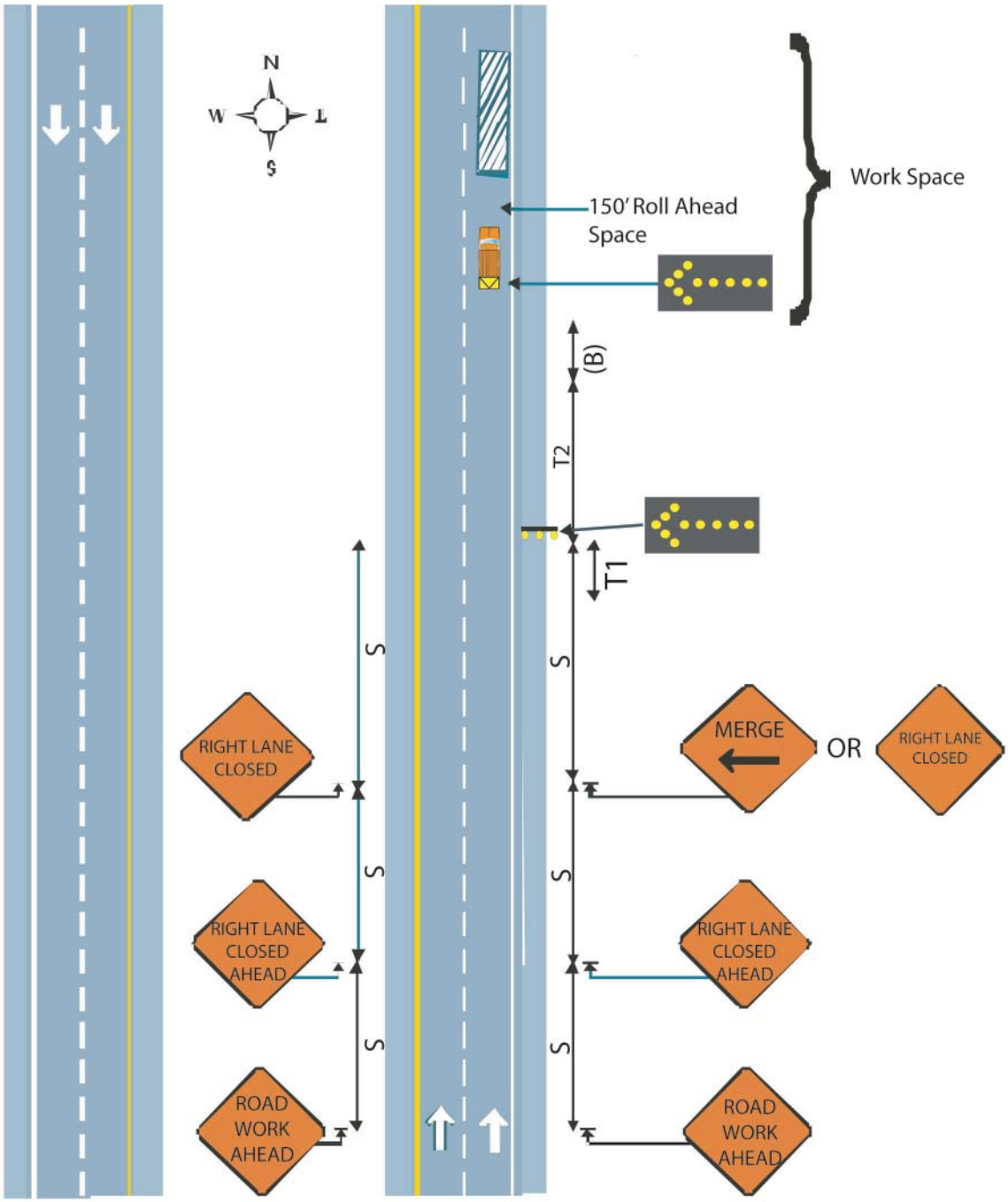
The overall minimum dimensions of the panels are 60 in. wide x 30 in. high for truck-mounted units and 96 in. wide x 48 in. high for trailer-mounted units. Panels for both units shall include 15 yellow elements.

Panels may be operated in one of three (3) operating modes:

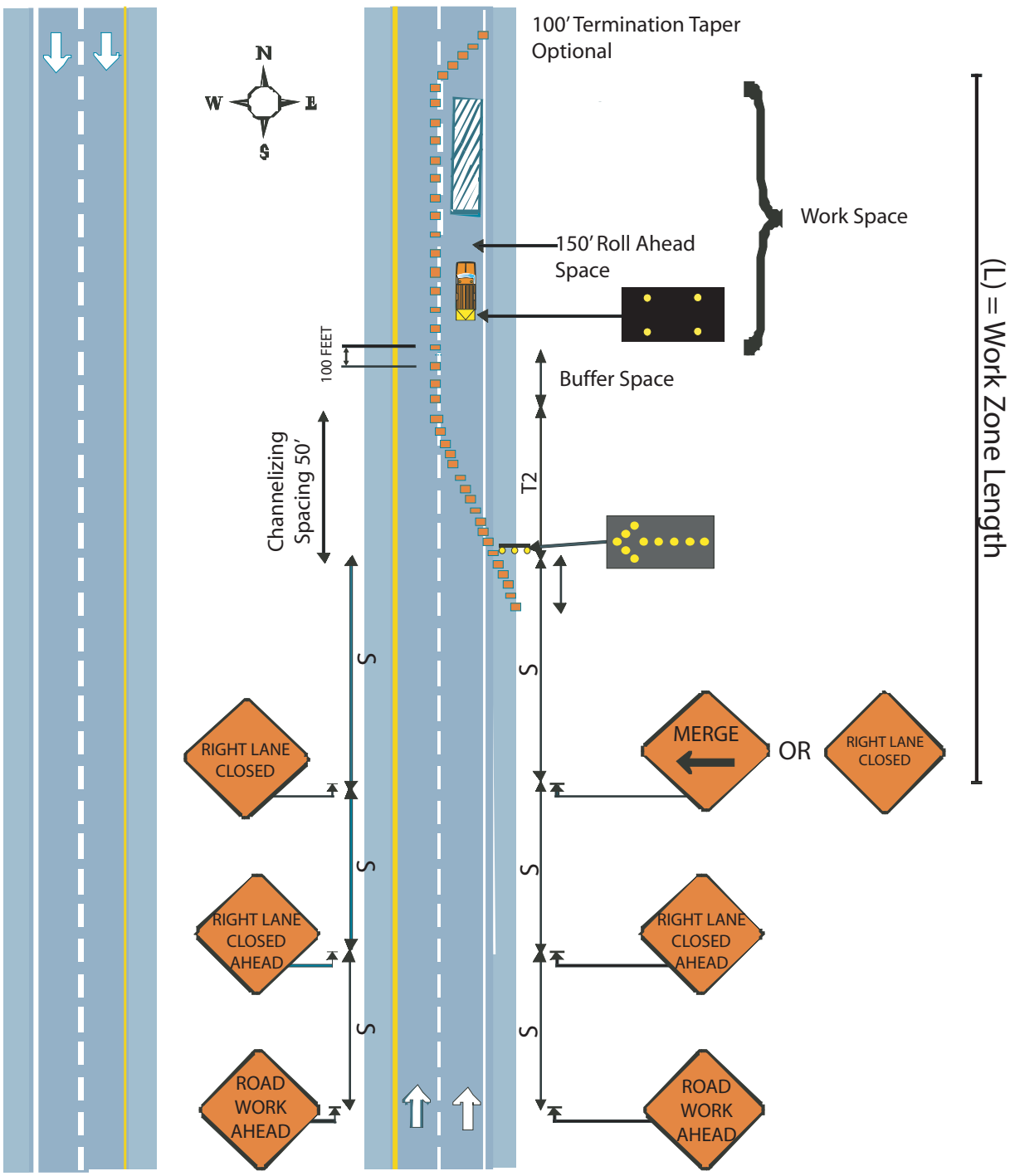
- Arrow (Right or Left)
- Double arrow
- Caution

- The arrow and double arrow modes are used for stationary or moving lane closures on multilane highways
- The arrow mode is used when traffic has no choice but to go left or right, while the double arrow mode is used when traffic has the choice to go left or right
- The caution mode is used for shoulder work, blocking the shoulder, work within a lane where the lane is not closed, and lane closures on two-lane, undivided highways

Note: In channelized operations, additional units located downstream of the taper area shall display the caution mode.



Without Channelizers



With Channelizers

These devices shall be/have:

- Functioning in the appropriate mode
- No more than one lamp, of those to be energized, out in stem and no lamps out in the arrow head(s) when in the arrow (single or double-headed) and no lamps out when in the caution (four (4) corners) modes
- Appropriately dimmed at night. When used during night operations, these displays shall be dimmed by 50 percent

Any lamp drawing less than 60% of its original power draw or producing less than 60% of its original output is considered out.

For stationary lane closures, the panel should be deployed on the shoulder or within an adjacent closed lane at the beginning of the lane or one-lane, two-way taper. Where adequate space or the temporary traffic control plan does not permit this placement, the unit may be placed within the taper of the closed lane. When closing multiple lanes, a separate unit shall be used to close each lane.

For moving lane closures on two-lane, undivided highways, the panel shall be deployed within the lane to be closed.

For moving lane closures on multi-lane highways, one panel should be deployed on the shoulder and another shall be deployed within the lane to be closed. Where adequate space does not permit deployment of the unit on the shoulder, the unit may be positioned partially in the lane to be closed. When an interior lane is being closed by itself, both units shall be deployed within the lane to be closed. When closing multiple lanes, a separate unit shall be used to close each lane.

A minimum lateral clearance of three (3) feet, measured horizontally from the edge of the panel to the edge of the traveled way, is recommended for trailer-mounted units deployed as specified in the previous paragraphs.

A minimum mounting height of seven (7) ft., measured vertically from the bottom of the panel to the roadway, is recommended for trailer-mounted units. For truck-mounted units, the panel mounting height should be as high as practical.

When deployed, the panel shall be sighted and aligned with approaching traffic to ensure visibility of the display.

Except when panels are located behind a taper or are truck-mounted, five (5) channelizers should be used to delineate each panel. These channelizers should be positioned on the upstream end of the unit to form a taper leading up to traffic side of the unit. The recommended length of this taper is 100 ft.

Channelizers

Channelizing devices are commonly used to delineate the traffic path through a work area. Guidance for channelizer spacing is available in the EPG. In addition, channelizers may be used as a warning device to mark specific hazards or as described in Article 616.1.3.3.1, Workspace. Channelizer spacing may be reduced at the discretion of the designer to one-half the spacing shown for off ramp gore areas, intersections, sharp curves, etc. For hazards in or adjacent to the roadway, use a spacing of 20 ft. or less.

The function of channelizers is to warn motorized and non-motorized traffic of conditions created by temporary activities or conditions in or near the roadway and to guide them through or around these conditions. Uses for these devices include the following:

- Provide smooth and gradual traffic flow from one lane to another, onto a bypass or detour, or into a narrower traveled way
- Separate traffic from the activity area, pavement drop-offs, opposing traffic or non- motorized traffic
- Separate non-motorized traffic from the activity area or unsafe conditions.
- Delineate spot obstructions
- Supplement other traffic control devices

There are four (4) types of channelizers used to perform these functions:

- Trim-line channelizers
- Cones
- Drums
- Direction indicator barricades

Trim-line channelizers (preferred option) are conical-shaped devices that are orange in color, 42 in. tall, 8 in. diameter at the base and augmented with alternating bands of orange and white retroreflective sheeting.

These devices are particularly effective in areas like ramps and intersections or where there is limited lateral clearance. In these situations, they provide greater warning and delineation functions than cones while maintaining a smaller footprint than drums.

Cones are conical-shaped devices that are orange in color and 28 inches in height. Cones shall be used on daytime operations only.

- Cones may be used in lieu of trim-line channelizers for daytime operations <u>on minor roads only.</u>
- ***Cones may be used in incident response or emergency applications.***

Drums are cylindrical-shaped devices that are orange in color, 36 in. tall, a minimum of 18 in. diameter, and augmented with alternating bands of orange and white retroreflective sheeting.

Direction indicator barricades are 36 in. tall devices consisting of a 24 in. wide x 12 in. tall retroreflective orange panel with a horizontal arrow on top and a 24 in. wide x 8 in. tall panel of alternating orange and white retroreflective stripes at a 45 degree angle on bottom.

Channelizer spacing shown in the following table below:

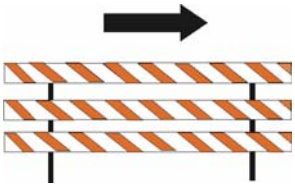
Speed Limit, mph	Channelizer Spacing [1] ft.	
	Taper	Buffer/Work Areas
0-35	35[2]	50[2]
40-45	40[2]	100[2]
50-55	50[3]	100[2]
60-70	60[3]	100[3]

[1] Channelizer lengths may be reduced to discourage traffic encroachment.
[2] Spacing reduced to 1/2 at intersections.
[3] Spacing may be reduced to 1/2 at intersections.

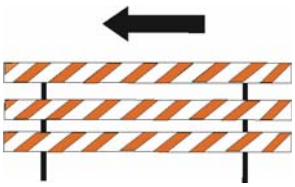
Barricades

A barricade is a portable device used to close, restrict or delineate all or a portion of the right of way to motorized and non-motorized traffic. Each unit contains a number of rails augmented with stripes of alternating orange and white retroreflective sheeting on the side facing traffic.

- Where a barricade extends entirely or partially across a roadway, the stripes should slope downward at a 45 degree angle across the entire barricade array in the direction in which traffic is to pass.

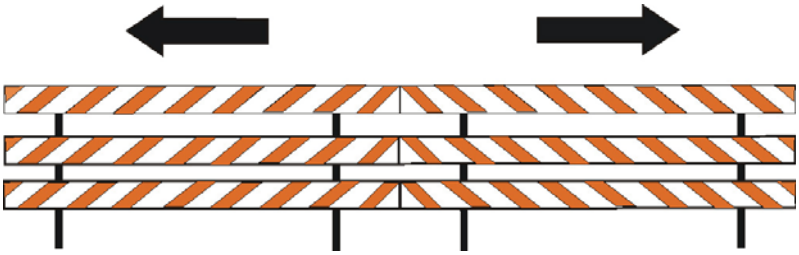


(Traffic passes to right)



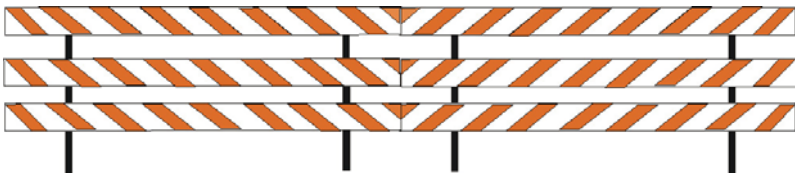
(Traffic passes to left)

- Where both right and left movements are provided, the stripes should slope downward at a 45 degree angle away from the center of the barricade array.



(Left and right traffic movement is provided)

- Where no movements are provided, the stripes should slope downward at a 45 degree angle toward the center of the barricade array.



(No movement of traffic provided)

The Type I (one rail) and Type III (three rail) barricade configurations are used on the state highway system.

The Type III barricade is the preferred option to perform the previously noted operations.

The Type I barricade is acceptable for use in non-motorized traffic operations on all highways and in emergency road closures on two-lane, undivided highways.

When a roadway is closed, but access is still allowed for local traffic or work vehicles, ***barricades may be offset to facilitate movement into and out of the closed area.***

One barricade is required for every 8 ft. of pavement, so a typical roadway with two (2) 12 ft. lanes will require three (3) barricades and with two (2) 4 ft. shoulders will require four (4) barricades.

(Typical installation of Type III Barricade with 12' lane no shoulder)

Type C warning lights may also be specified where additional impact is deemed appropriate.

Barricade Signs and Lights

Signs may be attached to the barricade and shall:

- Be light weight (roll up or plastic)
- Not obscure more than 50% of the top two (2) rails
- Not obscure more than 33% of all three (3) rails

Type C warning lights may be attached to the barricade and shall:

- Be light weight (3.3 lbs. or less)
- Have battery pack mounted no higher than 18" (lights over 3.3 lbs.)
- Shall not cover any portion of the barricade face

If signs and lights can not meet mounting requirements they shall:

- Be mounted on a separate crashworthy device
- Located 7 to 10 feet behind the barricade

Temporary Traffic Barrier

A temporary traffic barrier may be used in lieu of or in addition to channelizers separating motorized traffic from the workspace, an unsafe condition, or non-motorized traffic. It is not used to form tapers.

Due to the amount of resources needed to put barrier in place, this option is generally reserved for long-term stationary operations where the need for the noted function is critical.

If a barrier is desired, consult with appropriate engineering staff for design requirements prior to installation.

When used, the barrier should be supplemented with delineation for increased visibility. This delineation shall match the applicable pavement marking color.

In general, the preferred installation method for temporary concrete traffic barrier is free-standing, which requires a minimum buffer area of 2 feet behind the barrier to allow for lateral deflection in both work areas and lane separation situations. When free-standing installations are used on bridge decks, a buffer area of 4 feet is required. Concrete traffic barrier may be placed 6 inches from the edge of bridge decks if tie-down straps are used, however, a buffer area of 3 feet must be maintained. On bridge decks where lateral deflection cannot be tolerated, the barriers shall be bolted through the bridge deck. A proper transition from free-standing barrier to barrier with anchor bolts shall be installed on bridge decks. The method of installation on bridge decks is determined by MoDOT's Bridge Division and shown on the bridge plans.

When a temporary concrete traffic barrier has been displaced from its original location due to vehicle impact or other incidents the barrier shall be returned to its original position and pinned together, as originally designed. When the barrier cannot be realigned, articles must be added to provide a 75 foot overlap or the barrier must be anchored. Anchoring is achieved by pinning the barrier into the pavement or by drilling the overlapping barrier articles together with steel rods. Anchoring the barrier into the pavement is not recommended unless that segment of pavement is planned to be replaced or will not be part of the final traveled way. Care must be taken when drilling barrier to prevent damaging reinforcement steel. If any reinforcement steel is damaged by drilling, the barrier cannot be used except when barrier articles are overlapped and secured together.

Appropriate channelizing devices and pavement marking are always used in front of barrier tapers for lane closures, shoulder closures, and transition areas for temporary bypasses or connections. Wherever practical, a lateral buffer space should be provided between the edge of the driving lane and the barrier, and a longitudinal buffer space should be provided between the channelizer taper and the barrier taper.

Barrier Height Transition

Any end of the barrier installation susceptible to being hit by vehicular traffic shall be protected with a crashworthy end treatment. This requires installation of a barrier height transition for speeds less than or equal to 35 mph or an approved crash cushion for speeds greater than or equal to 40 mph.

Barrier Flare

As an option, barrier may be flared at a rate of 8:1 back to the limits of the clear zone, back slope or curb provided the side slope is 1V:6H (6:1) or flatter.

Crash Cushion

Crash cushions are designed to absorb energy of an impacting vehicle and reduce the force on a passenger to an acceptable level. An approved crash cushion is installed on the exposed end of the barrier when the normal posted speed on an existing facility, or the design speed of a temporary facility, is greater than 35 mph. A crash cushion is required on the upstream end for divided facilities, and on both ends for all two-way facilities.

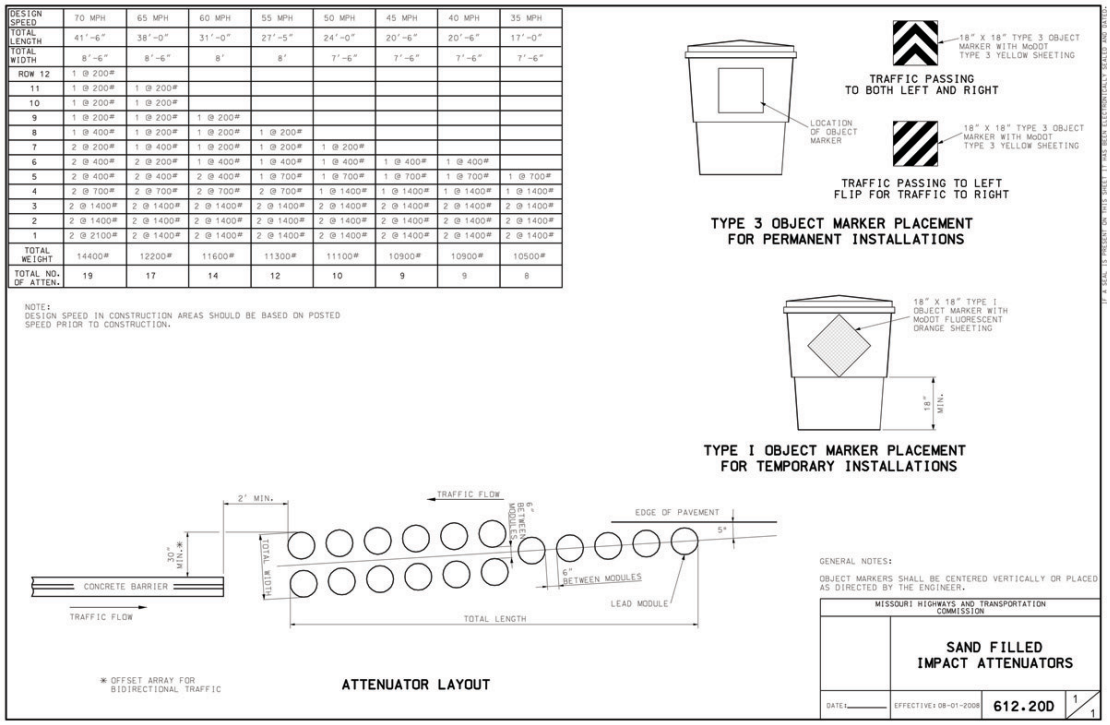
Crash cushions are systems that mitigate the effects of errant vehicles impacting roadside obstacles such as fixed objects or exposed barrier and guardrail ends. The system is designed to accomplish this by either smoothly decelerating the vehicle to a stop or redirecting the vehicle.

Due to variability of site conditions, systems shall be selected on a case-by-case basis. Consult appropriate engineering staff for this assistance.

This system consists of a group of freestanding plastic barrels configured in increasing weights from the impact point toward the object. Such an array transfers the vehicle’s momentum to the increasing masses of sand in the barrels and provides a gradual deceleration.

Each barrel is designed with a specific weight of sand to absorb the energy of an errant vehicle.

The sand barrel array's "footprint" length and width and the number of barrels will change based upon the vehicle speed. ***Refer to Standard Plan 612.20 for details.***



DESIGN SPEED	70 MPH	65 MPH	60 MPH	55 MPH	50 MPH	45 MPH	40 MPH	35 MPH
TOTAL LENGTH	41'-6"	38'-0"	31'-0"	27'-5"	24'-0"	20'-6"	20'-6"	17'-0"
TOTAL WIDTH	8'-6"	8'-6"	8'	8'	7'-6"	7'-6"	7'-6"	7'-6"
ROW 12	1 @ 200#							
11	1 @ 200#	1 @ 200#						
10	1 @ 200#	1 @ 200#						
9	1 @ 200#	1 @ 200#	1 @ 200#					
8	1 @ 400#	1 @ 200#	1 @ 200#	1 @ 200#				
7	2 @ 200#	1 @ 400#	1 @ 200#	1 @ 200#	1 @ 200#			
6	2 @ 400#	2 @ 200#	1 @ 400#	1 @ 400#	1 @ 400#	1 @ 400#	1 @ 400#	
5	2 @ 400#	2 @ 400#	2 @ 400#	1 @ 700#	1 @ 700#	1 @ 700#	1 @ 700#	1 @ 700#
4	2 @ 700#	2 @ 700#	2 @ 700#	2 @ 700#	1 @ 1400#	1 @ 1400#	1 @ 1400#	1 @ 1400#
3	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#
2	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#
1	2 @ 2100#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#	2 @ 1400#
TOTAL WEIGHT	14400#	12200#	11600#	11300#	11100#	10900#	10900#	10500#
TOTAL NO. OF ATTEN.	19	17	14	12	10	9	9	8

NOTE:
DESIGN SPEED IN CONSTRUCTION AREAS SHOULD BE BASED ON POSTED SPEED PRIOR TO CONSTRUCTION.

TYPE 3 OBJECT MARKER PLACEMENT FOR PERMANENT INSTALLATIONS

TYPE I OBJECT MARKER PLACEMENT FOR TEMPORARY INSTALLATIONS

* OFFSET ARRAY FOR BIDIRECTIONAL TRAFFIC

ATTENUATOR LAYOUT

GENERAL NOTES:

OBJECT MARKERS SHALL BE CENTERED VERTICALLY OR PLACED AS DIRECTED BY THE ENGINEER.

MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION

SAND FILLED IMPACT ATTENUATORS

DATE: EFFECTIVE: 08-01-2008 612.20D 1/1

Truck-mounted Attenuators

Truck-mounted attenuators are energy-absorbing devices attached to the rear of trucks used as protective vehicles. These devices are designed to protect the motorist and protective vehicle driver upon impact.

In general, the guidelines for the use of these devices are shown in

Table 612.1 Use of TMA's

Highway Type	Operation Location and Duration		
	In Lane		On Shoulder and Ramps and at Intersections
	Mobile	Stationary	
Two-Lane Undivided	Recommended	Recommended	Recommended
Multi-lane Undivided	Required	Recommended	Recommended
Multi-lane Divided[1]	Required	Required	Recommended

[1] On MoDOT's internal interstate maintenance operations, the host vehicle shall be a Heavy-Duty Single Axle Truck style or heavier, and meet the truck-mounted and trailer-mounted attenuator manufacturer's recommendations.

Truck-mounted attenuators shall be periodically inspected to ensure their functionality. Damaged parts shall be promptly repaired or replaced. Vehicles equipped with TMA's should be checked to make sure they are properly ballasted.

Examples of when a truck-mounted attenuator may be used:

- High volume/high speed situations
- Low volume/high speed situations
- Emergency situations
- Mobile and moving operations
- Stationary operations

Temporary Traffic Control Signals

Temporary traffic control signals are used at haul road or equipment crossings, on one-lane, two-way operations, and at temporary intersections located within the temporary traffic control zone to assign vehicular right of way. Typically, this is done with temporary span-wire installations or trailer-mounted units.

Consideration of the following factors will assist in the design and application of a signal installation.

- Site characteristics (e.g. safety and traffic needs; traffic volumes and speeds; sight distance and turning restrictions; side streets and driveways; parking; pedestrians; existing traffic control devices; human factors; etc.)
- Temporary traffic control design details (e.g. work staging; operation location and duration; feasibility of using other temporary traffic control measures; placement of this and other temporary traffic control devices; etc.)
- Functional aspects (e.g. signal phasing and timing requirements; full-time or part-time operation; actuated, fixed-time, or manual operation; interconnection with other temporary or permanent signals; etc.)
- Operational issues (e.g. power source; operation, inspection, and maintenance needs; record keeping; etc.)

When used, signals shall be installed and operated in accordance with EPG 902 Signals. In addition, the signals shall meet the physical display and operational requirements of conventional signals.

A traffic engineer or their designee shall approve all timing of the signal. In one-lane, two-way situations, this timing shall include an all-red interval of sufficient duration for traffic to clear the portion of roadway controlled by the signal.

A minimum lateral clearance of 3 ft., measured horizontally from the edge of the trailer to the edge of the traveled way, is recommended for trailer-mounted units. When deployed, signal heads shall be properly aligned with approaching traffic to ensure visibility of the indications. ***Five (5) channelizers should be used to delineate each trailer-mounted signal.*** These channelizers should be positioned on the upstream end of the unit to form a taper leading up to traffic side of the unit. ***The recommended length of this taper is 100 ft.***

Automatic Flagger Assistance Device (AFAD)

Intellistrobe

RC Flagman

Intellistrobe- The Intellistrobe model has the light indicators and a stop arm. The unit can be controlled from a transmitter carried by the operator who is located away from the unit. It is also equipped with a Lane Intrusion Alarm, which is activated when traffic crosses the safety pneumatic hoses and enters the work activity area.

RC Flagman-The mechanical flagger system consist of a red and amber indication signal head, and a PVC flagger arm. The RC Flagman is placed at one end of the work zone substituting one human flagger, and is remotely controlled by a human flagger located at the other end of the work zone.

Temporary Pavement Markings

Pavement markings are the primary means of channelizing and providing guidance to traffic. However, when temporary traffic control activities impact the use of a roadway or when operations eliminate permanent pavement markings, existing pavement markings, or lack thereof, can confuse the motorist.

Changes in roadway use caused by long-term operations should be accompanied by pavement marking revisions (i.e., the removal or obliteration of any pavement markings that are not applicable to current roadway use and the installation of temporary pavement markings). For operations of shorter duration, the other temporary traffic control devices (e.g. channelizers, signs, etc.) deployed will be relied on to provide traffic with the needed channelization and guidance cues. Pavement marking revisions for shorter duration operations may be a possibility but should be considered on a case-by-case basis.

Elimination of permanent pavement markings for a distance of 200 linear ft. or more caused by operations such as leveling course, patching, seal coat, spot sealing, crack pouring, milling and scrub sealing shall be accompanied by the installation of temporary centerline and lane line pavement markings and **NO CENTER STRIPE signs**, as specified in 616.23.2.5.7 Pavement Markings.

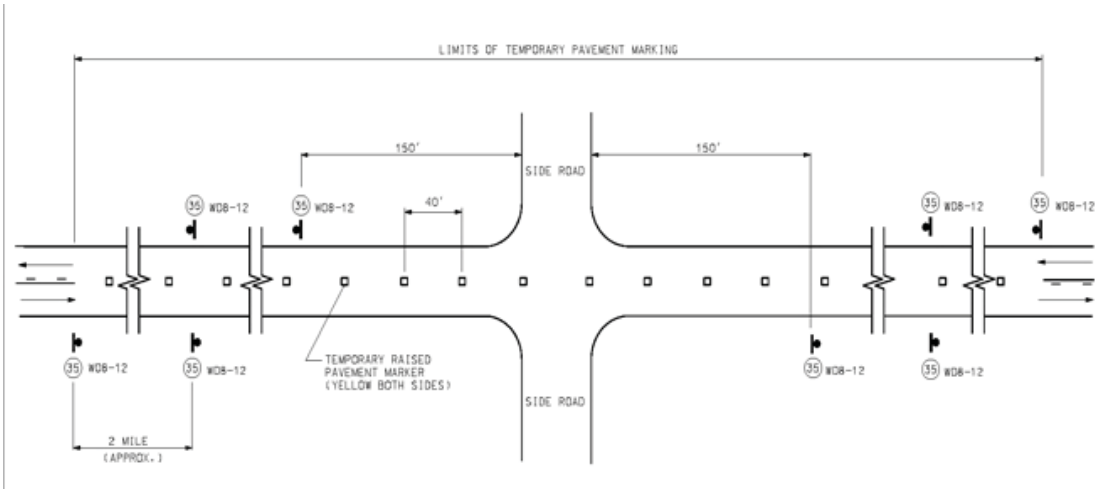
In addition to providing temporary pavement markings, NO CENTER STRIPE signs may also be warranted. NO CENTER STRIPE signs are black-on-orange warning signs used on two-lane and two-lane with auxiliary lane facilities where no-passing zone centerline marking is eliminated for 200 linear ft. or more.

These signs are placed in advance of the missing no-passing zone centerline markings area at the recommended sign spacing. For extended areas continuously or intermittently missing no-passing centerline marking, ***NO CENTER STRIPE signs should also be installed within 150 ft. after the intersection of a state highway and at two-mile spacing throughout the affected area.*** Upon the discretion of the supervisor, additional NO CENTER STRIPE signs may be installed within 150 ft. after other intersections. When a sign placed at the two-mile interval and one placed after an intersection fall within one-eighth mile of each other, the sign placed at the two-mile interval may be eliminated.

When temporary pavement markings and/or NO CENTER STRIPE signs are necessitated by either a change in roadway use or the elimination of permanent pavement markings, the following provisions shall be incorporated into the operation.

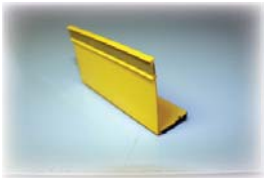
- Those performing the operation shall be responsible for coordinating the procurement, installation, maintenance and removal, as applicable, of pavement markings, temporary or permanent, and any NO CENTER STRIPE signs.
- Temporary pavement markings and any NO CENTER STRIPE signs shall be in place prior to opening a roadway to traffic. However, on ***two-lane highways with AADTs less than 1000, installation of pavement markings may be delayed up to 5 working days***, initiated by the elimination of the permanent pavement markings, provided the required NO CENTER STRIPE signs are in place as prescribed previously prior to opening the facility to traffic.
- Temporary centerline and lane line pavement markings and any NO CENTER STRIPE signs shall be in accordance with ***Standard Plan 620.10.***
- Permanent pavement markings should be installed no later than 15 calendar days after any operation has been completed. However, delays in installation should be minimized where possible.
- Removal or obliteration of all pavement markings shall be complete and leave minimal pavement scarring. Concealing any pavement marking with black paint or asphalt is not acceptable.

Guidelines for installation of temporary pavement markings along with diagrams can be found in the EPG under Standard Plan 620.10



Temporary Pavement Marking

There are four (4) means typically used to provide temporary pavement marking: preformed short-term pavement marking tape, Type 1 temporary raised pavement markers, Type 2 temporary raised pavement markers and pavement marking paint. ***Refer to Standard Plan 620.10 for diagrams listing temporary pavement marking application requirements.***

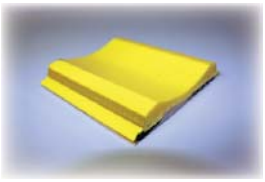


Type 1 temporary raised pavement markers consist of an L- or T-shaped flexible tab with a retroreflective sheeting on both faces of the vertical article and a pressure-sensitive adhesive on the base. These markers, available in white and yellow, are typically ***used to temporarily mark centerlines and lane lines by applying them to the road surface at 40-ft. intervals*** prior to or after, depending on the type of surface treatment, an operation and removing the protective film covering the retroreflective sheeting upon completion of the operation. This spacing may be reduced by one-half when marking intersections, ramp gores and other transitional areas.

Type 1 markers are the preferred means of providing temporary marking on rough surfaces.

- Type 1 temporary markers are used on surface treatment projects and are installed before the surface treatment is applied.
- Type 1 temporary markers are also used for temporary edgeline marking and may be used as part of the “cluster marking” for lane lines on divided highways.

Type 2 temporary raised pavement markers consist of a plastic dome with reflectors on the sides and a pressure-sensitive adhesive on the base. These markers, available in white and yellow, are typically ***used to temporarily mark changes in normal roadway use by applying them to the road surface at 40-ft. intervals.*** This spacing may be reduced by one-half when marking intersections, ramp gores and other transition areas.



Type 2 markers work well on concrete and smooth asphaltic surfaces.

- The Type 2 temporary marker may be used on final surfaces on paving projects.
- The Type 2 markers are also part of the “cluster marking” for lane lines on divided highways.

Preformed short-term pavement marking tape consists of a 4-in. wide retroreflectorized tape with a pressure-sensitive adhesive on the back. The tape, available in white and yellow, may be used to provide a surrogate permanent pavement marking or it may be cut into 4-ft. long articles and applied to the road surface at 40-ft. intervals as a temporary pavement marking. The length and spacing of the latter pavement marking may be reduced by one-half when marking intersections, ramp gores and other transitional areas. This material is typically used to temporarily mark changes in normal roadway use and to provide temporary marking of centerlines and lane lines when permanent pavement markings are eliminated. It is not recommended for locations where the materials will be subjected to heavy traffic, in areas of heavy turning movements, on short radius curves, or on roadways having loose aggregate on the surface, since the material will not adhere well under these conditions.

Pavement marking paint consists of applying a 4-in. wide strip of acrylic waterborne paint with drop-on glass beads for retroreflectivity. The paint, available in white and yellow, may be used to provide a surrogate permanent pavement marking or it ***may be applied in 4-ft. long articles at 40-ft. intervals*** as a temporary pavement marking. The length and spacing of the latter pavement marking may be reduced to one-half when marking intersections, ramp gores and other transition areas. This material is typically used to temporarily mark changes in normal roadway use and to provide temporary marking of centerlines and lane lines when permanent pavement markings are eliminated.

Module 11: Quality Requirements

Temporary traffic control devices shall be installed and maintained in an acceptable condition. Unless specified otherwise, this requirement does not mandate the use of new devices. However, it does necessitate the use of functional devices. Unacceptable devices shall be replaced or corrected in accordance with the contract documents or, in the absence of a contract, as directed by MoDOT's representative.

Quality Standards

It is with this possibility in mind and to provide the means to comply with the *Manual on Uniform Traffic Control Devices'* Section 1A-05 that MoDOT established ***Article 616.19 in the EPG***. These quality standards are applicable to all temporary traffic control devices and are to be used by those responsible for the installation, operation, maintenance and inspection of temporary traffic control devices as a guide to determine if those devices are acceptable for use on the state highway system.

These standards should be applied at several stages:

- Prior to delivery to the work zone
- During initial setup
- Routinely during the course of work

Such scrutiny will ensure the effectiveness of the temporary traffic control devices throughout the life of the work zone.

General

All temporary traffic control devices shall be:

- In conformance with the requirements of the MUTCD and MoDOT Standards
- Installed and maintained at locations and in orientations that maximize safety and minimize disruption to traffic flow
- Aligned with the road user's line of vision
- Positioned as to not obstruct other applicable traffic control devices
- Free of any appreciable dents, holes, deformations, abrasions, tears, marks, stains, residues, fading or other deficiencies that affect the operational performance of a device; or, are cause for failure of a device to conform with the requirements of the *MUTCD* or MoDOT Standards to be considered crashworthy
- Properly covered, turned, stowed, or removed when not in use

Barricades, Channelizing Devices and Signs

These devices shall be:

- Reasonably plumb to the pavement
- Safely and neatly ballasted, as needed
- Clearly visible and legible/distinguishable to approaching traffic during the day and, if applicable, at night
- Refer to sign covering practices and, for examples of unacceptable devices, refer to unacceptable standards

Warning Lights

These devices shall be:

- Visible from a distance of 3,000 ft. on a clear night for Type A (low-intensity, flashing) and Type C (low-intensity, steady-burn) and from a distance of 1,000 ft. on a sunny day without the sun directly on or behind the devices for Type B (high-intensity, flashing) warning lights
- Illuminated at appropriate times
- Securely affixed to the host

Flashing Arrow Panels

These devices shall be/have:

- Functioning in the appropriate mode
- No more than one lamp, of those to be energized, out in the stem and no lamps out in the arrow head(s) when in the arrow (single- or double-headed) and no lamps out when in the caution (four (4) corners) modes
- Appropriately dimmed at night
- Any lamp drawing less than 60% of its original power draw or producing less than 60% of its original output is considered out

Changeable Message Signs

These devices shall be/have:

- Displaying the prescribed message at an appropriate cycle
- Clearly legible to approaching traffic with minimal display abnormalities
- Appropriately dimmed at night

Temporary Pavement Markings

These devices shall be:

- In place at applicable times
- Reasonably aligned longitudinally
- Clearly visible to approaching traffic during the day and night
- Completely removed when no longer applicable

Sign Coverings

These items shall be:

- Sized to match the sign to be covered
- Positioned to cover most of the sign face
- Designed to prevent “bleed through” of the covered sign and damage to the permanent sign installation
- Constructed with non-metallic handles
- Adequately secured to the host sign assembly

Examples of acceptable sign covering practices:

Examples of unacceptable sign covering practices:

Unacceptable Devices

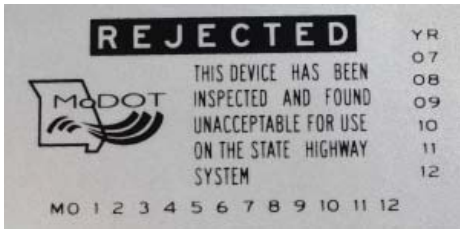
Shown below are examples of unacceptable temporary traffic control devices. These examples apply to all such devices.

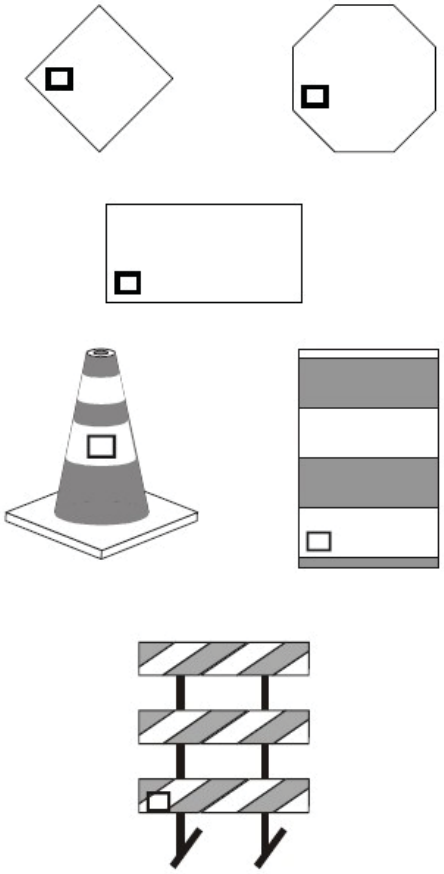
Rejection Stickers

R11-52 REJECTED Decal (Order No. MoDOT 46)

REJECTED stickers, with appropriate month and year designated, may be used by MoDOT personnel to identify unacceptable temporary traffic control devices. For barricades, channelizing devices and signs, the sticker should be located on the front-, left and lower-most retroreflective area on the device. For other devices, the sticker should be located in a conspicuous place on the device.

Below are examples of rejection sticker locations:





Module 12: Creating a Safe Driving and Work Environment

Work zones can present motorists with atypical driving conditions. These conditions may increase the potential for vehicle on object, vehicle on vehicle, and vehicle on worker incidents. Therefore, it is essential that the WZS review the setup and operation of the work zone and make field adjustments to minimize risk.

- ***Equipment and Material*** – Only equipment and materials necessary to perform the work are to be located within the work zone. Unnecessary or non-essential items shall be removed from the roadway or stored in an acceptable staging area. This includes personal vehicles, hauling equipment, idle traffic control devices, machinery, etc.
- ***Traffic Control Devices*** - Devices must fulfill a need, provide appropriate and pertinent information, be properly located, and meet quality standards. Devices failing to do so are to be adjusted, replaced, or removed, as appropriate, from the roadway. Unused devices are either stored off site at an acceptable staging area or in a safe manner along the roadside. Care is to be taken to ensure devices are installed and operated in accordance with crashworthiness requirements. This is particularly true for crash cushions, portable concrete traffic barrier, and TMAs where energy absorption, device deflection, vehicle redirection, and roll ahead dynamics are critical to the safe performance of the devices.
- ***Workers*** - Personnel should be limited to those necessary to perform the work. Persons not performing actual work on the road should remain in a vehicle until their services are required. All personnel should be attired in proper PPEs. Workers performing traffic control functions, such as flagging, shall make themselves readily visible to oncoming traffic.
- ***Conditions*** - Care should be taken to avoid or minimize conditions which may impose safety concerns to traffic. For example: dirt, debris, dust, etc., resulting from work activity should be removed or abated; severe geometrics, blunt ends, open excavations, etc. should be avoided, delineated, or shielded, as appropriate; and driving opposed to traffic, should be restricted to areas where the traffic and work spaces are separated by a physical barrier.
- ***Traffic*** - The WZS should actively monitor traffic operations in advance of and through the work zone and make appropriate corrections to the temporary traffic control to improve movement throughout the operation. Evidence of accidents, hard braking, displaced devices, traffic backups, and displeased motorists are indicators of a poor performing work zone that needs modifying.

Work Zone Inspections

The act of designing a work zone or putting that plan into action does not guarantee satisfactory performance in the field. For that reason, it is vitally important that work zone inspections be performed to assess compliance with temporary traffic control requirements and the safety of both the motorist and the worker. By identifying any concerns and addressing them as soon as practical, we can avoid situations that may reduce the effectiveness of the temporary traffic control measures deployed and potentially improve the overall performance of future work zones.
Work zone inspections, similar to other inspection processes, have a quality control and a quality assurance component. These two (2) inspection categories are discussed in more detail below.

- **Quality Control Inspections** are normally performed by the contractor, subcontractor, field operation and inspection personnel responsible for installing, operating, maintaining, and removing the work zone. Inspections performed at different times throughout the life of the operation or project to ensure the temporary traffic control devices are in good condition, function properly, meet requirements, and provide adequate guidance to the motorists. While the results of such inspections may not be documented, the performance of them is important to the overall quality and operation of the work zone and should not be dismissed. There are four (4) different types of work zone quality control inspections – Pre-Installation, Post-Installation, Routine, and Removal. A description of each type of these inspections follows.
- **Pre-Installation Inspections** are performed at a staging area or maintenance facility prior to deploying temporary traffic control devices in the field. The purpose of this inspection is to ensure the proper devices are available, in good condition, and working properly before they are put into service. Inspection of the work zone location should not be overlooked during pre-installation inspections because modifications to the temporary traffic control plan may be necessary to accommodate field conditions. As with the devices, it is better to identify and address problems before installing the devices.
- **Post-Installation Inspections** are performed after the temporary traffic control devices have been deployed and after any modifications or phase changes. The purpose of this inspection is to ensure the work zone is set up correctly, the devices are working properly, and traffic responds appropriately to the guidance provided to them.
- **Routine Inspections** are performed at regular intervals throughout the life of the work zone. The purpose of this inspection is to identify any concerns with the quality, performance, and placement of the temporary traffic control devices or motorists' response so they may be remedied.
- **Removal Inspections** are performed during the removal of the temporary traffic control devices from the work zone or when they are returned to the staging area or maintenance facility. The purpose of this inspection is to identify and complete any needed repairs and replacements to the devices before they are put back into inventory.

Inspections

To provide acceptable levels of operations, routine daytime and nighttime inspections of temporary traffic control elements should be performed as follows:

A. Individuals who are knowledgeable (trained in traffic control) in the principles of proper temporary traffic control should be assigned responsibility for safety in temporary traffic control zones.

B. As the work progresses, temporary traffic controls and/or working conditions should be modified in order to provide safe and efficient motorist movement and to promote worker safety.

C. Temporary traffic control zones should be carefully monitored under varying conditions of traffic volume, light, and weather to check that applicable temporary traffic control devices are effective, clearly visible, clean, and in compliance with the temporary traffic control plan.

When to Inspect:

Work zone supervisors need to check the flow of traffic to ensure traffic is flowing as it was designed:

- Immediately after work zone set up
- After any modifications
- At night
- Intermittently throughout the duration of the job
- Under adverse weather conditions such as wind, rain, fog or snow

Work Zone Inspection Form

Work Zone Information

District_____ County_____ Designation/Route/Direction_____ Project #_____ Work Zone # _____

Route/Intersection_____(Beginning) Route/Intersection_____(Ending)

Weather: Clear___Cloudy___ Rain___ Snow___ Ice___ Windy____

Date:_____ Time:_____AM/PM Reviewer User ID: _____

Yes/No/Not Applicable	**Items Reported**
Yes/No	Does this work zone present an immediate danger to the traveling public or workers and need to be addressed immediately?

Warning

Y /N /NA	1. The changeable message sign (CMS) and/or dynamic message sign (DMS) is aligned with the road user's line of vision.	Y /N /NA	3. The CMS/DMS has an acceptable lateral clearance from the roadway.
		Y /N /NA	4. All signs were present and in proper sequence.
Y /N /NA	2. The CMS/DMS cycle is consistent with the driver's operating speed.	Y /N /NA	5. Signs are free from obstructions (vegetation, traffic control devices, etc.).

Signing - Vision

Y /N /NA	1. The CMS/DMS has the proper light intensity for the work zone conditions.	Y /N /NA	4. The arrow board has the appropriate light intensity for the work zone conditions.
Y /N /NA	2. Sign(s) location and placement is appropriate for field and geometric conditions.	Y /N /NA	5. The temporary traffic signal(s) is clearly visible to oncoming traffic.
Y /N /NA	3. The arrow board is aligned with the road user's line of vision.	Y /N /NA	6. The arrow stem did not have in excess of one lamp out.

Signing - Message

Y /N /NA	1. The CMS and/or (DMS) is reporting the proper message.	Y /N /NA	5. The arrow board is functioning in the appropriate mode.
Y /N /NA	2. The CMS/DMS display is understandable.	Y /N /NA	6. The arrow head did not have any lamps out.
Y /N /NA	3. The work zone signs convey the proper message.	Y /N /NA	7. The stop bar or sign clearly indicates where to stop for a signal.
Y /N /NA	4. There was appropriate sign coverage, when required.	Y /N /NA	8. Appropriate use of “No Center Stripe” sign(s).

Personnel

Y /N /NA	1. The flagger was using proper safety attire and equipment for the work zone activity.	Y /N /NA	4. The flagger is attentive and focused on traffic control.
		Y /N /NA	5. The flagger has an escape route.
Y /N /NA	2. The flagger is in a safe and appropriate location in relation to the work zone activity, equipment, and travel roadway.	Y /N /NA	6. The flagger location was properly illuminated.
		Y /N /NA	7. All workers are safely within the boundaries of the work zone.
Y /N /NA	3. If more than one flagger is present, they are communicating properly with each other.		

Channelizing Devices/Barricades

Y /N /NA	1. Channelizer location and placement is appropriate for field and geometric conditions.	Y /N /NA	4. The pavement markings are installed and removed properly and are not in conflict with other markings.
Y /N /NA	2. The work zone uses appropriate transition (taper). If no, is it too long or too short (please circle)?	Y /N /NA	5. The pavement markings are visible in current environmental conditions.
		Y /N /NA	6. The barricade(s) have appropriate striping for work zone usage.
Y /N /NA	3. The pavement markings are complete and appropriate for the work zone activity.	Y /N /NA	7. The barricade location and placement is appropriate for field and geometric conditions.

Speed

Y /N /NA	1. The appropriate speed limit is set for the work zone. If no, was it too high or too low (please circle)?

Yes/No/Not Applicable	Items Reported
	Timeliness
Y /N /NA	1. Lane closures are appropriate for the work performed.
Y /N /NA	2. Traffic flow did not slow or stop unnecessarily.
Y /N /NA	3. The traffic queue is not unnecessarily excessive.
Y /N /NA	4. The temporary traffic signal(s) is operating at an appropriate timing to accommodate traffic queues.
Y /N /NA	5. If a detour was used, the length of the detour was acceptable.
	Cleanliness
Y /N /NA	1. Sign(s) are clean, visible, and suitable for work zone conditions.
Y /N /NA	2. Channelizer(s) are clean, visible, and suitable for work zone conditions.
Y /N /NA	3. Barricade(s) are clean, visible, and suitable for work zone conditions.
	Safety
Y /N /NA	1. The traffic queue is within the work zone signs.
Y /N /NA	2. The arrow board lateral clearance is at an acceptable distance from the roadway.
Y /N /NA	3. The channelizers are proper and approved ballasts.
Y /N /NA	4. The barricades are proper and approved ballasts.
Y /N /NA	5. The signs are proper and approved ballasts.
Y /N /NA	6. The temporary traffic signal is operating correctly.
Y /N /NA	7. The Automatic Flagger Assistance Device is operating correctly.
Y /N /NA	8. The Truck or Trailer Mounted Attenuators were located properly within the stationary or moving operation work zones.
Y /N /NA	9. Work zone lighting location, placement, and intensity is appropriate for the field and geometric conditions.
Y /N /NA	10. Fleet lighting location, placement, and intensity is appropriate for the field and geometric conditions.
Y /N /NA	11. Equipment and/or vehicles are moving in the same direction as traffic flow.
Y /N /NA	12. Edge drop-off is appropriate for the field and geometric conditions.
Y /N /NA	13. There were no unnecessary adverse pavement conditions (e.g., ruts, pot holes, bumps, debris, etc.).

Provide necessary detail on "No" ratings:

Reviewer shall convey any comment(s) to appropriate district staff. The above comment(s) were conveyed to

Name: _____

Title: _____

Date and Time of Review: / / _____ : _____ a.m./p.m.

If necessary, immediate feedback given to : _____

Phone Numbers for Work Zone Issues

D1	816.387.2350	D6	314.340.4100
D2	660.385.3176	D7	417.629.3300
D3	573.248.2490	D8	417.895.7600
D4	816.622.6500	D9	417.469.3134
D5	573.751.3322	D10	573.472.5333

Addressing Work Zone Deficiencies

Once you have identified a deficiency or it has been brought to your attention, the time frame for correcting it is based on an evaluation of the exposure. Exposure is determined by the combination of the number of people affected and the severity of the deficiencies. These two (2) factors give an indication of the danger faced by both the motorists and workers. Good judgment must be used to determine the severity of the exposure.

Once the incident situation has been evaluated, a determination should be made on the response priority of the incident based on established priority levels.

PRIORITY 1: Urgent. Respond as soon as possible (day or night, weekends or holidays), suspending other lower priority work, if necessary. Represents an immediate hazard to the public.

PRIORITY 2: Response should be accomplished as soon as practical during normal working hours, suspending other lower priority work if necessary. Either the condition represents a potential safety concern or the feature is not performing as intended.

PRIORITY 3: Response should be accomplished with a higher urgency than routine maintenance.

LANE CLOSURE NOTIFICATION: When a lane is closed one (1) hour or more a lane closure notification is required.

The following priority listing has been established as a guideline for districts to use when responding to incidents. Deviations from these response priorities should be documented with reasons for not following the established guidelines. Individual responders must be allowed to exercise discretion and good judgment, based on existing conditions and circumstances surrounding the incident.

An incident may require response at all three priority levels with only a portion of the work being emergency in nature. EXAMPLE: A large accident with significant structural damage to a bridge, a light pole knocked down off the roadway, a guide sign knocked down and damage to landscape plantings.

	PRIORITY 1	PRIORITY 2	PRIORITY 3
PRIORITIES ARE GUIDELINES AND MAY BE UPGRADED IF PRIMARY CONTACT DEEMS NECESSARY	**Urgent. Respond as soon as possible (day or night, weekends, or holidays) suspending other lower priority work if necessary. Represents an immediate hazard to the public.**	**Response should be accomplished as soon as practical during normal working hours, suspending other lower priority work if necessary. Either the condition represents a potential safety concern or the feature is not performing as intended.**	**Response should be accomplished with higher urgency than routine maintenance.**
LANE CLOSURE NOTIFICATION: When a lane is closed one (1) hour or more a lane closure notification is required.			
TRAFFIC CONTROL IN WORK ZONES			
SAFETY DEFICIENCIES (e.g., Improper flagging position and procedure; missing PPEs and devices; faulty devices and safety appurtenances; hazards; glare; improper tapers; etc.)	X		
PERFORMANCE DEFICIENCIES (e.g., missing pavement markings; improper device spacing, marking, and dimension; traffic congestion; inappropriate speed limits; displaced and damaged devices; etc.)		X	
AESTHETIC DEFICIENCIES (e.g., Leaning signs; dirty devices; bad sign covering; improper storage; CMS messaging, etc.)			X

Module 13: Tort Liability and Risk Management

This article provides an overview of risk management principles, tort liability, and techniques for monitoring and evaluating existing facilities and programs.

Issues of risk management and tort liability are becoming major determinants of planning, engineering, and implementation programs for motorists.

Agency concerns about potential liability can either lead to innovation and substantially improved facilities and programs or they can lead to a “do nothing” approach. Ignoring risks does not make them go away. Taking systematic steps to identify and evaluate risks and to develop an effective risk management program are essential measures, even if you cannot afford to remedy all problems immediately.

Negligence: An act or omission within the scope of the duties of an individual, agency, or organization that leads to the harm of a person or of the public; the failure to use reasonable care in one’s actions.

To prove negligence, the plaintiff’s attorney must prove each of these conditions:

- The defendant has a duty to use reasonable care: Do the defendant’s duties include responsibility for some element of the accident (site, vehicle, etc.)?
- The defendant did not responsibly carry out that duty (was negligent): Did the defendant exercise ordinary care performing his or her duty in a reasonable and prudent way?
- The defendant’s failure to carry out that duty (negligence) was directly responsible for the injury (“proximate cause”).
- The plaintiff was not guilty of contributing to the cause of the accident through comparative negligence.
- The plaintiff incurred damages resulting from the incident.

Intent Matters

What if you have been made aware of a potentially hazardous condition and an injury occurs before you have taken steps to correct the condition? Agencies have a responsibility to fix problems, but the courts tend to favor good will and intent to find solutions, even if some conditions are too expensive to fix immediately. Again, a great deal will depend on the length of time that has passed between identifying the condition and the injury. If it can be shown that a reasonably short period has elapsed and that the agency or other party is taking positive steps toward correcting the condition, the defense position will be improved.

If it had not identified potential risks and taken steps toward risk reduction, the defense will be substantially weakened.

Signing a hazardous condition has long been recognized as an important interim treatment for many conditions. Failing to sign a known condition is difficult to defend. Signing and warning offers two (2) types of benefits: (1) People are more cautious, so the number of incidents and injuries are reduced; and (2) The attempt to alert

the public about a potentially hazardous condition generates good will and makes it more difficult for a plaintiff 's attorney to argue that the plaintiff was surprised by the condition.

Signing should follow standard signing and marking practices. What if you have identified a potentially hazardous condition and have taken steps to correct it?

Assuming the responsible agency has carried out its duties using ordinary care in a responsible way, it will be more difficult to prove negligence. The burden of responsibility may well shift to the injured party whose contributory negligence may have led to the incident.

Minimizing Liability: What can we do?

There are effective ways to minimize liability in temporary traffic control zones.

- Document your duties and responsibilities
- Follow "Standards of Care"
  - National/agency standards and guidelines
  - MUTCD, MoDOT Specs
  - Traffic Control Plan
  - Document any deviations from the standards
- Minimize project duration
- Search for deficiencies
  - If you find problems, FIX THEM
- Keep workers trained and up-to-date
  - Document training history
- Share concerns with supervisors, managers
  - Document conversations
- Prioritize Safety…always
- Key Word: DOCUMENTATION
  - Photos
  - Video
  - Drawings
  - Inspections/Checklists

Acronyms and Abbreviations

AADT	Average Annual Daily Traffic
ADA	Americans with Disabilities Act
AFAD	Automated Flagging Assistance Device
ANSI	American National Standards Institute
AWZT	Advance Work Zone Training
DMS	Dynamic Message Signs
EPG	Engineering Policy Guide
FHWA	Federal Highway Administration
FPS	Feet per second
FT	Feet
ISEA	International Safety Equipment Association
Lbs	Pounds
MHTC	Missouri Highway & Transportation Commission
MoDOT	Missouri Department of Transportation
MPH	Mile per hour
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
PCMS	Portable Changeable Message Signs
PDM	Project Development Manual
PI	Public Information
PRT	Perception-Reaction Time
TCFO	Traffic Control for Field Operations
TCP	Traffic Control Plan
TL	Test Level
TMA	Truck Mounted Attenuator
TMP	Transportation Management Plan
TO	Transportation Operations
TTCD	Temporary Traffic Control Devices
VPH	Vehicles per hour
WZS	Work Zone Specialist

Definitions

Activity Area - Area of a temporary traffic control zone where work activity takes place. It is comprised of the work, traffic and buffer spaces.

Advance Warning Area - Area of a temporary traffic control zone where traffic is informed of the upcoming temporary traffic control zone.

Advance Warning Rail System - Three barricade rails installed to enhance a warning sign and flags.

Area Lighting - Lighting used at night to guide traffic through the temporary traffic control zone.

Annual Average Daily Traffic (AADT) - Volume of vehicular traffic using a article of highway on an average day.

Barricade - Temporary traffic control device consisting of one or three appropriately marked rails used to close, restrict or delineate all or a portion of the right of way.

Barrier-Mounted Sign - Sign mounted on a temporary or permanent traffic barrier.

Buffer Space - Area within the activity area free of equipment, material, and personnel used to provide lateral and/or longitudinal separation of traffic from the workspace or an unsafe condition.

Channelizer - Temporary traffic control device used to guide traffic or delineate an unsafe condition.

Cluster Marking - A group of Type I and/or Type II temporary pavement markings installed on the roadway shoulder or centerline, as described in Standard Plan 620.10.

Crash Cushion - Temporary traffic control device used at fixed object and other desirable locations to reduce crash severity.

Daytime/Daylight - Period of time from one-half hour after sunrise to one-half hour before sunset.

Detour - Temporary rerouting of traffic onto an existing facility to avoid a temporary traffic control zone.

Diversion - Rerouting of traffic around an activity area using a temporary roadway or portions of an existing parallel roadway.

Divided Highway - Highway with physical separation of traffic in opposite directions.

Downstream Taper - Visual cue to traffic that access back into a closed lane is available.

Emergency Operation - Work involving the initial response to and repair/removal of Response Priority 1 items.

Fine Sign - Regulatory sign indicating the applicability of additional fines in a temporary traffic control zone.

Flag System – A flag bracket and two flag assemblies. Flags are used to enhance signs.

Flagger - Person who provides temporary traffic control by assigning right of way.

Flashing Arrow Panel - Temporary traffic control device with a pattern of elements capable of flashing displays (i.e. left/right arrow, double arrow, caution mode) used to provide warning or guidance to traffic.

Fleet Lighting - Rotating or flashing lights used to increase the visibility of work-related vehicles and equipment in the temporary traffic control zone.

Guide Sign - Sign showing route designations, destinations, directions, distances, services, points of interest or other geographical, recreational or cultural information.

High Speed - Posted speed of 50 mph and above.

Highway - Any facility constructed for the purposes of moving traffic.

Incident Area - Temporary traffic control zone where temporary traffic control devices are deployed in response to a traffic incident, natural disaster, special event, etc.

Intermediate-Term Stationary Operation - Daytime work occupying a location from more than one daylight period up to 3 days or nighttime work occupying a location more than 30 minutes.

Lane Taper - Temporary traffic control measure used to merge or shift traffic either left or right out of a closed lane.

Lateral Buffer Space - Obstacle-free area adjacent to the workspace or an unsafe condition that provides room for recovery of an errant vehicle.

Lighting Device - Temporary traffic control device illuminating a portion of the roadway or supplementing other traffic control devices.

Long-Term Stationary Operation - Work occupying a location longer than 3 days.

Longitudinal Buffer Space - Obstacle-free area in advance of the work space or an unsafe condition that provides room for recovery of an errant vehicle.

Low Speed - Posted speed of 45 mph and below.

Low Volume - 500 or less AADT. The rule of thumb is to count the number of vehicles passing a single reference point over a five-minute period. If not more than three vehicles pass the reference point in that period, then the road can be considered low volume for the purpose of installing work zone traffic control.

May – Permitted; is for optional practice(s) with no requirement or recommendation.

Mobile Operation - Work on the roadway that moves intermittently or continuously.

Motorized Traffic - Movement of vehicles and equipment on the roadway.

Multilane Highway - Highway with two or more driving lanes in the same direction of travel.

Nighttime - Period of time from one-half hour before sunset to one-half hour after sunrise.

Non-Motorized Traffic - Movement of pedestrians, bicycles, horse-drawn vehicles, etc. on roadway or within the right of way.

One-Lane, Two-Way Taper - Temporary traffic control measure used to channelize traffic through an activity area occupying one lane of an undivided, two-lane roadway.

Pavement Marking - Lines, markers, words and symbols affixed to the pavement surface to channelize and guide traffic.

Pilot Car - Vehicle used to guide a queue of vehicles through the temporary traffic control zone.

Portable Changeable Message Signs (CMS) - Temporary traffic control device capable of displaying a variety of messages to traffic.

Portable Sign - Sign mounted on temporary supports (e.g. self-driving post, easels, fold up stands, barricades, etc.).

Post-Mounted Sign - Sign mounted on a non-portable post (e.g. perforated square steel tube, U-channel, wood, etc.).

Protective Vehicle - Vehicle used to protect workers or work equipment from errant vehicles (e.g. pick up, dump truck, loader, etc.).

Regulatory Sign - Sign giving notice of traffic laws or regulations.

Roadway - Portion of highway, including shoulders, intended for use by motorized traffic.

Rural - Area generally characterized by lower volumes, higher speeds and fewer turning conflicts and conflicts with pedestrians. Includes unincorporated areas designated by community boards.

Safety Apparel - Personal protective equipment worn by a worker to improve visibility (e.g. vests, hats, etc.).

Shall – Mandatory; **Shall** and **Will** indicate mandatory practice. Contract documents often contain independent definitions.

Short Duration Operation - Daytime or nighttime work occupying a location up to 30 minutes.

Short-Term Stationary Operation - Daytime work occupying a location more than 30 minutes, but less than 12 hours.

Should – Strongly recommended; indicates something is expected or typically necessary. The action is not absolutely mandatory but deviation from this practice calls for engineering documentation.

Shoulder Taper - Temporary traffic control measure used to close the shoulder.

Sign - Traffic control device conveying a static message to traffic through words or symbols.

Speed Limit - Maximum speed applicable to a article of highway as established by law.

Stop Bar - Solid white pavement marking extending across an approach lane to indicate the point where traffic is to stop.

Supplemental Warning Methods - Temporary traffic control enhancements used to increase the effectiveness of select temporary traffic control devices or the awareness of the entire temporary traffic control zone.

Taper - Series of channelizers and/or pavement markings used to move traffic into the intended path.

Temporary Traffic Barrier - Temporary traffic control device used to create a physical separation between traffic and the workspace, an unsafe condition, or non-motorized traffic.

Temporary Traffic Control Device - Item used to regulate, warn or guide traffic through a temporary traffic control zone.

Temporary Traffic Control Plan - Describes temporary traffic control measures to be used for moving traffic through a temporary traffic control zone.

Temporary Traffic Control Signal - Temporary traffic control device used to assign right of way through automatic means.

Temporary Traffic Control Zone - Article of highway where traffic conditions are changed due to a work zone or an incident area through the use of temporary traffic control devices, law enforcement or other authorized officials. It extends from the first warning sign or rotating/strobe lights on a vehicle to the last temporary traffic control device.

Termination Area - Area of a temporary traffic control zone returning traffic to the normal path.

Traffic - Highway user.

Traffic Space - Area within the activity area in which traffic is routed through the activity area.

Transition Area - Area of a temporary traffic control zone where traffic is redirected out of the normal path and into the traffic space.

Traveled Way - Portion of roadway intended for the movement of motorized traffic.

Truck-Mounted Attenuator (TMA) - Device designed to attach to the rear of protective vehicles to absorb the impact of an errant vehicle or inattentive driver.

Undivided Highway - Highway with no physical separation of traffic in opposite directions.

Urban - Area within the limits of incorporated towns and cities where the posted speed is 60 mph or less.

Vehicle-Mounted Sign - Sign mounted on a protective vehicle used in short duration and mobile operations or on a pilot car.

Warning Light - Flashing or steady-burn, amber light units attached to temporary traffic control devices to increase their target value.

Warning Sign - Sign giving notice of a situation or condition that might not be readily apparent.

Work Duration - Length of time an operation occupies a location.

Work Lighting - Lighting used at night to perform activities within the workspace.

Work Location - Portion of right of way in which work is performed.

Workspace - Area within the activity area closed to traffic and set aside for workers, equipment, materials and a protective vehicle, if one is used upstream. Channelizers usually delineate workspaces.

Work Vehicle - Any vehicle by which work is performed.

Work Zone - Temporary traffic control zone where temporary traffic control devices are deployed for construction, maintenance or utility- related work activities.

Work Zone Length - Distance from last sign in the advance warning area to the last temporary traffic control device in the same direction or the last sign in the advance warning area in the opposing direction, whichever is longest.

Refer to ***902.12*** Glossary for definitions of interchange, intersection and right of way.