

Pavement Markings

Pavement markings have important functions in providing guidance and information to drivers. In some cases they supplement regulations or warnings given by other devices. In other cases they are used alone and produce results that cannot be obtained by any other device.

Pavement markings can also enhance safety. Centerlines have been shown to cut crash frequency by 29% compared to roads without them. Marking types include not only pavement and curb marking but also object markers, delineators, colored pavements, barricades, channelizing devices, and islands.

Pavement markings have limitations. They are obliterated by snow, may not be clearly visible when wet, and may not be very durable under heavy traffic. It may be necessary to refresh them every year or more often. Despite these limitations, pavement markings are still used because of their unique advantage: they convey information to drivers without diverting their attention from the road.

This bulletin introduces basic concepts for pavement markings. It should also help in applying the standards of the *Manual on Uniform Traffic Control Devices (MUTCD)* and the *Wisconsin DOT Supplement. The Traffic Control Devices Handbook* will also help. Refer to the MUTCD for details.

Materials

Many materials can be used for pavement marking. The choice depends on cost, durability, retroreflectivity, pavement surface, and drying time.

Paint Water-based paint, applied either cold or hot, is the most commonly used pavement marking. It is low cost with a short drying time, but its visibility on wet nights is just moderate. Traffic and snow plowing wear it away in about a year. Oil-based (alkyd) paint, when used, must meet environmental air quality restrictions on volatile organic compound (VOC) emissions.



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Thermoplastics These pavement-marking materials are made of thermoplastic heated to about 400° F and spread onto the pavement surface. Glass beads to increase reflections can be spread on top, mixed in, or both. Thermoplastics have a long service life, good visibility, and good retroreflectivity. The no-track time is short, and cost is mid-range. Special application equipment is required.

Epoxy Also applied as a liquid with special equipment, epoxy has good visibility and retroreflectivity, and cost is moderate. No-track time is 5-20 minutes. Markings last 3 to 4 years.

Tapes Pre-formed tape can be either inlaid as part of new construction, or overlaid. It has excellent visibility and retroreflectivity and lasts 7-8 years, but is higher cost. Wet reflective tape has excellent wet night retroreflectivity with about a 4-year life. Cost is medium and durability is poor. Modifications are being made to produce a tape with both durability and wet night retroreflective quality.

Conventional paints are most cost effective for low-volume roads. In higher traffic areas, where conventional paints must be renewed in less than one year, thermoplastics or other durable marking products may be more economical. Using them also reduces the frequency of travel delays and hazards of construction zones during application. Whichever material you use, it should remain the correct color and adequately reflectorized throughout its useful life.

Markings that must be visible at night shall be retroreflective. In general this applies to all pavement markings except parking lines and curb markings. For paint, glass beads are mixed in or dropped on the markings while still wet. Durable products are made with reflecting materials. In pedestrian areas, marking materials should not create slipping or tripping hazards. Raised pavement markers can be useful to supplement pavement marking, but cost is a factor, and they must be correctly installed. Wet reflective tape is another supplement option.

General principles

Pavement markings should conform to the following general principles:

Color

Pavement markings must be yellow or white. Red and blue are used in special cases:

- Yellow longitudinal lines separate traffic flowing in opposite directions, or mark the left edge of the pavement on one-way roadways.
- White longitudinal lines separate traffic flowing in the same direction, or mark the right edge of the pavement.
- Contrasting black marking placed next to a white marking may be used to make the white line stand out on light-colored pavements.
- Words and symbols, crosswalk and stop lines are white.
- Red and blue are used in special cases. Blue is for parking spaces for persons with disabilities; red for raised pavement markings for roadways that shall not be entered such as one-way streets or alleys.

Width

- Line width indicates the degree of emphasis. Normal centerlines and edgelines are 4"-6" wide. A wide line is at least twice the width of a normal line.

Number

- Double lines—two normal width lines separated by a discernible space—indicate maximum restriction: driving across them is prohibited.

Solid vs. broken

- Solid lines discourage crossing and should not be crossed. Broken lines may be crossed.
- A broken line is formed of segments and gaps, usually in the ratio of 1:3. For example, on rural roads a 10' segment would be followed by a 30' gap.
- Dotted lines provide guidance and are generally used as line extensions. They have noticeably shorter segments: for example, a 2' line and a 2' to 6' gap. A dotted line where a lane is dropped or added may consist of a 3' line and a 9' or 12' gap. The marking shall be the same color and width as the line it extends. A normal-width line may be used to extend a wide line through an intersection.

Centerlines

A centerline separates traffic traveling in opposite directions and is usually at the geometrical center of the pavement. Centerlines give drivers important guidance and can significantly enhance safety. They have been shown to cut crash frequency by 29%. Use is as follows:

Required (shall)

- Paved urban arterials or collectors 20' or more in traveled-way width and 6000 vehicles per day or more.
- All paved two-way streets or highways with three or more traffic lanes.

Recommended (should)

- Paved urban arterials and collectors that are 20' or more in traveled way width with 4000 vehicles per day or more.
- Rural paved roads that have a traveled width of 18' or more and 3000 vehicles per day or more.

Optional (may)

- Paved 2-way traveled ways 16' or more in width. Use engineering judgment for traveled ways less than 16' wide due to the potential for vehicles to encroach on pavement edges or opposing traffic.

The centerline markings on two-lane, two-way highways shall be one of the following:

- A normal broken yellow line with passing permitted.
- A double line, one normal broken yellow line and one normal solid yellow line where passing is permitted in one direction.
- A double line of two normal solid yellow lines where passing is prohibited in both directions.



When a centerline is used, no passing zone markings shall be used at horizontal and vertical curves.

No-passing zones

A no-passing zone at hills and curves shall be used where the sight distance is less than the minimum necessary for safe passing at the prevailing or posted speed based on a documented engineering study.

Table 1 shows traffic speeds and the corresponding minimum sight distance required for passing. These must be measured and marked by a trained person with an assistant.

No-passing zones are also warranted before particularly hazardous areas such as narrow bridges, railroad crossings, in advance of divided highways, and at certain intersections.

Table 1: Traffic speeds and minimum sight distances

Speed (MPH) ¹	Min. sight distance (ft) ²
25	450
30	500
35	550
40	600
45	700
50	800
55	900

¹ generally posted or statutory ² from MUTCD 2003 edition

Mark no-passing zones with a 4"-6"-wide solid yellow line placed on the right of the centerline. To mark no-passing in either direction, use two solid yellow, 4"-6"-wide lines separated by a discernable space, usually 4"-6".

In a rural area a no-passing zone should be at least 500' long. If the minimum sight distance (Table 1) is less than 500', add the extra marking at the beginning.

When the distance between the end of one no-passing zone and the beginning of the next no-passing zone

Table 2: Minimum distance between No-Passing zones¹

Speed limit	Minimum distance
25-30 MPH	.10 miles
35-40 MPH	.13 miles
45-50 MPH	.16 miles
55 MPH	.21 miles

¹ from WisDOT Traffic Guidelines Manual

is less than 400', the zones should be extended through the intervening distance per the MUTCD. Table 2 gives the minimum distances used by WisDOT on state highways between zones at various speeds. WisDOT distances are more conservative than the MUTCD.

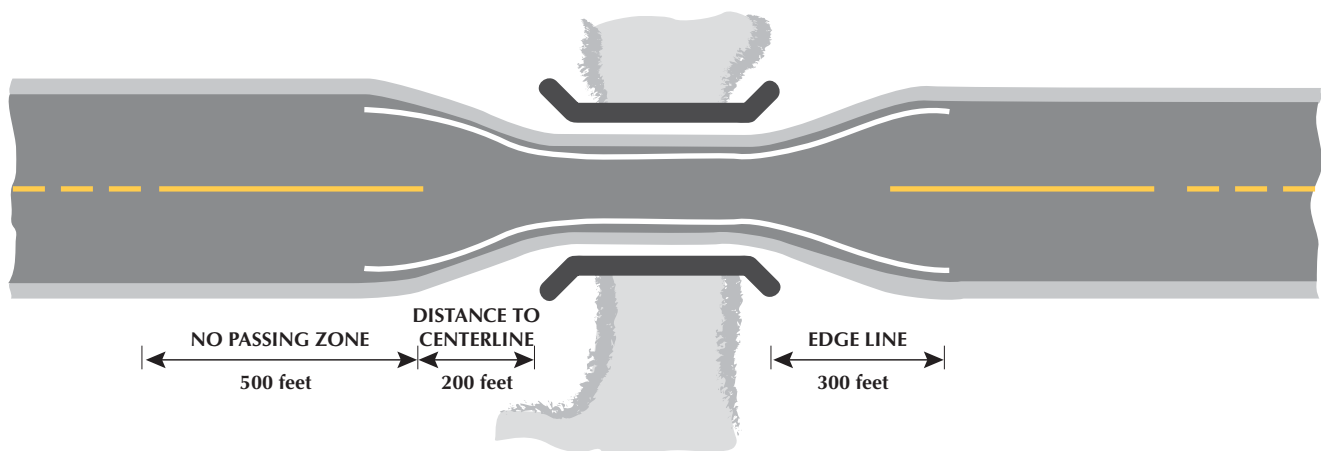
A no-passing zone begins at the point where the sight distance first shrinks below the minimum (Table 1). The zone ends where the sight distance becomes longer than the minimum. It requires two people to determine no-passing zones.

Pavement markings for one-lane bridges (less than 18' wide) deserve special attention. Do not carry the centerline over the bridge. The illustration below shows one way to use pavement markings to call attention to a one-lane bridge. Warning signs are also required in accordance with the MUTCD. See TIC publication No. 7, **Signing for Local Roads**.

Lanelines

Broken lines, called lanelines, separate lanes of traffic in the same direction. They are usually a normal broken white line which permits lane changing.

Use a normal solid white line as the lane line in critical areas where you wish to discourage lane changing such as an approach to a busy intersection. Wide solid lane markings may be used for greater emphasis.



Pavement markings call attention to a one-lane bridge.



Edgelines

Pavement edgeline markings give drivers a guide to the edge of the pavement and also enhance safety. A study of rural highways in Kansas showed that edgelines will yield benefits exceeding their costs if an average of one non-intersection crash occurs annually every 15.5 miles of roadway. Edgelines are a particularly valuable visual reference during bad weather and poor visibility, especially along curves. They can also be used to mark the pavement edge to reduce driving on paved or unpaved shoulders. Break edgelines for intersections, major driveways or interchanges. Continue edgelines through minor driveways unless a full width turn lane has been provided. Wide solid edgeline markings may be used for greater emphasis.

Required (shall)

- Rural arterials 20' or more in width and 6000 vehicles per day or more.
- Freeways and expressways.

Recommended (should)

- Rural arterials and collectors 20' or more in width and 3000 vehicles per day or more.

Optional (may)

- Other paved streets based on engineering study.



May be placed on streets and highways that do not have centerlines.

Channelizing lines

Channelizing lines can be used to form channelizing islands where traffic is going in the same direction on either side of the island. They shall be a wide or double wide solid white line. White diagonals or chevron marking can be placed between the channelizing lines for greater emphasis.



Yield lines

Yield lines are white and shall consist of a row of solid white isosceles triangles pointing toward approaching traffic. They are not required, but may be helpful at roundabouts, mid-block crosswalks, or other locations with yield signs.

Stop lines

Stop lines are solid white lines and should be 12"-24" wide. Stop lines emphasize the stop condition and indicate where to stop. They are not required, but are helpful in many situations. For example, visibility may be better at a point closer to the intersection than the stop sign can be placed. The stop line can be used to show this to drivers. Stop lines should be a minimum of 4' in advance of a marked crosswalk. Do not use stop lines with yield signs. Place no closer than 4' from the nearest edge of the intersecting travel way and no more than 30'.

Crosswalks

On roads where traffic is not controlled by signals or stop signs, crosswalk markings warn the motorist of a pedestrian crossing point. On controlled intersections, crosswalk markings primarily guide pedestrians in the proper paths. Do not use crosswalk markings indiscriminately. Only an engineering study should recommend installing crosswalks where there are no traffic signals or stop signs.

Crosswalk lines are two parallel solid white lines normally spaced 6' (minimum) apart. They shall be a minimum of 6" and maximum of 24" in width. Wider lines may be considered when, for example:

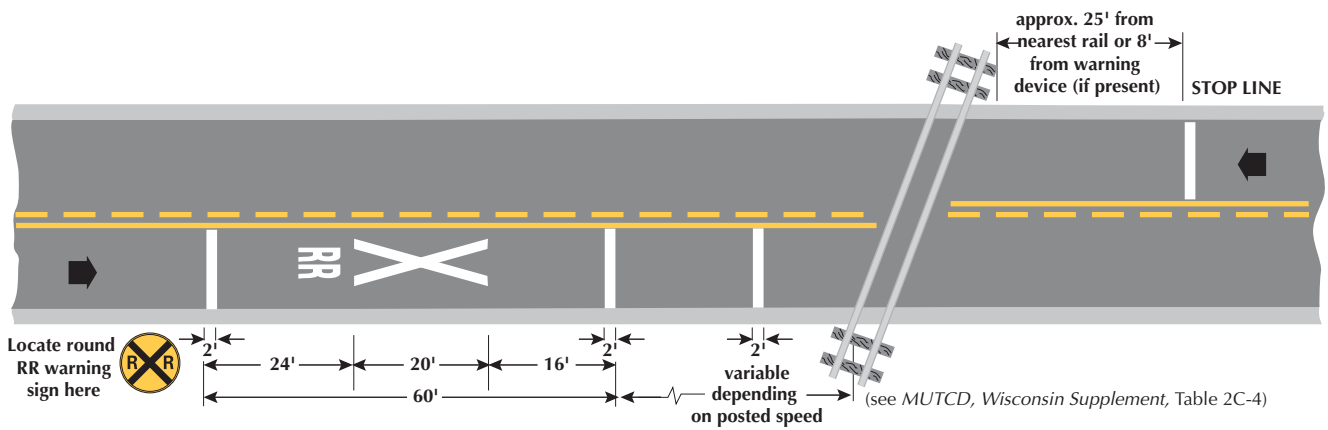
- Traffic speeds are above 35 MPH.
- There is no advance stop line.
- Drivers don't expect crosswalks.

Colored pavements alone are not considered a traffic control device. Crosswalk lines must outline them.

For added visibility, mark the area inside the crosswalk with white diagonal lines at a 45-degree angle. These lines should be about 12"-24" wide and spaced 12"-60" apart. Use these diagonal lines on crosswalks at unexpected areas, where many pedestrians are crossing without any other traffic control device, and where physical conditions make added visibility desirable. Pedestrian crossing signs are also useful. Zebra stripes (lines longitudinal to traffic flow) provide added visibility and target value especially at roundabouts. See the roundabout photo on page 6, for an example.

Railroad crossings

Special pavement markings are required before railroad crossings with signals or automatic gates and at all crossings where the prevailing speed of highway traffic is 40 MPH or higher (see W-MUTCD, Part 8). Railroad crossing pavement markings may be omitted in special situations such as:



Markings for a highway-rail grade crossing.

- highway speed limit or prevailing speed is 35 MPH or less and there are no active RR warning devices, or
- track is a minor spur where trains operate at 15 MPH or less, or
- approach distance is less than 250' rural or 100' urban.

Pavement markings before a grade crossing are an "X" with an "RR" behind them. A wide line is placed above and below the "X". Identical markings must be placed on each approach lane. All markings should be white and reflectorized. Stop bars must extend from the centerline to the edge of the pavement at 90 degrees to the direction of travel. Place the W10-1 round RR warning sign at the first cross line. A stop bar at railroad tracks should be no closer than 25' from the nearest rail.

Words and symbols

Word and symbol markings may guide, warn or regulate traffic. They should not have more than three lines of information and must not be used where a movement that would otherwise be legal is prohibited, unless they accompany standard signs. Letters or numerals should be 6' or more in height. Repeat signs or markings in advance of where they actually take effect to help drivers select the appropriate lane. The word "ONLY" may be used to supplement lane use arrow markings.

All letters and symbols should conform to the standard alphabet for highway signs and pavement markings contained in **Standard Alphabets for Highway Signs and Pavement Markings** (Wisconsin DOT Region offices should have a copy available for you to use.) Use large



Arrow symbols channelize traffic at intersections where turns are mandatory.



letters, symbols and numerals. Messages of more than one word should read “up” (the first word is nearest the driver). For low speed roads make the space between lines at least four times the height of the character.

Since uncontrolled use of pavement markings can confuse drivers, minimize the number of different word and symbol markings. Symbol messages are generally preferable to word messages.



Where through traffic lanes approaching an intersection are “captured” and a turn becomes mandatory, a pavement marking turn arrow shall be used accompanied by standard signs.

Markings for roundabouts

A roundabout has a yield entry and a central island; and the approach is flared or widened.

- Yellow edgelines may be placed around the inner (left) edge of a circular roadway.
- A white line should be used on the outer (right) side of the circular roadway.
- Dotted lines should be used across the lane(s) entering the roundabout.
- Do not extend edgelines across exits from the circular roadway.
- Strongly consider crosswalk marking for pedestrians. Zebra markings can be especially useful.
- Yield line (isosceles triangles) may be used on approach roadways.
- Bicycle lane markings shall not be used on the circular roadway of the roundabout intersection.



Delineators

Delineators are retroreflective devices mounted above the roadway surface and along the side of the roadway showing the alignment of the road. They are particularly beneficial where roadway alignment might be confusing or unexpected, such as lane reduction transitions and curves, or to provide effective guidance at night and during adverse weather. Retroreflective elements shall be at least 3” across and mounted 4’ above the road.

The color of a delineator shall match the edgeline it is next to. On a one-way road, for example, delineators on the left side must be yellow and white on the right. According to a Wisconsin statute delineators used to mark driveways must be blue.



Delineators on the left side of a one-way road are yellow.



Culvert delineators are white with black at the top.

Use white delineators with black at the top to mark culverts. Delineators on horizontal curves should be spaced so that several are always simultaneously visible to the road user.

Curb markings and islands

Curb marking is optional and does not have to be reflectorized. Where curbs are marked, colors shall conform to the general principles of markings.

- *White* — separates traffic flow in the same direction, i.e. right turn pork chop islands can be painted white or left unpainted. Consider type 2 or 3 object markers, delineators, or a W12-1 double down arrow sign to mark the end of longer islands.
- *Yellow* — separates traffic flow in the opposite direction. However, it also may be used on curbs to designate no parking zones as part of a local policy on marking colors.



Right turn islands can be painted white.

Object markers

Object markers are used to mark the end of roadways (red color), islands (generally yellow), bridges (clearance strippers, yellow/black), or other objects. Line the object marker up with the inner edge of the obstruction. Mounting height should be 2' minimum to the bottom of the object marker (W12-1 double down arrow sign) at islands. Clearance strippers shall be 4' minimum mounting height.

Planning and maintenance

Pavement markings deteriorate. Paint, the most common material, needs to be reapplied at least every year. Since it is a costly addition to the maintenance budget, it should be started with the understanding that it must be continued. If striping is discontinued, don't just quit painting and let the markings fade away. The decision should be made as a policy decision with reasons documented. If there is a lawsuit you will need to document the decision.

Plan ahead for annual marking work. You may prefer to schedule it for fall, waiting until after all roads have been resurfaced or seal coated. However this places a demand on the striping crew, trying to finish all the work before weather ends the season. Breaking the program into two operations, one in the spring and a final round in the fall, may result in better prices from striping contractors; they are looking for work in the spring.

Markings should be applied quickly on newly paved or sealed roads, as soon as possible. This requires coordination and planning. Long delays with no lines are a problem and should be avoided. On new asphalt roads, striping may require two coats.

Remove pavement markings that are no longer required. For example, if a stop bar is no longer needed, paint it over or remove it.

Markings have a very important function in guiding and informing the road user. Section 3A.02 of the MUTCD says you shall remove markings that are no longer applicable because they may cause confusion to the road user.

Summary

The *Manual on Uniform Traffic Control Devices*, 2003 ed., with the 2005 *Wisconsin Supplement*, are the Wisconsin standard. Using these, or the latest approved revisions, will ensure statewide consistency in signing and marking.

- Pavement markings effectively convey information without diverting attention from the road, but are of limited value if covered by snow, water or traffic.
- A centerline is normally used on higher volume roads or on hazardous stretches. Segments and gaps in the ratio of 1:3 form a broken line.
- Pavement markings must be reflectorized.
- No-passing zones must be marked if a centerline is used. A qualified person must survey them.
Remember: you need two people to do this right.
- Yellow pavement marking lines separate traffic flowing in opposite directions or mark the left edge of the pavement on one-way roadways.
- White lines separate traffic flowing in the same direction or mark the right edge of the pavement.
- Line width indicates the degree of emphasis. Normal centerlines and edgelines are 4"-6" wide.
- Curb marking colors shall conform to the general principles of markings, and as determined by locally adopted policy.

Resources

Manual on Uniform Traffic Control Devices, 2003 Edition. Ordering information at <http://mutcd.fhwa.dot.gov>

Low Cost Safety Improvements, FHWA, March 2004 (workshop material) available at: www.fhwa.dot.gov/resource-center/teams/safety, or call FHWA at 708/283-3545.

Signing for Local Roads, Wisconsin Transportation Bulletin, No. 7, Wisconsin Transportation Information Center, revised 2005.

The Standard Alphabet for Highway Signs and Pavement Markings is available from WisDOT at 608/266-2375 or contact your nearest WisDOT Region office.

The Traffic Control Devices Handbook, ITE, 2003. Available at www.ite.org or 202/289-0222.

Traffic Guidelines Manual, WisDOT. Available from WisDOT by calling 608/266-2375.

Wisconsin Supplement to the MUTCD (W-MUTCD), WisDOT 2005. Available from WisDOT, 608/266-2375 or at <http://www.dot.wisconsin.gov/business/engrserv/wmutcd.htm>

Videotapes

Free loans are available through county Extension offices. See the TIC's current *Videotape Lending Library Catalog* at <http://tic.engr.wisc.edu>. Some examples that relate to marking are:

Markings and Islands, IRF, 19 min., #17749

Right Before Your Eyes, ATSSA, 10 min., #17439

Sign Maintenance and Installation, FHWA, 27 min., #17821

Signs, Marking and Delineation, FHWA, 43 min., #16860

Traffic Control Devices, FHWA, 24 min., #16861

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