Evolution of the U.S. Pavement Marking System

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One of the earliest known applications of road markings can be traced back to ancient Mexico on a road near Mexico City (1) sometime about 1600 A.D. The centerline was placed to separate opposing traffic and was created using lighter-colored stones in the pavement. In more modern times, other road markings may have been used in isolated instances in the late nineteenth century on bridges. Painted road markings in the early twentieth century appeared in various cities at various times and there is no consensus on where the first pavement markings appeared in the U.S. One publication indicates that the first painted lines were stop lines painted on roads in Portsmouth, Virginia in 1907. New York City appears to have first used markings for crosswalks in 1911. Similar lines were used in Providence, Rhode Island and Minneapolis, Minnesota in 1913 and 1914, respectively (2).

It is not possible to ascertain where the first longitudinal pavement marking was first used in the U.S. One publication indicates that in 1911 or 1912, the first lane marking was made just in side the entrance to a park in Cincinnati, where the most used roadway was narrow and many collisions had occurred (3). However, it appears that Wayne County, Michigan (Detroit area) was one of the first areas to use centerlines on a widespread basis. These early centerlines may have been used as early as 1911, but were certainly in place by 1922 (4). Indio, California also makes a claim to the earliest centerline, with the first use dating back to 1924 (4). At this time, there were few, if any, standards or guiding principals for markings. Where those standards or guiding principles did exist, they were on a local level and there was no coordination between local agencies.

DEVELOPMENT OF NATIONAL MANUALS

During the twentieth century, there has been a continuous evolution in the national standard for traffic control devices. Since 1935, this document has been known as the *Manual on Uniform Traffic Control Devices* (MUTCD). Prior to its initial publication in 1935, there were two different predecessor documents. Table 1 summarizes the evolution of these documents. A series of articles on the history of the MUTCD provides a more complete description of the evolution of these documents (5, 6, 7).

Early Manuals

The American Association of State Highway Officials (AASHO) *Manual and Specifications for the Manufacture, Display, and Erection of U.S. Standard Road Markers and Signs* was published in January 1927 (8). This manual was the first national manual on traffic control devices, but it addressed only signs in rural areas, setting forth the design and use for each type of sign. Despite its name, pavement markings were not addressed in the document. In the earliest days of traffic control devices, some types of signs were referred to as road markers and this creates confusion with pavement markings.

Table 1. Evolution of U.S. Traffic Control Device Standards

Year	Name	Month/Year Revised
1927	Manual and Specifications for the Manufacture, Display, and Erection of U.S. Standard Road Markers and Signs	4/29, 12/31
1930	Manual on Street Traffic Signs, Signals, and Markings	No revisions
1935	Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)	2/39
1942	MUTCD - War Emergency Edition	No revisions
1948	MUTCD	9/54
1961	MUTCD	No revisions
1971	MUTCD	11/71, 4/72, 3/73, 10/73, 6/74, 6/75, 9/76, 12/77
1978	MUTCD	12/79, 12/83, 9/84, 3/86
1988	MUTCD	1/90, 3/92, 12/93, 2/98, 12/96, 6/98, 1/00

During the time that AASHO was developing its rural signing manual, the National Conference on Street and Highway Safety (NCSHS) was developing a manual for the use of traffic control devices in urban areas. They published the *Manual on Street Traffic Signs, Signals and Markings* in 1930 (9). The urban manual conformed with the AASHO rural manual in virtually all respects, except that material addressing traffic signals, pavement markings, and safety zones was added. Among other applications, the urban manual indicated that markings could be used for the centerline of a street, for the center line on a curve having a radius less than 600 feet, for the center line at and approaching hill crests, for traffic lanes on streets wide enough for three or more lanes, at all signalized intersections (especially opposite safety zones), and for traffic lanes for turning at street intersections. Appendix 1 presents the language from the markings portion of the 1930 urban manual.

1935 Manual on Uniform Traffic Control Devices

The inherent conflicts created by the existence of two manuals were quickly recognized and efforts were initiated to develop a single manual for both rural and urban conditions. AASHO and NCSHS formed the Joint Committee on Uniform Traffic Control Devices (JC) in 1932 and published the original edition of the *MUTCD* in November 1935. Each part (signs, markings, signals, and islands) was subdivided into articles and sections addressing specific traffic control device aspects such as legal authority, application and location, design, and maintenance. The markings portion was further divided into divisions addressing regulatory and guidance markings and warning markings on hazardous objects. This format required the user to look at several different sections to obtain all the information about a particular type of marking.

The 1935 *MUTCD* defined markings for pavements, curbs, and objects. Lines could be marked with construction joints, paint, or pavement inserts. White, yellow, or black could be used, depending on which color would provide the greatest contrast. Lines could be between four and eight inches wide. Stripes and gaps were supposed to be equal in length and between 5 and 75 feet.

Centerlines were required only on approaches to hill crests, short radius curves, curves with a restricted view, or pavements wider than 40 feet. When the centerline was used everywhere, a distinctive line was required at all points of hazard. The 1935 MUTCD was revised in 1939, and the revision included numerous refinements to the pavement marking guidelines. Appendix 1 presents some of the key language from the markings portion of the 1935 MUTCD and its 1939 revision.

1942 Manual on Uniform Traffic Control Devices

The onset of World War II placed many demands on highway travel and traffic control in the United States and the JC determined that a War Emergency Edition of the *MUTCD* was needed to address these conditions. To a large extent, the 1942 edition avoided changes in standards other than those needed for the prosecution of the war, recognizing that numerous changes would be desirable when peace was restored. The most significant elements of the 1942 MUTCD were changes in the standards to conserve materials for the war effort and the addition of material on traffic control in blackout conditions.

The 1942 War Emergency MUTCD continued to allow the use of white, yellow, or black. However, the material indicated that white paint was rapidly replacing black paint for centerline applications. This was particularly significant for blackout conditions, under which black markings were not visible. Yellow was reserved for barrier lines and curb markings. This MUTCD described the need for alternative yellow pigments so that chromium could be used to support the war effort. Included was a statement that earth pigments should be used for yellow instead of converting barrier lines to white.

1948 Manual on Uniform Traffic Control Devices

As World War II neared an end, traffic engineers began gearing up for a long-needed revision to the manual. Higher vehicle speeds had created many pressing needs for advances in size, illumination, retroreflectorization, use of symbols, and pavement markings. The 1948 MUTCD was the first real opportunity to widely implement the lessons learned from the experience gained from the first MUTCD. Unfortunately, there continued to be a lack of reliable research data and the 1948 edition was based largely on the experience and opinions of experts rather than on scientific engineering or factual data. There were many changes in content and organization in the 1948 MUTCD. Each of the four parts (signs, markings, signals, and islands) was reorganized so that every device was completely addressed in one location.

The changes in pavement markings were few, but evoked considerable discussion and debate. New specifications were established for centerlines and no-passing zones. White was specified for all applications (including as a broken centerline) except for double centerlines on multilane highways and no-passing zone barrier lines, where yellow was recommended (10). This was the most controversial question faced by the committee, and a final decision was reached only after much discussion and two special polls of the state highway departments (11). However, white continued to be permissible for use in these applications. The manual recommended against the use of pavement edge lines. White and yellow were the only colors permitted for markings. Figure 1 indicates how color was specified for pavement markings.

Longitudinal lines were four to six inches wide. Broken lines used a 15-foot stripe with a 25-foot gap.

Pavement markings and patterns were a controversial issue just after World War II because there was no national consensus in use. The variability in states' practices is illustrated in Figure 1, which is a summary of the various methods used by states to mark centerline and no passing areas on two-lane pavements in the United States in 1949.

The 1948 MUTCD was revised in 1954. While this revision is best known for changing the color of the Stop sign from yellow to red, it included a significant marking revision. The revision was the first MUTCD language to require retroreflectorization of pavement markings, for all rural markings that had application at night. Appendix 1 presents some of the key language from the markings portion of the 1948 MUTCD and its 1954 revision.

1961 Manual on Uniform Traffic Control Devices

The 1961 MUTCD was the first to be organized in parts, chapters, and sections as used in the modern *MUTCD*. New material was added to address traffic controls for construction and maintenance operations, signing for civil defense, and freeway signing. The importance of the manual was indicated by a federal requirement that all traffic control devices used on federal-aid highways conform to the standards in the 1961 edition. The new edition tried to avoid departure from the basic standards of previous editions, but provided for much greater uniformity in traffic control devices. Many of the alternatives previously permitted for a given device were eliminated and a single standard was substituted. The value of symbols continued to be recognized, but few symbols were introduced.

In the markings part of the manual, conflicts over the color of no-passing zone markings were eliminated by specifying yellow for centerlines and eliminating the use of white, as permitted in earlier editions. Table 2 presents the possible uses of white and yellow markings as specified in the 1961 MUTCD. That manual presented the following reasons for using yellow for the specified pavement marking applications:

(1) It contrasts with the normal white center or lane lines and thus gives emphasis to the hazard;
(2) Yellow has been accepted as a symbolic warning color in signs and signals; and
(3) It is consistent with the standard for no-passing-zone markings approved by the American Association of State Highway Officials and is in use in more than two-thirds of the States for barrier lines.

Reference Notes

Thirty States (shaded) are using the geometry or pattern described in the new Manual on Uniform Traffic Control Devices in making bituminous pavements, but five of these use a solid black line for center line on concrete pavements. Twenty-five use the standard pattern on all types of pavements.

MAP SHOWING METHODS OF MARKING CENTER LINE AND NO PASSING AREAS ON TWO LANE PAVEMENTS IN THE UNITED STATES AND THE CANADIAN PROVINCES OF ONTARIO, QUEBEC AND BRITISH COLUMBIA.

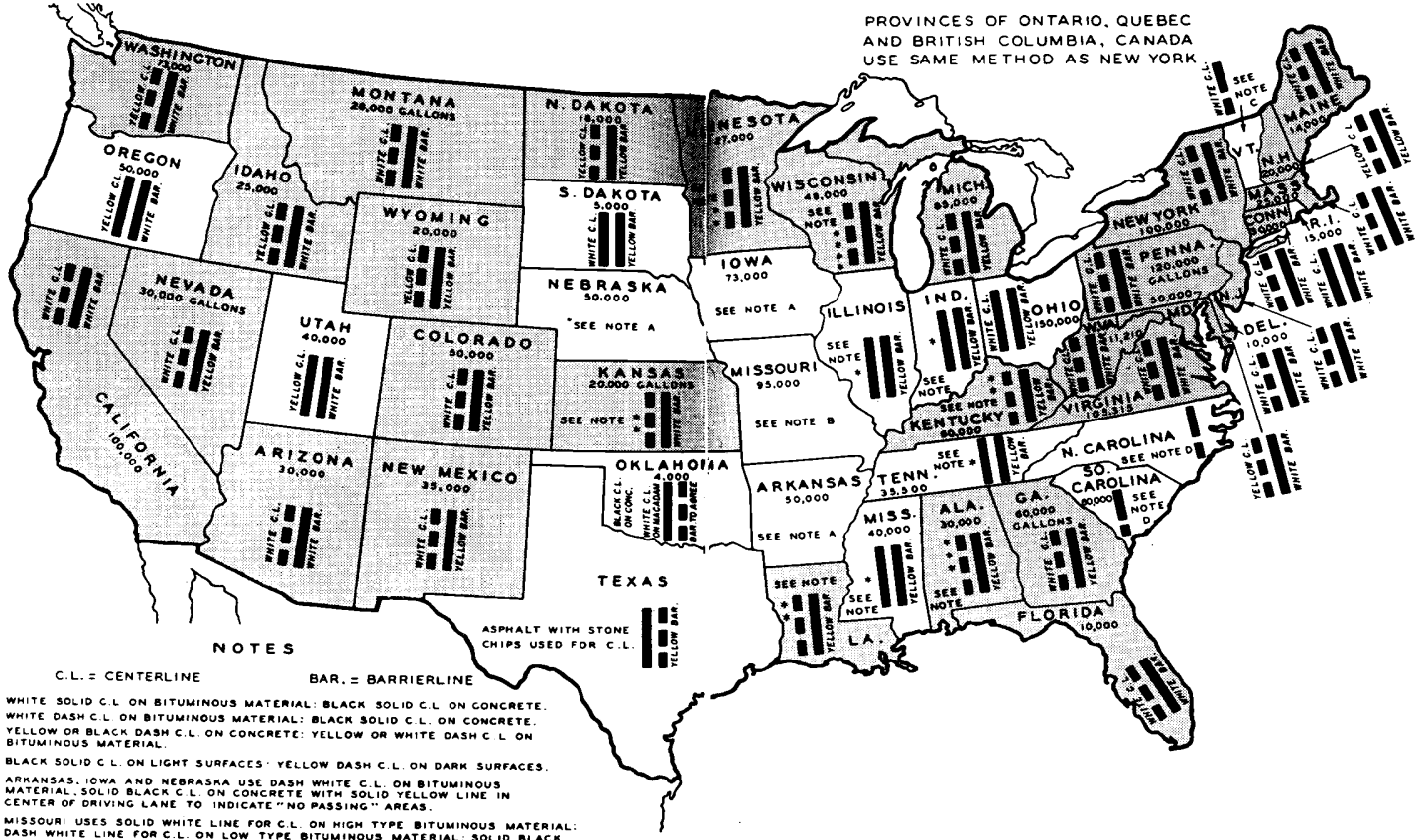

Figure 1. Summary of Pavement Marking Patterns in the U.S. in 1949 (12)

Table 2. Meaning of Pavement Marking Color in the 1961 MUTCD

Yellow markings shall be used for:	White markings shall be used for:
1. Double center lines on multilane pavements. 2. No-passing barrier lines at: a. No-passing zones on two- and three-lane roads. b. Pavement-width transitions. c. Approaches to obstructions which must be passed on the right. d. Approaches to railroad crossings. 3. Curb markings: a. To show parking prohibitions covered by signs or ordinance. b. On islands in the line of traffic.	1. Center lines on two-lane rural roads and city streets. 2. Lane lines. 3. Pavement edge lines. 4. Paved-shoulder markings. 5. Channelizing lines. 6. Approaches to obstructions which may be passed on either side. 7. Turn markings. 8. Stop lines. 9. Crosswalk lines. 10. Parking space limit lines. 11. Word and symbol markings.

Centerlines, lane lines, and barrier lines were specified to be four to six inches wide, while edge lines were specified to be two to four inches wide. The length of stripes and gaps remained at 15 and 25 feet, respectively. The permissive use of a white edge line was added and the 1948 MUTCD recommendation against edge lines was eliminated.

The 1961 MUTCD is the only peacetime manual that was never revised. Appendix 1 presents some of the key language from the markings portion of the 1961 MUTCD.

1971 Manual on Uniform Traffic Control Devices

The 1971 MUTCD is a very close relative of the current MUTCD. The objectives of the 1971 edition were to update the 1961 edition, provide more flexibility in application, and to eliminate contradictions. It was the first MUTCD to become the responsibility of the Federal Highway Administration (FHWA) who assumed responsibility for the MUTCD shortly after the 1971 edition was published. It was also the MUTCD that introduced the large number of symbol signs in an attempt to promote international uniformity of signing. The increased significance of legal definitions were indicated by the fact that this edition was the first to include definitions for "should," "shall," and "may" requirements.

The most significant markings change in the 1971 MUTCD was establishing yellow as the color used to separate opposing traffic when used as a centerline. With this change, white could no longer be used for a centerline. The 1971 edition also introduced the use of red markings. The various uses of pavement marking colors indicated by the 1971 MUTCD were:

- Yellow lines delineate the separation of traffic flows in opposing directions or mark the left boundary of the travel path at locations of particular hazard.
- White lines delineate the separation of traffic flows in the same direction. White continued to be used for the left edge line on divided roads.
- Red markings delineate roadways that shall not be entered or used by the viewer of those markings.

The width of all long lines was specified to be four to six inches and the recommended stripe and gap length of broken lines continued to be 15 and 25 feet. Edge line in the 1971 MUTCD are the only practice that varies from current marking practices. Left edge lines were specified to be white, except where obstructions exist to restrict the area beyond the edge line from use as an emergency refuge, in which case the left edge lines were yellow.

The 1971 MUTCD was the first MUTCD to be revised on a regular basis, with eight volumes of rulings on requests for interpretations, changes, and experiments. Unfortunately, few of these revisions were actually distributed to all manual owners on a widespread basis. A few key revisions addressed the use and color of pavement markings.

1978 Manual on Uniform Traffic Control Devices

By 1978, there were over 500 rulings involving changes and interpretations to the 1971 *MUTCD*, and over 100 approved changes affecting nearly every page. Unfortunately, it was estimated that only 20 percent of *MUTCD* owners had received all eight volumes of the rulings. Therefore, the 1978 edition of the *MUTCD* was published in order to provide an up-to-date manual. The format of the manual was changed to a binder with loose-leaf pages.

Most of the changes to the markings section were intended to further clarify the meaning and application of some markings. The most significant marking change in the 1978 MUTCD was adoption of the current practice for the use of yellow pavement markings – as a centerline on two-way roadways and as the left edge line on one-way (divided) roadways. The stripe/gap ratio was also changed in the 1978 MUTCD, with the length of the stripe changing to 10 feet and the gap length changing to 30 feet.

The 1978 MUTCD was revised four times. Markings changes within these revisions included a requirement that edge lines be used on all rural multilane highways and the lowering of the driver eye height for marking no-passing zones.

1988 Manual on Uniform Traffic Control Devices

By 1988, FHWA had officially adopted over 130 changes to the 1978 *MUTCD*. Most of the changes were distributed in the four revisions to the 1978 edition. However, over one-half of them had not been distributed. Additionally, the concept behind the loose-leaf format had not worked well. As a result of these two factors, FHWA decided to publish a new edition of the MUTCD in 1988 to provide an up-to-date manual. The 1988 edition included all changes made to the 1978 edition in Revisions 1 through 4, plus a number of additional changes which were added as Revision 5. The changes to permanent markings in Revision 5 were generally minor.

The 1988 MUTCD has been revised seven times. The most significant change affecting markings is the last revision which established mandatory (shall) and recommended (should) use of centerline and edge line markings based on ADT and road width. Figure 2 presents the changes to centerline and edge line warrants established by this revision.

The FHWA replaces the fifth paragraph of section 3B-1 of the 1988 version of the MUTCD with the following:

Center line markings shall be placed on paved, 2-way traveled ways on streets and highways having one or more of the following characteristics:

1. Urban and rural arterials and collectors with traveled ways 6 meters (20 feet) or more in width with an ADT of 6000 or greater.
2. Urban and rural traveled ways with 3 lanes or greater.

Center line markings should be placed on paved, 2-way traveled ways on streets and highways having the following characteristics:

1. Urban arterials and collectors with traveled ways 6 meters (20 feet) or more in width with an ADT of 4000 or greater.
2. Rural arterials and collectors with traveled ways 5.4 meters (18 feet) or more in width with an ADT of 3000 or greater.

Center line markings may be placed on other 2-way traveled ways on any street and highway.

On traveled ways less than 4.8 meters (16 feet) wide, an engineering study should be used in determining whether to place center line markings on traveled ways due to traffic encroaching on the pavement edges, due to traffic being affected by parked vehicles, and due to traffic encroachment into the lane of opposing traffic where edge line markings are used.

The FHWA replaces the second paragraph of section 3B-6 of the 1988 version of the MUTCD with the following:

Edge line markings shall be white, except they shall be yellow for the left edge in the direction of travel of the traveled ways of a divided or one way street or highway.

Edge line markings shall be placed for paved traveled ways on streets and highways with the following characteristics:

1. Freeways,
2. Expressways, and
3. Rural arterials with traveled ways 6 meters (20 feet) or more in width with an ADT of 6000 or greater.

Edge line markings should be placed on paved travel ways for streets and highways with the following characteristics:

1. Rural collectors with traveled ways 6 meters (20 feet) or more in width.
2. Other paved streets and highways where engineering study indicates a need.

Edge line markings may be placed on the traveled way on any other street or highway with or without center line markings.

Edge line markings may be excluded based on engineering judgment where the travel way edges are delineated by curbs or other markings.

Figure 2. 1988 MUTCD Revision on Centerline and Edge Line Warrants

OTHER EVOLUTIONARY ISSUES

In addition to the evolution of MUTCD principles for markings patterns and the use of color, there is an evolutionary history behind other important marking issues that could impact the conversion from a yellow-white to all-white system. These include retroreflectivity requirements, color definitions, and marking materials.

Retroreflectivity

Nighttime visibility of pavement markings has been addressed in some fashion in every edition of the MUTCD, although it was not until the 1954 MUTCD revision that there was a requirement for retroreflective markings. The 1935 MUTCD contained an appendix which provided a standard specification for white pavement paint. Although retroreflective markings were not used at this time, a portion of this specification addressed nighttime visibility of the marking materials, stating:

> *"The night visibility of the reflected paint as measured by an Illuminometer in photometric apparatus at an angle of incidence of 88°20' with an angle of reflection of 87°8', shall be at least ten foot-candles when compared to a ground standard milk glass plate having an angle of diffuse reflection of approximately 77 percent and furnishing an Illuminometer reading of three foot-candles."*

The 1942 MUTCD was the first to describe the practice of using glass beads on the paint to provide retroreflectivity. The 1948 MUTCD also described the use of glass beads to provide retroreflective markings and provided the following regarding the use of retroreflective markings:

> *"Reflectorization for better night visibility is desirable for almost all markings, but it is neither practical nor necessary requirement in all cases. Reflectorization is of doubtful value on well-lighted city streets, for example, and it is not ordinarily essential for center or lane lines where there are no special hazards. At least the following markings should normally be reflectorized:*
>
> 1. *Center lines on miultilaned pavements.*
> 2. *No-passing barrier lines at:*
>   *(a) No-passing zones on two- and three-lane roads.*
>   *(b) Pavement-width transitions.*
>   *(c) Approaches to obstructions in the roadway.*
>   *(d) Approaches to railroad crossings.*
> 3. *Striping on vertical surfaces of objects in and adjacent to the roadway."*

As mentioned previously, there was not requirement (shall condition) for pavement marking retroreflectivity until the 1954 revision of the 1948 MUTCD. This revision required that all rural markings that had application at night be retroreflectorized. In the 1961 MUTCD, requirements for marking retroreflectivity were expanded so that all pavement markings having application at night were required to be retroreflectorized. Language in the 1961 MUTCD indicated that retroreflectorization was desirable even on streets with illumination. However, the 1971

MUTCD softened the retroreflectivity language somewhat and stated that markings having application at night be retroreflectorized, unless ambient illuminated assured adequate visibility. The following statement has remained the same in the 1971, 1978, and 1988 MUTCDs.

> *"Markings which must be visible at night shall be reflectorized unless ambient illumination assures adequate visibility. All markings on Interstate highways shall be reflectorized."*

Although there has been a requirement for retroreflectorized pavement markings in the MUTCD for almost forty years, this requirement has no specific values of retroreflectivity. In 1985, the Center for Auto Safety (CAS) petitioned the FHWA to initiate rulemaking on the issue of minimum standards of retroreflectivity for traffic control devices. That petition contended that the range of drivers was not being accommodated by the traffic control devices allowed in the MUTCD with respect to nighttime conspicuity dependent upon retroreflective illumination. In April 1985, the FHWA published a request for comments and a notice of proposed amendment to the MUTCD in the *Federal Register*. The *Federal Register* notice summarized the problem and asked ten questions regarding retroreflectivity of signs and markings.

Several years later, Congress included the following requirement in the 1993 Department of Transportation Appropriations Act:

> *"The Secretary of Transportation shall revise the MUTCD to include a standard for a minimum level of retroreflectivity that must be maintained for traffic signs and pavement markings which apply to all roads open to public travel."*

The FHWA research program on the nighttime visibility of traffic control devices preceded the CAS petition for minimum levels of retroreflectivity for signs and markings. This research program continued through the 1980s and into the 1990s. This research included several different research studies, which are described in a draft FHWA report that presents research recommendations for minimum levels of in-service retroreflectivity for pavement markings (13). These values are presented in Table 3.

At the present time, the FHWA is awaiting recommendations from an American Association of State Highway and Transportation Officials (AASHTO) retroreflectivity task force before proceeding with development of a proposed rule on pavement marking retroreflectivity. The FHWA has indicated that a proposed rule on pavement marking retroreflectivity is not to be expected before late 2001 at the earliest.

Table 3. FHWA Research Recommendations for Minimum Retroreflectivity Values

Option 1		Non-Freeway, ≤ 40 mph	Non-Freeway, ≥ 45 mph	Freeway, ≥ 55 mph
Option 2		≤ 40 mph	≥ 45 mph	≥ 60 mph, > 10,000 ADT
Option 3		≤ 40 mph	45-55 mph	≥ 60 mph
With RRPMs	White	30	35	70
	Yellow	30	35	70
Without RRPMs	White	85	100	150
	Yellow	55	65	100

Source: Reference (13).
Note: Retroreflectivity values are mcd/m^2/lux and measured at 30 meter geometry.
RRPMs – Retroreflective Raised Pavement Markers.

Color Definitions

At various times during the evolution of the MUTCD, white, yellow, red, and black have been used as pavement marking colors. Throughout their evolution, the various editions of the MUTCD have indicated that pavement marking colors should correspond to the color requirements for signs. Table 4 summarizes the language regarding marking color in the various editions.

Table 4. Pavement Marking Color in the MUTCD Since 1948

MUTCD	Color Language
1948	The correct color for yellow traffic paint is the same as that specified for highway signs. Color cards showing this "highway yellow" may be obtained from the Public Roads Administration.
1961	The correct color for yellow traffic paint is the same as that specified for highway signs. Color cards showing this "highway yellow" may be obtained from the Public Roads Administration on request.
1971, 1978, and 1988	The colors for pavement markings shall conform to the standard highway colors.

On December 21, 1999, the FHWA issued a proposed rule to change the specification for the color of signs and pavement markings. The proposed rule provides specifications for both daytime color of yellow, white, blue and red pavement markings and nighttime color of yellow and white pavement markings. Although not specifically indicated in the proposed rule, FHWA staff have indicated that these color specifications are intended to represent end-of-service life values for pavement marking color. In other words, markings that are not within the defined 1931 CIE chromaticity coordinates, or within the daytime luminance factors limits, should be replaced. There are several controversial aspects associated with this proposed rule, one of which is that there is currently no instrument capable of measuring nighttime pavement marking color in the field.

Materials

Various materials have been used over the years for pavement markings. All the types have consisted of basically the same components, a resin or binder, a pigment, and a solvent. A resin or binder is used to hold the pigments together in a film as well as provide adherence to the roadway. Pigment is used to impart color to the marking as well as provide hiding and various chemical aspects such as UV resistance. Solvent is typically used to add fluidity to the material to make for ease of handling. The various pavement marking types have typically been known by the type of resin or some characteristic of the resin that is present, for example, oil based or water borne.

There have been several milestones in the use of the various types of materials. The first milestone was the use of mobile equipment to apply the pavement marking material, namely a solvent or oil based paint. This type of paint was typically a slow dry oil based material taking upwards of a half an hour to dry. Coning of the applied traffic stripe line was necessary to prevent tracking of the material. The use of glass beads to provide retroreflectivity was another milestone. With the advent of heated equipment and faster solvent combinations, the paint's drying time was accelerated such that the application train could be spread out to prevent tracking. This eliminated the need for coning but it also necessitated the use of better quality control in order to get the proper embedment of the glass beads.

The next milestone came about with the introduction of more durable materials, such as epoxy, thermoplastic, preformed tape, etc. These materials were needed as traffic volumes rose and snow removal operations increased in order to maintain markings over the winter or for more than one year.

The latest watershed event has occurred due to concerns over the volatile organic compounds (VOC) that have been used in traffic markings. These VOCs are primarily the solvents. The removal of VOC has resulted in a shift from oil or solvent based materials to water borne materials such as acrylics.

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APPENDIX – MUTCD LANGUAGE

The early national manuals on traffic control devices provide a fascinating insight into the evolution of our current system of traffic control devices. Unfortunately, there are not many of these early manuals available to modern traffic professionals and there is little knowledge about their content. This is especially true of those that are more than about 40 years old, as there are no longer any active professionals that used the documents during their careers.

This appendix presents some of the most pertinent language from the markings portion of four manuals: the 1930 urban manual, the 1935 MUTCD and its revision, the 1948 MUTCD and its revision, and the 1961 MUTCD. The text presented in this appendix is not the entire marking portion of all of these manuals and it does not include any of the figures that were presented in these documents.

1930 NCSHS URBAN MANUAL

In 1930, the National Conference on Street and Highway Safety published the *Manual on Street Traffic Signs, Signals, and Markings*. This manual addressed the use of traffic control devices in urban areas and was the first national manual to address signals and markings (signs had been previously addressed in the AASHO rural sign manual). Section 3 of the urban manual described the use of pavement markings

SECTION 3-STREET TRAFFIC MARKINGS

The use of markings on obstructions in streets is absolutely necessary. Markings on pavements and curbs are of great assistance to a driver, because they do not divert his attention from the control of the vehicle. Their use, however, is subject to very definite limitations. In wet weather they can not be clearly seen, especially at night; and in those parts of the country where snow falls they may often be entirely covered by the snow. Markings on pavements are quickly worn off by traffic and must be renewed often, at considerable expense. Markings should be so placed that they may be seen easily, and the observance of the message which they convey should be rigidly enforced.

RECOMMENDATION 72. — *Types and Purposes of Markings.*

The following are approved kinds of markings:
(a) Lines on pavement.
(b) Colors on curbing.
(c) Words on pavement or curbing.
(d) Cross-hatching or checkerboard squares on obstructions.

RECOMMENDATION 73. — *Pavement Lines.*

The following are approved uses of lines on pavements:
(a) Center line of a street.
(b) Center line on a curve having a radius less than 600 feet.
(c) Center line at and approaching hill crests.
(d) Traffic lanes on streets wide enough for three or more lanes.
(e) At all signaled intersections and especially opposite safety zones.
(f) Traffic lanes for turning at street intersections,
(g) Stop line at entrance to through traffic street.
(h) Street-car clearance limits at turning points.
(i) Boundaries of pedestrian crosswalks.
(j) Parking-space limits.
(k) Stalls for parking other than parallel.
(1) Directional lines consisting of series of arrows in center of traffic lane.
(m) Warning of approach to a railroad crossing.

Lines to mark center lines of streets are desirable where there is considerable traffic in each direction. Additional lines marking traffic lanes are desirable in streets wide enough and with sufficient traffic to carry two or-more well defined streams of traffic in one or both directions. On signaled streets, even where continuous longitudinal lines are not justified, lines extending from 50 to 75 feet each way from each signaled intersection are desirable to aid in holding stopped traffic to the right side of the street.

Center lines should be used to hold traffic to its proper side on curves of less than 600-foot radius, and also on hill crests where the view ahead is insufficient to permit overtaking and passing in safety. Lines on hill crests should extend down the hills far enough to discourage attempting to pass when it cannot be accomplished before traffic approaching over the hill top might block the way.

The marking of crosswalk boundaries is one of the most important uses of pavement lines, and should be used extensively whenever there is considerable pedestrian movement, Such lines encourage pedestrians to obey traffic signals and indicate to motorists where they may look for pedestrians and where they must stop when facing "Stop" signs or signals. Such crosswalks are particularly essential at irregular intersections where otherwise neither the pedestrian nor the motorist can determine the proper place for the pedestrian to cross.

Traffic lanes for turning at street intersections are desirable to expedite safe turning movements, and the marking of street-car clearance limits serves a similar purpose.

The marking of parking space limits tends to prevent dangerous encroachment on fire hydrant zones, intersection areas, and the like. The marking of parking stalls for angle parking enables all operators to park at the same angle with a minimum of waste space.

Special directional lines can sometimes be used effectively to route traffic in a mariner that could not easily be indicated by any other means. A directional line shall be short and shall have an arrow head on one end to indicate direction.

RECOMMENDATION 74. — *Railroad Crossing Pavement Markings.*

Pavement markings should be employed as a supplementary advance warning of approach to grade crossings on hard surfaced, heavy traveled highways where rail traffic is fast or frequent. The standard form approved by the American Association of State Highway Officials (see Figure 18) should be used.

RECOMMENDATION 75. — *Curb Markings.*

Curb markings are used principally to show the regulations applying to vehicles stopping or standing next to the curb. They are most effective if different colors are used to distinguish different regulations. The colors given below shall be used for the purposes shown:

Prohibited stopping	Red
Passenger zone (loading and unloading of passengers only)	White
Loading zone (passengers and material)	Yellow
Limited time parking	Green

This code is intended for use in places where there are frequent variations in the regulations in a comparatively short distance. Where a single regulation applies to a long distance. Signs should be used instead of curb markings.

RECOMMENDATION 76. — *Wording on Pavement or Curb.*

(a) A message on a pavement or a curb shall be brief and clear.

If it is not, the driver of a vehicle will not have time to read or to comprehend it. Although such messages are effective under certain conditions, they should be used sparingly.

RECOMMENDATION 77. — *Round Inserts.*

(a) A round insert shall be made of aluminum, non-rusting steel, monel metal, brass, or other material that will show a bright contrasting surface under the action of traffic.

(b) The diameter of the insert shall be not less than 4 inches.

(c) Inserts shall be spaced about 12 inches on transverse lines and about 18 inches on longitudinal lines.

(d) The insert shall be attached to the pavement by anchor bolts or a similar device.

(e) It shall not project above the level of the pavement more than half an inch.

(f) It shall have a rounded surface so that it will present a smooth contour to the wheels of vehicles.

RECOMMENDATION 78. — *Rectangular Inserts.*

(a) A rectangular insert that is made of brick, stone, rubber, metal, or other material shall be of a permanent color different from that of the pavement.

(b) The inserts shall be set to form lines, either continuous or broken.

(c) They shall be embedded in the pavement so that their upper surfaces are flush with the level of the pavement.

RECOMMENDATION 79. — *Paint.*

(a) A painted line shall be not less than 4 inches wide.

(b) A line painted on a bituminous pavement shall be white or yellow; one painted on concrete shall be black or white.

(c) A painted line shall be frequently renewed in order to insure its plain visibility at all times.

RECOMMENDATION 80. — Canvas.

(a) Canvas markings shall be attached to the pavement with cement so firmly that the lines will remain true under all conditions of use and in all kinds of weather.

(b) Their color shall be white or yellow.

RECOMMENDATION 81. — *Mushroom Buttons.*

(a) Large mushroom buttons that project several inches above the pavement shall not be used at any point where they may interfere with traffic.

If a mushroom button projects several inches above the pavement it forms a hazard even if it is illuminated. Such buttons may be satisfactorily used to mark non-traffic spaces in a wide pavement.

1935 MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

In 1935, the very first edition of the MUTCD was published. The markings part of the manual was divided into a division on regulatory and warning markings and a second on warning markings on hazardous objects. Each division was further divided into groups addressing legal authority, application and location, design, and maintenance. The 1935 MUTCD was revised once in 1939 and the entire portion of the revision on marking is included.

In the 1935 MUTCD, all sentences that established a standard (shall condition) were printed in bold text and the bold text is replicated in this appendix.

PART II — MARKINGS
DIVISION A — REGULATORY AND GUIDANCE MARKINGS

Article A-I-Legal Authority

Pavement and curb markings, being almost exclusively within the boundaries of public highways, are seldom placed except by public authority. No other agency should be permitted to place them.

Section 201-Legal Authority

Markings shall be placed only by the authority of a public body or official having jurisdiction for the purpose of regulating, warning or guiding traffic.

The model for legal authority in the Uniform Vehicle Code and Model Traffic Ordinances referred to in Section 101 is equally applicable to markings.

Article A-II-Application and Location

The proper and judicious application and location of pavement and curb markings may be very helpful in safeguarding and expediting traffic. It is highly important, however, that there be both wise selection of points for marking and accurate location of the markings in accordance with the accepted standards.

Section 202-Lines on Pavements

Lines are marked on pavements for regulatory purposes as follows:

(a) Center of roadway in dangerous locations
(b) Traffic lanes
(c) Pavement edges
(d) Turning limits and street car clearances at turns
(e) Boundaries of pedestrian crosswalks
(f) Limit lines at through highways and signaled intersections
(g) Approach to an obstacle or reduced roadway width
(h) Change from two-way to one-way street
(i) Boundaries of safety zones
(j) Parking limits and stalls

Arrows are marked on pavements for directional purposes to indicate the center of a route to be followed.

Section 203-Center Lines

Line markings on pavement shall be placed on the medial line of the roadway in the following locations:

(a) On the approaches to the crest of a hill where the clear view ahead is less than 500 feet.
(b) On all curves having a radius less than 600 feet or where the clear view ahead is less than 500 feet.
(c) On pavements wider than 40 feet.

Center lines should also be marked:

(a) On the approaches to a railroad grade crossing (except of a minor siding or spur) for a distance of 350 feet from the center of the nearest railroad track.
(b) On the approach to a traffic control signal for a distance of not less than 50 feet from the limit line, and as much more as may be necessary to cover the distance within which vehicles are commonly aligned.
(c) On two-lane roadways narrower than 16 feet.
(d) Wherever there is a large volume of traffic.

In some states the practice is to use center lines on two-lane roadways only at points where overtaking and passing is hazardous and unlawful. In others, they are extensively used even on straight level stretches as aids to driving. Wherever the latter practice is followed, **distinctive lines shall be used at the points of hazard**. A double line is suggested for this purpose.

Section 204-Lane Markings

Line markings to form lanes are especially desirable:

(a) On roadways wide enough to carry more than two streams of traffic.
(b) Between safety zones and sidewalk curbs where there are two or more lane spaces available.
(c) On the approaches to hill crests and railroad grade ’&Rd 4an curves where the roadway is wide enough to accommodate four or more lanes.

Longitudinal lines used to form lanes should be so spaced across the roadway as to allow not less than 10 feet of width for each lane of moving traffic and not less than 7 feet for vehicles parked parallel to the curb.

On highways marked with an odd number of traffic lanes, the middle lane shall be discontinued on bill crests and curves throughout any section of the highway where the clear view ahead is less than 500 feet, on bridges narrower than the adjoining pavements, and at signalized intersections; and the lane lines bounding this middle lane shall con.

verge to a single center line which shall be continued throughout the length of the danger zone.

The foregoing applies particularly to three-lane highways, on which overtaking and passing at such places is extremely dangerous.

In some instances, lane lines are distinguished from center lines by being broken into sections, while center lines in four, six or eight lane roadways should be continuous in all cases.

Section 205-Street Car Clearance Limits

Curved lines are frequently used at intersections to indicate the limits of turning movements, the clearance of the overhang of turning street cars, and vehicle lanes outside such clearance lines or around islands.

Section 206-Crosswalks

Crosswalks shall be marked at all intersections where there is material conflict between vehicular and pedestrian movement.

The marking of crosswalk boundaries is most important and should be used extensively wherever there is considerable pedestrian movement. Such lines encourage pedestrians to walk in designated spaces, and are particularly essential at irregular intersections where otherwise the pedestrian cannot determine the proper place to cross. They also indicate to motorists where they must look for pedestrians. Marked crosswalks should also be provided at other points where there is substantial pedestrian movement, as at long loading islands, schools, churches and in the middle of long blocks in shopping districts.

Section 207-Limit Lines

Limit lines shall be used when it is important that vehicles, in compliance with a STOP sign, traffic control signal or officer's stop indication, stop behind a point not indicated by a marked crosswalk.

While it is not absolutely necessary to mark the limit line in conjunction with a mandatory sign where the sign can be placed opposite the desired point, it is imperative where the physical layout of the intersection prevents this.

A flexible sign marker or the word STOP marked on the pavement may be a helpful auxiliary in securing proper observance of the stop rule.

The word "STOP" shall never be marked on a pavement or used on a flexible sign marker where a stop is not always required.

Some communities have improperly used this word marking to designate the limit line at traffic control signals.

In some jurisdictions, additional transverse lines are marked on the streets approaching a signalled intersection at a distance in advance of the limit lines to indicate to the motorist the point beyond which he can continue to travel at legal speed and clear the intersection during the period that the warning yellow light is displayed before appearance of the red STOP light.

Section 208-Approach to an Obstruction

Pavement markings shall be used to give warning of the approach to an obstruction unless the obstruction is within an intersection.

The marking of guide lines on the pavement to indicate the safe limits for traffic to clear an obstacle in the roadway is of almost as much value as the marking on the face of the obstacle itself.

Section 209-Boundaries of Safety Zones

The pavement area restricted for use as a safety zone may be marked by lines or -buttons in cases where no raised platform has been installed, but their use should be supplementary to the installation of adequate end and side protection of the zone in accordance with the standards presented in Part IV (see Sections 409 and 410).

The use of lines, buttons or lines and buttons without other protection to designate a so-called safety zone is dangerous and is not recommended.

Section 210-Parking Space Limits

The marking of parking space limits tends to prevent dangerous encroachment on fire hydrant zones, bus stops, taxicab stands, loading zones, approaches to corners and clearance spaces for islands. Both pavement and curb markings are used for this purpose.

Parking space limits are indicated on the pavement by lines marked perpendicular to the curb and extending into the roadway the width of a vehicle. In cases where angle parking is permitted, the marking of lines to indicate the limits of stalls enables all operators to park at the same angle with a minimum of waste space.

Section 211-Route Directions

Special directional markings consisting of a series of short arrows in the center of the lane can sometimes be used to route traffic in a manner that could not be indicated by any other means.

Section 212-Approach to Railroad Crossing

Markings to give warning of approach to a railroad crossing are frequently used, especially on rural highways. They consist of several lines and letters arranged in a distinctive design which is never used for any other purpose.

Section 213-Pavement Edges

Line markings on the pavement may be located along the sides of the roadway, especially on bridges, to indicate the limit of safe approach to the edge of the pavement. These are of great benefit at night on dark colored roadways.

Diagonal guide lines should also be used wherever a roadway changes to a narrower width so as to provide sufficient distance to permit traffic to make the transition (see Section 234).

Section 214-Word Markings

Word markings shall not be used for mandatory messages without supporting signs.

Words marked on the pavement or sidewalk curbs are used sometimes to convey brief directional or informatory messages supplementary to standard signs. While such word markings present their message without diverting attention from the roadway, a message of more than three words is difficult to apprehend.

Flexible sign markers carrying words may be used instead of words painted on the pavement, but only supplemental to standard signs.

Section 215-Button Markings

Buttons that project several inches above the pavement, whether illuminated or not, shall not be used at any point where they can interfere with traffic.

Buttons may be used to mark Don-traffic areas in a wide pavement. In such cases constantly high visibility should be maintained.

Section 216-Curb Markings

Curb markings in color to show parking regulations are of value in showing exactly where parking is restricted, especially where the regulations vary within short distances, but they are not generally effective except as supplementary to standard signs.

Markings on the vertical faces of curbs are effective at the ends of angle or perpendicular parking stalls to indicate parking time-limits and to indicate street names and house numbers. Time-limit markings on curbs where parallel parking is in use have not proved effective.

Article A-III-Design

Section 217-Lines on Pavements

Lines may be marked on pavements by:
(a) Construction joints in the pavement, filled with material of contrasting color.
(b) Construction of the pavement with adjacent strips of different materials showing variation of surface.
(c) Paint or lacquer of contrasting color applied to the surface.
(d) Inserts set into or attached to the body of the pavement.

Section 218-Construction Joints

Many roadways, especially those made of concrete, are built in two or more longitudinal strips wide enough to accommodate a lane of traffic, the joints between the strips being filled with an elastic waterproof compound of a different color than that of the pavement. Such joint lines are very effective in holding traffic in the lanes thus defined.

Transverse lines of this character may also be useful for traffic control purposes, marking limit lines or crosswalks. In the case of pavements laid with transverse joints at regular intervals, however, any joints intended to serve for traffic control purposes must be distinctive in appearance.

Section 219-Contrasting Pavement Materials

Many roadways wider than required for two traffic lanes are built with a single lane of concrete pavement on each side of the roadway and macadam or other material between. The surface of this medial area has a different color and surface texture from the concrete and serves very effectively to hold the opposing streams of traffic apart so that the center is used only for passing,

Section 220-Paint and Lacquer

A common method of marking lines on pavements is by painting, for which purpose special paints and lacquers having durable qualities have been developed @see Appendix E). Disadvantages of this method are that lines subjected to continuous wear from traffic require frequent renewal at considerable expense, even when painting machines are employed, and if they are not renewed as needed they become quite ineffective. An advantage of painted lines is that they can be relocated from time to time if traffic or roadway conditions are altered. They are also very effective while in good condition.

Section 221-Inserts

Inserts are sometimes placed in the pavement to give the appearance of a line. There are several general types:

(a) A narrow strip of contrasting colored concrete set when the pavement is constructed.
(b) Blocks, usually rectangular, set into the pavement.
(c) Disks, usually circular, attached to the pavement.

22la-Rectangular inserts shall be of a permanent color different from that of the pavement, and shall be set so that their upper surfaces are flush with the level of the pave. pavement. They shall be set end to end to form a continuous line, or they may be separated by spaces not greater than the length of a single insert so that the appearance will be that of a broken line.

22lb-Round inserts shall show a bright surface contrasting with that of the pavement under the action of traffic, shall be not less than 4 inches in diameter and shall be spaced not more than 16 inches apart center to center on transverse lines nor more than 36 inches apart center to center on longitudinal lines. (They may be set as much closer together as desired.) They shall have a rounded surface so that a smooth contour will be presented to the wheels of vehicles, and they shall not project more than ½ inch above the level of the pavement. They shall be permanently fixed in place by anchor bolts or some similar effective device.

Section 222-Widths of Lines on Pavements

Lines marked on pavements shall be not less than 4 nor more than 8 inches wide.

Very wide lines lose their distinctiveness and authority, instead of emphasizing it, as is generally intended.

Section 223-Lengths of Longitudinal Broken Lines

Longitudinal broken lines and the intervening spaces shall be of equal length, within the following limits:

Center lines and lane markings, 5 to 75 feet
Street car clearance lines, 2 to 4 feet
Traffic guide lines, 4 to 10 feet

An arrowhead shall be placed on each section of a traffic guide line.

It is important that the arrows in traffic guide lines be short enough so that the vehicle driver can always see at least two of them. Long directional lines with a single arrowhead at the

extreme end which cannot be seen until the end is approached are useless and are likely to be confused with lane markings.

Section 224-Words on Pavements

Words are usually marked on pavements by painting or stenciling, although in some instances round inserts have been used satisfactorily.

The letters should be greatly elongated in the direction of traffic movement because of the small angle at which approaching drivers view the letters (see Fig. 224). If more than one line of words is used, the separating space should be about twice the height of the letters.

Section 225-Colors for Lines or Words on Pavements

On pavements it is difficult to secure a color which will show a strong contrast under all conditions. White, yellow and black are the colors commonly used, depending upon the color of the pavement.

Section 226-Markings to Eliminate Center Lane at Hazardous Points

Markings to eliminate the center lane at hazardous points (see Section 203) shall be made as follows:

(a) A center line shall be marked through the area where the unobstructed view in both directions is less than 500 feet.
(b) The ends of the center line shall be connected with the ends of the lines marking the center lane by straight lines at an angle of I in 20 with the center line.

Section 227-Crosswalks

Both boundaries of a marked crosswalk shall be indicated by line markings across the entire roadway.

To facilitate pedestrian cooperation in traffic regulation, pedestrians should know exactly where they are to cross the street, and should feel reasonable security not only against vehicles approaching the intersection, but also against those turning within it. Single line crosswalks fail in this, and are not recommended.

Section 228-Limit Lines

Limit lines, where used, shall be marked across the right half of the roadway at the point behind which vehicles; must stop in compliance with a signal or sign (see Fig. 228).

Section 229-Approach to an Obstruction

Pavement markings to give warning of approach to an obstruction shall be in the form of two lines starting 6 inches outside of each corner of the approach end of the obstruction and converging at a point distant ten times the width of the obstruction, from which point a single line shall be extended 100 feet farther from the obstruction (see Figs. 229 and 229a).

Section 230-Pavement Markings for Parking Regulations

Pavement markings to indicate parking regulations, when used, shall be as follows:

(a) For parallel parking a line 6 feet long at right angles to the curb at each end of a prohibited zone indicated by curb markings.
(b) Where angle parking is permitted, a series of lines spaced not less than 7 feet apart, measured at right angles to such lines, and located at the established angle with the curb to form parking stalls.

In the first case the line is used to indicate more clearly the limit beyond which a vehicle must stand to clear the prohibited zone, and should be used only for parking parallel with the curb.

In the second case the angle of the lines with the curb is usually approximately 45 degrees. This is the most effective angle, considering both ease of access and pavement occupancy. While perpendicular parking does not occupy any more of pavement area and will accommodate more cars for a given length of curb, the difficulties of access are so great and there is so much interference with other

1939 MUTCD REVISION — PART II - MARKINGS

Section 202 - Lines on Pavements

Eliminate from paragraph (a) the words "in dangerous locations."

Insert now paragraph (c):

(c) "No Passing" zones in conjunction with center lines and traffic lane markings.

Reletter present paragraph (c) and succeeding paragraphs.

Section 203 - Center Lines

Change first paragraph:

Line markings on pavement shall be placed on the medial line of the roadway in the following locations:

(a) On the approach to the crest of a hill where the clear view ahead is less than the required passing sight distance for the prevailing speed at that location.

(b) on any curve having a radius less than 600 feet or where the clear view ahead is less than the required passing sight distance for the prevailing speed at that location.

(c) On pavements wider than 40 feet.

Eliminate last paragraph. (Matter to be covered by now Section 204.1 and revised Section 226.)

Section 204 - Lane Markings

Transfer bold-face paragraph and next succeeding paragraph with revisions indicated to now Section 204-1- Retain last paragraph of Section 204.

(Now) Section 204.1 - "No Passing" Markings

In bold-face type.

In zones on 2-lane highways marked with a center line where overtaking and passing is dangerous and unlawful there shall be marked alongside the center line; on the side from which crossing the line is prohibited, auxiliary marking as described in Section 226.

In ordinary type:

In such markings it should be noted that the purpose is to prevent overtaking and passing wherever the clear view ahead is inadequate for safe passing without being unduly restrictive when the danger zone is passed. Therefore in each direction approaching a hillcrest the auxiliary marking should begin a considerable distance below the hillcrest but terminate Just beyond it. The same principle will often apply at curves and other points of hazard.

In bold-face type (revised from present Section 204):

On highways marked with an odd number of traffic lanes, there shall be such marking that the middle lane will be discontinued on hillcrest and curves throughout any section of the highway where the clear view ahead is insufficient for safe passing at railroad grade cross @ a, on bridges narrower than the adjoining pavements, and at signalized intersections.

In ordinary type:

The foregoing applies particularly, to 3-lane highways on which overtaking and passing at such places is extremely dangerous. Essential requirements in the design of such marking are indicated in Section 226.

Lane markings should not be depended upon solely to prevent overtaking and passing in hazardous areas, but such areas should be marked by NO PASSING signs as indicated in Section 109a.

Section 226 - Markings to Prohibit Over-taking and Passing at Hazardous Points

Change title of section as above indicated.

Substitute for present text:

In bold-face type:

Auxiliary markings to indicate zones on 2-lane highways where overtaking and passing is prohibited shall be by means of additional lines of a different width or color from the center line or by additional broken lines of the same color.

In ordinary type:

Various methods of marking are being tried to indicate NO PASSING zones on 3-lane highways. The essential requirement is that traffic in each direction shall be diverted to the right an ample distance before reaching the point of hazard. Any marking permitting traffic in either direction to reach such point of hazard in or to the left of the center of the roadway, is strongly disapproved.

Section 228 - Limit Lines

Add in ordinary type

A limit line several feet In advance of the crosswalk has been found effective in a number of cities in preventing motorists from encroach upon the crosswalk.

Section 229 - Approach to an Obstruction

Change paragraph:

Pavement markings to give warning of approach to an obstruction shall be in the form of two lines starting 6 inches outside of each corner of the approach end of the obstruction and

converging at a point distant at least ten times the width of the obstruction, from which point a single line shall be extended 100 feet farther from the obstruction (see Figs. 229 and 229a).

Add in ordinary type:

The greater the normal speed of approaching traffic, the greater should be the length of the pavement markings.

Section 234 - Pavement Edges

Where a line marking is used to connect the edge of a wider pavement with that of an adjacent narrower section, the length of the diagonal connecting line should be at least ten times the offset distance.

1948 MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

The 1948 MUTCD represented the first opportunity to implement the lessons learned from using the 1935 MUTCD. One of the most significant changes was that material on legal authority, application/location, design, and maintenance were all addressed together for each type of devices, instead of separating them as had been done in the 1935 and 1942 manuals. The language in this appendix represents two chapters from the markings part of the 1948 manual (introduction, pavement and curb markings) and the markings language from the 1954 revision. It does not include the chapters of the manual that covered object markings and reflector markings. As with the 1935 MUTCD, standard statements (shall conditions) were shown in bold text.

PART II — MARKINGS
A-INTRODUCTION

Section 118.-Functions and Limitations of Markings

Markings have definite functions to perform in a proper scheme of traffic control. Int some cases they are used to supplement the regulations or warnings of other devices such as traffic signs or signals. In other instances they obtain results, solely on their own merits, that cannot be obtained by the use of any other device. In such cases they serve as a very effective means of conveying certain regulations and warnings that could not otherwise be made clearly understandable.

Markings also have definite limitations, especially when applied to pavement and curbs, where they may be entirely obliterated by snow, are not clearly visible when wet, and are not very durable when painted on surfaces exposed to traffic wear. In spite of these limitations, however, they have the advantage under favorable conditions that they can convey warning or information to the vehicle driver without diverting his attention from the roadway.

Section 119.-Legal Authority

Markings shall be placed only by the authority of a public body or official having jurisdiction for the purpose of regulating, warning, or guiding traffic.

Pavement and curb markings, being exclusively within the boundaries of public highways, should never be installed except by public authority. Delineators and markings on objects as a warning of their hazardous locations are also normally within the highway right-of-way, and should be subject to the same jurisdictional regulations.

A suitable model of legislation for the placing of markings is to be found in Act V of the Uniform Vehicle Code (secs. 19, 30, 31, 32, 33, 37). Interference with official markings is prohibited in section 38 of the same act.

Section 120.-Standardization

Markings, where used, shall be uniform in design, position, and application. As in the case of all other traffic control devices, it is imperative that markings be uniform so that they may be recognized and understood instantly.

Section 121.-Types of Markings

Markings as defined for the purposes of this manual are of a number of types:

1. Pavement markings:
    (a) Center lines (secs. 128-130).
    (b) Lane lines (secs. 131-133).
    (c) No-passing-zone markings (secs. 134-136).
    (d) Pavement edges (sec. 137).
    (e) Pavement-width transitions (sec. 138).
    (f) Approach to obstructions (sec. 139).
    (g) Streetcar clearance lines (sec. 140).
    (h) Turn markings (sec. 141).
    (j) Stop lines (sec. 143).
    (j) Cross-walk lines (sec. 144).
    (k) Route directions (sec. 145).
    (l) Approach to railroad crossing (sec. 146).
    (m) Parking space limits (sec. 147).
    (n) Word markings (sec. 148).
2. Curb markings for parking restrictions (sec, 149).
3. Object markings:
    (a) Objects within the roadway (secs. 151-153).
    (b) Objects adjacent to the roadway (sec. 154).

4. Reflector markers:
   (a) Hazard Markers (sec. 156).
   (b) Delineators (sec. 157).

Section 122,-Materials

The most common method of applying pavement, curb, and object markings is by means of paint. A continuous improvement in paints and in equipment and methods of application has resulted in a vary wide use of pavement markings. Equipment is in use that is capable of placing single, double, or triple striping on a highway, in different colors, and of solid or broken type of line, while operating at a speed of 10 to 15 miles per hour. Hand equipment can be used to place transverse or special markings, at intersections or elsewhere, at a reasonable cost.

A relatively recent development in pavement markings is the use of minute glass "beads" (actually true spheres) embedded in the pavement-marking material to produce a retrodirective reflecting surface. The glass-beaded surface returns a greatly increased proportion of the incident light back in the direction of its source, and causes the markings to appear luminous at night under normal head-lighting. While the beads have little or no effect in the daytime, the visibility of the markings by night is greatly improved. Although the initial cost of such reflectorized markings is considerably higher than for ordinary traffic paint, a number of highway departments have reported that the increased life of the markings, especially at heavily traveled locations, more than compensates for the difference in cost.

Pavement markings may also be in the form of small units of metal or other material attached to or set into the pavement surface. Such units may be rectangular, round, or of special shape, and may be, assembled into solid or broken lines.

Flat units on or in the pavement surface shall be of permanent colors as specified for pavement markings, and shall be set so that their upper surfaces are essentially flush with the pavement surface. They may be placed in continuous contact, or separated by small spaces approximately, equal to the length of a single unit. Either type of line may be used where a solid line is prescribed in this manual. Particular care should be taken to see that alinement and spacing are accurate, to insure a good appearance.

Metal inserts shall have a surface that will remain bright under the action of traffic, thus contrasting with the color of the pavement. Nonmetallic inserts shall be of permanent colors as specified for pavement markings. Inserts shall be not less than 4 inches in diameter if round, or of approximately equivalent area if of other shape, and shall be spaced not more than 16 inches apart center to center, on transverse lines, nor more than 36 inches apart on longitudinal lines. They shall have rounded surfaces presenting a smooth contour to the wheels of vehicles, and shall not project more than one-half inch above the level of the pavement. They shall be permanently fixed in place by anchor bolts or similar effective devices.

Similarly, unit letters, symbols, or stripes may be attached to or set into the pavement surface, as an alternative type of pavement marking. These should be essentially flush with the pavement surface, and should not become unduly slippery when wet, especially if they are of considerable area. They should be of permanent colors as specified for pavement markings,

Metal and plastic inserts and flat marker units in or on the pavement surface, are used principally in urban areas, where heavy traffic rapidly destroys painted markings, and where frequent repainting not only is costly but causes undue traffic delays. In rural areas speed of application makes painting the preferred form of marking.

While successful experiments have been reported with permanent built-in pavement markings of white or colored concrete or inlaid bricks or blocks, their use has not been widespread.

The use on the pavement surface of small metal or plastic studs with inserted reflector buttons is not recommended. Experience has shown that they are destroyed by snow plows, they cannot be kept clean and effective, and they are a hazard to motorcycles.

Large "mushroom" buttons, or bars, of cast iron or concrete several inches high, with or without reflectors, lights, symbols, or messages, are favored in some cities to mark pedestrian islands or to assist in channelizing traffic. In these applications they are, in effect, curbs or islands (secs. 322, 325, 341, 349, 360). They are not a suitable alternative to signs or pavement markings. They should not be located where they constitute an unexpected hazard for motor vehicles, and their use on rural highways is strongly disapproved.

Object markings are ordinarily painted directly on the surface of the obstruction. If the surface will not retain paint readily, some flat surface of wood or metal should be printed with the proper marking and attached to the obstruction. Where a reflectorized coating is desirable, it will often be necessary to use a separate surface for satisfactory application. Reflecting buttons or clusters may be, attached directly to the, obstruction or installed on separate posts immediately in front of it.

Delineators and hazard makers may consist of single reflectors, clusters of reflectors, or small panels of uniform shape covered with a reflecting coating, mounted on separate posts. To be effective they must be of retrodirective character and of adequate brilliance.

Section 123.-Colors

Pavement markings shall be either white or yellow in color.

The correct color f or yellow traffic paint is the same as that specified for highway signs. Color cards showing this "highway yellow" may be obtained from the Public Roads Administration.

Bright metal buttons are to be regarded as the equivalent of white paint in pavement markings.

White shall be used for:

1. **Center lines on two-lane rural roads and city streets.**
2. **Lane lines.**
3. **Pavement edges.**
4. **Streetcar clearance lines.**
5. **Turn markers.**
6. **Stop lines.**
7. **Cross-walk lines.**
8. **Parking space limits.**
9. **Route directions.**
10. **Word markings.**

For the following markings it is recommended that yellow be used, but white is permissible:

1. Double center lines on multi-laned pavements.
2. No-passing barrier lines at:
   (a) No-passing zones on two- and three-lane roads.
   (b) Pavement-width transitions
   (c) Approaches to obstructions in the center of the roadway.
   (d) Approaches to railroad crossings.

The markings for which yellow is recommended are all solid guide lines or regulatory lines to the left of which it is unsafe or illegal to travel when they are applied as prescribed in this manual. Yellow is favored for several reasons:

1. It contrasts with the normal white center or lane lines and thus gives emphasis to the hazard.
2. Yellow has been accepted as a symbolic warning color in signs and signals.
3. It is consistent with the standard for no-passing-zone markings hitherto approved by the American Association of State Highway Officials and in use in many States.

Curb markings to show parking prohibitions covered by signs or ordinance shall be yellow. Markings on vertical surfaces of objects within the roadway or dangerously close thereto shall consist of alternate black and white stripes.

Objects adjacent to the roadway, such as guard rails, trees, and rocks, may be painted white as a useful guide to night traffic.

In reflector markers, delineators shall be white, and markers indicating the location of hazardous objects shall be white or yellow.

Section 124.-Types of Striping

A broken line shall be used for center or lane lines where these lines are only guide lines that may be crossed at the discretion of the driver.

Since most center and lane lines are only for guidance, the saving in paint through the use of broken lines is an important economy. High-speed striping machines have been constructed that are capable of repainting broken lines accurately and neatly, permitting a saving of more than 60 percent in paint, with little or no increase in the cost of application.

A broken line, with segments and gaps well proportioned, appears to be as effective as a solid line for guide purposes. On rural highways a commonly used standard is 15 foot segments with 25-foot gaps. In the application of a given gallonage of paint per mile, such relatively short segments will give a better line that if longer segments, with correspondingly longer gaps, are used. On the other hand, very short segments and gaps have been found to cause an unpleasant flickering sensation.

On urban streets the line segments and gaps, especially the latter, should be considerably reduced in length. Short sections of broken line, such as are used for intersection approaches, require the use of short segments, closely spaced.

Broken lines are also prescribed for streetcar clearance lines, and for turn marking (secs. 140, 141).

A solid line shall always be used for longitudinal markings where the line is of a regulatory character and is not to be crossed, that is, for center lines of two-way multi-laned roads with an even number of lanes, and for lines indicating no-passing zones.

In a combination striping of solid and broken lines, the solid or barrier line has significance only if it is on the right-hand side of the combination stripe, as viewed by the driver, i.e., in or adjacent to the traffic lane to which it applies.

Section 125.-Width of Lines

Longitudinal pavement lines shall be from 4 to 6 inches wide.

The most common width is 4 inches, but 6-inch lines, favored by a number of highway departments, provide added visibility. Narrower 3-inch lines have been used as a means of economizing in paint, but they are not regarded as adequate for standard use.

Transverse lines on pavements must be much wider than longitudinal lines to be equally visible. Stop lines may have to be as wide as 24 inches where approach speeds are high.

Section 126.-Reflectorization

Reflectoization for better night visibility is desirable for almost all markings, but it is neither a practicable nor necessary requirement in all cases. Reflectorization is of doubtful value on well–lighted city streets, for example, and it is not ordinarily essential for center or lane lines where there are no special hazards. At least the following markings should normally be reflectorized:

1. Center lines on multi-laned pavements.
2. No-passing barrier lines at:
    (a) No-passing zones on two- and three-lane roads.
    (b) Pavement-width transitions.
    (c) Approaches to obstructions in the roadway.
    (d) Approaches to railroad crossings.
3. Striping on vertical surfaces of objects in and adjacent to the roadway.

Section 127.-Maintenance

All necessary markings shall be kept in good order and clearly visible at all times. Unless this is done they may create serious hazards by giving a false sense of security, especially in the case of cross walks.

The frequency of repainting depends on the type of surface, composition and rate of application of paint, climate, and volume of traffic. Particular care should be taken, especially in the case of broken lines, to paint over the old markings as exactly as possible, otherwise they will appear increasingly ragged after successive repaintings.

B-PAVEMENT AND CURB MARKINGS

Section 128.-Center Lines

A center line is used to designate the center of the traveled portion of a roadway carrying traffic in both directions. Under some circumstances, as at a pavement-width transition, it need not be at the geometrical center of the pavement. On all major rural highways having an even number of lanes, and on many urban streets and less important rural roads, center lines are necessary and should be applied throughout the entire length of the pavement. In urban locations and on some rural roads where a continuous center line is not required, short sections of center line are useful on approaches to busy intersections, marked cross walks, or railroad crossings, and around curves or over hillcrest. When so used, the center line serves both to warn of any unusual condition and to or organize and control traffic through a hazardous or congested zone.

A line marking the center of a one-way roadway is a lane line, as described in section 131.

Section 129.-Center Lines on Rural Roads

The center line on a two-lane paved rural highway shall be a broken white line, not less than 4 nor more than 6 inches wide. Line segments 15 feet in length, with 25-foot gaps, are recommended.

Where a center line is applied only at special locations on a highway, it should generally be used where overtaking and passing is unsafe, as over hillcrests, around curves, and at railway grade crossings and intersections, or wherever traffic control requires a clear indication of the roadway center. At intersections the line should extend in advance of the intersection a sufficient distance to keep vehicles definitely in single line while approaching. **Short sections of center lines used for regulatory purposes, requiring that drivers keep to their proper lane, shall be solid white lines**.

On four-lane undivided rural pavements, or on pavements of a greater even number of lanes, the center line shall consist of two solid lines, each not less than 4 inches nor more than 6 inches wide, separated by a space of not less than 2 inches. Such lines should normally be reflectorized.

Since this center line is, in effect, a continuous no-passing striping, to the left of which it is illegal to drive (sec. 134), it is recommended that the two lines be yellow. As an alternative, white lines are permissible.

As a guide to the application of center-line markings the following warrants are suggested:

1. Center lines should be placed throughout the length of:
    (a) Two-lane pavements carrying average annual traffic volumes in excess of 2,000 vehicles per day.
    (b) Two-lane pavements narrower than 20 feet carrying average annual volumes in excess of 1,000 vehicles per day.
    (c) Two-lane pavements narrower than IS feet carrying average annual volumes in excess of 500 vehicles per day.
    (d) All four-, six-, and eight-lane undivided pavements.
2. Center lines should also be placed on all two-lane pavements carrying annual traffic volumes in excess of 300 vehicles per day at the following locations:
    (a) On the approaches to the crest of a hill where the clear view ahead is less than 500 feet.
    (b) On the 100 feet in advance of and beyond any curve having a radius of less than 600 feet or where the sight distance is less than 500 feet.
    (c) On the approve to a traffic control signal or arterial highway for a distance of not less than 100 feet from the Stop line, and as much more as may be necessary to cover the instance within which vehicles are commonly alined.

3. Center lines should also be placed at locations where the accident record indicates the need for them, and on hard-surfaced roads in areas where the entire roadway is likely to be obscured frequently, as by fog.

Section 130.-Center Lines on Urban Streets

Center lines on city streets shall be broken white lines, not less then 4 inches nor more than 6 inches wide. To preserve the effect of continuity where traffic is heavy, speeds are low, or blocks short, the line segments, and especially the gaps, should be relatively short.

Long sections of such lines should not be used on streets providing less than two lanes for free-moving traffic in each direction, exclusive of parking lanes. This minimum street width does not apply to the use of short sections of center lines around curves, over hillcrests, or on approaches to important intersections and marked cross walks. **Short sections of center line for regulatory purposes shall be of solid design.**

Small units of metal or other material attached to or set into the pavement surface are frequently used in cities as an alternative to painted markings. These are discussed in section 122.

On wide, high-speed boulevards, and on controlled-access highways in urban areas, center-line standards shall be the same as those for rural highways.

Applications of center lines are shown in various illustrations herein, particularly figures 5, 10, 12, 14, and 17.

Section 131.-Lane Lines

Lane lines are helpful in the organization of traffic in its proper channels, and in increasing the efficiency of the use of the roadway surface at congested locations. They should be used:

1. On all rural highways with an odd number of traffic lanes.
2. In addition to the regular center line, on all rural highways of four, six, or eight lanes.
3. At important intersections, at cross walks, and in dangerous locations, on both rural highways and city streets.
4. At congested locations, particularly on city streets, where the roadway will accommodate more lanes of traffic than would be the case without the use of lane lines. These include:
   (a) Locations between loading islands and sidewalk curbs.
   (b) Other locations where the normal lane width is decreased.
   (c) Approaches to widened intersections.
5. On important one-way streets or highways were maximum efficiency in utilization of the roadway is desired.

Applications of lane lines are illustrated in figures 14, 15, and 17.

Section 132.-Lane Lines on Rural Roads

Lane lines on rural roads shall be broken white lines, not less than 4 inches nor more than 6 inches wide. Line segments 15 feet long, with 25-foot gaps, are recommended. The transverse spacing of lane lines, that is, the lane width, should not normally be less than 10 feet.

Section 133.-Lane Lines on Urban Streets

Lane lines on city streets shall be broken white lines, not less than 4 inches nor more than 6 inches wide. Due to relatively lower speeds, the line segments, and especially the gaps, should normally be shorter than in rural ,areas. In limited sections of lane lines, as at intersection approaches or between loading islands and sidewalk curbs, the line segments and gaps may be as short as 4 feet and of equal length.

The lane width defined by lane lines should not normally be less thin 10 feet, but a minimum of 9 feet is permissible where a maximum number of lanes must be made available, as at a signalized intersection where provision must be made for the most efficient storage of stopped vehicles in a street width reduced by the presence of a loading island. **On wide, high-speed boulevards and on controlled-access highways in urban areas the standards for lane markings shall be the same as those for rural highways**.

Section 134.-No-Passing Zones

No-passing zones should be established at vertical or horizontal curves and elsewhere on two- and three-lane highways where passing must be prohibited because of dangerously restricted sight distances or other hazardous conditions.

A no-passing zone shall be marked by a solid barrier line placed as the right-hand element of a combination stripe along the center or lane line. It is recommended that this barrier line be yellow (sec. 123), although white is a permissible alternative. The combination line may consist of either of the following, as illustrated in figure 12:

1. A normal broken white center or lane line continuing through the no-passing zone, with the solid barrier line placed to the right of it. Where no-passing zones in opposite directions overlap on a two-lane roadway there will be a solid barrier line on each side of the broken center line. Where the no-passing restriction applies only in the opposing direction, the barrier line will appear to the left of the broken center or lane line and will not have any controlling effect except on traffic in the opposing direction.
2. A double line replacing the single broken center line on a two-lane roadway, of which the right-hand stripe is the solid barrier line. Where no-passing zones in opposite directions overlap, there will be a double solid line, and where the no-passing restriction applies only in the opposing direction the solid line will be to the left of a broken line and will not have any controlling effect.

The barrier line shall be not less than 4 nor more than 6 inches wide, and shall be separated from the adjacent stripe by a space of not less than 2 nor more than 4 inches. It should normally be reflectorized for increased emphasis.

On unimportant two-lane roadways carrying little traffic, a center-line marking may be desirable although the marking of no-passing zones by means of barrier lines may not be economically warranted. Under such conditions a single-line markings, consisting of a broken white center line where passing is permitted and a solid white center line throughout no-passing zones in either direction, is recognized as a permissible alternative to the barrier-line design prescribed above. A single center line can be placed more cheaply, and on a narrow roadway is subject to less traffic wear than the double or triple barrier-line design. The single-line design, however, should be used with great caution. It lacks the directional characteristic of the barrier-line design for no-passing zones. Thus it forces the driver to stay on his side of the roadway for some distance after his sight distance has become adequate for passing, or it throws on him the responsibility for deciding when it is safe to pass, thus destroying the barrier significance of the solid line. Particular care should be taken to avoid an unnecessary and possibly confusing mixture of the two types of design in any given area.

Section 135.-No-Passing Zones on Two and Three-lane Roadways

On a two-lane roadway the combination no-passing line shall follow the center line throughout the no-passing zone. On a three-lane road the combination line shall start from the left-hand lane line of the center lane and shall extend at an angle of not less than 20 to 1 across the center lane to the right-hand lane line at the beginning of the no-passing zone, and thence extend along the lane line to the end of the zone (fig. 12).

No-passing-zones signs (R-11, R-12; sees. 39, 40) may be used to supplement the pavement markings here prescribed.

It is assumed that on highways of four or a greater even number of lanes it is not necessary to cross the center line to overtake and pass other vehicles. No specifications, therefore, are provided for the marking of no-passing zones on such highways. The double center line is to be regarded as a continuous no-passing marking, consisting of two barrier lines which must not be crossed from either side.

Section 136.-Warrants for No-Passing Zones

The warrant for the establishment of a no-passing zone depends on the assumed design speed of the road and minimum sight distance necessary for safe passing at that speed. Sight distance on a vertical curve is the distance at which an object 41/2 feet above the pavement surface can just be seen from another point 41/2 feet above the pavement, as illustrated in figure 13. Sight distance on a horizontal curve is determined in similar fashion, measuring around the embankment or other obstruction that cuts off the view on the inside of the curve. **A curve shall**

warrant a no-passing zone, and shall be so marked, when the minimum sight distance for the assumed design speed is equal to or less than that listed below: [1]

Design speed (miles per hour) (feet)	*Minimum sight distance speed (feet)*
30	500
40	600
50	800
60	1,000
70	1,200

The beginning of a no-passing zone, point *a* in figure 13, is that point at which the sight distance first becomes less than that specified in the above table. The end of the marking, point *b*, is that point at which the sight distance again becomes greater than the minimum specified. **In no case shall the marking be less than 500 feet in length. If the actual no-passing distance is less than 500 feet in length, the additional length of marking shall be added at the beginning of the zone**.

For methods of determining the beginning and end of no-passing zones, see *A Policy on Criteria for Marking and Signing No-Passing Zones on Two and Three Lane, Roads*, American Association of State Highway Officials; or the *Traffic Engineering Handbook*, published jointly by the Institute of Traffic Engineers and the National Conservation Bureau.

On urban streets it is not ordinarily necessary to mark no-passing zones. Speeds are generally low, and a normal center line is usually sufficient to keep vehicles in line, On boulevards or parkways, where no-passing zones may have to be marked, the standards should be the same as for rural highways.

Section 137.-Pavement Edges

Line markings on the pavement have sometimes been used alone the sides of the roadway, especially on bridges, to indicate the limit of safe approach to the edge of the pavement. Experience has shown that such lines are easily mistaken for center or lane lines, with the result that drivers attempt to pass to the right of them and so run off the road. They are therefore not recommended. Reflector markers are much preferable for the purpose intended (secs. 156, 157). **Pavement edge lines shall be solid white lines, not less than 4 nor more than 6 inches wide. When used, they shall supplement rather than replace standard center and lane lines**.

[1] *Adapted from A Policy on Criteria for Marking and Signing No Passing Zones on Two and Three Lane Roads*, American Association of State Highway Officials.

Section 138.-Pavement-Width Transitions

Line markings should be used to indicate points where the pavement width changes to a lesser number of lanes. There are a number of situations possible, as illustrated in figure 14, depending on which lanes must be offset or cut out, and the amount of offset. One or more lane lines must be discontinued and the remaining center and lane lines must be connected in such a way as to merge traffic into the reduced number of lanes.

Lines marking pavement-width transitions shall be not less than 4 nor more than 6 inches wide, and of standard center or lane-line design. Converging lines shall have a length of not less than 20 times the offset distance.

Through the transition area, in the direction of convergence, the line separating the opposing directions of traffic should be of no-passing- zone design, either the double solid center line of a multi-laned road or a normal broken center line with an adjacent barrier line as prescribed for no-passing zones (sec. 134). Such no-passing markings should normally be reflectorized.

Pavement-width transition lines, in themselves, are not a sufficient warning at such locations, and should be used only to supplement standard signs, guardrails, or delineators.

Section 139.-Approach to an Obstruction

Pavement markings shall be used to warn of the approach to a fixed obstruction within a paved roadway. Obstructions within the roadway are hazards that should not be permitted to exist if avoidable, but where they cannot reasonably be eliminated everything possible should be done to prevent vehicles from colliding with them. An obstruction may be in the center of the roadway, in which case all traffic must keep to the right of it, or it may be so located as to be between two lanes of traffic moving in the same direction. The markings in either case must be designed to deflect traffic away from the obstruction by a diagonal line or lines of unmistakable meaning.

Obstruction pavement markings shall consist of a diagonal line, or lines, extending from the center or lane line to a point 1 foot to the right side, or to both sides, of the approach end of the obstruction (fig. 15).

The length of the diagonal markings should be determined by the, formula L = S X W where L equals the length in feet, S the design speed in miles per hour, and W the width of the obstruction in feet.

In no case shall the diagonal line be less than 150 feet in length in rural areas or 50 feet in urban areas. If traffic is required to pass only to the right, the diagonal line shall be marked to the right and shall be of one of the following designs:

1. A normal broken center line flanked by a solid barrier line, as specified for no-passing zones (sec. 134). The barrier line shall extend along the center line in advance of the diagonal line for a further distance equal to the length of the diagonal line.
2. On a roadway not marked with a continuous center line, a solid line which shall be extended, on the roadway center line, a further distance in advance equal to the length of the diagonal line.
3. On roads of four lane, or more a simple continuation of the double center line prescribed for such roads (sec. 129).

In addition, a solid white diagonal line may be extended to the left of the obstruction, to outline the triangular area from which traffic must be excluded for safety**. If traffic may pass either to right or left of the obstruction, there shall be two solid white lines diverging from the lane line, one to either side of the obstruction. In advance of the point of divergence a single solid line shall be extended in place of the normal broken lane line for a distance equal to the length of the diverging lines.**

All lines used in obstruction approach markings shall be not less than 4 nor more than 6 inches wide. They should preferably be reflectorized. As an added safeguard it is desirable, especially where traffic is permitted to pass to both right and left of an obstruction, to place broad transverse, diagonal, or longitudinal lines in the triangular area between the guidelines, as shown in figures 15 and 20.

Similar markings are desirable at channelizing islands not so designed as to divert traffic naturally from them.

Obstruction approach markings shall be used only to supplement adequate markings on the obstruction itself as prescribed in section 151.

Section 140 Streetcar Clearance Lines

It is often desirable to mark lines on the pavement to indicate the limits and the clearance of the overhang on turning streetcars.

Streetcar clearance lines shall be broken white lines, with segments and gaps of equal length not exceeding 2 feet. They shall be not less than 4 nor more than 6 inches wide.

On curves of short radius it is necessary to use very short dashes and spaces, to preserve the appearance of continuity in- a broken line.

Section 141Turn Markings

Markings to restrain drivers from starting left turns before reaching the intersection, or to guide turning vehicles, are sometimes used at the intersections. Such markings have not satisfactorily standardized, but if used they should be so designed as to indicate the proper course

for turning vehicles without being needlessly confusing to through traffic or traffic making other turns. Typical designs are shown in figures 16 and 42.

Lines used in turn markings shall be broken white lines, not less than 4 nor more than 6 inches wide. As in the case of streetcar clearance lines, they should be made up of short dashes and short spaces.

Section 142.-Transverse Lines

Because of the low angle at which pavement markings are viewed from an approaching vehicle it is necessary that all transverse lines be proportionately widened to give visibility equal to that of longitudinal lines, or to avoid apparent distortion where longitudinal and transverse lines are combined in symbols or lettering. This applies particularly to Stop lines, cross-walk markings, railroad-crossing markings, and word markings.

Particular attention must be given to the maintenance of transverse lines which, because of their position on the pavement, are subject to constant wear by every vehicle that passes.

Section 143.-Stop Lines

Stop lines (or Limit lines) should be used in both rural and urban areas only where it is important to indicate the point behind which vehicles are required to stop in compliance with a Stop sign, traffic signal, officer's direction, or other legal requirement.

Stop lines shall be solid white lines, not less than 12 nor more than 24 inches wide. They shall extend across all approach lanes, usually to the center line (figs. 3, 17)**.**

On urban streets where speeds are not high a width of 12 to 18 inches is usually sufficient.

Stop lines, where used, should ordinarily be placed 4 feet in advance of the nearest cross-walk line. In the absence of a marked cross walk, the Stop line should be placed at the desired stopping point, in no case more than 30 feet or less than 4 feet from the nearest edge of the intersecting roadway.

If a Stop line is used in conjunction with a Stop sign, it should ordinarily be placed in line with the Stop sign. However, if the sign cannot be located exactly where vehicles are expected to stop, the Stop line should be placed at the stopping point.

The word STOP shall not be placed on the pavement in advance of a Stop line, unless every vehicle is required to stop at all times.

Section 144.-Cross-walk Lines

Cross walks should be marked at all intersections where there is material conflict between vehicular and pedestrian movement. Marked cross walks should also be provided at other appropriate points where there is substantial pedestrian movement, as at long loading islands (sec. 320), or where pedestrians are permitted to cross between intersections, or where pedestrians could not otherwise recognize the proper place to cross.

Cross-walk lines, in both rural and urban areas, shall be solid white lines, marking both edges of the cross walk. They shall be not less than 4 nor more than 12 inches wide (fig. 17).

If no advance Stop line is provided, it may be desirable to increase the width of the Cross-walk line on the approach side to as much as 24 inches.

On urban streets. where speeds are relatively low, a width of 6 inches is usually adequate.

The width of the cross walk between Cross-walk lines is usually determined by the width of the sidewalks so connected **The width shall in no case be less than 6 feet**.

To facilitate pedestrian cooperation in traffic regulation, pedestrians should know exactly where they are to cross the street, and should feel reasonable security not only against vehicles approaching the intersection, but also against those turning within it. Single-line crosswalk markings fair in this, and are strongly disapproved. Two lines are necessary to define the cross-walk area, and should always be used.

Section 145.-Route Directions

As a supplement to standard route markers, or where directions cannot be satisfactorily indicated by any other means, special directional markings can sometimes be used on the pavement. These may consist of one or more arrows, with or without route numbers, in the center of the lane. A typical example is illustrated in figure 17.

Directional markings shall be white in color.

Section 146.-Approach to Railroad Crossing

Pavement markings consisting of a cross, the letters RR, a no-passing center line, and certain transverse lines shall he placed on all paved approaches to railroad crossings, except at minor sidings or spurs or in urban areas where other protection is afforded. Such markings shall be white except for the no-passing barrier line, which should preferably be yellow. These markings should normally be reflectorized.

The design of railroad-crossing pavement markings shall be essentially as illustrated in figure 18. The symbol and letters are elongated to allow for the low angle at which they are viewed.

While these marking have value is a means of attracting the attention of the driver to the proximity of a railroad grade crossing, because they ire distinctively difference from all other pavement markings, they are only auxiliary to the standard signs or signals (secs. 88, 89) which must be installed in every case

Section 147.-Parking Space Limits

The marking of parking space limits on urban streets tends to prevent encroachment on fire hydrant zones, bus stops, loading zones, approaches to corners, and clearance spaces for islands. Such parking space limits may be indicated on the pavement by lines marked perpendicular to the curb and extending into the roadway the width required by a parked vehicle, usually 7 feet. As a further refinement a line may be placed parallel to the curb connecting the street ends of these perpendicular lines, indicating the outside boundary of the parking zone. The zone may be divided into stalls by the use of lines perpendicular to the curb and so spaced that each Stall is long enough to accommodate one parked vehicle, usually 20 feet. In this case a short line, parallel to the curb, may be placed at the end of each stall line, in place of the continuous line extending the length of the parking zone (fig. 17).

The marking of stalls is especially beneficial where parking meters are used.

Angle parking, is generally not desirable, though occasionally it may be justified as, for example, on an unusually wide pavement where passing traffic is light and relatively slow moving. Where angle parking is permitted the marking of lines to indicate the limits of stalls enables all drivers to park at the same angle with a minimum of waste space.
All lines for parking spaces shall be solid white lines, not less than 4 nor more than 6 inches wide.

Section 148-Word Markings

Word markings on the pavement may be used for the purpose of guiding, warning. or regulating traffic. They should be limited to as few words as possible, never more than three.

Word markings shall not be used for mandatory messages except in support of standard signs. They shall be white in color.

The letters should be greatly elongated in the direction of traffic movement because of the low angle at which they are viewed by approaching, drivers. One method of designing elongated letters and numerals is illustrated in figure 19.

On high-speed roads, especially where traffic is heavy, messages of more than one line are undesirable and should generally be avoided. It is difficult to read and understand a message when the words are necessarily spread over so great a distance that they are not all legible at one time.

Where prevailing traffic speeds are greater than 35 miles per hour large letters and numerals should be used, 8 feet or more in height; and, if the message consists of more than one word, it should read "up", i.e., the first word should be nearest the driver. The space between lines should be at least four times the height of the characters.

On the other hand, where prevailing traffic speeds are 35 miles per hour or less, it is possible to use smaller letters and numerals, and to space the lines closer together so that an entire message of as many as three lines may be seen and read at one time. In this case, a message of two or three lines should be arranged to read "down," i.e., with the first word farthest from the driver. The spacing between the lines should be equal to the height of the characters.

The word STOP shall never be used on the pavement in advance of a Stop line, unless every vehicle is required to stop at all times.

Figures 3, 16, and 17 show uses of word markings on the pavement.

Section 149.-Curb Markings for Parking Restrictions

Curb markings may be used to show where parking is prohibited at all times. They should not be used except on curbs along which parking is legally prohibited, either by general ordinance, as at fire hydrants, adjacent to corners, and opposite loading islands', or by the erection of standard no-parking signs.

The curb marking shall be of a solid yellow color, covering the face and top of the curb.

Experience has shown that the public does not easily understand a color code where several colors are used in curb marking to indicate different types or degrees of parking restrictions. Curb markings are accordingly recommended only to show that parking is prohibited at all time Other restrictions-should be shown by standard parking.

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Section 126.-Reflectorization

Section 126 now makes the reflectorization of certain rural pavement markings mandatory. The section is revised in its entirety, as follows:

All rural pavement markings, if having application at night, shall be reflectorized. Reflectorizing is not ordinarily essential on well-lighted city streets, but on other streets it is generally desirable for markings that must be visible at night.

1961 MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

The 1961 MUTCD was the last that allowed the use of white markings to separate opposing traffic. It is also the only peacetime MUTCD that was not revised.

PART II — MARKINGS
A-INTRODUCTION AND GENERAL SPECIFICATIONS

Section 2A-1 Functions and Limitations of Markings

Markings have definite and important functions to perform in a proper scheme of traffic control. In some cases they are used to supplement the regulations or warnings of other devices such as traffic signs or signals. In other instances they obtain results, solely on their own merits, that cannot be obtained by the use of any other device. In such cases they serve as a very effective means of conveying certain regulations and warnings that could not otherwise be made clearly understandable.

Pavement markings have definite limitations. They may be entirely obliterated by snow, are not clearly visible when wet, and are not very durable when painted on surfaces exposed to traffic wear. In spite of these limitations they have the advantage, under favorable conditions, of conveying warnings or information to the driver without diverting his attention from the roadway.

Pavement markings that are otherwise warranted or prescribed cannot, of course, be applied to unpaved roadways.

2A-2 Legal Authority

Markings shall be placed only by the authority of a public body or official having jurisdiction for the purpose of regulating, warning or guiding traffic.

Pavement and curb markings, being exclusively within the boundaries of public highways, should never be installed except under public authority. Delineators and markings on objects as a warning of their hazardous locations are also normally within the highway right-of-way, and should be subject to the same jurisdictional regulations.

A suitable model for the legal authority for the placing of markings is presented in the Uniform Vehicle Code (secs. 1-139, 11-201, 11-205, 15-104, 15-105, 15-106). Interference with officials markings is prohibited in section 11-206 of the same code.

2A-3 Standardization

Markings shall be uniform in design, position, and application. As in the case of all other traffic control devices, it is imperative that markings be uniform so that they may be recognized and understood instantly by all drivers.

2A-4 Types of Markings

Markings as defined for the purposes of this manual are o
number of types:

1. Pavement Markings:
   (a) Center lines (secs. 2B-1, 2, 3).
   (b) Lane lines (secs. 2B-4, 5, 6).
   (c) No-passing-zone markings (secs. 2B-7 to 10).
   (d) Pavement edge lines (secs. 2B-11, 12, 13).
   (e) Paved-shoulder markings (sec. 2B-12).
   (f) Pavement-width transitions (sec. 2B-14).
   (g) Channelizing lines (secs. 2B-15, 16).
   (h) Approaches to obstructions (secs. 2B-17, 18).
   (i) Turn markings (sec. 2B-19).
   (j) Stop lines (sec. 2B-21).
   (k) Crosswalk lines (sec. 2B-22).
   (1) Approaches to railroad crossings (sec. 2B-23).
   (m) Parking space limits (sec. 2B-24).
   (n) Word and symbol markings (sec. 2B-25).
   (o) Lane-use control markings (sec. 2B-26).
2. Curb markings for parking restrictions (sec. 2B-27).
3. Object markings:
   (a) Objects within the roadway (secs. 2C-2, 3, 4).
   (b) Objects adjacent to the roadway (sec. 2C-5).
4. Reflector markers:
   (a) Hazard markers (sec. 2D-2).
   (b) Delineators (secs. 2D-3, 4, 5).

2A-5 Materials

The most common method of placing pavement, curb, and object markings is by means of paint. A continuous improvement in paints and in equipment and methods of application has resulted in a very extensive use of pavement markings. Equipment in general use is capable of placing single, double, or triple lines on a highway, solid or broken, in different colors, while operating at a speed of 6 to 10 miles per hour. Small self-propelled stripers are available that can lay a triple line, but their operating speed is only about 1 ½ miles per hour. The chief advantage of these small machines is that they can be readily transported to isolated projects in a light truck. Hand equipment can be used to place transverse or special markings, at intersections or elsewhere, at a reasonable cost.

The night visibility of pavement markings is increased by the use of minute glass "beads" (actually true spheres) embedded in the pavement-marking material to produce a retrodirective reflecting surface.

The glass-beaded surface reflects a high proportion of the incident light from headlamps directly back toward its source in a narrow cone having enough divergence to reach the driver's eyes in his normal position above the headlamps, thereby causing the markings to appear luminous at night. Although the initial cost of such reflectorized markings is higher than for ordinary traffic paint, a number of highway departments have reported that the increased life of the markings, especially at heavily traveled locations, more than compensates for the difference in cost.

Thermoplastic materials for pavement marking are finding increased use at locations subject to extreme traffic wear. Experience at heavy traffic locations has indicated an average service life equivalent to eight applications of beaded traffic paint. **Thermoplastic markings shall conform to the color, reflectorization, and dimension specifications for paint markings**.

Flat units on or in the pavement surface shall be of permanent color as specified for pavement markings, and shall be set so that their upper surfaces are essentially flush with the pavement surface. They may be placed in continuous contact, or separated by small spaces approximately equal to the length of a single unit. Either type of line may be used where a solid line is prescribed in this manual. To insure a good appearance, particular care should be taken to see that alinement and spacing are accurate.

Metal inserts shall have a surface that will remain bright under the action of traffic, thus contrasting with the color of the pavement. Nonmetallic inserts shall be of permanent colors as specified for pavement markings. Inserts shall be not less than 4 inches in diameter if round, or of equivalent minimum area if of other shape, and shall be spaced not more than 16 inches apart, center to center. They shall have rounded surfaces, presenting a smooth contour to the wheels of vehicles, and shall not project more than three-fourths inch above the level of the pavement. They shall be permanently fixed in place by anchor bolts, adhesive, or similar effective means.

The epoxy resin adhesives have proved extremely effective in attaching plastic or cement-bonded inserts to concrete or asphaltic Pavements. These adhesives harden in from 15 to 30 minutes so that final mixing must be done on the job. To insure an effective bond, the pavement should be spot sandblasted or wire brushed and blown free of dust and loose materials.

Unit letters, symbols, or stripes may be attached to or set into the pavement surface, as an alternative type of pavement marking. These should be essentially flush with the pavement surface, and should not become unduly slippery when wet. **They shall be of permanent colors as specified for pavement markings.**

Metal and plastic inserts and flat marker units in or on the pavement surface are used principally in urban areas, where heavy traffic rapidly destroys painted markings, and frequent repainting not only is costly but causes undue traffic delays. In rural areas speed of application makes painting the preferred form of marking.

While successful experiments have been reported with permanent built-in pavement markings of white or colored concrete or inlaid bricks or blocks, they are not adaptable to reflectorization nor to any change in layout for altered traffic conditions, and their use is not recommended.

The use on the pavement surface of small metal or plastic studs with inserted reflector buttons is not recommended. Experience has shown that they are destroyed by snow plows, they cannot be kept clean and effective, and they are a hazard to motorcycles.

Large "mushroom" buttons, or bars, of cast iron or concrete several inches high, with or without reflectors, lights, symbols, or messages, should not be used for pavement markings. They are sometimes used to designate pedestrian islands or to assist in channelizing traffic. In these applications they are, in effect, curbs or islands, and they should be restricted to such applications (part IV). They should not be located where they constitute an unexpected hazard for motor vehicles. The use of raised bars (commonly known as "jiggle bars") to discourage the use of certain pavement areas (sec. 4A-3) can be effective, provided that such bars are not so high as to cause hazard or damage.

Object markings are ordinarily painted directly on the surface of the obstruction. If the surface will not retain paint satisfactorily, some flat surface of wood or metal should be painted with the proper marking and attached to the obstruction. Where a reflectorized coating is desirable it will often be necessary to use a separate surface for satisfactory application. Reflecting buttons or clusters may be attached directly to the obstruction or installed on separate posts immediately in front of it.

Delineators and hazard markers may consist of single reflectors, clusters of reflectors, or small panels of uniform shape covered with a reflecting coating, mounted on separate posts (secs. 2D-2, 2D-4). To be effective they must be of retrodirective character and of adequate brilliance.

2A-6 Colors

Pavement markings shall be white or yellow in color. The use of black in the gaps of a broken pavement line is permissible where the pavement itself does not provide sufficient contrast. This use of black does not establish it as a standard color for pavement markings, but is only a means of achieving contrast on a light colored pavement.

The correct color for yellow traffic paint is the same as that specified for highway signs.[2]

White shall be used for:
1. Center lines on two-lane rural roads and city streets.
2. Lane lines.
3. Pavement edge lines.
4. Paved-shoulder markings.
5. Channelizing lines.
6. Approaches to obstructions which may be passed on either side.
7. Turn markings.
8. Stop lines.
9. Crosswalk lines.
10. Parking space limit lines.
11. Word and symbol markings.

Yellow shall be used for:
1. Double center lines on multi-laned pavements.
2. No-passing barrier lines at:
    (a) No-passing zones on two and three-lane roads.
    (b) Pavement-width transitions.
    (c) Approaches to obstructions which must be passed on the right.
    (d) Approaches to railroad crossings.
3. Curb markings:
    (a) To show parking prohibitions covered by signs or ordinance.
    (b) On islands in the line of traffic.

Yellow is prescribed for the markings indicated for several reasons: (1) It contrasts with the normal white center or lane lines and thus gives emphasis to the hazard; (2) Yellow has been accepted as a symbolic warning color in signs and signals; and (3) It is consistent with the standard for no-passing-zone markings approved by the American Association of State Highway Officials and is in use in more than two-thirds of the States for barrier lines.

Markings on vertical surfaces of objects within the roadway or dangerously close thereto may consist of alternate black and white stripes, or the surface may be painted white. **All white**

[2]Color cards showing this "highway yellow" may be obtained from the Bureau of Public Roads on request.

areas shall be reflectorized.

Objects adjacent to the roadway, such as guardrails, trees, and rocks, may be painted white as a useful guide to night traffic.

Roadway delineators shall be white, except that yellow delineators may be used to mark expressway ramps in interchange areas. Hazard Markers (including clearance markers) shall be yellow or striped black and white.

2A-7 Types of Lines

A broken line shall be used for the center lines on two-lane rural roads and for lane lines, where these lines are only guide lines that may be crossed at the discretion of the driver. Center lines are of great importance for the guidance of drivers and to help separate traffic proceeding in opposite directions. On two-lane rural roads these objectives can be satisfactorily accomplished, with economy, by the use of broken lines. Similarly, lane lines which help keep vehicles traveling in the same direction in their proper lateral positions should be marked by broken lines.

A broken line, with segments and gaps well proportioned, is as effective as a solid line for guide purposes. The standard ratio of stripe to gap is 3 to 5. On rural highways, a commonly used standard is 15-foot segments with 25-foot gaps. However, on mountain or other roads with many short-radius curves, 9-foot segments with 15-foot gaps will maintain better continuity, particularly where maintenance patching occasionally eliminates a line segment. In the application of a given gallonage of paint per mile, such relatively short segments (9 to 15 feet) will give a better line than if longer segments, with correspondingly longer gaps, are used.

On urban streets the line segments and gaps may be considerably reduced in length but the 3 to 5 ratio of stripe to gap should be maintained.

High-speed striping machines have been constructed that are capable of repainting broken lines accurately and neatly.

A broken line permits a saving of more than 60 percent in the amount of paint required, as compared with a solid line, with little or no increase in the cost of application. Solid white lines are used for guide lines where the line may not ordinarily be crossed at the discretion of the driver or where crossing of the line is to be discouraged. These include center lines on city streets, channelizing lines, pavement edge lines, and approach markings to obstructions which may be passed on either side. Transverse pavement lines are also solid white lines.

Solid yellow lines are used for guide or regulatory lines to the left of which it is unsafe or illegal to travel. Where a combination solid and broken line is used, the solid yellow, or barrier, line has significance only if it is on the right-hand side of the combination line, as viewed by the driver, i.e., in or adjacent to the traffic lane to which it applies.

2A-8 Width of Lines

Center lines, lane lines, and barrier lines shall be 4 to 6 inches wide. The most common width is 4 inches, but 6-inch lines, favored by a number of highway departments, provide added visibility. Narrower 3-inch lines have been used as a means of economizing in paint, but they are not recommended.

The width of a channelizing line (sec. 2B-15) may vary from the normal line width (4 to 6 inches) to a maximum of 12 inches, depending on the emphasis required.

Pavement edge lines shall be 2 to 4 inches wide.

Transverse lines on pavements must be much wider than longitudinal lines to be equally visible. Stop lines may have to be as wide as 24 inches where approach speeds are high.

2A-9 Reflectorization

All pavement markings having application at night shall be reflectorized. Reflectorization is not ordinarily essential where high-level illumination is present, but even on well lighted city streets it is generally desirable that markings which must be visible at night be reflectorized.

2A-10 Maintenance

All markings shall be maintained in effective condition at all times.

The frequency of repainting depends on the type of surface, composition and rate of application of paint, climate, and volume of traffic. Particular care should be taken, especially in the case of broken lines, to paint over the old markings as exactly as possible. Otherwise they will appear increasingly ragged after successive repaintings.

B-PAVEMENT AND CURB MARKINGS

Section 2B-1 Center Lines

A center line is used to designate the center of the traveled part of a roadway carrying traffic in both directions. Under some circumstances, as at a pavement-width transition, or where an extra uphill traffic lane is provided, it need not be at the geometrical center of the pavement. On all major rural highways having an even number of lanes, and on many urban streets and less important rural roads, center lines are necessary and should be applied throughout the entire length of the pavement. In urban locations and on some rural roads where a continuous center line is not required, short sections of center line are useful on approaches to busy intersections, marked crosswalks, or railroad crossings, and around curves or over hillcrests. When so used, the

center line serves both to warn of any unusual condition and to organize and control traffic through a hazardous or congested zone.

Lines dividing a one-way roadway into two or more lanes are lane lines (sec. 2B-4).

2B-2 Center Lines on Rural Roads

The center line on a two-lane paved rural highway shall be a broken white line, not less than 4 nor more than 6 inches wide. Where a solid channelizing line (sec. 2B-15) is used as a center line, however, the width of the solid line may vary from the normal line width to a maximum of 12 inches, depending on the emphasis required. Line segments having a 3 to 5 ratio of stripe to gap are standard and segments 15 feet in length, with 25-foot gaps, are recommended.

On four-lane undivided rural pavements, or on pavements of a greater even number of lanes, the center line shall consist of two solid yellow lines, each not less than 4 inches nor more than 6 inches wide, separated by a space of not less than 3 inches.

Since this center line is, in effect, a continuous no-passing line to the left of which it is, under the Uniform Vehicle Code and the laws of many States, illegal to drive (sec. 2B-7), it is logical that the two lines should be yellow.

As a guide to the application of center-line markings, the following warrants are suggested:

1. Center lines are desirable on all paved highways and as a minimum should be placed throughout the length of:
   (a) Two-lane pavements carrying average annual traffic volumes in excess of 1,000 vehicles per day.
   (b) Two-lane pavements narrower than 20 feet carrying average annual volumes in excess of 500 vehicles per day.
   (c) Two-lane pavements narrower than 18 feet but not less than 16 feet in width carrying average annual volumes in excess of 300 vehicles per day. Center lines should not be used on pavements narrower than 16 feet.
   (d) All four- , six- , and eight-lane undivided pavements.
2. Center lines should be placed at other locations where the accident record indicates the need for them, and on hard-surfaced roads in areas where driver visibility is likely to be reduced frequently, as by fog.

2B-3 Center Lines on Urban Streets

The center line on a two-way city street with less than four lanes for moving traffic at any time shall be a solid white line. Such a line shall he not less than 4 nor more than 6 inches wide. For increased emphasis, a wider channelizing line may be used for the center line (sec. 2B-15).

The center line on a two-way street with four or more lanes for moving traffic at all times shall be a double solid yellow line except on a street involving reversible lane control. In such case a single solid white line (sec. 2B-15) may be used.

A line marking the center of a one-way street is a lane line and shall be a broken white line.

Applications of center lines are shown in various illustrations herein, particularly figures 1-8, 2-1, and 2-4.

2B-4 Lane Lines

Lane lines are helpful in the organization of traffic in its proper channels, and in increasing the efficiency of the use of the roadway surface at congested locations. They should be used:

1. On all rural highways with an odd number of traffic lanes.
2. In addition to the double solid center line, on all undivided rural highways of four or more lanes.
3. At the approaches to important intersections and crosswalks, and in dangerous locations, on both rural highways and city streets.
4. At congested locations, particularly on city streets, where the roadway will accommodate more lanes of traffic than would be the case without the use of lane lines. These include:
    (a) Locations between loadings islands and sidewalk curbs.
    (b) Other locations where the normal lane width is decreased.
    (c) Approaches to widened intersections.
5. On one-way streets or roadways where maximum efficiency in utilization of the roadway is desired.

Applications of lane lines are illustrated in figures 2-3 to 2-8, and 2-1 1.

2B-5 Lane Lines on Rural Roads

Lane lines on rural roads shall he broken white lines, not less than 4 inches nor more than 6 inches wide. Line segments 15 feet long, with 25-foot gaps, are recommended. A solid channelizing line (sec. 2B-15) used in place of a lane line may vary in width from the normal line width to a maximum of 12 inches. The transverse spacing of lane lines, that is, the lane width, should not normally be less than 10 feet, with 12 feet as the desirable width.

2B-6 Lane Lines on Urban Streets

Lane lines on city street shall he broken white lines, not less than 4 inches nor more than 6 inches wide. Due to relatively lower speeds, the line segments and gaps may be shorter than in rural areas, maintaining a 3 to 5 ratio of length of stripe to length of gap. A solid channelizing line (sec. 2B-15) used in place of a lane line may vary in width from the normal line width to a maximum of 12 inches.

The lane width defined by lane lines should not normally be less than 10 feet, but a minimum of 9 feet is permissible where a maximum number of lanes must be made available, as at a signalized intersection where provision must be made for the most efficient storage of stopped vehicles.

On wide, high-speed boulevards and on controlled-access highways in urban areas the standards for lane markings shall be the same as those for rural highways.

2B-7 No-Passing Zones

No-passing zones shall be established at vertical and horizontal curves and elsewhere on two- and three-lane highways, where passing must be prohibited because of dangerously restricted sight distances or other hazardous conditions.

The legal basis for the establishment of no-passing zones is set forth in section 11-307 of the Uniform Vehicle Code as follows:

(a) The (State highway commission) is hereby authorized to determine those portions of any highway where overtaking and passing or driving to the left of the roadway would be especially hazardous and may by appropriate signs or markings on the roadway indicate the beginning and end of such zones, and when such signs or markings are in place and clearly visible to an ordinarily observant person every driver of a vehicle shall obey the directions thereof.

(b) Where signs or markings are in place to define a no-passing zone as set forth in paragraph (a) no driver shall at any time drive OD the left side of the roadway within such no-passing zone or on the left side of any pavement striping designed to mark such no-passing zone throughout its length.

2B-8 No-Passing Zone Markings

A no-passing zone shall be marked by a solid harrier line placed as the right-hand element of a combination line along the center or lane line. This barrier line shall be yellow.

The barrier line shall be not less than 4 nor more than 6 inches wide, and shall be separated from the adjacent line by a space of not less than 3 nor more than 4 inches.

The combination line shall consist of either of the following, as illustrated in figure 2-1:

1. A normal broken white center or lane line continuing through the no-passing zone, with the solid yellow barrier line placed to the right of it. Where no-passing zones in opposite directions overlap on a two-lane roadway there will be a solid yellow barrier line on each side of the broken white center line. Where the no-passing restriction applies only in the opposing direction, the barrier line will appear to the left of the broken center or lane line.

2. A trouble line, of which the right-hand line is a solid yellow barrier line. The left-hand line will be either a normal broken white center line or a solid yellow barrier line governing the opposing direction of traffic. Where the solid yellow barrier line is on the left of a broken white line the passing restriction will apply only to the opposing direction of traffic.

2B-9 Application of No-Passing Zone Markings

On a two-lane highway the combination no-passing line shall follow the center line throughout the no-passing zone. On a three-lane highway the combination line shall start in advance of the no-passing zone at the left-hand lane line of the center lane and shall extend diagonally across the center lane to the right-hand lane line at the beginning of the no-passing zone, and thence extend along the lane line to the end of the zone (fig. 2-1). The combination line shall extend across the center lane at an angle of not less than 20 to I where the off peak 85-percentile speed is 40 m.p.h. or less, and at least 30 to I where speeds are greater than 40 m.p.h.

No-passing-zone signs (sees. 1B-21, 22) may be used to emphasize the existence and extent of a no-passing zone, in addition to the pavement markings here prescribed.

In no case shall the marking be less than 500 feet in length. If the actual no-passing distance is less than 500 feet, the additional length of marking shall be added at the beginning of the zone. Less than 400 feet of distance between successive no-passing zones is not sufficient for unrestricted passing. In such cases, the one-direction barrier line, or the two-direction barrier line, or the two-direction barrier line, whichever is appropriate, should connect the zones.

It is assumed that on two-way roadways of four or a greater even number of lanes it is not necessary to cross the center line to overtake and pass other vehicles. The double yellow center line prescribed for such highways is to be regarded as a continuous no-passing marking, which must not be crossed from either side.

On urban streets it is not ordinarily necessary to mark no-passing zones. Speeds are generally low, and a center line is usually sufficient to keep vehicles in line. On boulevards or parkways, where no-passing zones may have to be marked, the standards should be the same as for rural highways.

The no-passing barrier line is also used on two-way roadways at pavement-width transitions (sec. 2B-14) and on approaches to obstructions which must be passed on the right (sec. 2B-18). It may also be used on approaches to intersections.

2B-10 Warrants for No-Passing Zones at Curves

A no-passing zone at a horizontal or vertical curve is warranted where the sight distance as defined below is less than the minimum necessary for safe passing at the prevailing speed of

traffic. Sight distance on a vertical curve is the distance at which an object 4 feet above the pavement surface can just be seen from another point 4 feet above the pavement, as illustrated in figure 2-2. Similarly sight distance on a horizontal curve is the distance measured along the center line (or right-hand lane line of a three-lane highway) between two points 4 feet above the pavement on a line tangent to the embankment or other obstruction that cuts off the view on the inside of the curve (fig. 2-2). A curve shall warrant a no-passing zone and shall be so marked where the sight distance is equal to or less than that listed below for the prevailing (off peak) 85-percentile speed:

85-percentile speed (m.p.h.):	Minimum sight distance (feet):
30	500
40	600
50	800
60	1,000
70	1,200

The beginning of a no-passing zone (point *a* in figure 2-2) is that Point at which the sight distance first becomes less than that specified in the above table. The end of the zone (point *b*) is that point at which the sight distance again becomes greater than the minimum specified.

2B-11 Pavement Edge Lines

Pavement edge lines shall be solid white lines not less than 2 inches nor more than 4 inches wide. They shall be used only as a supplement to and not as a substitute for standard center and lane lines. Pavement edge lines are not a substitute for adequate road delineation markers.

The purpose of line markings on the edge of the pavement is generally threefold: (1) to reduce travel, particularly by the heavier vehicles, on shoulders of lesser structural capacity than the adjacent pavement, (2) to make driving more comfortable, particularly at night and during inclement weather, by providing a continuous guide for the driver, and (3) to reduce accidents.

2B-12 Right-Hind Edge Line and Paved-Shoulder Markings

The shoulder area on various types of highways varies greatly in both width and character, ranging from narrow and unpaved, not suitable for driving in emergencies, to high-type paved shoulders 10 feet or more in width.

The varied conditions require different edge-marking treatment. Insofar as possible, uniformity must be maintained. However, exactly the same treatment cannot be applied to all conditions of pavement edge and shoulder.

The need for placing a pavement edge marking also varies with the character of the pavement edge and the shoulder. The several conditions generally encountered are treated separately as follows:

1. *No shoulder or unsurfaced shoulder*.-Under these conditions, pavement margins are sometimes raveled and broken. The shoulder is frequently rough and unsafe for emergency use except at low speeds. With adverse light and weather, it is often difficult to distinguish the exact edge of the pavement.

With the unsurfaced shoulder, there is no evidence that edge lines have been mistaken for lane lines. The unpaved shoulder condition with the probability of roughness, loose material, or a drop-off at the pavement edge is a strong warrant for the use of a pavement edge line.

2. *Paved shoulders*.-Pavement edge marking presents a special problem where the pavement surfacing is extended over part or all of the shoulder width.

The most effective means of differentiating paved shoulders from the traffic lanes is by a definite contrast in surface appearance, riding characteristics, and texture. The through traffic lanes and the shoulder area should be clearly defined at all times, particularly at night or in inclement weather when visibility is poor. This can best be accomplished by a design which specifies contrasting color and texture. Relatively coarse stone chips for the shoulder treatment are desirable to provide an audible warning to the driver as well as the contrast in color and texture.

Where the contrast is sharp enough there is no need for a line marking to indicate the edge of the traffic lane. However, there is no objection to its use if required for uniformity in areas where pavement edge markings are in general use.

Where the contrast is not sharp and the paved shoulder is 8 feet or less in width, the appearance of a traffic lane can be avoided to a considerable extent by placing the edge marking on the shoulder 1 to 2 feet from the edge of the traffic lane. This reduces the apparent width of the paved portion of the shoulder sufficiently to discourage its use as a driving lane. With a paved shoulder less than 8 feet in width, structurally adequate to carry all traffic, presenting no hazard due to stopped vehicles, and where it is not objectionable for traffic to encroach slightly on the shoulder, there is little evidence of need for edge striping; it may, however, be provided as an additional guide to drivers.

Where the contrast is not sharp and the paved shoulder is more than 8 feet in width, the problem is accentuated. Under these conditions, a line marking at the edge of the traffic lane causes the shoulder to appear to the driver as another lane for traffic. There is definite evidence of confusion under these conditions. Wherever there are wide shoulders with no sharp contrast between through lanes and shoulder, a hazard may exist due to stopped vehicles being hit by vehicles which wander onto the shoulder. Special treatment is required if moving traffic is to be confined to the traffic lane. Such conditions are a strong warrant for use of shoulder delineation with diagonal lines.

The pavement edge line under these conditions should be placed on the shoulder I foot from the theoretical traffic lane, with diagonal markings on the shoulder to show definitely that it is not intended for use as a traffic lane. These diagonal markings should be 12 inches in width with spacing varied from 20 feet in low speed areas to 100 feet in areas where operating speeds are 50 miles per hour or over.

A typical layout for these shoulder markings is shown in figure 2-3.

2B-13 Left-Hand Edge Line

On a one-way roadway, a left-hand edge line frequently is helpful. This line marking should normally be a single solid white line 4 inches in width. This type of marking is an effective means of delimiting the median area of a divided highway (fig. 2-3). Where special emphasis is required adjacent to curbs, in areas of poor visibility, or on medians less than 16 feet in width the double yellow barrier line or solid channelizing line should be used. Where the media2i is paved flush with the traffic lanes, the double barrier line shall be used in all cases.

2B-14 Pavement-Width Transitions

Line markings should be used to guide traffic at points where the Pavement width changes to a lesser number of lanes. **Line markings at pavement-width transitions shall be not less than 4 nor more than 6 inches wide and of standard design for center, lane, or barrier lines. Converging lines shall have a length of not less than that determined by the formula L = S x W, where L equals the length in feet, S the (offpeak) 85-percentile speed in miles per hour, and W the offset distance in feet. On new construction, where no 85-percentile speed exists, the design speed may be used.**

A number of situations are possible, as illustrated in figure 2-4, depending on which lanes must be off set or cut out, and the amount of offset. One or more lane lines must be discontinued, and the remaining center and lane lines must be connected in such a way as to merge traffic into the reduced number of lanes.

Through the transition area, in the direction of convergence, the line separating the opposing directions of traffic should be of no-passing-zone design, either the double solid center line of a multi-laned road or a normal broken center line with an adjacent barrier line as prescribed for no-passing zones (sec. 2B-8).

Line markings at pavement-width transitions are not sufficient, in themselves, to guide traffic safely through such locations. Standard signs, and guardrails, edge lines, or delineators (sec. 2D-4) must be used in conjunction with the pavement markings.

2B-15 Channelizing Line

The channelizing line shall be a solid white line. The width of the line may vary from the width of a normal center or lane line to a maximum of 12 inches depending on conditions and the emphasis required. Generally, 8 to 12 inches is desirable.

The wide solid traffic line is a useful traffic control device for channelizing traffic and discouraging lane changing. This device is used where traffic may proceed on either side, but where crossing the line is to be discouraged even if not legally prohibited.

The channelizing line is useful to form traffic islands in a paved area and to separate turn lanes from the main traffic lanes, where a more restrictive barrier, such as a curb, is impractical or would create a hazard. The wide line will outline a neutral area and guide traffic, but the consequences are not severe if it is driven over inadvertently or to avoid an accident. The use of this marking is, of course, limited to locations where a positive restriction in the form of a physical barrier is not required.

The solid line may be used in lieu of the broken lane line to accentuate the lane marking in critical areas and more clearly define the traffic lanes where it is advisable to discourage lane changing. Typical locations for use of this marking are tunnels where width is restricted, interchange areas where unnecessary lane changing is detrimental to smooth traffic flow, and areas where visibility is poor due to weather conditions. The solid lane line is applicable to both one-way and two-way roadways.

The wide solid line may also be used in lieu of the normal-width center line on urban streets to emphasize the center line or to distinguish it at points where solid lane lines are used. On a two-lane two-way road the solid line may be placed on the center line where emphasis is needed and a barrier stripe is too restrictive.

A single solid white line may be used to separate the primary traffic lanes from lanes for special use, such as uphill climbing lanes or transit lanes.

Another use of the channelizing line is in the marking of exit and entrance ramps (sec. 2B-16).

Typical examples of uses of the channelizing line are shown in figures 2-5 to 2-8, and 2-11.

2B-16 Marking of Exit and Entrance Ramps on Expressways

Use of the channelizing lane at exit ramps of expressways provides a neutral area which reduces the possibility of conflict with the curb nose and also directs turn-off traffic at the proper angle for smooth divergence. At entrance ramps the line promotes safe and efficient merging with the through traffic. (See figures 2-6 and 2-7.)

Exit ramp marking.-A solid white line at least 8 inches in width shall be placed along the sides of the triangular neutral area between the edges of the main roadway and the exit ramp lane at the gore of every exit ramp terminal. With a parallel deceleration lane, a broken white line shall be placed from the apex of the triangular area for a distance of approximately one-half the length of the full width deceleration lane. Where additional emphasis is desired, diagonal markings may be used within the neutral area.

Entrance ramp marking.-A solid white line at least 8 inches in width shall be placed along the side of the triangular neutral area adjacent to the ramp lane at the gore of every entrance ramp terminal. With parallel acceleration lanes, a broken white line shall be placed from the apex of the triangular area for a distance of approximately one-half the length of the full width acceleration lane. With tapered acceleration lanes a similar broken white line may be placed beyond the solid line but not beyond the point where the tapered line meets the outer edge of the near through lane.

Interstate.-The above-described exit and entrance ramp markings are those prescribed for use on the Interstate System.