Chapter 3 Traffic Control Devices

3.1 General

Traffic control devices (TCDs) are all signs, signals, markings, and other devices used to regulate, warn, or guide traffic placed on, over, or adjacent to a street, road, or highway pedestrian facility or bikeway, by authority of the agency having jurisdiction over the road.

The purpose of TCDs is to promote road safety by providing for the orderly and predictable movement of all motorized traffic. The proper use of TCDs provides the reasonable and prudent driver who is unfamiliar with the area with the information necessary to travel the road safely and lawfully.

This chapter is neither a substitute for engineering knowledge or sound judgment, nor is it intended to be a legal document requiring the installation of any specific TCD.

Use the standards and guidance contained in the Manual on Uniform Traffic Control Devices (MUTCD) for all signs and traffic markings intended to control or regulate use on National Forest System Roads (NFSRs). An exception is permitted where there is an approved state supplement applicable to similar public roads. In that situation, conform with the state supplement to avoid confusing motorists. Document deviations from the MUTCD in the road operation and maintenance plan (FSM 7731.15 – Signing and Traffic Control Devices).

The intent of this chapter is to provide Forest Service guidelines that supplement or complement the MUTCD for the most common signing and marking situations on conventional NFSRs (over 400 average annual daily traffic) and low-volume NFSRs (less than 400 average annual daily traffic).

This chapter is neither a substitute for engineering knowledge or sound judgment, nor is it intended to be a legal document requiring the installation of any specific TCD. The decision to use a particular device at a particular location should be made on the basis of engineering judgment or an engineering study of that location. Decisions may vary from site to site even with similar conditions. If there are any questions about the applicability of these Guidelines to a particular situation, consult the MUTCD, traffic engineering textbooks, or a knowledgeable traffic engineer. Traffic engineering assistance may be obtained through the Forest, Regional, or Washington Office Sign Coordinator, state departments of transportation, Federal Highway Administration (FHWA), or a traffic engineering consultant.

As detailed in Chapter 1 of these Guidelines:

Shall (Standard) means a required, mandatory, or prohibitive practice.
Should (Guidance) is a recommended but not mandatory requirement.
May (Option) carries no requirement or recommendation.

The MUTCD specifically applies to those NFSRs that are open and maintained for use by standard passenger car traffic, namely Maintenance Level (ML) 3, 4, and 5 roads. ML 2 roads are neither intended nor maintained for standard passenger car use, but user safety is a consideration on these roads as it is on all roads. Any regulatory or warning signs needed on ML 2 roads shall be consistent with the MUTCD and these Guidelines. The size, retroreflectivity, and materials of guide signs on ML 2 roads shall follow the standards as outlined in this chapter.

Acquisition, installation, and use of nonstandard symbols or traffic control devices require Washington Office approval (FSM 7160.41b).

All nonconforming devices shall be brought into conformance as part of systematic upgrades by the year 2014.

3.1.1 Manual on Uniform Traffic Control Devices Compliance Dates and Mandated Changes for Devices

The MUTCD contains both compliance dates and upgrades/changes to existing signs and devices that are mandated. Federal agencies are to have their own manuals in substantial conformance with the MUTCD and the changes contained therein within 2 years. These Guidelines and supplements to the MUTCD contained in FSH 7109.31 complete that mandate.

When TCDs are no longer serviceable, they shall be replaced with MUTCD conforming devices. All nonconforming devices shall be brought into conformance as part of systematic upgrades by the year 2014.

New construction or reconstruction of highways or bikeways shall have traffic control devices conforming to the latest edition of the MUTCD installed before that highway or bikeway is opened to the public for unrestricted travel.

Specific target compliance dates for implementation of particular changes have been established by FHWA. See the MUTCD, chapters 1-3 for full details. Those most applicable to NFSRs appear in Table 3-1.

Table 3-1—Compliance dates for MUTCD changes

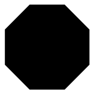
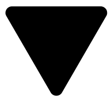
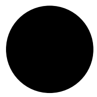
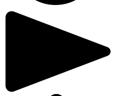
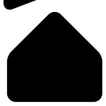
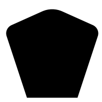
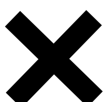
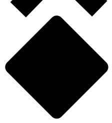
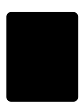
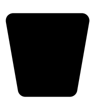
MUTCD section	Item and brief description of changes needed	Compliance date
2A.19	Lateral offsets, crashworthiness of signs	1/17/2013
2C.04	Increased size of warning signs – W5-2	1/17/2008
2C.04	Increased size of warning signs – W10-1	2014*
2C.16/5C.05	NARROW BRIDGE SYMBOL sign – eliminate symbol	2014*
2C.25	PAVEMENT ENDS SYMBOL sign – remove	2014*
2C.40	Vehicular traffic signs – new symbols	2014*
2C.41	Nonvehicular signs – eliminate crosswalk lines and use diagonal downward pointing arrow sign – W16-7	1/17/2011
2D.46	Reference location signs (mileposts) – location, spacing, and design (green color)	2014*
3B.01	Yellow centerline pavement markings	1/3/2003
3B.07	Edge lines – warrants for use	1/3/2003
3C.01	Object marker design and placement	2014**
6F.03	Temporary traffic control devices – crashworthiness	1/17/2005
6F.58	Channelizing devices – crashworthiness	1/17/2005
6F.59	Cones – width of retroreflective strips	2009**
6F.63	Type I, II, or III barricades – crashworthiness	1/17/2005
8B.08	Rail grade crossing sign (crossbucks) – retroreflective strip on support and number of tracks sign – R15-2	1/17/2011
8B.04	Rail grade crossing advance warning signs – remove existing W10-6 signs	1/17/2006
9B.17	Bicycle warning sign – W11-1 – eliminate crosswalk lines and use downward pointing arrow – W16-7 – at crossing	1/17/2011

* Actual date is 10 years from effective date of final rule for the 2003 MUTCD.
** Actual date is 5 years from effective date of final rule for the 2003 MUTCD.

3.2 Traffic Control Device Shapes

Table 3-2 shows typical traffic control sign shapes.

Table 3-2—Traffic control sign shapes

Shape		**Signs**
	Octagon	STOP
	Equilateral triangle (1 point down)	YIELD
	Circle	Highway-Rail Grade Crossing (Advance Warning)
	Pennant shape/isosceles triangle (longer axis horizontal)	NO PASSING
	Pentagon (pointed up)	School Advance Warning
	Pentagon (shape rounded)	County Route
	Crossbuck (two rectangles in an “X” configuration)	Highway-Rail Grade Crossing
	Diamond	Warning Series
	Rectangle (including square)	Regulatory Series Guide Series Warning Series Recreation Symbols
	Trapezoid	Recreational and Cultural Interest Area Series National Forest Route

3.3 Traffic Control Device Sign Materials

3.3.1 Substrates (Signboards)

Permanent retroreflective TCD signs may be manufactured on specific substrates.

High Density Overlay (HDO) Plywood. HDO is dense plywood with hard surfaces to which vinyl retroreflective sheeting will adhere. This material provides a stable surface, is more easily repaired than other alternative materials, readily available, cost effective, and less susceptible to vandalism than some other materials. One disadvantage is that porcupines and other animals will eat this sign substrate.

Fiberglass-Reinforced Plastic (Polyplate). This material works well for smaller signs. Performance is very similar to HDO except it is not appealing to animals. Signs exceeding 36 inches in any unsupported dimension require cross bracing or mounting on a plywood backing.

Aluminum. Use of aluminum is usually limited to the smaller-sized signs. Signs greater than 48 inches require cross bracing or mounting on a plywood backing. Aluminum is more easily damaged by bullets and other forms of vandalism. However, due to its durability, thin cross section, and relatively light weight, it is often used for short-duration temporary traffic control applications, such as warning signs for a road surface blading operation. It is normally more expensive than other alternative substrates. The expansion/contraction of the material may also contribute to early sign failure.

Wood Plastic Composites (WPC). This material is a composite containing natural wood fibers and thermoplastic resinous material. It is considered to be a "biobased" and "green" material. The wood portion comes from underutilized and previously nonmerchantable woody materials from fire thinning, and the thermoplastic portion comes from high-density polyethylene from recycled milk bottles. It is comparable in price to other substrates and has a longer lifetime than solid wood products. The material is highly durable, less susceptible to vandalism, and resists termites, other insects, rodents, and gnawing animals such as porcupines. It is a heavy material. Larger signs may need stronger supports. Shipping should be considered when doing cost comparisons.

Plastics (Solid and Corrugated), Vinyl Rollup, and Other Synthetic Materials. These are also used for temporary traffic control signs.

Other existing substrate materials are available, and additional substrate materials are being developed. The use of these other substrate materials is allowed with the approval of the Regional Sign Coordinator. Some tracking of product effectiveness and longevity may be required.

Regulatory, warning, and guide signs for roads and motorized trails intended to be seen at night shall be retroreflective or illuminated . . . .

3.3.2 Retroreflective Sheeting and Retroreflectivity

Regulatory, warning, and guide signs for roads and motorized trails intended to be seen at night shall be retroreflective or illuminated to show the same shape and color by both day and night.

Higher-grade retroreflective sheetings produce better nighttime visibility where needed. Fluorescent colors provide additional visibility where a situation requires special attention. Consider using fluorescent and high-visibility sheetings for signs in areas of higher use or frequent driver confusion and at locations where accidents continue in spite of the presence of TCDs

The relative merits of some retroreflective sheeting types that are readily available are shown in Table 3-3. New retroreflective sheetings not covered in Table 3-3 may be used as long as the signs meet the standard requirements for color and shape, both by day and night.

The formula: C = TC/PL expresses a comparative cost analysis for the different sheetings.

Where: C = cost per year of life
TC = total cost of sign, post, hardware, and installation
PL = performance life, which is the expected life or manufacturer's warranty (where available)

Table 3-3—Retroreflective sheeting comparisons and uses

Type of sheeting*	Expected life[1]	Approximate relative cost[2]	Remarks
Type I Engineering grade	5 to 7 years No warranty	1.0	Used most by Forest Service in the past. Provides adequate levels of retroreflectivity for temporary signs and permanent white-on-brown guide signs in some situations. No markings on sheeting to distinguish it from lower grades of sheeting. No retroreflective warranty!
Type II Super engineering grade	10 years Warranty	1.2	Typically one and one half times Type I retroreflective brilliance. Works well, better than Type I, in areas of competing light sources and higher vehicle speeds. Provides additional retroreflectivity for guide signs for high speed (45 miles per hour and over) areas. Identifying marks on sheeting. Retroreflectivity warranted by manufacturer.
Type III and IV High intensity	10 years Warranty	1.6	Approximately three times Type I retroreflective brilliance. Use for most regulatory and all warning signs. Lowest grade of retroreflective sheeting used by most states. Identifying marks on sheeting. Retroreflectivity warranted by manufacturer.
Type VII, VIII, X Prismatic sheetings	10 years Warranty	3.0	Three to six times Type I retroreflective brilliance. May be used for regulatory or warning signs when more visibility is needed. Identifying marks on sheeting. Retroreflectivity warranted by manufacturer.
Type IX	10 to 12 years	3.0	Six times Type I retroreflective brilliance. Better suited for viewing from large vehicles such as RVs and large trucks and for reading signs with smaller-sized legends.

*American Society for Testing and Material
[1]Retroreflectivity degrades less than 50 percent in this time.
[2]Approximate relative cost of a sign as compared to Type I

Sheeting types are based on nighttime performance. Daytime performance is comparable for all types of ordinary colored sheeting. Fluorescent colored sheetings offer improved daytime visibility.

Besides cost and past experience, some practical considerations influence decisions on which type of retroreflective sheeting to order:

- Anticipated vandalism may dictate choosing the least expensive sheeting.
- Fabrication and stockpiling signs of different sheeting types may not be efficient or practical.

Installing retroreflective signs is only the beginning. Proper maintenance ensures that signs continue to provide intended function and display sufficient retroreflectivity to guide traffic at night.

Night observations with headlights can reveal signs that have damaged or faded retroreflectivity. A high-intensity (1 million or higher candlepower) spotlight can be used in daylight hours to quickly identify signs with questionable retroreflectivity, which could then be checked by comparison or by a reflectometer.

Section 2A.09 of the MUTCD, Minimum Retroreflectivity Levels, is reserved. That section will be based on Federal Highway Administration rulemaking, which will probably include minimum levels of retroreflectivity measured scientifically.

3.4 Colors for Traffic Control Devices

Colors for all traffic control devices are mandatory for consistent application in the MUTCD. These colors shall be used regardless of which jurisdictional authority installs signs to control traffic. The colors are listed below for convenience. See Table 2A-4 in the MUTCD for a complete color use listing.

RED shall be used only as a background color for STOP signs, DO NOT ENTER messages, and WRONG WAY signs. Red shall be used as a legend color for YIELD signs, parking prohibition signs, and the circular outline and diagonal bar prohibitory symbol. Red shall also be used on closure barricade panels for other than construction and maintenance purposes.

BLACK shall be used as a background on ONE WAY signs and certain weigh station signs. Black shall be used for messages on white, yellow, and orange signs.

WHITE shall be used as the background color for most regulatory signs, except STOP signs. White shall also be used for the legend and border on brown, green, blue, black, and red signs.

ORANGE shall be used as a background color for construction and maintenance signs.

FLUORESCENT RED ORANGE OR **FLUORESCENT YELLOW ORANGE** also may be used for temporary traffic control such as construction, maintenance, incident management, and utility work signs. Fluorescent colors provide increased visibility, especially in the low-light conditions of dawn and dusk.

YELLOW shall be used as a background color for warning signs, except where orange is specified, and for school signs except where an optional color is allowed. (See also YELLOW GREEN below.)

BROWN shall be used as a background color for guide and information signs on NFSRs and for recreational or cultural interest signs on conventional highways. Brown also should be used for motorist services on NFSRs.

GREEN shall be used as a background color for conventional highway guide signs and reference location signs (mileposts) on both conventional and low-volume roads and as a legend color with a white background for permissive parking regulation signs.

BLUE is used as a background color for information signs related to motorist services and evacuation route markers on conventional highways.

FLUORESCENT YELLOW GREEN only shall be used as the background color for school bus and school, playground, pedestrian, and bicycle warning signs.

FLUORESCENT PINK only shall be used as the background color for incident management signs.

3.5 Sign and Legend Size

3.5.1 Sign Size

Regulatory and warning sign sizes for low-volume roads are listed in the MUTCD Table 5A-1. Conventional road (over 400 seasonal annual daily traffic [SADT] and 35 miles per hour) sign sizes are listed in the MUTCD, Table 2B-1 for regulatory signs and Table 2C-2 for warning signs. *Standard Highway Signs* contains the information needed for these signs to meet legend size requirements.

3.5.2 Guide Sign Legend Size

Legend size on signs is a function of the viewing distance and the amount of time available for viewing. Table 3-4 contains the minimum letter and symbol sizes that shall be used for guide signs. The speed used should be either the speed limit, if posted, or the speed that a vehicle could reasonably be expected to be traveling as the sign is viewed as determined by engineering judgment or engineering study.

Table 3-4—Legend size for guide signs on NFSRs

	Size of letters (*inches*)			Size of symbols (*inches*)		
	ML 3, 4, and 5 roads		ML 2 roads and roads within administrative or recreation sites	ML 3, 4, and 5 roads		ML 2 roads and roads within administrative or recreation sites
Speed (*mph*)	More than 400 SADT	Less than 400 SADT		More than 400 SADT	Less than 400 SADT	
50 and over	6	6	NA	24	24	NA
35-45	5	5	5	24	24	24
20-30	5	4	4	24	18	18
15 and under	5	4	3	24	18	12

3.5.3 Letter Font Series

Unless otherwise shown on the sign drawings, traffic control signs shall use the following fonts as defined in Chapter 9 of *Standard Highway Signs,* which contains American Standards Association (ASA) Standard Alphabets for Highway Signs:

Letter size	Font (ASA Series)
3- and 4-inch:	C
5- and 6-inch:	D
7 inches and above:	E

3.6 Signing Priority

Signing priorities for TCDs on NFSRs should be established for each administrative unit as part of a sign action plan. Priorities are appropriate for both first time installation and for sign replacement. Program implementation should consider the current level of signing and available funding and personnel. Priorities should address public health and safety first and may vary by road depending on the functional classification, the average daily traffic, and accident histories.

3.7 Driver Expectancy and Behavior

Drivers of different standards of roads are expected to drive with different levels of caution, based on what the driver expects to encounter ahead. The physical characteristics of NFSRs are usually readily apparent to the driver. After viewing the start of a road and driving a short distance, the alignment, surface type, road width, and ride quality usually suggest an appropriate safe speed to a prudent driver.

Driver expectancy and behavior on NFSRs also are influenced by what was experienced on the previous section of road. Studies have shown that what a driver has just encountered is what the driver expects on the next portion of the road. This includes the road surface, width, alignment, and overall maintenance condition of the road as well as the presence or absence of signs and other TCDs.

Past experiences with TCDs on other similar roads also contribute to driver expectancy. If the road is inconsistent from what a prudent driver would normally expect, the use of TCDs could be considered to reduce the "surprise element" created by an unexpected change in the road. Use of TCDs may reduce the uncertainty and allow the driver to proceed ahead with greater confidence. Examples of inconsistencies that may require TCDs are:

- Paved road changing to a gravel road.
- Sharp curve on the end of a straight section of road.
- Double-lane road or wide road narrowing to a single-lane road or bridge.

3.8 Engineering Judgment and Studies

Engineering judgment is performed by an individual knowledgeable in TCDs.

Engineering studies and engineering judgment are specific terms defined in the MUTCD and used throughout the highway industry to denote evaluations that are performed by qualified individuals for certain tasks involving traffic control devices. Care needs to be taken to comply with the requirements denoted for these evaluations.

3.8.1 Engineering Judgment and Studies Defined

Many signing needs on NFSRs may be determined based on **engineering judgment**. This less technical type of evaluation consists of a review, evaluation, and decision for the situation by those knowledgeable in the proper application of principles, standards, guidance, and practices for TCDs.

An engineering study is a more formal, analytical, and comprehensive analysis, evaluation, and written record of available pertinent information for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. It may include information such as the following:

- Accident history and analysis
- Spot speed studies
- Curve speed studies
- Traffic counts and classification
- Existing and anticipated road conditions

An engineering study shall be performed by an engineer or under the supervision of an engineer.

It also includes the application of appropriate principles, standards, guidance, and practices as contained in approved sources such as the following:

- The MUTCD
- Appropriate state policies and MUTCD supplements
- Recognized traffic engineering texts
- Forest Service standards and guidelines

An engineering study shall be performed by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer.

Engineering studies are normally limited to roads open to passenger car traffic. Studies are more likely to be used for roads with the following characteristics:

- Higher speeds
- Higher traffic volumes
- Mixtures of commercial and recreation traffic
- High accident frequencies
- Severe accident consequences

An engineering study shall be documented regardless of its complexity.

3.8.2 Documentation of Engineering Judgment and Studies

Documentation of engineering judgment is not required in the MUTCD; however, it is advisable to document all decisions regarding regulatory and warning signs. At a minimum, this documentation should have the date the work was done, the name and signature of the person making the judgment, and the conclusions made for the road segment. Documentation of engineering judgment may be recorded on a sign plan inventory for the road.

An engineering study shall be documented regardless of its complexity. If an engineering study determines that a new sign is needed, or that an existing sign is not needed, record the basis for the decision. This may be done by a brief entry on a sign plan such as “Ball Bank Study” or “Trial Speed Runs.”

It is equally important to document engineering judgment and engineering studies that conclude that no TCD is necessary. Engineering studies and documented engineering judgment should be placed in a permanent file for the road and a reference made on the sign plan. Retain the study as long as it is applicable to the road.

3.8.3 Specific MUTCD Engineering Study and Judgment Requirements

Requirements for performing engineering studies and engineering judgments for many TCDs and situations are scattered throughout the MUTCD. Two specific requirements are repeated here for emphasis:

“The decision to use a particular device at a particular location should be made on the basis of either an engineering study or the application of engineering judgment.” MUTCD, Section 1A.09.

“The use of warning signs shall be based on an engineering study or on engineering judgment.” MUTCD, Section 2C.02

Specific requirements from the MUTCD for engineering study or engineering judgment for conventional and low-volume road situations normally found on NFSRs are shown in Table 3-5.

Table 3-5—Specific MUTCD engineering study and judgment requirements

Sign or application	Sign #	Conditions	Decision based on: Engineering study	Engineering judgment
STOP	R1-1	SHOULD be used after need indicated by:		X
		SHOULD not be installed on major roads or multi-way stops unless:	X	
YIELD	R1-2	MAY be used at special problem intersections and instead of STOP signs when:		X
		SHOULD be used on low-volume roads where indicated by either:	X	X
SPEED LIMIT	R2-1	SHALL display speed limits established by law or regulation after:	X	
Advance placement distances	All warning signs	SHOULD be applied with:		X
Horizontal Alignment series	W1-1 thru 8 and W1-11	SHALL be used after need is determined by:		X
		SHOULD be used to determine Curve or Turn signs:		X
		MAY be used on low-volume roads after need is determined:		X
Intersection	W2-1 thru W2-5	MAY be used on low-volume roads after need is determined:		X
Hill sign series	W7-1	MAY determine requirements on low-volume roads:	X	
Advisory Speed plaque	W13-1	SHALL be used where need is indicated by:		X
		Unusual circumstances determined by:	X	
Supplemental plaques	W16	MAY be used with warning signs for additional information:		X
NO TRAFFIC sign	W18-1	MAY be used on unpaved, low-volume roads:		X
Centerline markings		SHOULD be placed on roads < 18 ft wide w/< 3,000 vehicles per day	X	
		SHOULD determine to use or not use on conventional roads 16 ft or less in width:		X
		SHOULD be placed on paved, low-volume roads where need is determined by either:	X	X
Edge line markings		SHOULD be placed on roads < 20 ft wide w/ < 3,000 vehicles per day:	X	
		SHOULD not be placed where safety is decreased:	X	X
		SHOULD be used on paved, low-volume roads where need is indicated by either:	X	X
Delineators		MAY be used on low-volume roads:		X
Object markers		MAY be used on low-volume roads when need is indicated by either:	X	X
Railroad grade crossings		SHOULD determine traffic control by highway agency and railroad:	X	
Temporary traffic control plans		SHOULD be prepared by:		X
Temporary traffic control devices		SHOULD decide design, selection and placement:		X

3.8.4 Placement or Removal of Traffic Control Devices Recommended in Engineering Judgment or Studies

Installation of TCDs as recommended by engineering judgment or engineering studies should occur in a timely manner.

Removal of existing TCDs should be supported by engineering judgment or engineering studies and should be documented. Existing devices, even though not appropriate or necessary, may have created a driving pattern by road users familiar with the road and may require that other actions be taken in conjunction with removal. TCDs recommended for removal in an engineering study should be removed in a timely manner so the unneeded messages do not breed disrespect for needed TCDs.

3.9 Elements in Engineering Studies

There are many elements included in an engineering study. Elements that are relevant to NFSRs are discussed below.

3.9.1 Speed Limits

Speed limits generally are not needed nor recommended on NFSRs.

Speed limits generally are not needed nor recommended on most NFSRs. Application of the “basic rule” found in state motor vehicle codes requiring that drivers travel at speeds “reasonable and prudent for conditions” is usually sufficient. Also, sight distance and physical characteristics of NFSRs often influence safe operating speeds.

Experience has shown that motorists’ speeds are usually governed more by conditions on roads than by posted speed limits. This is particularly true when enforcement is lacking.

If unreasonably low speeds are posted, the limit will be violated by a large number of drivers. This creates a credibility problem with drivers and breeds disrespect for all signs.

Follow all state and Federal laws and regulations when establishing speed limits.

Speed limits on NFSRs can be established under either Forest Service or state authorities:

- The Forest Service can establish speed limits on NFSRs under an order pursuant to 36 CFR 261.54. An engineering study in accordance with MUTCD requirements is necessary.
- The appropriate authorities, i.e., county commissioners, may establish speed limits in accordance with applicable state procedures. A simple resolution by the commissioners to set a speed on a road may be sufficient. These speed limits can be enforced by local authorities under state law.

It is often advantageous to develop an agreement for enforcement with local law enforcement agencies such that they can enforce speed limits on NFSRs.

New speed limits should not be established without a plan to enforce them, and existing speed limits should be removed should enforcement lapse.

3.9.2 Safe Speeds on Horizontal Curves

Consider the driver's expectations and behavior first when performing engineering judgments or engineering studies for a curve. Driver expectations of a curve are based on a complex variety of conditions. High speeds can be attained on long tangents, and a driver's expectancy is exceeded by the slower speeds necessitated by sharp curves. The greater the speed reduction required for a curve, the greater the probability of driver error at that curve. Too high a speed in a curve may relate to the driver's inadequate expectancy of the speed reduction required for the curve. Include consideration of the effects of travel during hours of darkness.

The greater the speed reduction required for a curve, the greater the probability of driver error at that curve.

Curves should be driven in both directions. The difference between the radius of the inside lane and outside lane plus differences in sight distance, prevailing speed, and grade may affect the driver's ability to transition to a safe speed for the curve and could result in different recommended curve speeds for the different directions of travel.

Consider the speed of vehicles at three locations.

Prevailing speed – the speed the driver is traveling on the road before the driver perceives a curve ahead.

Approach speed – the speed to which the driver transitions after perceiving the curve. This is the speed at which the driver enters the curve; it is affected by what the driver can determine beforehand regarding the severity of the curve. Natural features may be all that are needed for adequate guidance. A cut bank, trees, or brush on the outside of the curve make it easier for drivers to perceive the curve because there is a visual reference versus a fill slope on the outside. Consideration also must be given to the fact that roadside vegetation is less obvious during hours of darkness.

Speed profile – the speed of the vehicle as it traverses the curve. When drivers maintain a constant speed profile throughout the curve, it indicates the driver expected the curve and correctly selected an appropriate speed for the curve. Decreasing vehicle speeds while rounding the curve suggests the driver selected an approach speed that was too high.

The decision to sign a particular curve is based on the relationship of a constant speed profile to the prevailing speed. The constant speed profile, or recommended curve speed, shall be determined by engineering judgment or an engineering study by one or more of the following methods:

Curve sight distance – Safe speeds on single-lane roads are often dictated by sight distance. On these roads, and many roads without a centerline, sight distance should be checked first to determine whether it is the dominant factor for safe curve speed. Stopping sight distance for two-way single-lane roads should be twice the stopping sight distance for a comparable two-lane road.

Values for stopping sight distances for low-volume roads can be found in Figure 3C.1.

Trial runs by driving – This is a valid procedure for determining safe speeds on gravel and native surfaced low-volume roads.

The recommended curve speed can be determined through experience by driving the section of road in a vehicle that is representative of the traffic on the road. Several trial runs should be made at various speeds along the center of the travel lane in the direction that the curve will be traveled.

Determine the speed that allows the driver to negotiate the curve in a safe and comfortable manner. The advisory curve speed profile would be this speed rounded down to the nearest 5-mile-per-hour increment.

Trial runs with ball bank indicator – A ball bank indicator (also known as a manual inclinometer) is a device with a ball enclosed in a liquid filled tube. Typically, it is mounted on the vehicle dashboard. As the vehicle with the indicator travels around a curve, the ball is acted upon by centrifugal force. The reading of that force is measured in degrees on the indicator. Trial runs are made around the curve at various speeds until the ball-bank-indicator reading equals the predetermined degrees. The next lowest 5-mile-per-hour increment is then the advisory curve speed profile chosen for that curve in that direction.

Gravel and native surfaced low-volume roads could constitute an unusual circumstance where the skill of the engineer is needed before making a determination to use a ball bank indicator on such roads. Using the methods in encouraging safe speeds without speed limits could prove to be a better method.

Mathematical computation – Determine the radius of curvature from field measurements or design data. Look up the design speed for the radius of curvature and surface type in section FSH 7709.56, Transportation System Preconstruction Handbook. Verify the results obtained by a trial run and adjust if necessary. The advisory curve speed profile is the verified speed determined above, rounded down to the nearest 5-mile-per-hour increment.

The advisory speed may be the 85th-percentile speed of free-flowing traffic, the speed corresponding to a 16-degree ball-bank-indicator reading, or the speed otherwise determined by an engineering study because of unusual circumstances.

It is important to consider the standards used to post advisory curve speeds on adjacent county and state roads.

3.9.3 Speed Studies

Good judgment should be used when determining speeds on unpaved roads.

Speed studies are one part of an engineering study and are used to measure the speed characteristics at a specified location under the traffic and environmental conditions prevailing at the time of the study. Speed studies should be made during daylight hours, good weather conditions, and typical road conditions.

Good judgment should be used when determining speeds on unpaved roads. Newly constructed or recently bladed roads may allow traffic to travel at higher speeds than road surfaces that are potholed, rutted, washboarded, or covered with loose material. The best and worst road surface conditions expected should be considered when speeds are studied for curves or tangents.

Speed studies are used for various purposes:

- Determine prevailing speed (for use in studying the need for signs and/or advisory speeds for curves or other locations).
- Establish speed limits.
- Identify enforcement needs.
- Check on complaints of speeding.
- Analyze accident sites.

Speed studies may be conducted by several methods:

- Timing vehicles over a known distance.
- Following vehicles (staying far enough back to not affect their driving speed).
- Driving the road several times to determine a prudent, comfortable speed. for the average driver, without skidding the rear tires around the curve.
- Using radar.

The minimum sample size for a low-volume road speed check should be 30 vehicles for studies using timed vehicles or radar. Such a small sample should be used only for low-volume conditions. Normally, 50 to 100 vehicles or more are checked in order to maintain a high confidence level on higher volume highways. A confidence level of 95 percent is desirable. For low-volume NFSRs, speed checks may be needed on more than 1 day to obtain the necessary sample size.

All readings should be examples of the free-flowing conditions of the traffic stream. If there are several vehicles following a lead vehicle, delete observations on the trailing vehicles because the first vehicle could be controlling their speed.

Encouraging safe speeds without setting speed limits is a method of positive guidance that works well on unpaved roads...

The 85th-percentile speed is that speed at or below which 85 percent of the traffic is moving. It is determined by speed studies and generally is used in engineering studies to determine the prevailing speed. This prevailing speed is the speed that drivers desire to travel on the segment of road and should be used to set speed limits barring some other overriding condition.

3.9.4 Encouraging Safe Speeds Without Speed Limits

Encouraging safe speeds without setting speed limits is a method of positive guidance that works well on unpaved roads but also is applicable to low-volume, low-speed paved roads. It is appropriate for almost any low-volume road where establishing speed limits is deemed inappropriate or where speed limits cannot or will not be enforced. For example, most NFSRs are unpaved, and surface conditions are susceptible to changes throughout the year with or without surface maintenance. Where this is the case, posted speed limits could be inappropriate at times for some road conditions.

An alternative to posting speed limits is the common sense approach of installing warning devices giving positive guidance at locations where a driver's expectancy could be exceeded as determined through engineering judgments or engineering studies. Thus, drivers can travel at speeds they deem prudent, based on existing road conditions, but are warned when road geometry changes abruptly.

Consider the following when encouraging safe speeds without speed limits:

- Sharp curves after long tangents or other unexpected road geometry changes should be signed with the proper warning signs or devices.
- Where vehicles could be approaching a curve or other road anomaly at a high rate of speed, warning signs with advisory speed plates could be used.
- Where tangents lead to visible flat curves and then to increasingly sharper curves that automatically slow traffic and the curves are expected, signing might not be needed.
- Roads with long tangents and visible curves without major inconsistencies may not need any signs. Road users will choose their own prudent speed.

Using this “common sense” method of encouraging safe speeds without speed limits negates the need and expense of speed limit signs, orders, and enforcement costs. In addition, the TCDs alert drivers to road inconsistencies so they can travel at speeds they deem prudent based on current road conditions.

TCDs alert drivers to road inconsistencies so they can travel at speeds they deem prudent based on current road conditions.

3.9.5 Surface Changes

Surface changes need to be considered when performing an engineering study. Drivers are generally accustomed to asphalt or concrete pavements. Driving aggregate- or native-surfaced NFSRs provides a different experience, one that may need to be called to their attention. These roads usually require longer stopping distances. They generally have poorer visibility because of dust in the air and can have a rough driving surface because of washboarding, ruts, bumps, or potholes. In addition, loose gravel or other surface conditions can cause skidding around curves or even on straight sections of the road.

3.9.6 Vertical Curves

Sight distance is another important item to consider during an engineering study. This may be critical on crest vertical curves located on single-lane roads, or on any road where vertical and horizontal curves are combined.

3.9.7 Grades

Grades often exceed those normally experienced by drivers so additional stopping distance may be required. Drivers may not be aware of the effect of steep grades and various types of surfaces on the control and stopping distance of their vehicles.

3.9.8 Traveled Way Width

Most NFSRs are single lane, which creates a unique driving experience for drivers unfamiliar with this type of traveled way. Drivers may need to stop and back into a turnout to allow another vehicle to pass. Signing can help in some situations to inform drivers of the single-lane road with turnouts. Signs for single-lane roads typically are used at points where the driver is changing from a double-lane road to a single-lane road with two-way traffic.

3.9.9 Traffic Composition

Traffic on NFSRs may be mixed and could include heavy logging trucks, large construction, mining or logging equipment, vehicles towing trailers, motor homes, passenger cars, permitted ATVs, and trail cycles. Drivers may not be accustomed to these types of mixed traffic. Additional signing may be needed to inform drivers of these situations.

3.10 Mixed Use on NFSRs

. . . it may be necessary to allow a mix of highway and non-highway vehicles . . . .

Ideally, mixed traffic (street- and non-street-legal and licensed and unlicensed drivers) should not be allowed on the same road. In some situations, however, it may be necessary to allow a mix of highway vehicles with other types of traffic such as off-highway vehicles (OHVs) or snowmobiles. Some opportunities may exist on roads with low vehicle volumes and slow speeds. Other opportunities may exist on short road sections to connect disjointed OHV four-wheel-drive ways and snowmobile trails. In some situations, roads may need to be reconstructed before mixed use can be allowed.

The following priorities are to be used to minimize the potential conflicts of mixed use:

- Provide separate facilities.
- Separate use periods. Roads may be designated for separate use periods such as season, weekday/weekend, or day/night. Notify the public of the locations, effective dates, times, and duration that the roads may or may not be used. Provide appropriate signs as shown in Chapter 3A.
- Manage concurrent use.

Mix vehicle types such as OHVs and highway vehicles on the same travel route only after an engineering study or the application of engineering judgment of the route and designation and approval by the Forest Supervisor.

An engineering study should consider the functional aspects of the road and recreation opportunities of mixing traffic types on a route as well as the acceptable risk. The following items may be factors in the evaluation:

- Forest plans
- Access management objectives
- Road management objectives
- Traffic speed, volume, and composition
- Road standards such as alignment, speed, grade, surface, and sight distance
- Alternative routes/options
- Opportunities/facilities accessed
- Demand for use
- Environmental effects
- State law and/or Forest Service regulations
- Enforcement mechanism (coordination)
- Consultation with local county attorney/law enforcement
- Proposed signs and markers, public information, and education
- Mitigation measures (resource impacts and traffic control)
- Recreation Opportunity Spectrum and Visual Quality Objectives
- Risk analysis
- Inconsistencies

This list is not necessarily all-inclusive nor all-necessary for an evaluation of a route. Other factors may be considered as appropriate.

After a positive evaluation, prepare and keep on file an implementation and monitoring plan along with a map of the route and proposed signing and marking. Upon designation and prior to allowing any mixed use, the Forest Supervisor is responsible for appropriately signing and mapping the route such that the dual traffic use is clear to all users.