TURNOUTS. . .*what you need to know*

A clinic by Rich Kolm • 2008 PCR Convention "Sierra Memories" • Fresno, Calif.

Introduction

Reliable, trouble-free trackwork can provide more-realistic operation of trains and makes model railroading fun. Turnouts are an essential feature of trackwork, but can be trouble makers if not done right.

Prefabricated turnouts in HO scale are the primary focus of this clinic. It covers the options you have when selecting and using turnouts in the design and construction of a layout. While the dimensions and details are given for HO scale, much of the information can apply to the other scales as well. The mention of proprietary products is only for the information of clinic attendees and does not represent any endorsement.

The Internet has a wealth of information about turnouts and personal experiences are shared on various online discussion groups. Keep in mind that this clinic is not necessarily the final word on the subject and you may find other sources with a different viewpoint, valid or not.

Many thanks to Allan Gartner for material from his very informative website http://www.WiringForDCC.com.

Terminology

You can call it a "**switch**" or you can call it a "**turnout**." People operating the railroads call it a switch. The route of a train is changed by aligning the switch. Turnout is a civil engineering term used by railroads on design drawings and in specifications for construction of trackwork, and thus is used when designing and building a model railroad. With a turnout the term switch refers to the moveable switch-point rails.

• "**Split switch**" is a turnout where the moveable rails are "switch-points." This contrasts with the "stub" switch," an old now-obsolete design which has stub-end moveable rails.

• "**Switch-point rails**" have their "point" ends shaped to fit against the inside edge of the stock rails. When aligned for the straight route, the switch-point rail makes a smooth tangent because of a small bend in that stock rail. When aligned for the diverging route, the other switch-point rail makes a small angle with the straight stock rail, which is called the "point angle." A "switch rod" ties the switch-points together so they can move in unison.

• "**Stock rails**" are the two outside continuous rails.

• "**Closure rails,**" one curved and one straight, are the two inside rails between the switch-point rails and the frog.

• "**Frog**" is the part of the turnout that lets a flanged wheel track along a rail crossing another rail, as shown in Figure 2. There is a variety of prototype frogs:

—bolted-rail frog -- rails are bent to the required shapes and bolted together with steel spacers; this is the oldest design but still found on lightly used tracks.

—steel-casting frog -- a single casting with dimensions similar to a bolted-rail frog, found on lightly used tracks.

—rail-bound manganese-steel-casting frog -- used in turnouts with heavier and faster trains, now in common use.

—spring-rail frog -- on the main route the diversion wing rail is held against the frog point with springs for smooth tracking; wheel flanges have to force the flangeway open when tracking on the diverging route. usually at a slow speed.

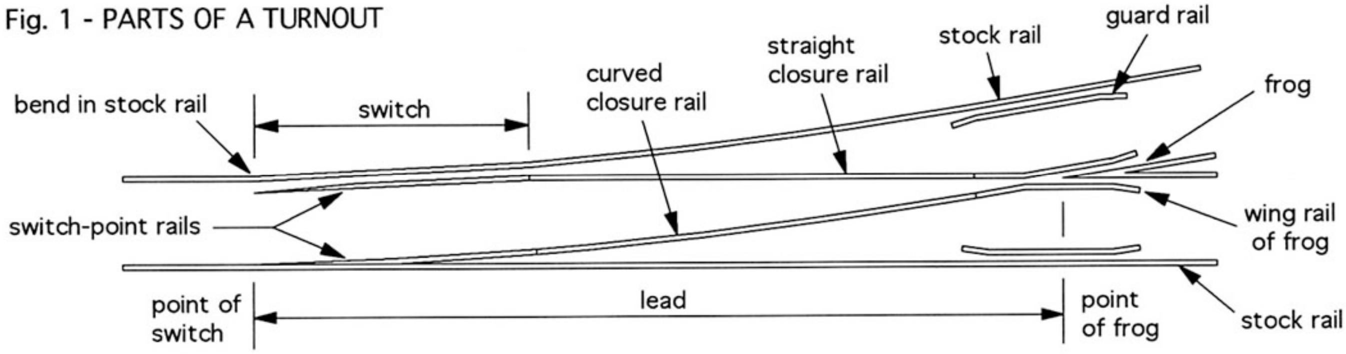
—self-guarded frog -- a steel casting with raised fins to guide the wheels through the frog; guard rails are not required opposite the frog; it is found in yards and on industrial sidings.

—moveable-point frog -- on high-speed main lines this frog allows long turnouts with small angles of diversion; the frog point moves at the same time as the switch-points.

• "**Frog point**" is where the running edges of two crossing rails come together. There is a "theoretical point," which is sharp and doesn't exist physically, and the "actual point," which on the prototype is blunted to about 1/2" wide.

• "**Wing rails**" are the parts of the frog that create the flangeways on each side of the frog point. Their purpose is to support the outside edge of the wheel tread as the wheel crosses the gap next to the frog point (Figure 2).

Fig. 1 - PARTS OF A TURNOUT



• "**Guard rails**" are installed along the stock rails opposite the frog, to assure that flanged wheels do not snag on the frog point. They may be fabricated of rail or castings.

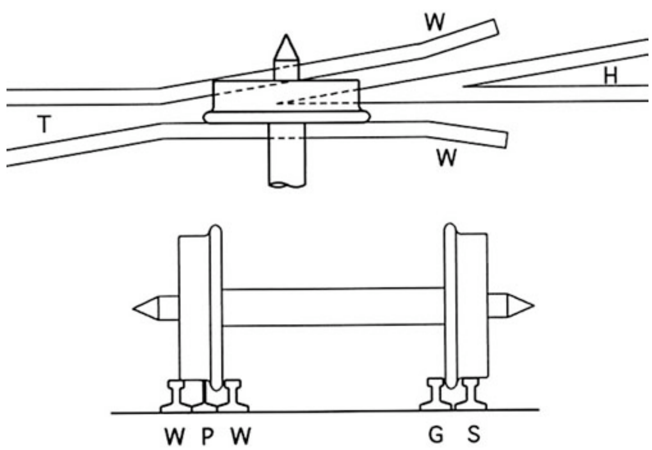
• "**Lead**" is the dimension along the straight leg of the turnout from the point end of the switch-points to the theoretical point of the frog (Figure 1).

• "**Head block**" is the extra large and long tie (or ties) which supports the switch-points, the adjacent stock rails, and the lever or machine for aligning the switch.

• "**Facing point**" and "**trailing point**" refer to the relationship of the switch-points to the direction of train travel. When the train is approaching a diverging route it's called a "facing point switch." When the train is approaching a converging route it's called a "trailing point switch," which is the safest, especially on fast main lines.

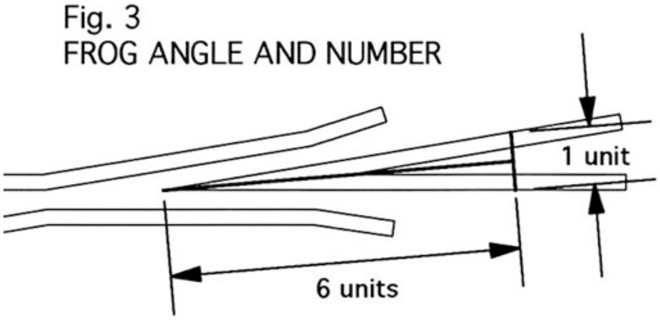
• "**Normal**" is the position of the switch-points when aligned to the main route. "**Reversed**" is the position when aligned to the secondary (or diverging) route. You'll see the letters "N" and "R" on the controls for turnouts on old CTC boards and on some model railroads.

Fig. 2
WHEEL TRACKING THROUGH A #6 FROG



P = point of frog W = wing rail S = stock raill
G = guard rail T = toe H = heel

Fig. 3
FROG ANGLE AND NUMBER



frog angle = 9° 32'
6 to 1 ratio = #6 frog and #6 turnout

• **The curved leg is not smooth.** A typical North American prototype turnout has straight switch-point rails and straight rails through the frog on both legs of the turnout. On the curved leg the switch-point rail makes an angle of about 1° or 2° when the point is against the straight stock rail, which is a sudden change for the wheels. Thus, the curved leg is not a continuous curve but is a combination of angle-straight-curve-straight. In the prototype, straight rail through the frog promotes reliable tracking and simplifies the stocking of right- and left-hand turnout parts. A large radius closure curve minimizes the effect of this.

Turnout dimensions

The nominal size of a turnout is represented by a single number (#6, #8, etc), which is determined by the angle at which the rails cross at the frog. Figure 5 shows how that number relates to the frog angle.

The largest possible closure radius for a given frog angle is a matter of geometry, as determined by the frog angle, switch-point length, and frog length. Those dimensions in turn establish the turnout length as represented by the lead (Fig. 1). A smaller angle (larger number) means a larger closure radius and a longer turnout as shown in the following table.

For a given frog angle, the lead length of prefabricated turnouts varies with the manufacturers and it is often shorter than necessary with a correspondingly smaller closure radius.

The dimensions in the following table are for HO scale from NMRA RP 12.3. The lead length and closure radius were specifically determined for model railroad purposes and may not be directly scaled from prototype standard dimensions.

Turnout Number	Lead	Frog Angle	Closure Radius
4	5.06"	14° 15'	15"
5	5.69"	11° 25'	26"
6	6.25"	9° 32'	43"
7	8.44"	8° 10'	49"
8	9.00"	7° 09'	67"
10	10.06"	5° 43'	117"

Types of turnouts

There are different types of turnouts designed to fit particular trackwork situations. The types more commonly available in modeling are as follows:

• **Conventional** -- The diverging route curves away from a tangent (straight) track. Left- or right-hand designation is the direction of diversion when looking at the turnout from the switch-point end. On main lines the straight leg should be the main route, if possible.

• **Curved** -- Both routes curve in the same direction, but with different radii. Left- or right-hand designation is the direction of curvature when looking at the turnout from the switch-point end. Curved turnouts can save space in some trackwork situations like yard leads. Equipment will track better on the larger radius leg, which should be the main route if possible.

• **Wye** -- The two routes curve in opposite directions, which can save space in some tight situations. A #4 wye matches the frog angle of #8 turnouts and a #3 wye matches the frog angle of #6 turnouts. However, the closure radius of a wye turnout is much smaller than the closure radius of the matching conventional turnout.

• **Three-Way** -- Two diverging routes curve in opposite directions from a center tangent track. This requires overlapping switch-points and three frogs. These may be found in yards and industrial trackage where speed is relatively slow.

• **Double-Slip Switch** -- This allows multiple routing options for a ladder or lead track of a yard in a cramped space. It is equal to four overlapping turnouts where two straight tracks cross, providing four different routes. The assembly of switch-points and special frogs is complex (and fascinating). As with the prototype, train speeds have to be relatively slow. They are not used on main lines. A single-slip switch is similar, but equal to only two overlapping turnouts where two tangent tracks cross, providing three different routes.

• **Dual-Gauge** -- this is a complex turnout required when three-rail trackage is used for both standard gauge and narrow gauge trains.

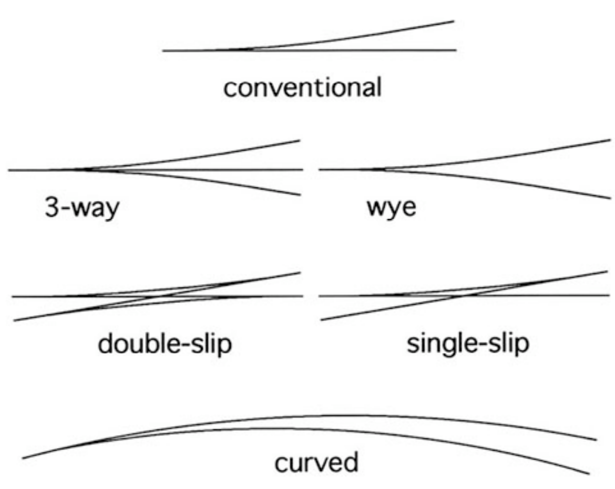
Modeling compromises

• **Length of Turnout** -- Most layouts have limited space. We use curves that are much sharper than the prototype, which allows us to compromise on turnout length as shown in this comparison:

	on the main line	in yards
prototype	#10 to #20	#8 or longer
model railroads	#6 to #8	#4 to #8

Longer turnouts (larger number) are more prototypical, have a more realistic appearance, and provide smoother operation on the curved leg. On the other hand, shorter turnouts (smaller number) can better utilize limited space and may be acceptable for operation of shorter engines and shorter cars. Operating problems can be avoided by carefully designing the layout before laying any track.

Fig. 4 TYPES OF TURNOUTS



• **Crossover** -- An example of the need to compromise on turnout length is a crossover between two parallel tracks. It involves two conventional turnouts and a short tangent track between the curved legs. This is a tight s-curve, which can be a problem with longer cars and locomotives if the turnouts are too short. The length required from switch-points to switch-points (parallel with the main line tracks, spaced 2" center-to-center in HO scale) is as follows. This is also the length required for a turnout from a main track to a parallel siding, from switch-points to beginning of the siding tangent.

	#6	#8	#10
length required in HO	16.5"	23.5"	27.0"
tangent between curves	5.6"	7.4"	9.3"

The #6 turnout is too short for a main line model railroad because of the tight s-curve it creates. If only the #6 fits, then you should use shorter cars and locomotives. The #8 is better and the #10 is best for smooth operation because of larger radius curves and longer tangents in between the curves. Some very large model railroads use #12 and #14 turnouts in such locations, more like the prototype. When possible, the crossover should be placed to make trailing-point rather than facing-point switches for main line trains.

• **Size of Rail and Ties** -- In HO scale, code 100 rail has been popular for many years, but is oversize for most situations. Code 70 is more-realistic for prototypical branch lines and short lines. In recent years, Code 83 has become the compromise for realistic appearance that is acceptable.

Along with code 83 rail, the manufacturers improved the size and spacing of ties to look more realistic. Prefabricated track with code 100 rail in HO scale has ties that are a scale 11" wide and spaced about 25" on center. With code 83 rail the ties are a scale 8" wide and spaced 20" to 22" on center. which is much closer to the prototype. Note that prototype dimensions of ties vary with the railroad, the era, and the type of track—SP in the steam-diesel transition era had different standards for ties applicable to main lines and branches and based on heavy or light traffic.

• **Curved switch-points** -- Typical prototype switch-points are straight. However, with the very short turnouts sometimes used in model railroading, the point angle for the diverging route would be too abrupt. So some manufacturers put a large radius curve in the switch-point rail, which is allowed by NMRA's recommended practices.

• **Switch-point clearance** -- When a switch-point is open the space between it and the stock rail is about 3-1/2" on the prototype, but is a scale 5" minimum in the NMRA HO standards. The visual difference is noticeable, but necessary in the model because of larger than prototype flanges and the possibility of electrical short when the switch-point is a different polarity than the stock rail. Turnouts designed to be compatible with DCC don't have this short circuit problem.

Some turnout manufacturers leave an even wider space, which is unnecessary and very unrealistic.

• **Frogs** -- In HO scale, frogs usually do not accurately represent the appearance of the prototype, especially modern rail-bound manganese-steel-casting frogs. Although, such frogs are available in kits and as parts (see Other Turnouts).

The frog on a turnout compatible with DCC must be electrically isolated because of the different electical polarity on each closure rail. Some prefabricated turnouts (and handlaid turnouts) have frogs made of soldered rail. Others have plastic or non-powered cast metal frogs, which create an unrealistic appearance and a loss of electrical pickup over an inch or more. A metal frog can be powered from electrical contacts linked to the switch throw mechanism. The compromise we have is functional frogs at the expense of prototypical accuracy.

Electrical configuration

With the advent of DCC, the electrical configuration of a turnout has become an important consideration. Analog DC can easily tolerate momentary short circuits. However, with DCC thre is full voltage on the rails and a short can shut down a layout or a power district. Also, locomotives need continuous pickup from the rails for power and control signal.

Electrical configuration varies with the manufacturers. Prefabricated turnouts are now "DCC-friendly" or "DCC compatible" or "improved for DCC." However, they might not be electrically reliable.

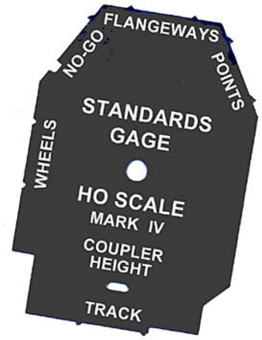
DCC-friendly means the switch-point rails are insulated from each other, each switch-point rail is always the same polarity as the adjacent stock rail, and the frog is electrically isolated.

E**lectrically reliable** means the turnout is DCC-friendly, has good electrical connections to all parts of the turnout, soldered without relying on point contact, and has a separate electrical feed to the frog with the polarity controlled by the switch-throwing machine or device. For additional details related to specific turnouts see Alan Gartner's website www.WiringForDCC.com.

NMRA Standards and Recommended Practices

NMRA Standards were introduced in 1936 as the primary basis for interchange of model railroad equipment. Standards S-1, S-3, and S-4 provide the important dimensions for track gauge, track and wheel relationships, gage and clearances at frogs and switch-points, and wheel tires and flanges.

NMRA Recommended Practices (RP) have been around since 1957 to supplement the Standards. Details and additional dimensions for turnouts are covered by the RP-12 series for different scales (O, S, HO, OO and On3, TT, HOn3, and N) and the RP-13 series for the various parts of frogs and guard rails. RP-25 specifies the well-known standard wheel contour designed with a tradeoff between optimum track holding ability and appearance.



The **NMRA Standards Gage** is essential for checking turnouts and is available from the NMRA. Its many uses related to turnouts are described in NMRA RP-2.

Copies of the NMRA Standards and Recommended Practices are available online at **www.nmra.org** where they can be viewed or downloaded as PDF files.

Prefabricated turnouts

In HO scale, there are several manufacturers who offer a variety of ready-to-use prefabricated turnouts. Listed in this section (in alphabetical order) are code 83 turnouts offered by some of the more prominent manufacturers. My personal comments are based on the characteristics which I consider to be important.

Prefabricated turnouts do not necessarily match all of NMRA's recommended dimensions. The manufacturers do try to meet track and flangeway gages and the frog angle, which are essential for reliable operation.

Note that some turnouts may have been changed since this list was assembled. Also, the list does not include turnout kits and made-to-order pre-assembled turnouts (see Other Turnouts below), turnouts already mounted on roadbed, nor sharp-radius sectional-track-type turnouts.

• ***Atlas*** offers a limited line of turnouts in code 83, which are less expensive. Super-Track are only #6 and Custom-Line are #4, 6, and 8. (Code 100 turnouts are also available.) The frog is cast metal, blackened, and electrically isolated. Guard rails are black plastic. Switch-points are formed from sheet metal. The space between open switch-point and stock rail is wider than necessary. Where the switch-points make contact with the stock rails the rail heads are notched, a potential snag point for wheel flanges. On my sample there is an abrupt angle between the switch-point rail and the closure rail on the curved leg. *Atlas* turnouts are DCC-friendly and the frog can be powered, but some parts of the turnouts need the addition of soldered connections for electrical reliablity. Modelers report satisfactory performance of *Atlas* turnouts. However, the overall appearance is not prototypical.

• ***Micro Engineering*** offers #6 turnouts in code 83. (Code 70 turnouts are also available.) The frog is a casting matching the rails, and is electrically isolated. Guard rails and switch-points are made from rail. The space between open switch-point and stock rail is wider than necessary. On the curved leg, tracking from stock rail to straight switch-point to closure rail to frog is very smooth. Switch-points have a spring lock with snap action; the spring can be removed if a switch machine is used. *Micro Engineering* turnouts are DCC-friendly and the frog can be powered. Some modelers add soldered connections to the switch-point rails for electrical reliability. Modelers report very good performance and the turnouts have a very good overall prototypical appearance. A set of plastic parts is included for prototype details.

• ***Peco*** offers a line of code 83 turnouts including #5, 6, and 8 and a curved #7, based on North American design and NMRA standards. They are relatively expensive. (Code 75 and 100 turnouts are also available, which are *Peco's* own unique design with small, medium, or large radius and all with the same 12° frog angle.) *Peco* turnouts come with a choice of frog design. The *Insulfrog* frog is a plastic core with metal-rail wing rails. The *Electrofrog* frog is made from rail and is electrically isolated with a wire lead already attached. Switch-points are formed from sheet metal. The space between open switch-point and stock rail is wider than necessary. Where the switch-points make contact with the stock rails the rail heads are notched, a potential snag point for wheel flanges. On the curved leg, tracking is very smooth. Switch-points have a spring lock with snap action; the spring can be removed if a switch machine is used. *Peco* turnouts are DCC-friendly and the Electrofrog must be powered. The Electrofrog turnouts have a very good overall prototypical appearance, marred slightly by the switch-points. The Insulfrog does not look prototypical.

• ***Walthers*** offers an extensive line of HO scale code 83 turnouts manufactured by *Shinohara*. (Code 70 and 100 turnouts are offered by *Shinohara* under its own name.) The conventional #8 turnout has a frog fabricated from rail and is electrically isolated. Guard rails and switch-points are made from rail and the switch-point on the curved leg is slightly curved, as allowed by NMRA. Space between open switch-point and stock rail is wider than necessary. On the curved leg, tracking is very smooth. However, the lead length is only 8" instead of the more-prototypical 9" specified by NMRA. This means the closure radius is smaller than the specified 67". Otherwise, the #8 turnout has a good overall prototypical appearance. Walthers turnouts are DCC-friendly and the frog can be powered. Some modelers add soldered connections to the switch-point rails for electrical reliability. Modelers report generally good performance.

The *Walthers* #10 turnout has a lead length of only 8.35" instead of the 10.06" specified by NMRA. This means the closure radius is much smaller than the specified 117". Also, the wing rails at the frog and the guard rails are much too long, which detracts from the appearance.

Turnouts, other than prefab

There are other turnouts available besides the prefabricated variety, including turnout kits, made-to-order pre-assembled turnouts, and turnouts built from scratch. The kits and scratchbuilding require some modeling experience and the patience to build fine and intricate mechanisms.

• **Scratchbuilt turnouts**, sometimes referred to as handlaid turnouts, have the advantage of being crafted to exactly fit the trackwork situation. Standard rail is fabricated into switch-points, frogs, and guardrails, which are spiked or glued to ties, properly dimensioned and gaged. Templates and fabrication jigs are available as are parts like frog castings. Scratchbuilding is obviously a lot more work, but it can save money.

• ***Central Valley Model Works*** (www.cvmw.com) offers a line of turnout kits in codes 83 and 70. Turnout sizes are #5, 6, 7, 8, and 9. The turnouts can be built straight or curved to fit special trackwork situations. The kits include a molded styrene tie block, white brass castings for the switch-point rails, a styrene block for making the frog, and a variety of detail parts.

• ***Railway Engineering*** (www.railwayeng.com) offers pre-assembled turnouts in codes 83, 70, and 55, which are normally made to order and may take some time to get (a few are in stock online). The gaged pieces, ready for spiking, are held together with tie-size strips of soldered circuit board that remain in place. Switch point and closure rails and the frog are one piece (no switch point pivots). All parts are fabricated from rail. Turnouts can also be ordered with wood ties.

• ***Proto:87 Stores*** (www.proto87.com) offers craftsman and ready-to-assemble turnout kits with a detailed plastic tie base. Wood ties are also available. Turnout sizes are #4, 6, 7, 8, 9, 10, and 12. Cast metal frogs are either regular or rail-bound manganese-steel type and switch-points are detailed metal castings. Parts are also available for scratchbuilding and for replacement of frogs in prefabricated turnouts.

• ***BK Enterprises*** (no website) has an extensive line of pre-assembled turnouts without ties (listed in the *Walthers* catalog), which are usually made to order and may take some time to get. The gaged pieces, ready for spiking, are temporarily held together with soldered strips.

Selecting turnouts for your layout

Your selection of turnouts has to take into account a number of factors:

• **Era being modeled** -- what rail size and track design?

• **Type of railroad** -- is it main line, branch line, short line, or a combination?

• **Appearance** -- trackwork is a model too -- do the turnouts have the quality and appropriate detials to look like the prototype?

• **Reliable train operation** -- do the turnouts properly fit the track configuration and the size of rolling stock? Closure radius must be large enough for the length of locomotives, especially the rigid wheelbases of steam locomotives. Closure radius must also be large enough for the length of cars, considering end overhang and the operation of couplers.

• **Space available** -- what are the space limitations that may affect the size of turnouts? Prototype turnouts are usually longer than we typically use for model railroads; use the longest that space allows. Short turnouts may dictate the use of smaller locomotives and rolling stock.

• **Electrical configuration** -- do the turnouts meet the needs of DCC? What additional electrical connections may be needed for long-term electrical reliability?

• **Your budget** -- prefabricated turnouts have a wide range of costs. This can affect your selection.

Using turnouts in layout design

• **Minimum size turnouts** for a model railroad, considering appearance and reliable train operation, are recommended as follows. Use longer turnouts if space permits.

main line crossovers	#8
main line sidings	#8
branch lines and short lines	#6
yards for 70' to 85' cars	#8
yards for 40' to 70' cars	#6
yards for shorter freight cars	#5
industrial sidings in tight places	#4

• **Carefully design** the track and turnouts and draw them on paper or on a computer before installing any trackwork.

Measure the actual turnouts to be used and be sure curved and tangent tracks will be properly aligned with each turnout. As with the prototype, the main track or main line should be on the straight leg of a conventional turnout whenever possible. Use other types of turnouts to save space in non-mainline applications.

Avoid creating tight s-curves. For smooth and reliable operation the minimum tangent should be equal to the longest car. Try to use longer turnouts for tight s-curves such as crossovers and entrances to parallel sidings.

• **Provide convenient access** to all turnouts and their switch-throwing devices for routine maintenance, occasional repairs, and future replacement. Don't bury them under non-removable scenery and try to avoid tight areas directly under other trackwork.

Installation of turnouts

Reliable operation of trains through turnouts depends not only on selecting the right turnouts but on their proper installation.

• **Before installing a turnout,** check the gaging of rails, points, and flangeways. It is not uncommon to find that a prefabricated turnout needs some adjustments to assure the best tracking of wheels through the turnout.

• **Use the NMRA Standards Gage** for the following turnout checks (instructions are included with the gage).

—track gage throughout each leg
—gage and span at the frog and guard rails
—flangeway depths
—flangeway widths at the frog
—switch point spread and gage

• **Track and turnout installation sequence:**

—carefully mark turnout locations on subgrade
—install roadbed
—install the turnouts first
—then fit the track to the turnouts

• **Visually check the alignment of the track and turnouts** as they are being installed—get your eye down close and sight along the turnout and track:

—do rail joints line up properly?
—are tangents really straight?
—are the curves smooth?

• **Other things to remember**:

—be careful when placing glue and ballast around switch points and throw rods to assure smooth unrestricted operation of the points

—stock rails adjacent to the switch-points may need extra spiking if the switch machine or switch throwing device is particularly forceful

—be sure to provide gaps at rail joints to allow for temperature expansion.