

Track & Components

3.1 Track Components

We begin our study with the prime component of the track – the rail.

3.1.1 Rail

Rail is the most expensive material in the track.² Rail is steel that has been rolled into an inverted "T" shape. The purpose of the rail is to:

- Transfer a train's weight to cross ties.
- Provide a smooth running surface.
- Guide wheel flanges.

The first rails were wooden. Later iron straps were added to the wooden rails to reduce wear. This was followed by cast iron rails and finally, steel rails were rolled from an ingot. (See Figure 3-1) Today, steel rail is rolled in a continuous casting process.

Over the years, the shape of rail has also changed. However, the "T" rail section, first rolled in 1831, has been the standard in North America ever since. Rails vary in weight and shape (known as "section").



Figure 3-1 Rolled Rail – Photo by J. E. Riley

Identification of Rail

The weight of rail is based on how much the rail weighs in pounds per yard. Over the past 200 years, increasingly heavier rail was required to handle the increased weight of locomotives and rolling stock and traffic volume increases. The largest rail commonly used today is 136 lb., although 140 lb. is still rolled and second-hand 152 lb. rail is available in limited quantities. AREMA has recently recommended a new rail section to maximize available head wear and minimize stress related failures. This section is the 141 lb., but is not yet widely in use. A rail's weight, along with its section and other information, is rolled as a raised character onto the web of the rail.

- RE: American Railway Engineering Maintenance of Way Association (AREMA).
- REHF: AREMA “head free” section.
- ARA-A: American Railway Association, “A” section.
- ARA-B: American Railway Association, “B” section.
- ASCE: American Society of Civil Engineers.



3.1.2 Ties

Ties are typically made of one of four materials:

- Timber
- Concrete
- Steel
- Alternative materials

For quality maintenance, ties should be not less than 8 ft. 6 in. in length. For moderately heavy or heavy-traffic conditions, especially on curves of 6 degrees or more, the 9-ft. tie is preferred, 7 in. by 9 in. in cross-section, because of the greater stability from the larger support and friction area. It also assists in restraining continuous welded rail.

For lines of moderate to medium tonnage, a tie spacing equivalent to 22 ties per 39-ft. rail (21-1/4 in.) is sufficient. Heavy tonnage lines or lines with sharp curves will find 24 ties per rail panel (19-1/2-in.) to have advantages in holding gauge and reducing bending moment stresses in the rail.

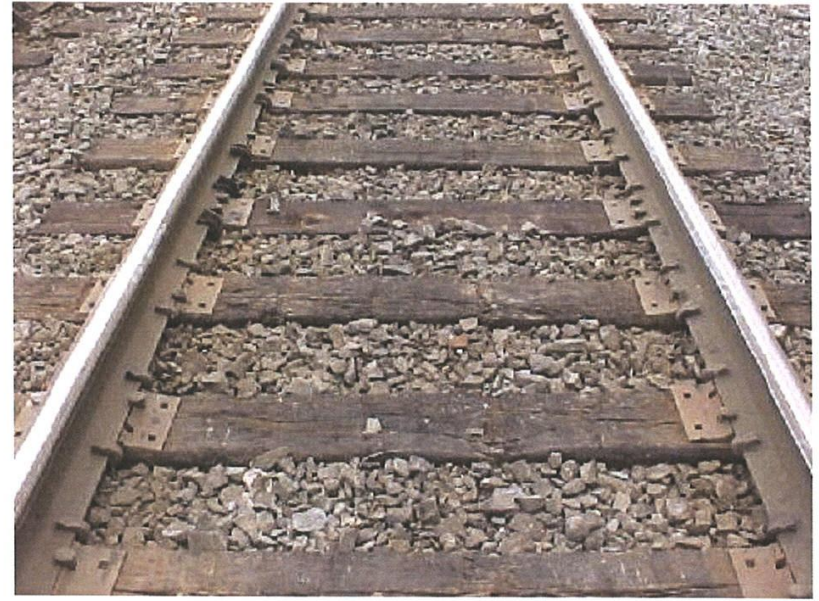


Figure 3-2 Hardwood Track Ties – Photo by J. E. Riley

Switch Ties

Switch ties (Figure 3-3) are commonly hardwood species, usually provided in either 6" or 12" increments beginning at 9'-0" up to 23'-0" in length. Nominal cross-section dimensions are 7" x 9", although larger ties are specified by some railways. The primary use for switch ties is relegated to turnouts (thus their name). However, they are also used in bridge approaches, crossovers, at hot box detectors and as transition ties. Some railways use switch ties in heavily traveled road crossings and at insulated rail joints.



Figure 3-3 Switch Timber – Photo by Craig Kerner

Softwood Ties

Softwood timber (Figure 3-4) is more rot resistant than hardwoods, but does not offer the resistance of a hardwood tie to tie plate cutting, gauge spreading and spike hole enlargement (spike killing). Softwood ties also are not as effective in transmitting the loads to the ballast section as the hardwood tie. Softwood and hardwood ties must not be mixed on the main track except when changing from one category to another. Softwood ties are typically used in open deck bridges.



Figure 3-4 Softwood Timber - Photo by J. E. Riley

Concrete Ties

Concrete ties (Figure 3-5) are rapidly gaining acceptance for heavy haul mainline use, (both track and turnouts), as well as for curvature greater than 2° . They can be supplied as crossties (i.e. track ties) or as switch ties. They are made of pre-stressed concrete containing reinforcing steel wires. The concrete crosstie weighs about 600 lbs. vs. the 200 lb. timber track tie. The concrete tie utilizes a

specialized pad between the base of the rail and the plate to cushion and absorb the load, as well as to better fasten the rail to the tie. Failure to use this pad will cause the impact load to be transmitted directly to the ballast section, which may cause rail and track surface defects to develop quickly.



Figure 3-5 Concrete Ties – Photo by Kevin Keefe

Steel Ties

Steel ties (Figure 3-6) are often relegated to specialized plant locations or areas not favorable to the use of either timber or concrete, such as tunnels with limited headway clearance. They have also been utilized in heavy curvature prone to gage widening. However, they have not gained wide acceptance due to problems associated with shunting of signal current flow to ground.



Figure 3-6 Steel Ties

Alternative Material Ties

Significant research has been done on a number of alternative materials used for ties. These include ties with constituent components including ground up rubber tires, glued reconstituted ties and plastic milk cartons. Appropriate polymers are added to these materials to produce a tie meeting the required criteria. To date, there have been only test demonstrations of these materials or installations in light tonnage transit properties. It remains to be seen whether any of these materials will provide a viable alternative to the present forms of ties that have gained popularity in use. (Figure 3-7)



Figure 3-7 Alternative Type Material Tie

3.1.3 Ballast Section

A principal purpose of the ballast section is to anchor the track and provide resistance against lateral, longitudinal and vertical movement of ties and rail, i.e., stability.⁵ Additionally, the ballast section bears and distributes the applied load with diminished unit pressure to the subgrade beneath, gives immediate drainage to the track, facilitates maintenance, and provides a necessary degree of elasticity and resilience. Good drainage is of utmost importance to assure required stability.

Ideal qualities in ballast materials are hardness and toughness, i.e., freedom from shattering under impact, durability or resistance to abrasion and weathering, freedom from deleterious particles (dirt), workability, compactability, cleanability, availability, and low first cost. The principal desired characteristic is maximum stability at minimum over-all economic cost, including frequency of maintenance cycle, life of rails, ties and fastenings, and the labor costs. Quality maintenance requires that more attention be given to the quality and characteristics of ballast. The practice of buying ballast purely because of low first cost or accessibility is clearly suspect.

More important factors, probably, are the shape of the ballast particle, its degree of sharpness, angularity, and surface texture or roughness. These factors have been shown to have a significant effect upon the stability and compactability of aggregates in general.

The ballast types most nearly meeting the ideal requirements, in order of preference, are granite trap rock, hard limestone, open hearth and blast furnace slags, other limestones, prepared gravels, chat, volcanic ash, pit-run gravel and coarse sand (as a last resort). There are other materials of local deposition that may be usefully considered, especially for light-traffic and industrial switching tracks.

3.1.4 Rail Joints

The purposes of the rail joint (made up of two joint bars or more commonly called angle bars) are to hold the two ends of the rail in place and act as a bridge or girder between the rail ends.⁶ The joint bars prevent lateral or vertical movement of the rail ends and permit the longitudinal movement of the rails for expanding or contracting. The joint is considered to be the weakest part of the track structure and should be eliminated wherever possible. Joint bars are matched to the appropriate rail section. Each rail section has a designated drilling pattern (spacing of holes from the end of the rail as well as dimension above the base) that must be matched by the joint bars.

DES OF RAIL JOINTS (FIGURE 3-8):

There are three basic types of rail joints (Figure 3-8):

- Standard
- Compromise
- Insulated



Figure 3-8 Conventional Bar, Compromise Bar & Insulated Joint Bar –
Photo by J. E. Riley

Standard Joints

Standard joint bars connect two rails of the same weight and section. (See Figure 3-9) They are typically 24" in length with 4-bolt holes for the smaller rail sections or 36" in length with 6-bolt holes for the larger rail sections. Alternate holes are elliptical in punching to accommodate the oval necked track bolt. Temporary joints in CWR require the use of the 36" bars in order to permit drilling of only the two outside holes and to comply with the FRA Track Safety Standard's requirement of maintaining a minimum of two bolts in each end of any joint in CWR.



Figure 3-9 Standard Head-Free Joint Bar – Photo by J. E. Riley

Compromise Joints

Compromise bars connect two rails of different weights or sections together. (See Figure 3-10) They are constructed such that the bars align the running surface and gage sides of different rail sections. There are two kinds of compromise joints:

- **Directional** (Right or Left hand) compromise bars are used where a difference in the width of the head between two sections requires the offsetting of the rail to align the gage side of the rail.
- **Non-directional** (Gage or Field Side) are used where the difference between sections is only in the heights of the head or where the difference in width of rail head is not more than $1/8$ " at the gage point. Gauge point is the spot on the gauge side of the rail exactly $5/8$ " below the top of the rail.



Figure 3-10 Compromise Joint Bar – Photo by J. E. Riley

Insulated Joints

Insulated joints are used in tracks having track circuits. They prevent the electrical current from flowing between the ends of two adjoining rails, thereby creating a track circuit section. Insulated joints use an insulated end post between rail ends to prevent the rail ends from shorting out.

There are three types of insulated joints:

- Continuous
- Non-continuous
- Bonded

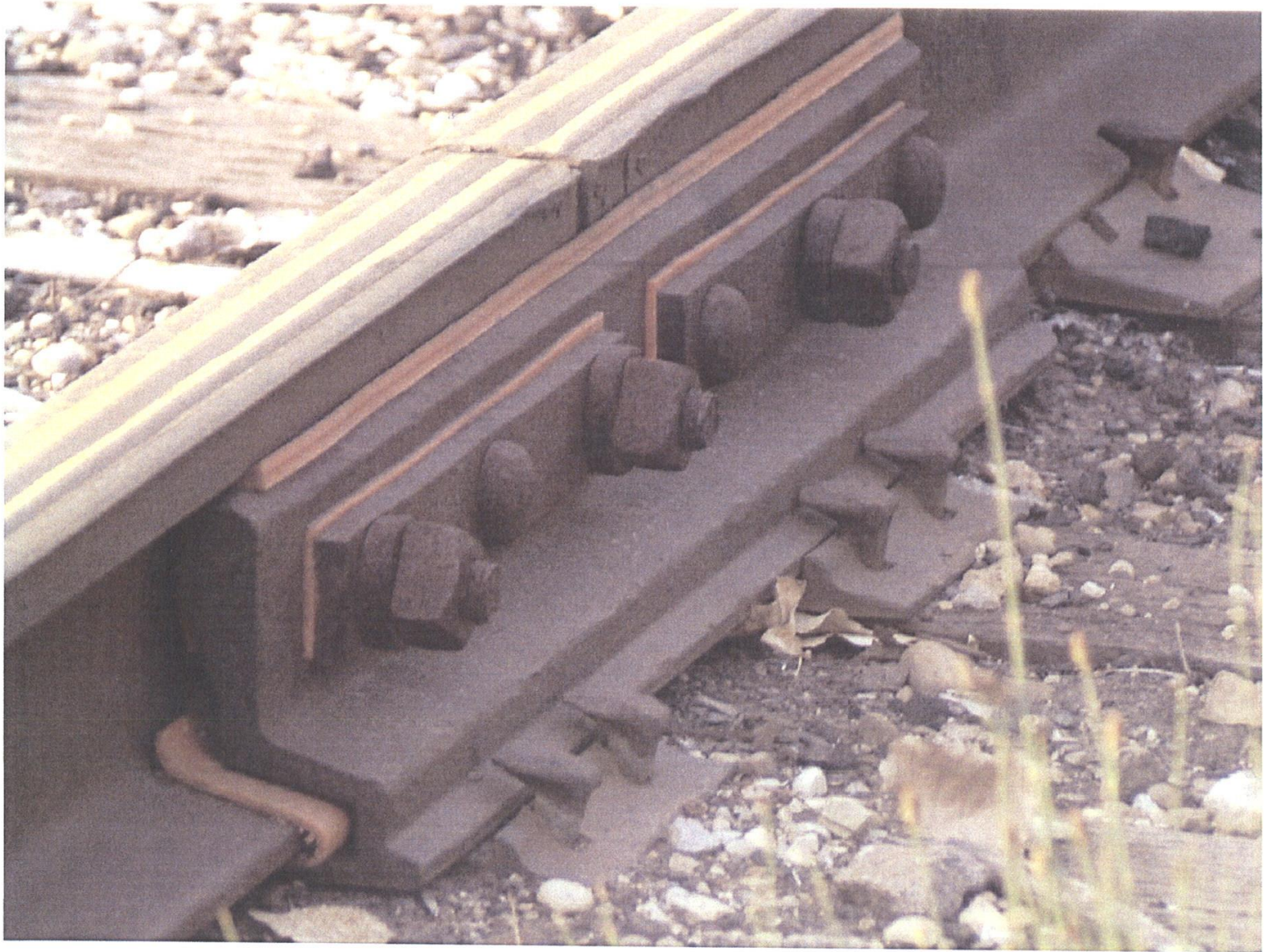


Figure 3-11 Continuous Insulated Joint – Photo by J. E. Riley

3.1.5 Tie Plates

The primary purpose of a tie plate is to provide a smooth and uniform bearing surface between the rail and the tie.⁷ This prevents the rail from cutting into the tie. The plate also helps to maintain gauge. Plates that are canted (typical cant is 1 in 40) tip the rail slightly to better distribute the wheel load to ties.



Specialty plates (Figure 3-15) used for elastic type hold-down fasteners, are also produced in large quantities. Various types of specialty plates are used at insulated joint locations where the rail ends are supported immediately underneath by a tie. A non-conductive plate must be used to prevent the shorting out of the two insulated rail ends.

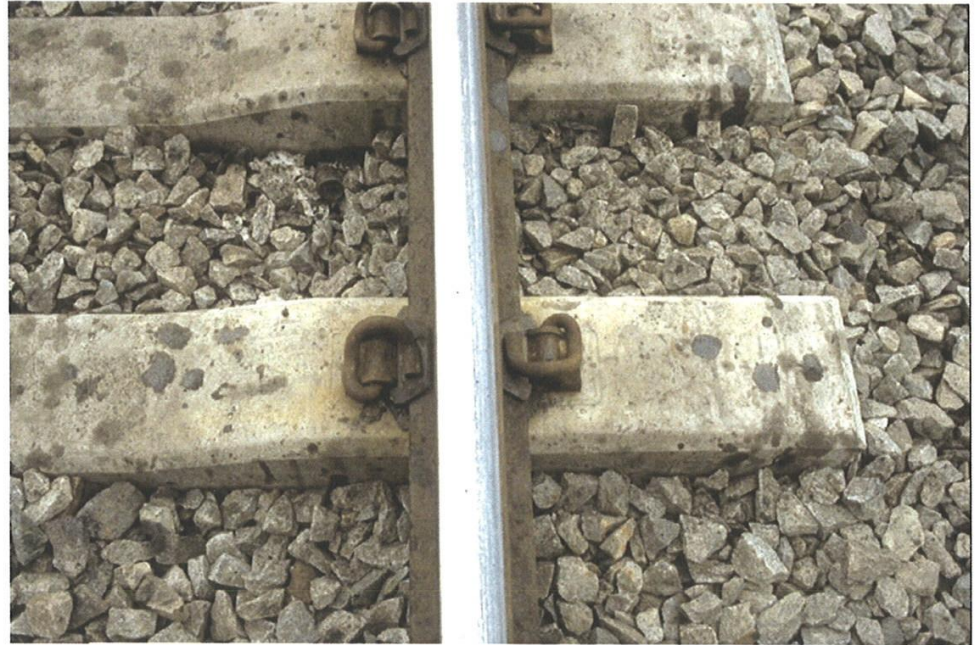


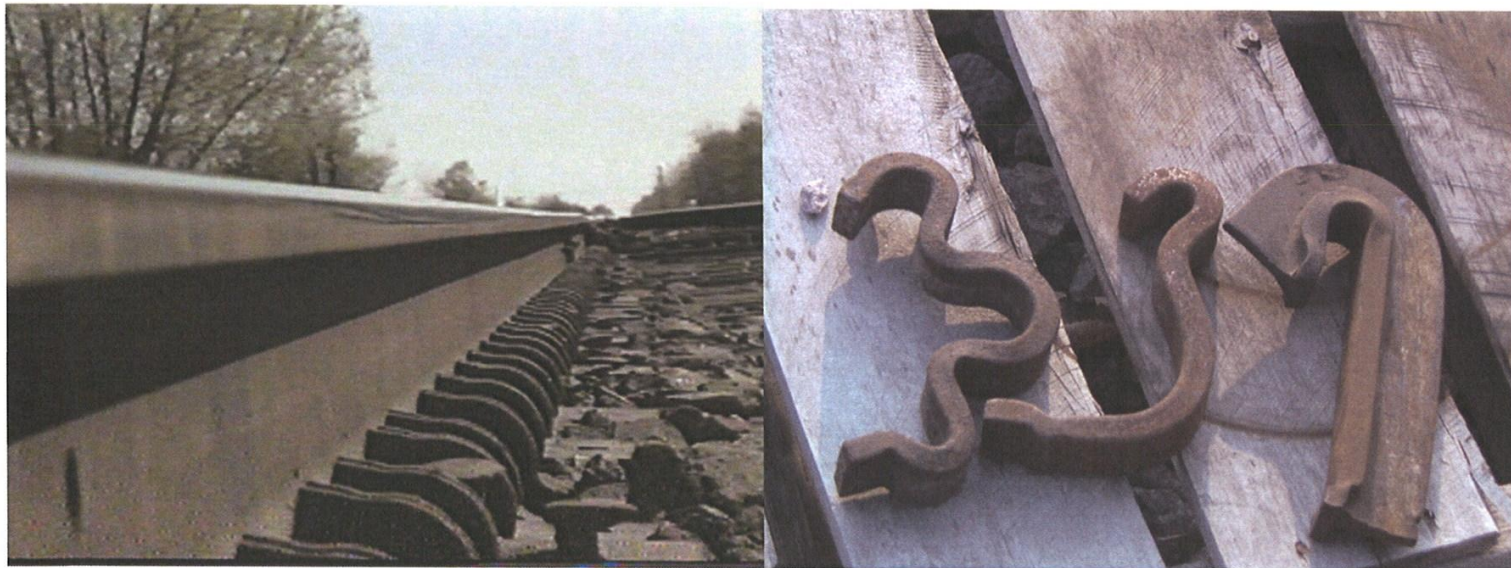
Figure 3-15 Pandrol Plate & Fastener on a Concrete Tie

3.1.6 Rail Anchors

Rail anchors are used to control the longitudinal running or creeping of the rail caused by changing temperature, grades, traffic patterns and braking action of trains.⁸ Anchors are applied directly to the rail base and lodge up against the tie. The tie is embedded in the ballast and the completed system together provides resistance against longitudinal and lateral movement. Anchors are made for a specific rail weight and base width.

Anchors manufactured today can be classified into two major groups: (See Figure 3-16)

- Drive-On
- Spring-Type



3.1.7 Fasteners

There are many different types of fasteners commonly used.⁹ Fasteners can be grouped by use as either connecting rail or track components together or to fasten rails to ties. Fastenings and hold-down devices, with modern tie plate design, are aimed primarily at reducing movement between the tie plate and the tie, both vertically and laterally. As the track deflects under a wheel load, a reverse curve with upward bending is formed immediately in front of and behind the wheel. Lateral restraint is necessary to prevent wide gauge and plate cutting. Vertical restraint also reduces plate cutting. The rail should be restrained within the tie plate shoulders, its own weight is usually sufficient, without unduly restricting the wave action in the rail. The plate must be held firmly to the tie by plate holding spikes to prevent any differential movement between plate and tie. The AREMA Manual for Railway Engineering gives a recommended

Spikes

Track Spikes

The purpose of the track spike is to first maintain gage between the running rails and to secondly secure the rail to the tie. The underside of spike head is sloped to fit the top surface of the rail base (Figure 3-17).

Spikes come in different lengths to ensure an adequate length of spike penetrates into the tie. The most common track spikes used are the $5/8"$ x $6"$ and the $9/16"$ x $5-1/2"$ for smaller rail sections. Spikes can be commonly secured in either 200 lb. kegs or 50 lb. kegs (Figure 3-18).



Bolts

Track bolts

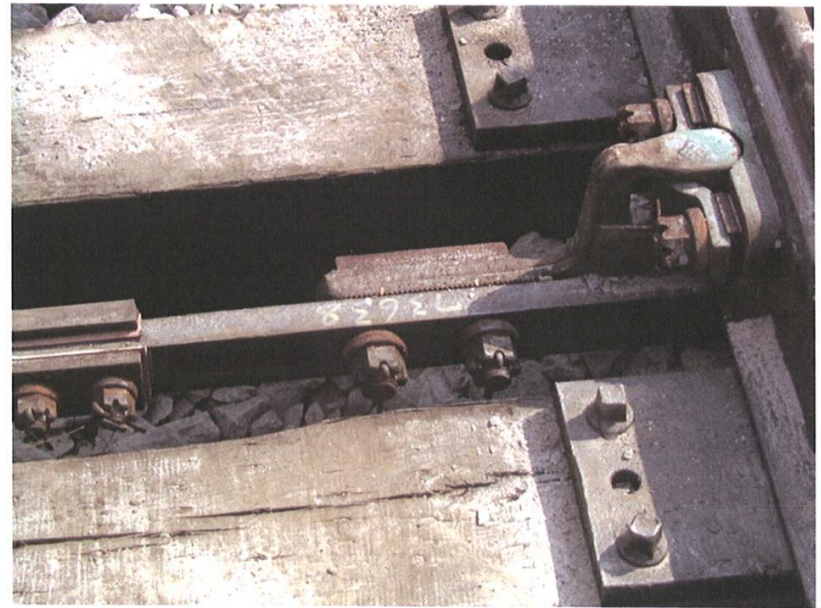
The track bolt (Figure 3-19) is used to connect rail ends together at a joint. Track bolt sizes are determined by the section of rail in use. Check the applicable railway standard to determine the proper bolt diameter and length. Track bolts are normally supplied as oval neck to prevent the bolt from turning when torqued. Track bolts are heat-treated and will stretch a little, thus they must be tightened after initial application. Track bolts are used with square nuts and spring washers. Over-torquing track bolts creates frozen joints, which in most cases, is undesirable.



Figure 3-19 1" x 6" Oval Necked Track Bolts – Photo by J. E. Riley

Rod and Clip Bolts

Rod bolts are typically square headed and drilled for a cotter pin to prevent the nut from falling off. They secure the switch rods in a turnout to the jaw clips mounted on the switch points. The clip bolts secure the clip or side jaw to the switch point and are also square headed with often a milled head that will permit the switch point to fit up tight against the stock rail. (See Figure 3-20)



3.1.8 Specialized Components

There are a number of specialty track items with which the engineer must be familiar.¹⁰
These components include:

- Derails

Derails

The purpose of the derail is to keep tracks free of unsecured rolling stock. When properly placed and in the derailing position, the derail will guide the wheels off the track. This prevents unintentional movement of rolling stock from fouling the main line.

The derail should be left in the derailing position whether or not there are cars occupying the track. Derails are designated as right hand or left hand for derailing in the desired direction. The engineer must select the appropriate model of derail on the basis of the rail section to be utilized. An under-sized derail will not properly cover the rail head and may not derail the car as intended. An over-sized derail may be damaged because of inadequate support.

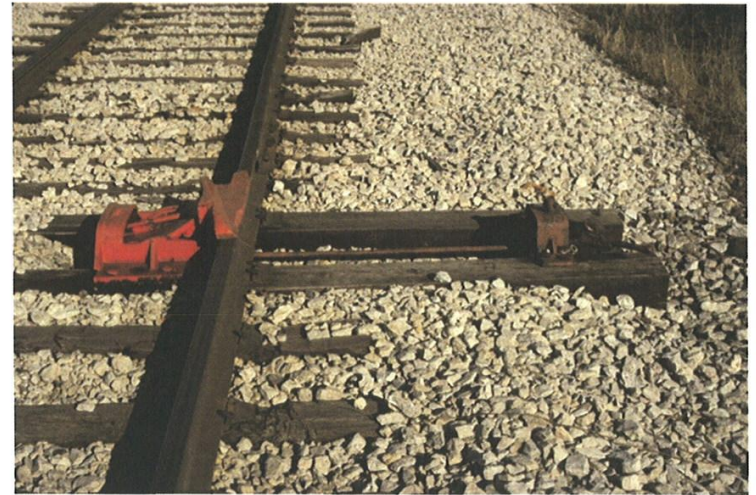


Figure 3-21 Sliding Derail

Bridge/tunnel/overpass Guard Rails

The purpose of installing bridge guard rails (Figure 3-24) is to keep derailed equipment from falling off an overpass or deck of a bridge, or striking the sides of a structure or piling up in a tunnel. Typically, the inner guard rail will be a T-rail section, which does not extend to the height of the running rail. The outside guard rails are usually timber members.



3.2 Turnouts

A turnout is a combination of a switch, a frog, the rails necessary to connect the switch and the frog, two guard rails, unless the frog is self-guarded, and a switch stand or switch machine for operating the switch.¹¹ A turnout begins with the switch and ends with the frog. The purpose of a turnout is to permit engines and cars to pass from one track to another.

3.2.1 Types of Turnouts

Turnouts can be categorized into three groupings:

- Lateral turnouts
- Equilateral turnouts
- Lap turnouts

Lateral turnouts (Figure 3-25) are defined as right hand when the diverging track runs to the right and left hand when the diverging track runs to the left when facing the turnout.

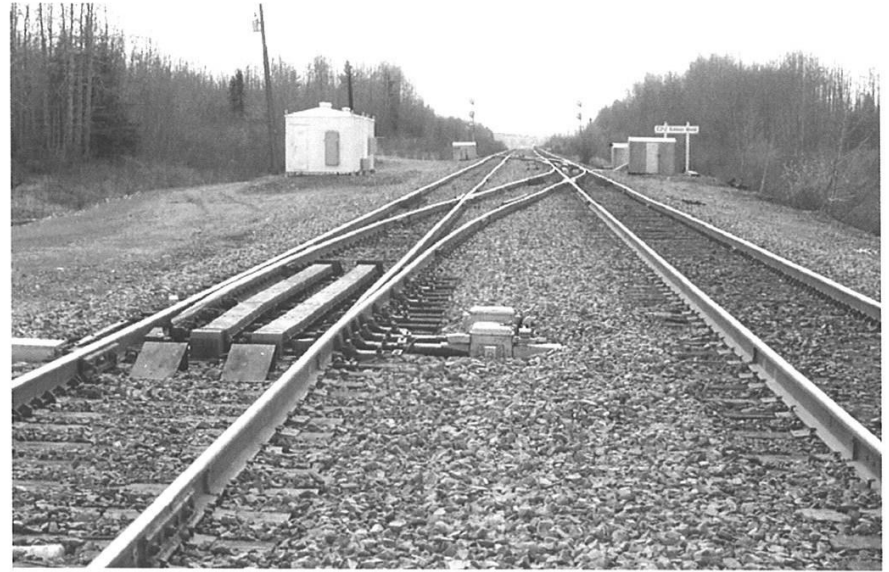


Figure 3-25 Lateral Right Hand Turnout

Equilateral turnouts (Figure 3-26) are common at the ends of double track territory (where two tracks go to one and vice versa). Both routes curve or diverge as opposed to only one route diverging in the lateral turnout. They are used for higher operating speeds or in congested areas. Half of the curvature is on the main track side and the other half is on the turnout side.



Figure 3-26 Equilateral Turnout - Photo by J. E. Riley

Basic Turnout Terminology

- Straight side called the main track or straight (normal) route.
- Curved side termed the turnout or diverging route.
- Facing point move is from points toward frog, either route.
- Trailing point move is from frog toward points, either route.
- Point of switch (PS) is the location where the diverging or straight route is determined.
- Heel of switch (HS) is the location at which the switch point pivots about.
- Switch is the area from Point of Switch to Heel of Switch.
- Toe of frog (TF) is the joint location ahead of the frog point connected to the closure rails.

- One-half inch point of frog (PF) is the location behind theoretical point of frog, where the gauge spread is $\frac{1}{2}$ ".
- Heel of frog (HF) is the joint location behind the point of frog.

The true definition of a turnout is the portion of the track assembly from PS to HF. But we commonly refer to all of the track structure resting on switch ties as the turnout.

Each turnout is identified as a number (e.g. # 10). The number of the turnout is determined by the angle of the frog (discussed later).

Every turnout consists of the following components:

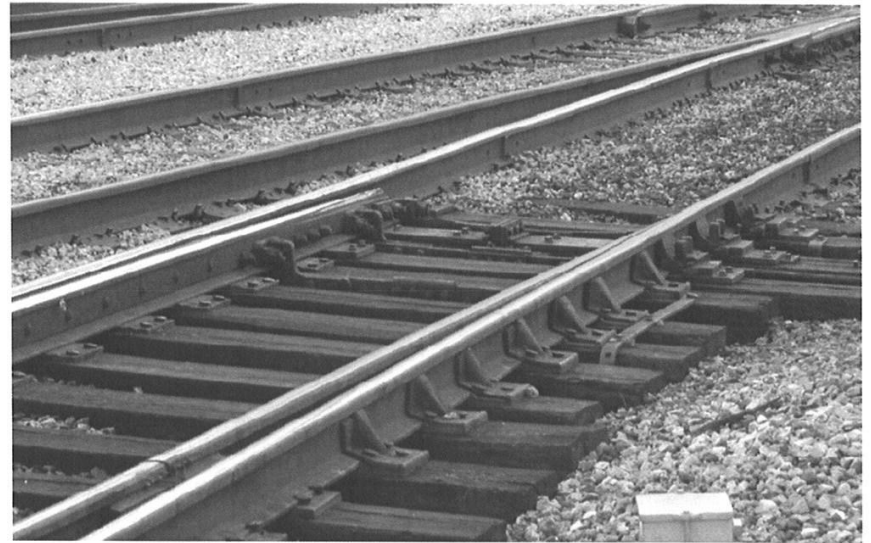


Figure 3-28 Switch Section of a Turnout – Photo by J. E. Riley

3.2.2 Switch

A switch is a device to deflect, at will, the wheels of a train from the track upon which they are running.¹² A switch refers to portion of turnout from Point of Switch (PS) to Heel of Switch (HS).

The split switch (Figure 3-28) is the most common switch used, although the tongue switch may be used on transit properties operating within pavement. The split switch consists of two switch or point rails connected by switch rods and operated as a unit. The switch rails are of full section at one end, and are tapered to a 1/4-in. or 1/8-in. point at the other end. The tapered end is called the point of switch and the other end is called the heel of switch. The switch rails rest upon metal plates fastened to the ties.

3.2.3 Switching Mechanism

There are two means of moving the switch points:¹³

- Hand operated (switch stand).
- Power operated (machine).

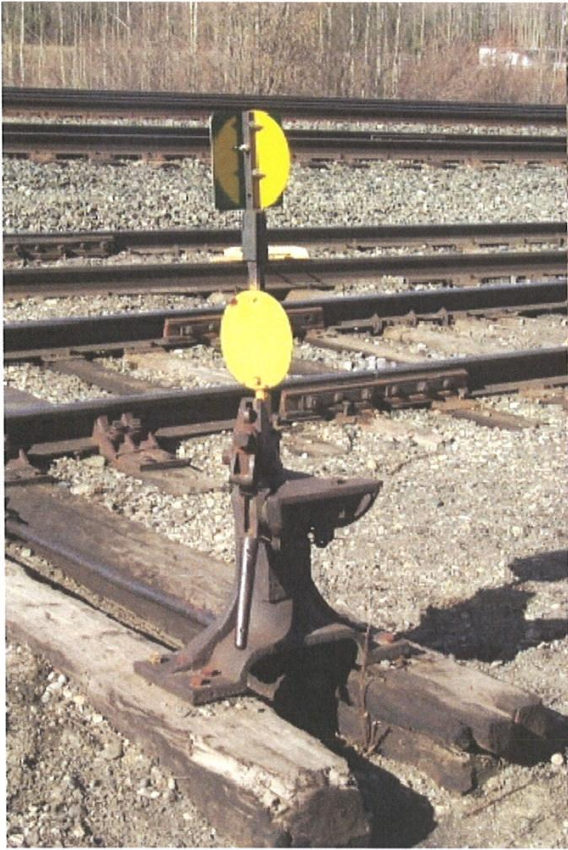


Figure 3-30 Hand Throw Switch Stand



Figure 3-31 Dual Control Switch Machine – Photo by J. E. Riley

3.2.5 Frog

A frog is a device at the intersection of two running rails to permit the flange of a wheel moving along one rail to cross the other rail.¹⁴ Turnout frogs may be classified as rigid frogs or spring-rail frogs. Both types of frogs are made with straight gage lines, except those used on street railways. The point is finished with a blunt point about 1/2 in. wide. The distance “P,” between the actual frog point and the theoretical point (intersection of gage lines) equals the width of the blunt point multiplied by the frog number (i.e., $1/2 N$).

Spring Frog

The spring frog (Figure 3-34) provides continuous support for the wheel as it transits through the frog flangeway. This frog has a moveable wing rail. The wing rail is held closed by a spring assembly. It also has an anchor block, thimble and a bent joint bar at the toe end to allow the wing rail to pivot. The guardrail pulls the wheels over, forcing the wing to open on the diverging side. The wing rail springs closed again after the wheels are through. Spring frogs are supplied as either right or left hand. To determine the hand of a spring frog, stand at the rigid wing end, facing the frog. The side the moveable wing is on indicates left or right.



Figure 3-34 Spring Frog - Courtesy of the Union Pacific Railroad

Bolted Rigid Frogs

Bolted rigid frogs (Figure 3-36) are made of machined rail bolted together. They are cheap to make and are used primarily in yards and secondary lines. They are designated as right or left hand. The straight route side of the bolted rigid frog point is continuous, whereas the diverging side of the frog point is milled to intersect the straight side frog point rail, hence the need to differentiate the hand of the frog.



Figure 3-36 Bolted Rigid Frog - Photo by J. E. Riley

Determining Frog Number

The frog used in a turnout determines the number of the turnout, e.g.:

- # 10 turnout uses a number 10 frog.
- # 12 uses a number 12 frog.

The point of the frog is machined off from the true (theoretical) point to where the spread is $1/2$ ". This is referred to as the actual point of frog. To find the number of the frog:

- Utilizing a tape measure, find the location behind the point of frog where the spread between the gauge lines equals an even increment of inches.
- Starting at that point, measure along the gauge line to the location where the spread between gauge lines equals one inch more than that previously measured.
- The distance in inches between the two locations where the gauge spread differed by one-inch equals the frog number.

3.2.6 Switch Ties

AREMA as well as many railways have standardized plans for the switch tie layout for the turnouts utilized on their property. The two switch ties under the switch mechanism are called head block ties (Figure 3-38). The ties under the heel block assembly are called heel block ties and those under the frog are called frog ties.



Figure 3-38 Head Block Ties

Rail Braces

A rail brace is used to resist the lateral thrust on the point and stock rails. Rail braces bear against the outside of the stock rails. They are secured to the gauge and switch plates. There are two general types in use with many variations of each.

- Adjustable (fastened with bolts).
- Rigid (older type, fastened with track spikes). (Figure 3-52)



Figure 3-52 Rigid Type Rail Braces

3.2.11 Guard Rails

Guard rails are used to prevent misrouting and derauling at the frog point and to prevent wheels from striking the frog point.¹⁹ (Figure 3-58) They may be of either the adjustable or non-adjustable type. The guard rail captures the back of the flange on the wheel opposite the frog and guides the other wheel through the throat opening of the frog. Thus, the mid-point of the guard rail must be positioned ahead of the frog point to ensure that the wheel is properly tracking when it reaches the throat of the frog.



Figure 3-58 Guard Rail

As with the rest of the track, but even more so, quality turnout and crossing maintenance demand initially a strong, stable base and excellent drainage. This may require special subgrade preparation including asphaltic or concrete pads, especially under crossings with high traffic densities. The use of catch basins and subsurface drainage systems are recommended where moisture conditions and traffic are both severe.

The proper location of a crossing or turnout is important. It should be placed off of curves. Sharp curvatures or reversals should be avoided at the back of the frog to avoid excessive lurching and lateral thrust in the frog area.



Figure 3-60 Dual Control Power Switch - Photo by J. E. Riley

3.4 Highway Crossings

The renewal of road crossings represents one of the largest budgetary expenditures faced by the Maintenance of Way and Signals Departments. Typically, railways will look for governmental partnership and participation when contemplating crossing renewal projects on all but farm and private crossings. Chapter 5, Part 8 of the AREMA Manual for Railway Engineering gives specific guidelines for the design, construction and maintenance of road crossings. The Commerce Commission of each state in the United States regulates the design, construction and installation of public road crossings within their respective state. This information is contained within bulletins accessible through their respective web pages.

There are many different types of road crossing materials that are commonly found throughout North America. These include: unsurfaced, timber, asphalt, asphalt with timber headers, concrete (both cast in place and precast) and pre-manufactured rubber. Some transit and light rail systems utilize specialty rail chairs to support an inner rail, thereby creating a proper flangeway in highway crossings. The type of crossing material used is determined primarily by the amount of vehicular traffic that uses the crossing.

Asphalt or Bituminous crossings (Figure 3-66) are used for crossings with all levels of traffic from light to heavy. These crossings are constructed by filling in the area between the rails with compacted base material covered by several inches of asphalt as surfacing material. In some cases, full-depth asphalt may be used between the rails. Depending on the level of train and highway traffic, the flangeways may either be formed in the asphalt itself or formed by the use of timber flangeway headers.



Figure 3-66 Asphalt & Timber Flangeway Crossing - Photo by Robert Schuster



Figure 3-67 Precast Concrete Crossing - Photo by J. E. Riley