1 Trackage General

1.1 Introduction and Intended Use

Track and right-of-way modeling is as much a part of model railroading as locomotives and cars. Good track design and construction are important for reliable operation as well as being a realistic model of full-size railroads. Prototype railroads follow standards and recommended practices for grades, curves, turnouts and other trackwork designs to ensure reliable operation. This **Recommended Practice** provides an overview of model railroad planning and design considerations for the same trackwork and for realistic appearance.

Successful operation of a model railroad requires sound engineering of its right-of-way and careful construction of its roadbed and trackage. Model railroad engineering is subject to many of the same considerations governing the prototype, such as climate, mountains, water obstacles, grades, clearances, curvature, easements, special trackage in yards, and other features. There is no one good plan or design as each person's available space, modeler interests and resources combinations are different.

1.2 References

This standard should be interpreted in the context of the following NMRA Standards, Recommended Practices, Technical Notes, and Technical Information.

1.2.1 Normative

- S-1.1 General - Proto Scales
- S-1.2 General - Standard Scales
- S-1.3 General - Scales with Deep Flanges
- S-3.1 Trackwork Proto Scales
- S-3.2 Trackwork Standard Scales
- S-3.3 Trackwork Deep Flanges

1.2.2 Informative

- RP-2 NMRA Standards Gage
- RP-7 Track Centers and Obstacle Clearances
- RP-7.1 Tangent Track Centers and Clearance Diagrams
- RP-7.2 Curved Track Centers
- RP-7.3 Curved Track Obstacle Clearances
- RP-11 Curvature and Rolling Stock
- RP-12 Turnouts
- RP-13 Guard Rail and Frog relationships
- RP-15.1 Rail
- TN-9 Wiring for DC and DCC
- D1j Grades and Angles
- D2 Scenery Series

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- D3b.1 Curves, Super Elevation and Easements
- D3b.2 Spiral Easement Graph
- D3b.3 Spiral Easements and Superelevation
- D3c Turnout Types and Terminology
- D8 Operations

1.3 Terminology

Term	Definition
Curve	Curved segment of track that forms a portion of a circle or arc. The prototype measures curves in degrees while modelers measure the radius.
Tangent	Straight track extending from the edge of a circle or arc.
Spiral Easement	A calculated rate of curvature change that connects a straight track to a fixed-radius circular curve. Also often called a transition curve.
Grade Compensation	The reduction of track steepness (gradient) through a curve to offset the extra rolling resistance that curves add compared to straight tracks.
Profile	The physical dimensions, cross-section, rail height (code), and roadbed structure used to support and power model trains.
Train Resistance	The load, or drawbar pull, on a locomotive caused by curves, vertical curves, car wheels, and uphill grades
Vertical Curve	A gradual transition piece of track that smooths out the change between a flat section and an inclined grade.

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2 Application

2.1 Railroad Alignment and Profile Type

First comes the decision as to the type of railroad to be modeled. Will it simulate the large trunk lines that so multiple locomotives can haul the 100-plus car trains at maximum speeds; requiring clearing trees, moving earth, bridging, tunneling or moving mountains to reduce curvature and grades? Will it follow the example of the smaller, less capital-intensive roads with steeper grades and sharper curves which require less grading, fewer bridges and tunnels. The type of terrain to be represented is the primary limitation and consideration such as flat lands of the Midwest, eastern older mountains, more challenging western mountains or rolling hills and rivers. Some busy main lines have steep grades and sharper curves on their less trafficked subdivisions. Most railroad alignments were selected between the 1860's and 1920's. Economic, geographic, and practical factors set the limits.

2.2 Railroad Trackage and Equipment

Next comes the trackage, which needs to be appropriate for the railroad location, the terrain it crosses, the expected traffic, and equipment available. Long locomotives, passenger car lengths, and specialty cars look best on large radius curves. Spiral easements should connect the curves, tangents, and vertical curves to make changes in grades. Short lines and narrow-gauge routes may

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have sharper curves and steeper grades. Therefore, the type of equipment and the motive power used should be kept consistent with the terrain and trackage to serve the railroad purpose.

2.3 Trackage Characteristics

The modeler must decide upon the degree of fidelity to the prototype for which the model railroad will be developed. NMRA Standards S-1.1 General Proto Scales, S-1.2 General Standard Scales and S-1.3 General Scales with Deep Flanges identify the classes for which the NMRA track Standards have been developed. The level of fidelity is the choice of the modeler's preference based on their interest in appearance, skills and modeling time available. The afore mentioned Standards describe each and the level of prototype fidelity.

2.3.1 Basic Track Planning Standards

Planning begins by using NMRA RECOMMENDED PRACTICES such as RP-11, Curvature and Rolling Stock to draw initial plans to determine what will fit the available space. The first step is to identify the space available for the model railroad. This is an iterative process involving outlining the possible benchwork and sketching different ideas for the layout of track for multiple alternatives. This RP correlates the size of the equipment and the minimum curvature that has been found to be reasonably practical for operations on a model railroad. It is a series of recommended practices and not hard rules.

As an example, including spiral easements between the body of curves and the tangents at each end may make it possible to reliably operate longer cars. Once the type of railroad and equipment are defined, and space is allotted for its construction; the detailed planning of the railroad can commence. Minimum curve radius and minimum turnout number (diverging angle) need to be followed. The basic layout of the track plan is so variable and subject to individual preference that no recommendations are attempted here.

Refer to informative ideas found in the NMRA DATA SHEET D3 series on Trackwork including roadbed, and the D8 series on Operations. Be sure the final track plan allows sufficient space for scenery per NMRA DATA SHEET D2, the Scenery series.

This is where the bench-work engineering starts. Be sure that it is solid and sturdy. All else depends on a solid foundation. Seasoned lumber or high-quality plywood ripped to dimensional lumber sizes should be used throughout and all joints are fastened securely. Some modelers have built metal benchwork to negate the effects of temperature and humidity change. Benchwork is another subject and we shall not elaborate further here.

2.3.2 Trackage Details – Curves, Spirals and Super Elevation

The best condition for flanged wheels is guided between straight and level rails to avoid derailment. Abrupt changes from tangent to curve alignment will cause misalignment of adjoining car ends because of the overhang. Couplers may not line up, diaphragms may be distorted, and cars may be more prone to derailment. Spirals easements are the best way to provide a transition or easement between tangent and curved track as used by the prototype railroads. An offset between the uniform curve radius and the tangent alignment makes it possible to include spiral easements.

Reverse curves are a particular problem and require a length of tangent (straight) track at least the length of the longest car to connect the two opposite spirals and curves. Each of the two curves should include a spiral to transition between the tangent tracks. Templates are a good way to be able to draw uniform curves, spirals and turnouts. Various methods of laying out these easements are found in DATA SHEETS D3b.1 – Curves, Superelevation and Easements, D3b.2 –Spiral Easement Graphs, and D3b.3 – Spiral Easements and Superelevation: Construction. [

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2.3.3 Clearance and Track Centers

NMRA Recommended Practice RP-7 Clearance series specifies necessary dimensions to ensure that all equipment will clear trackside structures and scenic features beside tangent track. End and side overhangs of all equipment will require increased clearances and widened Track Centers between multiple tracks as specified in RP-7.2 and RP-7.3 – Track Centers. Just as curves are eased, additional clearance should be eased the same way. Remember, good track work 'flows' smoothly without abrupt changes in direction or gradient. Most railroads must curve, but experience teaches that curves should be kept as large in radius as the track plan and space available will permit.

2.3.4 Trackage Details Grades and Vertical Curves

Another basic element of model railroad engineering is grades. Lifting the entire weight of the part of the train that is on the incline between different levels of track creates the need for additional drawbar pulling from the locomotive(s). The steeper the grade, the greater the load. Care should be taken to see that changes in grade are joined by a long, eased, vertical curve. Abrupt or jerky changes of grade cause couplers to bind or disengage, or pilots can short across the rails, or wheels lift from the railhead. Smooth flowing track work is still the goal in the vertical plane as well as in the horizontal plane. Curves also increase train resistance. Just like the prototype, a curve laid on a grade will combine into an even greater load resistance, than from either alone. The sharper the curve the more grade reduction compensation needed. NMRA DATA SHEET D1j – Grades and Angles describes the calculations for grades.

2.3.5 Trackage Details, Turnouts

When a single-track branches into two tracks a turnout is created. DATA SHEET D3c – Turnout Types and Terminology Construction details and precise dimensions for turnouts in the different scales are covered in the RP-12 – Turnouts series. Crossing one rail over another is the most critical problem in track construction. Clearance for the wheel flange requires an interruption of the railhead, and this interruption requires the use of Frogs, Guard Rails, and Wing Rails, as described and dimensioned in the RP-13- Guard Rail and Frog Relationship series of Recommended Practices.

Special trackage, such as turnouts from a curve, gauntlets, or crossings, have too much variety to permit treatment here. The prototype only adds turnouts and crossings where absolutely necessary, due to expense and maintenance. They avoid where possible turnouts and crossings in curves. Due to space limitations, modelers sometime install curved turnouts and build crossings in curves, although it is not prototype practice. Just remember that ALL trackage must meet all the requirements specified in the STANDARD S-3 – Trackwork series. Your NMRA Standards Gauge is invaluable in checking track and wheel dimensions as well as coupler height. The Instruction Sheet RP-2 explains how to properly check dimensions with your NMRA Standards Gauge.

Dimension P of Trackwork STANDARDS S-3.1, S-3.2, and S-3.3 defines the closest approach of the open turnout point rail to its adjacent stock rail in order to assure that no electrical or mechanical interference can occur, while encouraging the more prototypical appearance of the minimum gap allowable.

2.3.6 Trackage Details, Rails

Since all elements of trackage are made from sections of rail, the selection of which rail to use becomes important. RP-15.1 – Rail relates the weight of a one-yard length of prototype rail to the height of modeled rail for various modeling scales. This RP allows the modeler to select rail that most closely simulates the prototype rail being modeled. And since various types of trackage must join, the cross section of each particular size rail must conform to certain specifications if it is to

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match and permit the use of common components such as rail joiners and spikes. RP-15.1 Rail also contains rail cross-section specifications. When transitioning from lighter rail on a siding or a customer's spur to the mainline, care must be taken to ensure that the tops of the rails align.

Brass, Steel, and Nickel-Silver are the chief materials used for making rail. Brass is noted for its conductivity and good solderability, while Steel has half the conductivity of brass and only fair solderability. Nickel Silver has only half the conductivity of Steel; but solders even better than Brass. Tractive effort on all three materials will be equal when the railheads are polished and clean, but oxide buildup on Brass and even more so on Steel increases the possible tractive effort on these materials. Nickel-Silver is nearly oxide-free and requires minimum maintenance and cleaning while providing constant tractive effort of locomotives. See TN-9 Wiring for DC and DCC for more information on rail resistance and how to avoid voltage drops.

2.3.7 Trackage Details, Rail Joiners

Through-bolted joint bars like those of the prototype are seldom practical with the smaller rail sizes, so where rails must be joined, rail joiners wrapping around and under the base of the rail. Rail joiners to be effective must fit the rail closely in order to hold adjoining rail ends in close alignment and avoid derailments. Compensation should be made for the extra height of the rail at these joints to prevent a high spot in the track.

Track within curves should be of a continuous radius, excepting the easements into and out of tangent track. Often in track laying, modelers will install rail joiners and solder them so that the rail will have a uniform radius. This is best done with the ends of the rail straight and the inside rail heads in alignment. Once the rail joiner is soldered, the rail(s) can be bent to conform to the curve, maintaining a kink free continuous radius.

One should not rely on soldered rail joiners to supply electrical power from one section of rail to the next. Solder joints can break and the resistance of rail is significant, resulting in voltage drop the further it is from the power station. Refer to TN-9 Wiring for DC and DCC for recommendations on wiring.

One should also consider that track or rail from different sources may vary in cross section dimensions, height, contour and width of the rail head. When possible, one should source all material from one manufacturer. When this is not practical, care should be exercised to ensure that the inside of rail heads are in alignment before soldering. If not soldering, shimming may be necessary to align the rail heads.

Only where excellent stability of both temperature and humidity are maintained is it practical to solder all rail joints. Expansion and contraction of the wood base structure of the model railroad will cause distortion and shifting of track except under very closely controlled climate conditions.

Since few environments can maintain high levels of temperature and humidity control, the addition of expansion joints on tangent track is recommended. Generally, the railhead should have a gap of about 0.020" (0.5mm) on straight sections of track. The NMRA Standards Gauge is a good tool to set this gap since it is constructed of stainless steel 0.020" thick.

Humidity changes have more effect on roadbed and bench-work stability than temperature. We can also control the temperature better than humidity. The season in which we lay track has an influence on the expansion gap size. In the colder months of the year humidity is usually lower. During this time wooden benchwork and roadbed are contracted. In warmer months humidity rises, and the roadbed expands causing a shift in track. However, much of this is dependent on one's local climate. A desert environment will be significantly different than a tropical island. If laying track during periods of high humidity the gap should be greater than in times of low humidity.

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2.3.8 Trackage Details, Track Laying

Model track can be laid in several ways, and many employ spikes, whether made of steel or molded integrally with their ties. While some modelers prefer not to drive the spikes home against the rail, preferring to leave the rail slightly free to move vertically as on the prototype, all spikes and other projections must be kept sufficiently below the railhead to prevent interference with the passage of wheel flanges. Dimension H of the STANDARD S-3 - Trackwork series governs this dimension. Extreme care must be taken in all rail laying operations that the surfaces of the railhead contacting the wheels extend smoothly in fair curves and without projections that will cause derailments. Where two rails join it is important that the radius of the edge of the railhead be maintained on each rail. If not aligned, touchup with a file to remove any projections is often sufficient to correct any issues.

Turnout points require particular attention in this respect since tests show that obstructions in the railhead of only 1% of Track Gauge G per RP-2 – NMRA Standards Gage can cause a strikingly high percentage of derailments.

Flexible track sections with molded-in spikes holding the rail should conform to same standards. Molded ties should be composed of stable, solvent-resistant materials.

2.4 Trackage Conclusion

It is an unfortunate truth that too many model railroads suffer from carelessly engineered and hastily constructed right-of-way and track. The finest model equipment built can perform only as well as the track on which it runs will permit. Time spent in preconstruction engineering together with sound and careful construction will be repaid many times over in satisfaction gained from the trouble-free performance of the models running over it. Remember that track, too, is a model.

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3 Document History

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