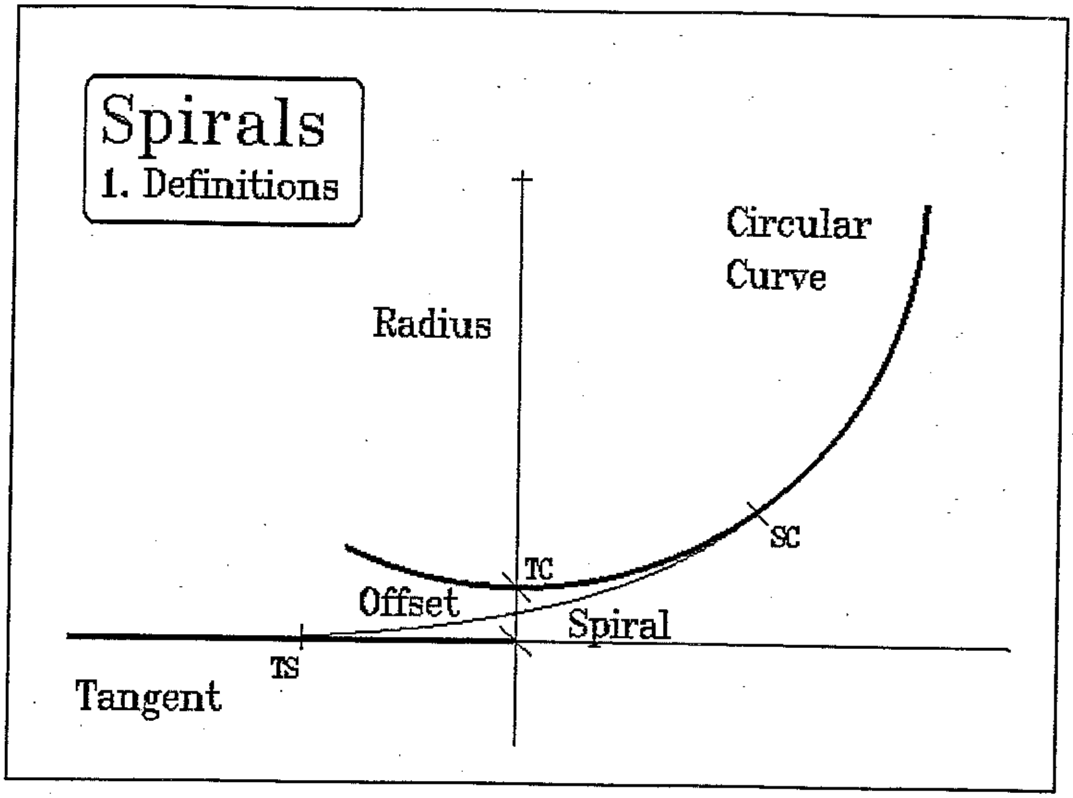

Spiralling into Curves

By Jim Moir

A few years ago I had the opportunity to make a fresh start at model railroading: new cars, engines, and track specs. No compromises, this time—a chance to do it right.

I wanted to run modern equipment, including 90-foot plate G autoracks and big six-axle diesels, and maybe even the odd "railfanning" steamer. Long, heavy trains were a must. Now, I knew that to have fun running this kind of rolling stock, 30" radius curves were a bedrock minimum. And the trackwork would have to be designed and built to a "better-than-zero" derailment standard.

Also, I did not want to be faced with a lot of the complications that result from running long cars and short cars together. It is well known that on entering curves, with adjacent cars of different lengths, the coupler swing can be so large as to cause derailments, especially with body-mounted Kadee couplers.

It is equally well known that using a spiral transition between the tangent (straight) track and the circular curve can reduce these curve problems. A close look at spiral transition curves seemed to be in order.

In particular, I wanted to know: 1) how long a spiral should be for each circular curve radius, for the lengths of various cars, and for combinations of car lengths; and 2) would using a spiral allow a reduction in the circular curve radius?

Surprisingly, the known model railroading literature didn't provide specific answers to these basic questions. I examined John Armstrong's books (e.g., Track Planning for Realistic Operation), the NMRA Data Sheets, and a number of other well known model railroading references including an article about spirals, with templates, in the October 1969 issue of *Model Railroader*. I also looked at a number of the computer bulletin boards that deal with model railroads.

Although there was plenty of information about spirals, there was ambiguity about the ideal spiral length. Suggestions varied from 9" to 30", and although questions about running cars of differing lengths were raised, there were no specific recommendations. Subsequent to the work mentioned here, the NMRA Layout Design SIG has published two articles on spirals (in December 1990, and August 1991). But still, things haven't changed.

So, because I was determined to "do it right," I consulted "real" railroad references, the American Railway Engineering Association (AREA) Manual and the Track Data Handbook, my old surveying text by Davis, Foote and Kelly, and Urquharts's Civil Engineering Handbook. (Once in a while education is useful.)

Why spirals?

Well, just how important or critical are spirals anyway?

As we all know, real railroads use a spiral to ease the acceleration into and out of curves. As a result, passengers and freight have a smoother ride, and the potential for derailments is reduced by turning engine and car trucks gradually.

Model railroads, having much sharper curves than the full-size railroad, enjoy a third advantage: reduction of coupler side-swing mismatch. Kadee #5 couplers have a limited side-swing of about 4 mm each, or 9 mm total between adjacent cars. If the required swing, or mismatch is greater than 9 mm, a derailment is certain.

Armstrong, in Track Planning for Realistic Operation (p. 45), calls this sideswing mismatch the "coefficient of lurch." This coefficient is a maximum where the circular curve meets the tangent. This coefficient can be reduced to zero with a "perfect" spiral.

Even 85' FC container flats sure would look good on the curves, if the end swings didn't mismatch so badly!

There are other advantages that modellers gain by using spirals. With the coupler mismatch reduced, uncoupling points can be placed one to two car lengths closer to the curve. Tracks where switching is done, such as those at yards, industries or passing tracks, will hold one or two more cars.

How about wide curves?

To get the same effect as a spiral, maybe all we need are really wide curves. Let's check that out. This is a straightforward geometry exercise, which relates car wheelbase (truck-center-pin to truck-center-pin), car length (over the coupler pulling faces), and curve radius. I measured eight typical cars and calculated a bedrock minimum radius, based on coupler swing at the tangent-curve point.

TABLE 1.

Car #	Lngth Ft	Kind	Radius Inches
1	26	HMA Ore	6
2	36	HM Ath. hopper	9.3
3	40	XM OVAR Box	12
4	50	XM MDC Box	17
5	55	LO Cov. Hopper	17
6	60	FB Blkhd Flat	26
7	85	FC Contr Flat	49
8	90	XP Hi-cube Box	53

This shows what a waste of space using a large curve would be. The 90' XP car, which can be used on a 30" curve, would need a 53" curve to "replace" a spiral. Even the 60' bulkhead flat would have problems entering a 30" curve.

Although not indicated here, these calculations showed, theoretically at least, that it should be possible to hitch a 90' XP to a 26' HMA and successfully move around a 30" curve. The only problem was getting into the curve from the tangent.

Spirals

The solution to reducing the "cofficient of lurch" or sideswing, is well known. It's the AREA spiral, a curve which has a gradually increasing radius, equal to the circular curve radius at one end and an essentially infinite radius at the tangent end where the spiral is, well, tangent.

There are other characteristics of a spiral easement. One is that the circular curve is "offset" a small amount from the tangent toward the curve center. This makes room for the increasing radius of curvature mentioned earlier. (See Fig 1.)

There are a few bits of "spiral jargon." The point where the spiral meets the tangent is called the point TS. Where the spiral meets the circular curve is SC. The point along the spiral opposite where the curve and the tangent would have met is TC. Note that the spiral passes exactly through a point midway along the offset. This point is called TC.

Another property of a spiral is that it is divided almost exactly in half along its length. One half is on the adjacent tangent while the other extends along the curve. This means that a spiral, in terms of space use, is almost free. The price is the amount of the offset (about 1/2" in HO) or about 2% of curve radius.

A spiral is easy to construct; the problem is surveying it out. Two commom methods used to lay out a spiral are to use a bent stick of the proper "bendiness," or to construct a template based on some calculations. The equations that describe a spiral are straightforward and relatively simple for a computer program to crank through. The main variables are the circular curve radius and the length of spiral. Radius we know, but spiral length?

Spiral Length

The recommended spiral length, for the full-size railroad, *(Turn to Page 12)*

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(From Page 4) depends on the track speed and the equipment, and works out to be in the order of 200 feet, or about 3 car lengths. Needless to say, the AREA Manual doesn't mention limitations due to the coupler swing of Kadee #5's.

Considering the ambiguities in the model practice, and the lack of guidance from the prototype, it was time for me to do some original measurements. The geometries of various spirals were calculated by a computer program, using 200' (27" in HO) as a starting point. Each spiral was plotted on graph paper, which was tacked to a sheet of homasote. Flex track was used to build a length of tangent, the spiral, and a portion of a circular curve. Curve radii from 18" to 36" were used.

The coupler swing of a few dozen cars, in various combinations of length and wheelbase, was measured along this section of track. This data was used to calibrate my computer program, called **E8**.

Perhaps not surprisingly, one form of the good ole' AREA curve was found to satisfy all cases of car length, curve radius, and car-to-car length combinations. Railroad car and track geometry is the same for all scales, so **E8** can be used for all scales.

Questions Answered

The answers to the two questions asked at the top of this article are:

1) The exact length of the spiral depends on curve radius. For derailment-free performance the length of the spiral should be a minimum of about 17" for standard gage HO, with an offset of about 0.44". The coupler "coefficient of lurch" will be zero.

This is suitable for all cars. Because the offset changes only minutely with spiral length, there is no advantage in using a shorter spiral for cars shorter than 90 ft.

The exact length of the spiral also depends on the amount of end-swing mismatch you are willing to accept. For the cars we tested the end-swing mismatch is zero, but for other equipment there may still be some end-swing mismatch. A longer spiral will be necessary to completely eliminate this. For example, if you run steam engines you may wish to experiment with longer spirals to reduce sideswing mismatch between the engine and the tender.

2) With a proper spiral, the minimum curve to run a 90' XP is 30". Without easements, that value is nearly doubled to 53". Also, with spirals, one can, if one wishes, hitch any car to any car, including the 26' HMA/90' XP combo.

A printout from **E8** can be made available to any OVAR member.

Bent Stick Comparisons

For comparison we laid out a few spirals using traditional techniques. We found that spirals constructed using the "bent stick" method, even knowing the correct offset, tend to leave off the first part (for our test "stick", one quarter of the effective length) of the spiral at the tangent end. The consequence of this is that the coupler swing is typically increased by about 2 mm. This seems small until one realizes that it is fully 25% of what's available, and therefore has the effect of limiting the maximum useable car length, and/or train make-up.

When our bent sticks were drawn tighter to get the full spiral length, there was a tendency to pull the spiral in towards the curve center, near the circular curve end of the spiral. This created the same sort of problems as above.

If you want trouble-free, and real, spirals, do it right: use the model-calibrated **E8** AREA spiral.

Use and Construction

During the design stage you can allow room for all of your spirals by adding 1/2" (in HO) to the radius of the curve. This is the value of the offset. The spiral itself is laid out during track laying.

There are lots of ways to lay out track, but I prefer to use templates to do the final layout. So that's how I lay out spirals. I also use the templates to check the position of the rails before the final "infill" spiking.

I make a spiral template in the following way. With a 17"- to 20"-long spiral, some 12" of tangent and a like amount of circular curve, the spiral template is typically 1-1/8 inch wide (or exact tie length) with overall dimensions of about 40" long, and 18" wide. Clearly, for getting into those tight areas, something flexible is needed. May I suggest bristol board? The template is made by plotting the data from **E8** on a piece of graph paper; glueing the graph paper to the board; and cutting along the easement curve.

The template can be used to lay out the track centerline, or the outside "tieline," as you prefer.

One way to use the template is to place the curve end of the template along the circular curve marking. Then rotate the template along the curve until the tangent end of the template is in line with the tangent marking. The point TC, that you marked on your template, should coincide with the point where the circular curve "met" the tangent.

Another way is to place the template along the tangent, with the template TC at the place where the cirucular curve is to start. The circular curve template is then aligned with the spiral template, with the two templates meeting at SC.

Remember to make allowance for the offset. This is done by shifting the center of the circular curve back from the tangent. If the template *won't* line up, i.e. if the spiral won't fit, then the first thing to check is whether enough room was made for the offset (about 1/2").

Adding spirals to existing track is done by making an allowance for the offset. You may have to create that by reducing the radius of curvature by the value of the offset, that 1/2". For example, a radius of 27.5" would be reduced to 27". However, as shown in Table 1, for wide curves, the performance gain will more than offset the loss in minimum radius.

Reverse curves are going to need a bit more room than the previous standard of 12". A reverse curve has two curves joined with a short section of tangent. How short can that tangent be? Half the spiral is along the tangent, or about 8.5" to 9". Two spirals, one for each curve, add up to 17"-18". The shortest tangent that can be between reverse curves, and still meet the standard we set out (any car to any car), is about 18".

Long Trains and Spirals

For those of us who like, or want, to run long trains on steep grades, the use of proper spirals will save us a fortune in smashed cars. Long trains, which need high tractive effort, are subject to pull-off or "stringlining." In its most dramatic form, cars are sent tumbling off the track inward on a curve. An example, three C424's in multiple, pulling 20 cars on a 2.5% grade with a 33" curve, can stringline the first car.

Usually stringlining shows up first as a single axle derailment (outboard axles of each truck), and usually near the end of the curve. This is because at the end of a curve, the coupler sideswing is at its most extreme, and therefore, so is the sidewise force on the car. Again, the use of a proper spiral will greatly reduce the coupler swing and the potential for stringlining.

The benefit of a spiral will show in two ways:

1) You can run longer trains (depending on the existing transition, about 60% longer). If you have, say, 27" curves, using proper spirals may increase the length of the train you can run, from about 15 cars to 24 cars.

2) You can place light cars (hoppers, coil cars) at the head of a long train. This means that you can run those empty HM/HT hoppers, without extra weights.

OK! You have great spirals and you still get stringlining. Now we are into car weights, train make-up and helpers, but that's a subject for another time.