Garden RAILWAYS® MAGAZINE

Understanding track and wheel standards

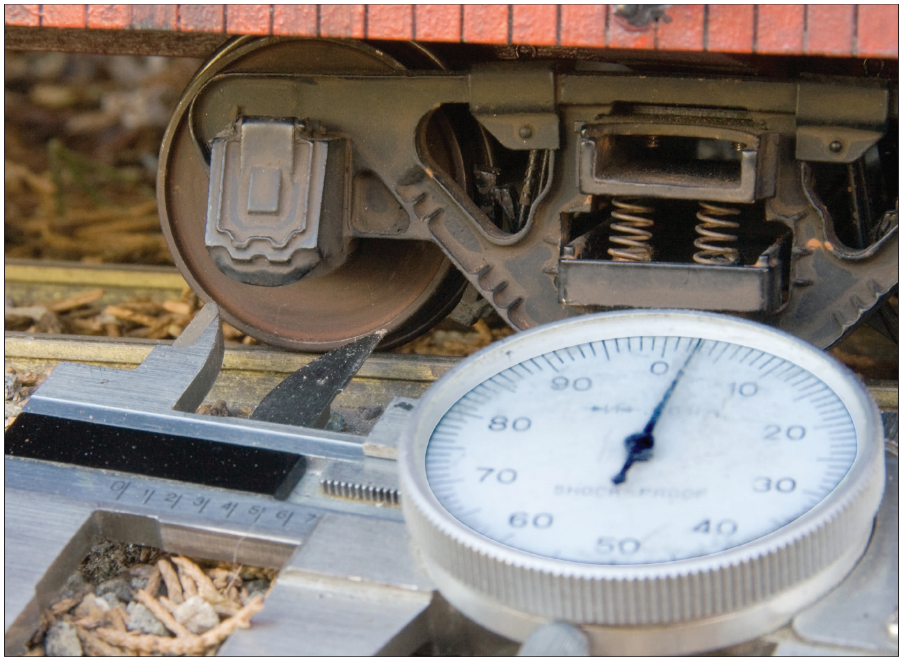
Track and wheel standards: Part 1

There are standards for many of aspects of life, and these are generally good things—they help to make more different things work together easier. For example, when you plug something into the USB port on your computer, standards that govern that interface ensure that what you plug in will work with your computer. One would hope, then, that when you buy a new train to put on your track, there would be standards the manufacturer adheres to that assure what you've bought will run with the rest of the trains in your collection.

There's good news and bad news on that front. The good news is that there *are* standards. The bad news is that there are actually multiple sets of standards, put forth by different model-railroading organizations. Also, manufacturers have long been known to ignore those standards and strike out on their own. In spite of this free-for-all, though, things generally work well together.

There's a strong consumer demand that all our trains run smoothly on the same track, which drives the manufacturers to promote cross-compatibility with others' products (couplers, unfortunately, notwithstanding). By and large, we can run any piece of equipment from any major manufacturer on our railroads without worrying about it derailing. Occasionally, things aren't quite right and wheels go "bump" through a switch, or something similar. That's where modelers can take advantage of the various published standards to help them troubleshoot and resolve the problem.

When you read a locomotive review in *GR*, you'll usually read something like "wheels meet NMRA and G1MRA standards" or "back-to-back spacing is narrower than standard." That means we've checked measurements on the wheels of a product and compared them to published standards. If there's anything grossly out of line with those standards, it could lead to difficulties in running on our railroads. If they meet the standards, there's a high probability they'll run fine, provided the track also meets the standards and doesn't have extreme twists or bumps that would cause issues.



Without some kind of standards for wheels and track, our models would not run reliably. Manufacturers don't always adhere to published standards so it's incumbent upon the modeler to learn the proper relationships between wheel and rail in order to remedy problems as they arise. PHOTOS AND ILLUSTRATIONS BY THE AUTHOR

Standards online

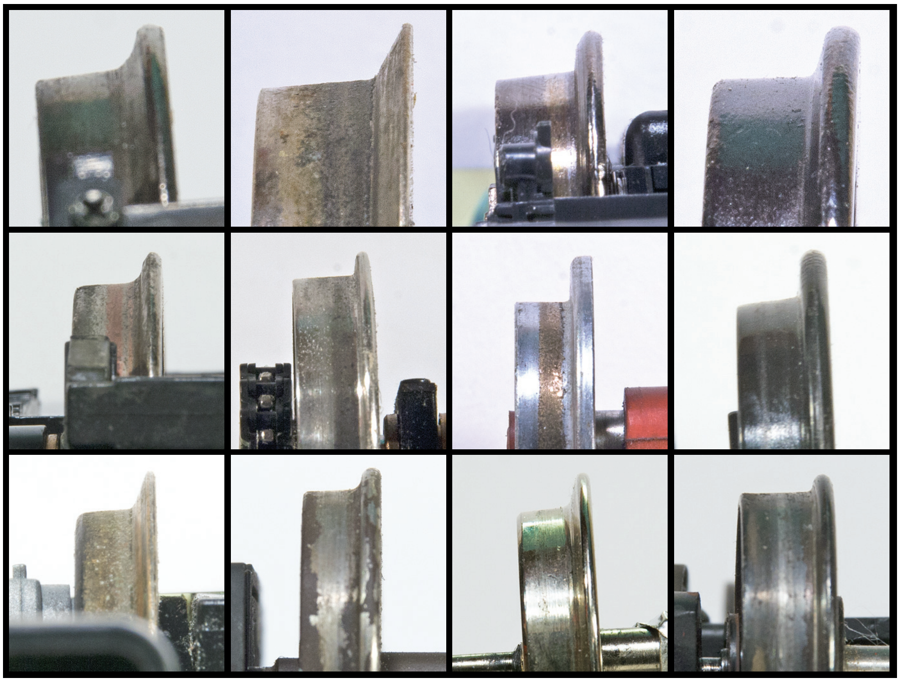
G1MRA: *http://www.g1mra.com/pdf/standard-dimensions-for-gauge1.pdf*
NMRA: *http://www.nmra.org/index-nmra-standards-and-recommended-practices*
(Standards S-3.2, S-3.3, S-4.2, and S-4.3 are the wheel-and-track standards.)

Different standards organizations

The NMRA (National Model Railroad Association) is the organization that covers model railroading in North America. They write standards for many aspects of model railroading in all scales. Despite that, the NMRA has never been much of an influence on large scale and, until just a few years ago, didn't really have cohesive, easy-to-understand standards that covered large scale. G1MRA (pronounced GIM-rah), the Gauge 1 Model Railway Association, is a UK-based organization centered specifically around trains running on 45mm track, with a pronounced emphasis on standard-gauge trains in 1:32 and 10mm (1:30.5) scales. G1MRA has been the dominant force in large scale, though not all aspects of their standards are adhered to (most commonly, those related to wheel flanges). I'll limit my discussion to G1MRA and NMRA standards, since they're similar and more in line with the vast majority of commercial products we operate.

NMRA's standards

Starting in 2007, I had the pleasure of working with the NMRA on developing their current standards for large scale. The standards were finally published in early 2010, so it was a fairly lengthy process from start to finish. When we began that process, we took the perspective that the standards had to be scale-neutral. The cornerstone of large-scale railroading in



1. Flanges come in all different sizes; even the same manufacturer may have differing wheel profiles. A sampling of flanges, from upper left to lower right: Accucraft passenger car, Aristo-Craft Eggliner, Aristo-Craft PCC car, Bachmann Big Hauler, Bachmann Spectrum, Berlyn, LGB locomotive, LGB boxcar, Piko, Sierra Valley, USA Trains, Rich Yoder Models.

2. The clearance on switches varies greatly, depending on the manufacturer. Above, a Piko switch has fairly wide flangeways, measuring 0.142" (wider than "standard"). Below, a Sunset Valley switch flangeway measures 0.113", which is within G1MRA and NMRA standards.

Table 1—Track and wheel standards

	NMRA target	NMRA range	G1MRA target	G1MRA range
TRACK				
Track gauge	1.772"	1.766"-1.782"	1.772"	1.752"-1.772"[1]
Check gauge	1.652"	1.648"-1.662"	1.654"	1.654"-1.674"
Span	1.537"	1.535"-1.555"	1.555" max	1.555" max
Flangeway	0.116"	0.091"-0.118"	0.120"	0.100-0.120"
WHEELS				
Back to back[2]	1.575"	1.560"-1.594"	1.574"	1.574"-1.594"
Check gauge	1.633"	1.619"-1.648"	1.634"	1.614"-1.634"
Flange depth[3]				
(NMRA "Deep Flange")	0.118" max	0.118" max	0.079" max	0.079" max
(NMRA "Standard")	0.066" max	0.066" max		
Flange width[3]				
(NMRA "Deep Flange")	0.074"	0.060"-0.076"	0.060"	0.040"-0.060"
(NMRA "Standard")	0.059"	0.041"-0.061"		
Wheel width[4]				
	No target	0.236"-0.271"	0.236"	0.216"-0.236"

Footnotes

1. G1MRA gauge may expand to 1.792" on tight curves.
2. NMRA standards allow for a narrower back-to-back dimension than G1MRA to accommodate thicker flanges. The NMRA's minimum back-to-back measurement still exceeds the maximum allowable span on the track.
3. The NMRA's values for flange depth and width are different for their "Standard" and "Deep Flange" standards, so both values are presented.
4. The NMRA's values are set so that a scale wheel width can be modeled, depending on the scale of the model being built. G1MRA's standards are based on the models being 1:32 (or thereabout) scale, thus the width represents a scale wheel width only at that scale.

North America is the ability for folks to run multiple scales on the same track. Some people mix and match, some run one scale one day and another the next. Either way, all of the scales have to run reliably on the same track. Fortunately, the standards are quite focused, covering only two aspects—the track and the wheels that roll on it. That means these standards can be largely independent of the scale of the model.

One of the most frequent questions I got from folks when working on the NMRA's standards was, "Why not just adopt G1MRA's standards?" Logically, that made sense. That organization has been around for decades and adopting theirs would save the trouble of having two sets of standards. That's pretty much where we ended up, with a few differences, mostly concerning wheel flanges.

That departure was in response to manufacturer feedback. I mentioned above that manufacturers were prone to doing their own thing. The sentiment they expressed was that their customers demanded "deep" flanges so their trains would stay on the track. Garden railroads are often built on less-than-solid foundations, so twists and bumps in the track

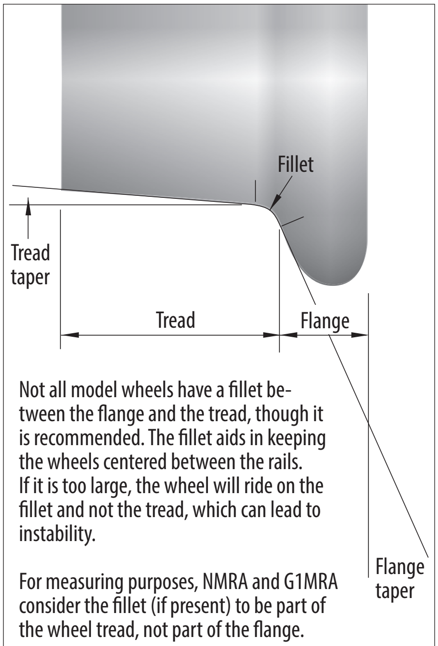
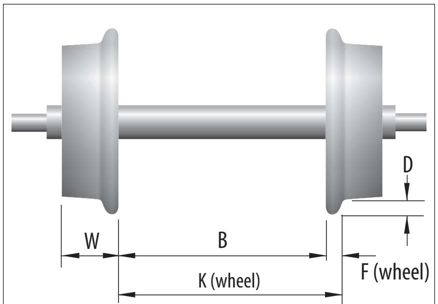
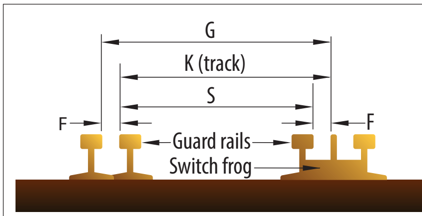


Figure 1
Wheel-profile components



B. Back-to-back
K. Check gauge (wheel)
F. Flange width (wheel)
D. Flange depth
W. Wheel Width

Figure 2
Critical wheel measurements



G. Gauge
K (track). Check gauge (track)
S. Span
F (track). Flangeway width

Figure 3—Track measurements

aren't uncommon. Deep flanges do help trains navigate uneven track.

There's a great deal of variation in flange depth in products on the market today, as can be seen in **photo 1**. We felt that flanges didn't need to be quite as deep as some manufacturers were producing but we could certainly allow for slightly deeper flanges than those the G1MRA standards suggested, especially if it increased the chance of manufacturer buy-in to using the standards. (After all, that's the goal of standards.)

Wheels and track

Let me back up a bit and define what, specifically, these standards cover and how they're measured. The standards cover wheels and track. With the wheels, the standards cover wheel width, flange width, flange depth, back-to-back spacing, and "check gauge" (**figure 1**). The check gauge is the back-to-back spacing plus the width of one flange. **Figure 2** shows the various components of the wheel profile.

With track, the standards cover the gauge of the track (the distance between the rails as measured from the inside edges) as well as key components of a switch, which is where most wheel/track conflicts arise.

With switches, there's gauge, span, flangeway width, and check gauge (**figure 3**). In this case, the check gauge for the track is the span plus the flangeway width. Switches are a common cause of derailments on the railroad so having consistency there is a big step toward establishing reliable operation in the garden (**photo 2**). In the next issue, I'll look at common conflicts between wheels and track and how to correct them, based on these standards (but I'm getting ahead of myself).

The standards consist of a "target value," which is the measurement the manufacturer or modeler should try to hit unless there are extenuating circumstances. Then, there is a "tolerance" to that value. In the case of the G1MRA standards, the target value is at one end, and the tolerance is either above or below that value. With the NMRA standards, the target is between a "plus" and "minus" tolerance. This is often "asymmetrical" so the plus and minus values might be different. A comparison of G1MRA and NMRA standards and range can be found in **Table 1**. While the table shows that they are not exactly identical, there is seldom a variation of more than a few thousandths of an inch between the two. In our scale, a difference of .005" is usually nothing to worry about.

Both G1MRA and NMRA have multiple levels of standards. G1MRA has their "Standard" standards and their "Fine Scale" standards. The latter are—as the name suggests—standards that result in wheels and track that are very close to prototypical appearance. Standards such as these are, for all practical purposes, difficult (to put it mildly) to use outdoors. The NMRA actually has three levels: "Deep Flange," "Standard," and "Proto." Like G1MRA's "Fine Scale" standards, the NMRA's "Proto" standards are designed to give a scale, prototypical appearance to wheels and track. For NMRA's large-scale standards, the "Standard" and "Deep Flange" measurements are largely identical, the principle difference being that the flange width and depth on the "Deep Flange" standards are greater than on G1MRA's "Standard" standards. The NMRA's "standard" flange depths are also shallower than G1MRA's "standard" flange depths.

The biggest concern I hear when standards are brought up centers around products that do not meet the standards. There's a fear that, if manufacturers adopt these standards, their older, non-compliant trains will no longer run reliably. In practical terms, that's not a big concern. Manufacturers have been not adhering to standards (besides their own) for 40+ years, running on track that *does* adhere to these standards. Just because there are standards doesn't mean that manufacturers are going to shift gears and comply. Some have gotten much better over the years, while others are still set in their ways. We're always going to have a wide range. What can you do when things go "bump?" That will be covered in the next issue.

KEVIN STRONG

Track and wheel standards: Part 2

Tuscarora Railroad Nº 3 nears an industrial spur in the town of Blacklog. Switches are an inevitable part of most model railroads. Proper relationships between wheels and track will ensure smooth operation over them. PHOTO AND ILLUSTRATIONS BY THE AUTHOR

Last issue, I discussed what track and wheel standards are. This time, I'm going to look at why we have them and how they help us achieve smooth-running operation in the garden. Without standards, things have a greater chance of not operating well together. If you've ever bought a cheap battery-powered toy train that is supposedly gauge 1, then tried to run it in the garden, you've likely discovered what happens when things aren't built to any kind of standard. Trains bounce through switches and tend not to stay on the track as well as our other trains. That's where standards come in. Standards provide a benchmark against which to compare our wheels and track so we can better diagnose and, we hope, correct problems as they arise.

What can go wrong? Lots, actually. That things don't go wrong more often sometimes makes me wonder why. There are many aspects of reliable operation that rely on close relationships between the wheels and rails. Let's start by looking at the most obvious aspect, gauge.

Gauge

The gauge of the track is simply the distance between the two rails, measured from the inside edges (**figure 1**). The NMRA and G1MRA standards have the target of the gauge we commonly use (gauge 1) set at 45mm (1.772"). Both organizations' standards allow for tolerances but the combined range is only from 1.752" to 1.882". Much wider than that, and the wheels risk falling between the rails; much tighter than that, and the wheels won't fit between the rails.

Wheels, too, have a gauge. This is where things get a bit murky, however, and you have to look at the wheel profile and do a little bit of math. Surprisingly, there is no "standard" for the gauge of the wheels. The gauge of the wheels is a calculated value derived by adding the thickness of both flanges to the back-to-back spacing, which do have set standards (**figure 2**).

As long as the wheel gauge is less than the track gauge, you're good, right? Not necessarily. If wheels are gauged too narrow, they could fall between the rails, even if the rails are in gauge.

There are a few factors that control whether or not wheels will fall between the rails. First, there's the thickness of the wheel itself. Standards allow for thicknesses from .236" to .271", and there are wheels that are outside of those norms. A thin wheel will be quicker to fall between the rails if the wheel gauge is narrow or the track gauge is wide (**figure 3**). Back-to-back spacing is also critical to properly gauged wheels. On properly-gauged track, a wheel with a back-to-back within standards should not fall between the rails, even if the wheels are on the thin end of

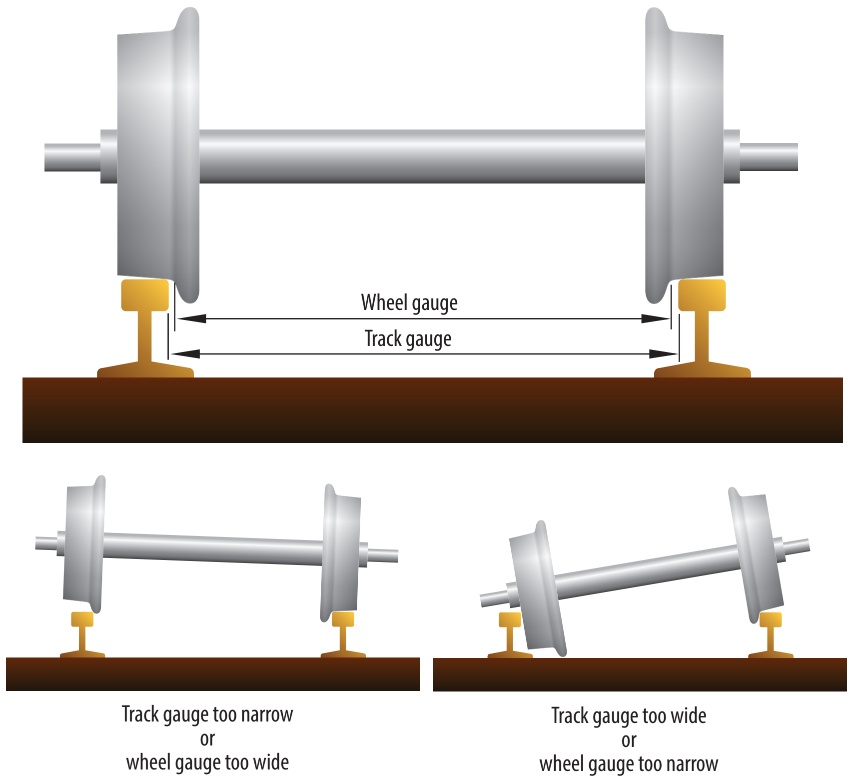


Figure 1—Track and wheel gauge

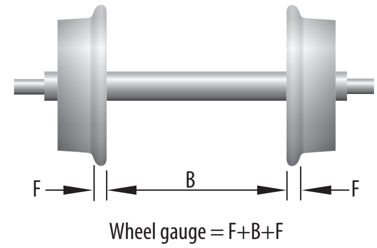
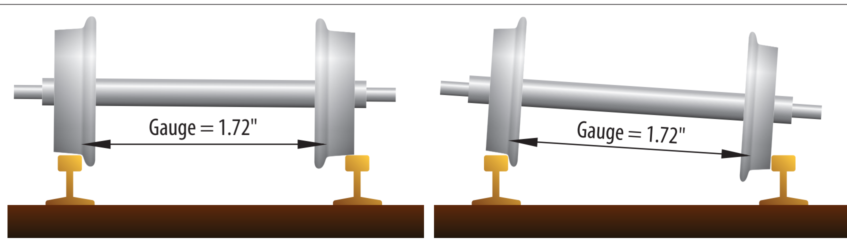
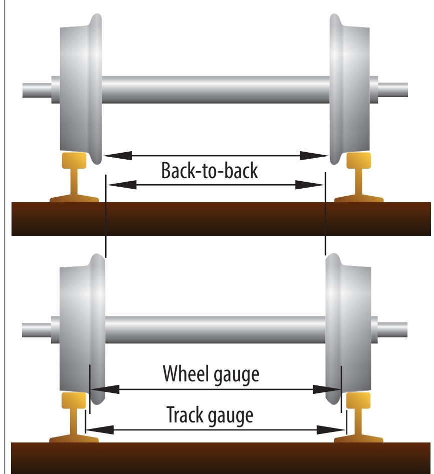


Figure 2—Wheel gauge



Thicker wheels (left) offer more "meat" on the tread, allowing the wheels to stay on top of the rails better in the event that the gauge of the track was to become wider than it should be.

Figure 3—Thick vs. thin wheels on too-wide track



When adjusting the back-to-back spacing of a wheel, you need to take into consideration the thickness of the flange. Wheels with thicker flanges may need back-to-back spacings to be on the narrow side of the standard.

Figure 4
Back-to-back spacing and flange thickness

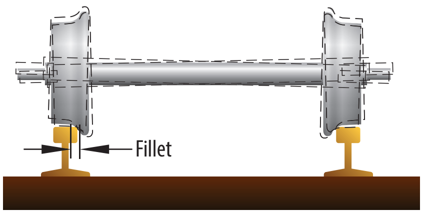
the spectrum. Acceptable ranges for the back-to-back dimension range from 1.560" to 1.594", with a recommended target at 1.575". There's more that affects this measurement, but I'll get to that later.

Why is there a range for back-to-back spacing? First, there's the aforementioned wheel thickness. Thin wheels may require a wider back-to-back dimension so they don't fall between the rails. There's also the flange thickness to take into consideration, which can vary greatly. If a wheel has particularly thick flanges, the back-to-back spacing needs to be narrowed so that the gauge of the wheel remains less than the gauge of the track (**figure 4**).

But that's still not "it" when it comes to wheels. While not a set standard, it's recommended that manufacturers put a small fillet (a rounded transition section) between the wheel tread and the flange. This helps keep the wheel between the rails and helps keep the flange from rubbing against the railhead. Typically, this fillet is quite small—on the order of .020" to .030". Every now and then, a manufacturer will get a bit exuberant with regard to the fillet. When this happens, even though the wheels are in gauge, there may be tracking issues because the wheel is riding on the fillet instead of the tread (**figure 5**). This can lead to unstable rocking and the train occasionally climbing the rails.

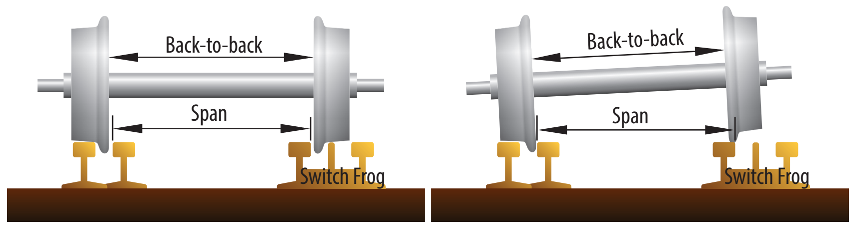
Switches

Nowhere are the relationships between wheel and rail more critical than at switches. Guard rails on a switch are there for a reason and they work best when everything is properly spaced. There are two critical pairs of dimensions when it comes to switches: the "span" of the switch (1.555" maximum) and the back-to-back spacing of the wheels (1.560" minimum—**figure 6**). If the span is wider than the back-to-back



If the fillet (radius between the flange and the tread) is too large, the wheel may ride on the fillet instead of the tread, leading to wobbling as the wheel rolls down the track. The wheel may be in gauge, but the oversized fillet results in uneven running.

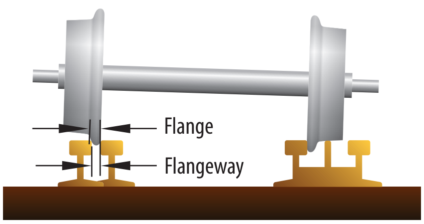
Figure 5—Oversized fillet



When the back-to-back dimension is greater than the span, wheels roll through the guard rails without problems.

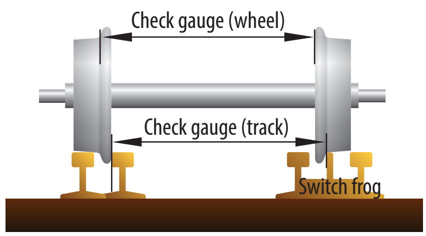
If the back-to-back dimension is less than span, wheels will climb up over the guard rails.

Figure 6—Span and back-to-back



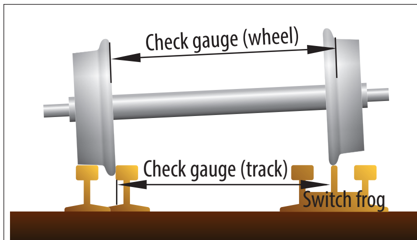
The flangeway must be wider than the thickness of the flange or the wheel will ride up between the rail and the guard rail.

Figure 7
Flange and flangeway clearance



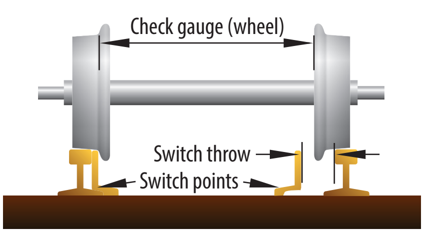
When the wheel check gauge is less than the track check gauge, the guard rail can do its job of keeping the flange away from the tip of the frog, ensuring the wheel heads the correct way through the switch.

Figure 8—Check gauge



If the wheel check gauge is greater than the track check gauge, then the flange of the wheel can hit the tip of the frog, leading to a derailment as the wheel may want to head down the wrong side of the switch.

Figure 9
Improper check gauge as a cause for derailments



The throw of the switch (the distance the points move from one side to the other) must be sufficient to provide enough clearance for the wheels to pass through without hitting the ends of the points.

Figure 10
Clearance at points of a switch

of the wheels, the wheels will ride up over the guard rails. It's rare that the span on the switch is too wide. When this occurs, it usually means the flangeways are too narrow. If the flangeways are too narrow, there's also the chance that the flanges won't fit (**figure 7**).

The other critical dimensional pairing is the "check gauge" of both the wheels and the switch (**figure 8**). On the switch, the check gauge is the distance from the tip of the point of the frog to the outside edge of the outer guard rail (1.648"-1.674"). That outer guard rail has one job—to keep the flange of the opposite wheel from hitting the tip of the frog or, worse, heading the wrong way. The wheels' check gauge is the back-to-back dimension plus the width of one flange (1.614"-1.648"). We often talk about the back-to-back spacing being the key dimension with our wheels, but the check gauge is really the driving dimension that allows smooth operation through switches, because it takes the flange width into consideration. The flanges on our models vary a lot, so adjusting the back-to-back so that it meets the standard isn't enough. The ranges exist to allow both back-to-back and check-gauge standards to be met.

The check gauge of the switch must be equal to or greater than that of the wheel. If the check gauge of the switch is too narrow, the guard rail can't do its job of keeping the flange from hitting the frog, but it needs help from the wheels, too. If the check gauge of the wheels is too wide, the guard rail also can't do its job (**figure 9**).

The check-gauge measurement also comes into play at the points of the switch, though in kind of an opposite application (**figure 10**). Here, the measurement from the stock rail to the point on the opposite side must be narrower than the check gauge of the wheel, so the wheel flange doesn't bump against the

Online extras

Learn more about scale and gauge by downloading our free chart. Go to *www. GardenRailways. com* and type "scale and gauge" in the search box.

open point. It's rare that this poses an issue, as most commercial switches have more than enough throw, but it's an important consideration for those who are handlaying their own switches.

You might also notice things going "bump" at the frog of a switch, even though everything checks out with regard to the wheels and track. One measurement that is often not discussed is the flangeway depth. This is the "floor" of the switch frog, if you will (**figure 11**). If this is shallower than the depth of the flange on the wheel, the wheel will ride up on the flange and bump upward as it passes. If the flangeway is deeper, there's a possibility the wheel may dip as it passes through the open area of the frog, just before getting to the point.

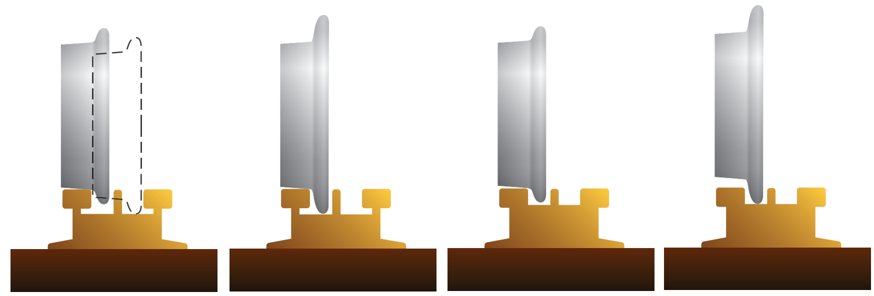


Figure 11—Flange and flangeway depth

Knowing what to look for and why things go "bump" on your track is half the battle. Fixing the problem is the next step. Wheels can be regauged and switches can be shimmed. That's easy to write on the page; it's not so clear-cut when you have a model or switch sitting on your workbench that needs to be adjusted. Next time, I'll talk about how to fix these issues, some of the hang-ups that turn a simple task into a nightmare, and one or two problems for which the only viable solution is, unfortunately, to live with it.

GARDEN RAILWAY BASICS

Track and wheel standards: Part 3

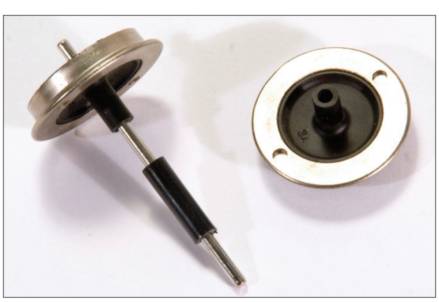
An East Broad Top Railroad 2-8-0 crosses the east switch at Blacklog as it prepares to return to Orbisonia. Switches are almost inevitable on any railroad and it's important to make sure our trains operate smoothly through them. That requires careful attention to the wheels and track to make sure things work well together. PHOTOS AND DRAWINGS BY THE AUTHOR

In the past two installments of this series (June and August issues) I discussed a lot of theory—the "whats" and "whys" of standards and how wheels interact with the rails upon which they ride. With that knowledge, you can troubleshoot the reasons why your trains are not staying on the track. However, diagnosing the problem is only half the battle. The other half is fixing the issue. Sometimes that's easy, sometimes it's not so easy, and sometimes you simply can't do a thing about it.

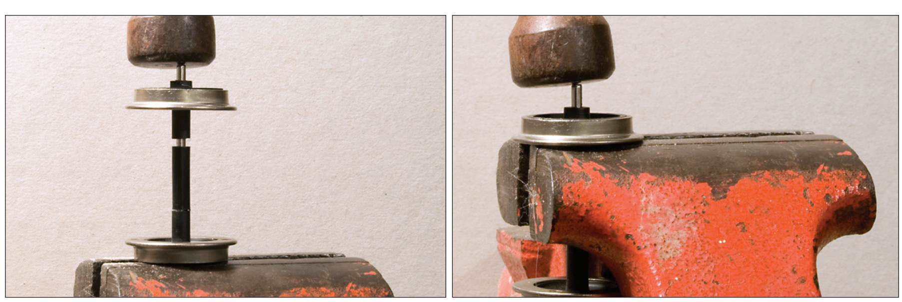
Wheel problems

The most common issue pertaining to derailments is out-of-gauge wheels. (Wheel gauge can be measured with an inexpensive digital caliper from places like Harbor Freight.) Whether the wheelsets are too wide or too narrow, the only way to fix this issue is to physically move the wheels on the axles. In the case of many commercial wheelsets, the wheels are simply pressed onto an axle (**photo 1**). Correcting the gauge of these is a simple matter of adjusting the position of the wheel. The easiest way to do this is with a vise and a hammer or rubber mallet (**photo 2**). You might also be able to repurpose a gear puller or wheel press if you have one lying around. Sometimes the wheel may include a plastic sleeve over half of the axle, which might need to be cut back in order to achieve the proper gauge (**photo 3**).

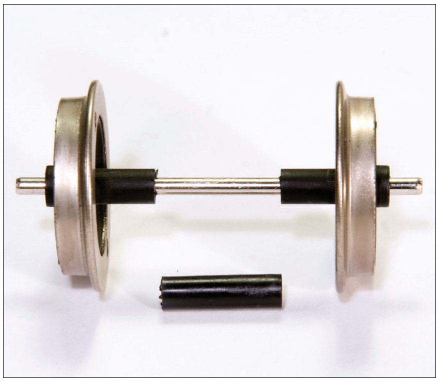
You'll occasionally find an axle with shoulders machined onto the ends to keep the wheels in gauge. One would hope this assembly would be accurately gauged but



1. Many large-scale plastic wheels are simply pressed onto steel axles, which makes adjusting the gauge fairly simple.

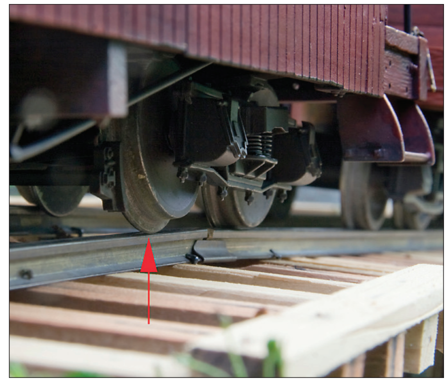


2. While there may be more elegant ways of adjusting the gauge of your wheels, a hammer and a vise provide a rudimentary-yet-effective means of doing so. On the left, tapping the end of the axle will result in the gauge being narrowed. On the right, the gauge will be widened.

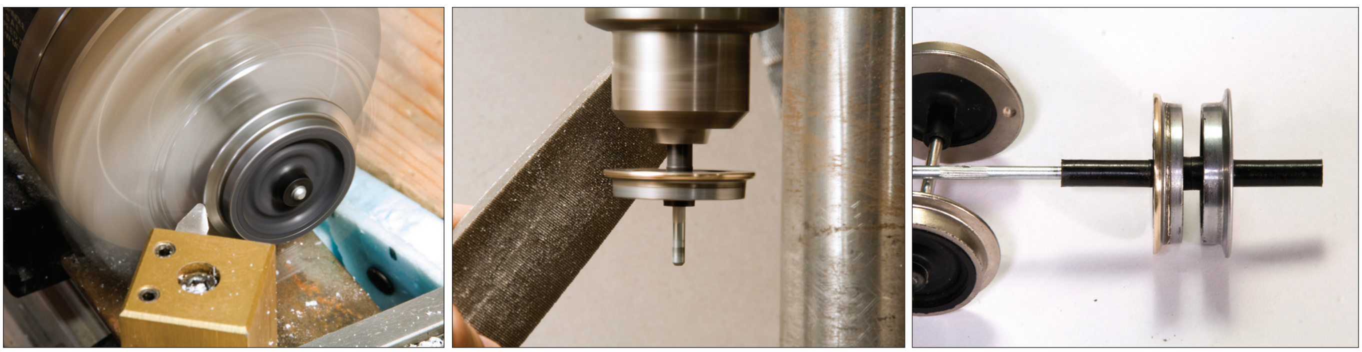


3. Some wheels have plastic sleeves on the axles that may keep you from narrowing the gauge. This sleeve may have to be cut back or removed altogether.

4. Some axles have shoulders machined onto them to set the gauge of the wheels. If the gauge proves to be too narrow, it's easy to add a thin washer between the wheel and the shoulder to widen the gauge. Narrowing the gauge requires removing material from the back of the wheel.



5. Shallow flanges tend to ride up and over the rails on uneven track if the trucks are too rigid. The fix for this is to use softer springs (if possible), replace the wheels with ones that have larger flanges, or fix the track so it's more even.



6. If you need to alter the profile of your wheels, nothing beats a lathe as the tool of choice (left). However, many people don't have lathes in their workshops. A drill press (center) makes a pretty good substitute. It's not as accurate but, in most cases, you can do a decent job of turning down the flanges. The end result is shown on the right. The left wheel has been turned down; the right is original.

there may be reasons for the need to adjust it. If the shoulders are too close together and the gauge is too narrow, you can simply pull the wheels out a bit, perhaps using a thin washer as a spacer between the back of the wheel and the shoulder (**photo 4**). If the shoulders are too far apart, it might be possible to remove some material from the back of the wheel or file the shoulder back so the wheels can be pressed on a little closer together. In a worst-case scenario, you can always replace the axle with another that has no shoulders, and gauge the wheels accordingly.

Wheels on locomotives (particularly the driven wheels) are usually not as simple to regauge. If a locomotive's wheels are gauged improperly, you'll need to examine how it's assembled to determine how to correct the gauge. It may not be possible—at least not easily. There are too many variations in assembly to go

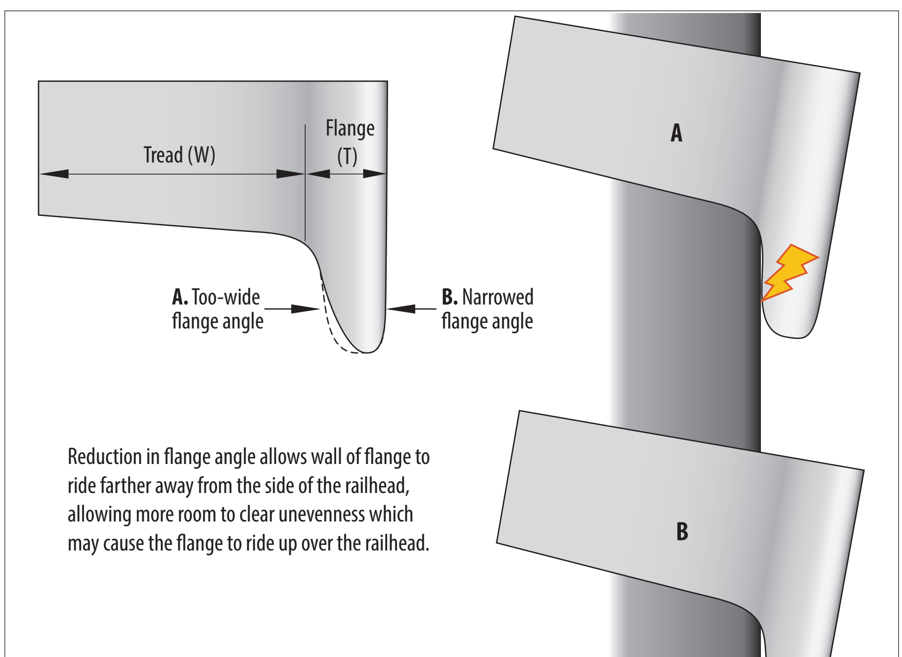
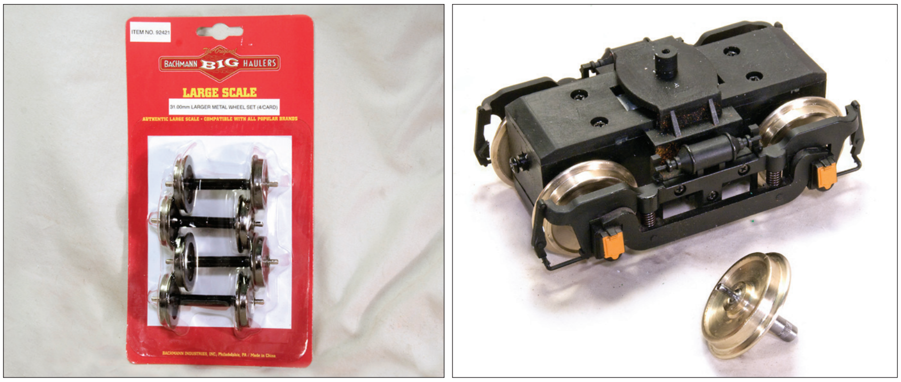


Figure 1—Flange shape



7. Replacement wheels for rolling stock are relatively easy to come by in a variety of diameters and materials (left). Replacements for locomotives are harder to find (right). These are from Northwest ShortLine, made for USA Trains and Aristo-Craft diesels.

8. Sometimes, the gauge of your track will be too wide or narrow as a result of damage or other environmental factors. Here, the author used a copper gauge bar to hold kinked rails in gauge. If you're using track power, you'll need to use an insulator between the gauge bar and the rail, or use plastic or other non-conductive material for the bar itself.

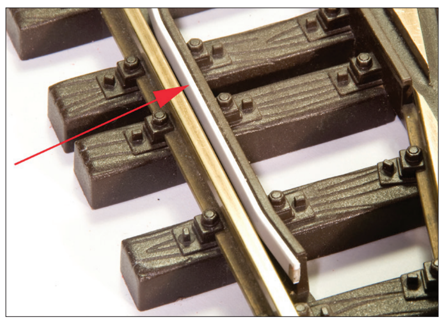
Loose spikes in wood ties or lots of play between the rail and the cast-on spike detail on plastic tie strips may lead to trains "spreading the rails" as the weight of the train forces the rail outward.

Figure 2—Spreading the rails

through each one in this column. If you find the wheel gauge of your locomotive to be problematic, your best bet would be to search the various large-scale forums on the Internet for a solution (if one exists). Gauge issues on locomotives aren't common but there are a few "usual offenders" and common fixes for them.

Sometimes, wheels can be in gauge and you can still have trouble with them. Usually the root cause of this lies in the profile of the wheel itself. One thing to look at is the shape of the flange. As discussed in part 1 of this series (June 2015), flanges come in a variety of shapes and sizes. Most of them work well but occasionally you'll find one that causes problems. Shallow flanges will cause problems if the track is too uneven; the solution there lies in making the track more even (**photo 5**). Sometimes it's not the depth of the flange but the shape of it that causes problems (**figure 1**). And, as I mentioned last time, an oversized fillet between flange and tread may cause the locomotive to rock on the rails.

The only real way to deal with problems with wheel profile is to change the profile. You don't need a lathe to change the profile of a wheel, although that's the "right tool for the job." In a pinch, you can mount the wheel in a drill press (**photo 6**). This presumes that you remove the wheel and mount it on a mandrel of some sort for proper turning, which is often easier said than done. If you can't change the profile of the wheel, you may be able to find replacement wheels. Wheels for rolling stock are pretty easy to come by (**photo 7**); replacement wheels for locomotives are much less common.



9. If the flangeway between the stock rail and guard rail is too wide, a shim can be added to the guard rail to narrow the gap.

Track difficulties

Of course, wheels are only half of the equation. The track may present issues of its own. The first problem that comes to mind is the gauge of the track itself. One would think that commercial track would be properly gauged, and, by and large, it is. However, there may be circumstances that cause the track to become out of gauge. As ties age, the gauge of the track can change. If you've hand-laid your track on wood ties, you may find the ties rotting after a while, and the spikes loosening, which may cause the gauge to expand as the weight of the trains spread the rails. (This happens on the prototype, too!)

If the ties are made of plastic, the sun's ultra-violet rays may cause them to become brittle and not hold the rails as tightly as they did originally. Also, if the molded-in spike heads are a little bit loose at the base of the rail, the rail may rock outward under the weight of a train (**figure 2**). The most obvious fix would be to replace the ties (that's what the prototype does). The prototype also uses "gauge bars"—metal bars that hold the rails in gauge. You can fashion gauge bars for the garden as well. If you're not running track power, you can use metal (**photo 8**). Otherwise, you could use a rigid plastic or maybe a strip of PC board.

Most track issues occur at switches, particularly around the frogs. The most common ailment of a switch is a flangeway that's too wide, causing the wheel to pick the tip of the frog. A narrow shim of styrene can sometimes be added to the guard rail to narrow this gap, thus increasing the check gauge and pulling the wheel away from the frog (**photo 9**). If the flangeway is too narrow, the wheel flange will be pinched as the wheel passes through. In this case, you can remove material from the guard rail to allow the wheel to pass through (**photo 10**).

It's also possible that the "span" of the switch (distance between the outside edges of the guard rails) is greater than the back-to-back spacing of the wheels. Most often, this is because the back-to-back spacing of the wheel is too narrow, and the wheel gauge needs to be widened. It's uncommon to find a span that's too

10. If the flangeway between the stock rail and the guard rail is too narrow, a little sanding can create more clearance.

11. You may find that the back-to-back spacing of some of your equipment cannot be altered but is less than the span between the guard rails on your switches. You can remove a little material from the guard rail next to the frog in that case.

12. If your wheels have deep flanges or your switches have shallow flangeways, you may find it necessary to deepen the flangeway on the frog. A little sandpaper or a grinding wheel in your Dremel tool makes it so things don't go "bump" as often.

wide on a switch but, if you do and the flangeway on the outside of the switch is correct, you can remove material from the wing rail on the frog to narrow the span to the proper distance (**photo 11**).

It's likely that your trains' wheels will bump a little as they run over the frog. Most commercial switches are designed with "flange bearing" frogs, meaning they're made so that the flanges ride on the floor of the flangeway so the wheels don't "bump" as they cross the gap in the frog rails. For that to work consistently, all the flanges need to be identical. That's unlikely, so you'll have to tolerate some bumping. If you find the flangeway depth too shallow, you can deepen it by sanding the floor a little (**photo 12**).

There may always be that one piece of equipment in your roster that, no matter how "perfect" the wheels and track are, will give you fits. However, if you know the "whats" and "whys" of the published standards, and can fix your errant wheels so that they meet these standards, you will go a long way toward eliminating the vast majority of derailments.