Safety Wiring of Railroad Fasteners

By ERIC WILDE

This article discusses the safety wiring practices that are used to secure fasteners in those areas of the railway car that are exposed to high vibration. Typically, all of the fasteners used to secure the various components of the trucks are safety wired, for example. Engine and generator components may also be safety wired to ensure reliable operation at all times.

Because of the high amounts of vibration that are experienced in some areas of a railway car and in order to prevent failures of fasteners that could prove catastrophic, due to their critical nature, safety wiring is applied to these fasteners to give an added measure of failure proofing.

In brief, safety wiring consists of a piece of wire which is passed through a hole drilled in a bolt head or nut and fastened to a secure object (e.g. another hole drilled in the part to which the bolt is applied) or another fastener in such a manner to cause tightening of the safety wire if the bolt or nut attempts to work itself loose under virbration.

There are two basic methods used in safety wiring: the single wire method; and the double twist method. Figures 1 and 2 show the difference. The double twist method is preferred in most cases and if it is at all practical to apply. The single wire method is usually reserved for wiring closely spaced fasteners (in this case, closely spaced means less than 2" apart) in configurations where it is impractical to apply the twist to the two wires employed in the double twist method. A circle of closely spaced bolts that are all to be safety wired might be a candidate for the single wire method, for example.

In the old days, soft steel wire was often used for safety wiring but rust can take its toll on this kind of safety wiring. It is not uncommon to find such wiring rusted away to the point where it is no longer holding anything (fortunately, in these cases, the rust has usually welded the fastener in to the point where it isn't coming out, regardless of the condition of the safety wire).

Nowadays, the most common applications of safety wiring are found in the aircraft and high-performance auto/motorcycle racing fields where the safety wire of choice is 302/304 annealed stainless steel wire in various sizes.

Fortunately for us, the type of wire used in the aerospace and automotive fields is adaptable to our needs and the 302/304 wire even nicely solves the corrosion problems experienced with the older types of wire.

Drilling Bolt Heads and Nuts

In order to apply safety wire, the fasteners must be drilled with holes that allow the wire to pass all the way through them. Sometimes such fasteners are available off the shelf but typically one has to drill them oneself.

Often, the types of fasteners to be secured with safety wire are hardened and drilling them is no picnic. Most often, cobalt drill bits are used for this application. If the smaller size safety wire is to be used, it is highly likely that broken bits will result. A package of ten or a dozen bits should be purchased at one time. With the larger size safety wire, breakage is not an issue but dulling still is. If you do not have the means to sharpen these bits (e.g. a diamond wheel in a Drill Doctor™), you should buy several as well.

Use plenty of cutting oil so that the bit stays well lubricated. In a pinch, I've heard reports that white lithium grease works too. Take your

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time and try not to overheat the bit (although cutting oil smokes when it is working). Be careful to drill straight so as not to break the bit. A vise and a drill press is very helpful.

A jig is available for drilling nuts across their flats so that the safety wire does not interfere with the bolt. These jigs are sold at the airplane supply shops and are only meant for the lighter safety wire. Made of hardened steel, essentially they hold the nut in place and provide a guide hole to aim the drill bit through two adjacent flats on a nut.

The best size for drilling railroad fasteners seems to be 7/64" or 1/8", which allows for even the .064" safety wire to be used. This size hole is commonly found on fasteners removed from older equipment and does not unduly weaken the larger fasteners used on railroad rolling stock.

Safety Wiring Tool

While safety wiring can probably be applied with a pair of needle-nose pliers, some vice grips and wire cutters, it is not always a wise idea to do so. If the wire is over-tightened, nicked or bent too sharply, it can be weakened and this could lead to failure at an inopportune moment. The proper way to apply safety wiring using the double twist method is with a safety wiring tool.

Milbar is the world's leading supplier of safety wiring tools and kits. At one time, Robinson was also a supplier of top-quality safety wiring tools but Robinson and Milbar are now owned by the same company, and they have relegated the Robinson name to the economy model, whereas Milbar remains as the deluxe line. As such, Milbar's Aero Twisters™ are exact replacements for the original Robinsons. Meanwhile, the top-of-the-line tools, from the safety wiring standpoint, are now the 25W and 26W pliers.

I'm not plugging a particular tool but these pliers have everything you could possibly want in a safety wiring tool. While others are certainly available (including some pretty good imports), these pliers have special jaws to ensure that the wire is not nicked or marred when it is being twisted. They will twist in either the clockwise or counter clockwise direction and they have an automatic return feature that lets you use one hand for safety wiring in those tight spots.

If you do go with another tool, you will probably at least want to look for one that is reversible, since it is good practice to twist the wire between pairs of bolts in opposite directions when doing a long run.

Safety Wire

Much of the safety wire readily available today comes from the Malin Company. The sizes commonly available in 302/304 stainless are .015", .020", .021", .025", .032", .041", .047" and .051". Other sizes are available (the .062" seems to be stocked by some aerospace distributors, for example) as are other alloys, particularly Inconel and Monel (which are intended for use in high temperature applications).

The most common wire size used by the aerospace and automotive fields is the .032" wire. For railroad use, heavier wire such as the .041", .051" and .062" wire is preferable, since the size of railroad fasteners is correspondingly larger. Heavier steel wire was used in the old days but it is no longer readily available. In stainless steel, the .062" diameter wire is the heaviest that can currently be found easily.

How to Apply Safety Wire

If you are safety wiring a nut or a bolt, torque it to its proper torque setting before applying the wire. Where possible align the holes that are going to be used to safety wire the fasteners in place, but **don't over- or under-torque them** to achieve alignment.

Your goal is to apply the wire so that, after installation, the safety wire should be slightly tight, so as not to allow the fasteners to move, but not so tight as to put undue static strain on the wire.

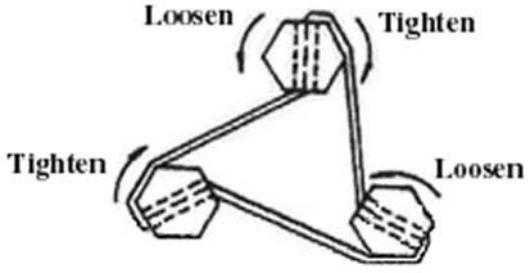

Figure 1: Illustration of how wire pull should act on connected bolts to tighten them.

Figure 2: Note that in the double twist method, the wire is twisted in alternating directions between pairs of fasteners.

Safety wire should always be installed in such a manner that the fastener tightens itself if there is ever any pull on the safety wire. The safety wire should **come around the top of the fastener** and back onto the securing unit so that the safety wire pull is in a tightening direction. To iterate, always bring the safety wire around the head of the fastener in a tightening direction, in as small a contour to the fastener as possible.

Never over-stress the safety wire. Doing so could weaken it and cause it to break under vibration or load. Over-stressing is generally caused by over-winding the safety wire. Pay particular attention that you don't nick or kink the safety wire.

To apply safety wire using a pair of safety wire pliers, begin by threading the wire through the fastener and doubling it back on itself. Use a little extra wire, because you can always cut it shorter but it is hard to cut it longer, especially when you've already wired two or three fasteners in a loop.

After you have wrapped the safety wire around the object, grip both ends of the wire in the jaws of the safety wire pliers and slide the outer sleeve down with your thumb to lock the handles.

Now grasp the knob located in the middle of the pliers and gently pull out. This will cause the pliers handles to turn, twisting the safety wire.

When you have the requisite number of twists, grasp the handles and squeeze. This will release the safety wire from the jaws of the pliers.

Use the cutters in the jaws to cut the safety wire to the proper length. Always leave 4 to 6 twists at the end then fold or tuck the twisted end away so that you don't snag yourself on it the next time you reach in to work on something

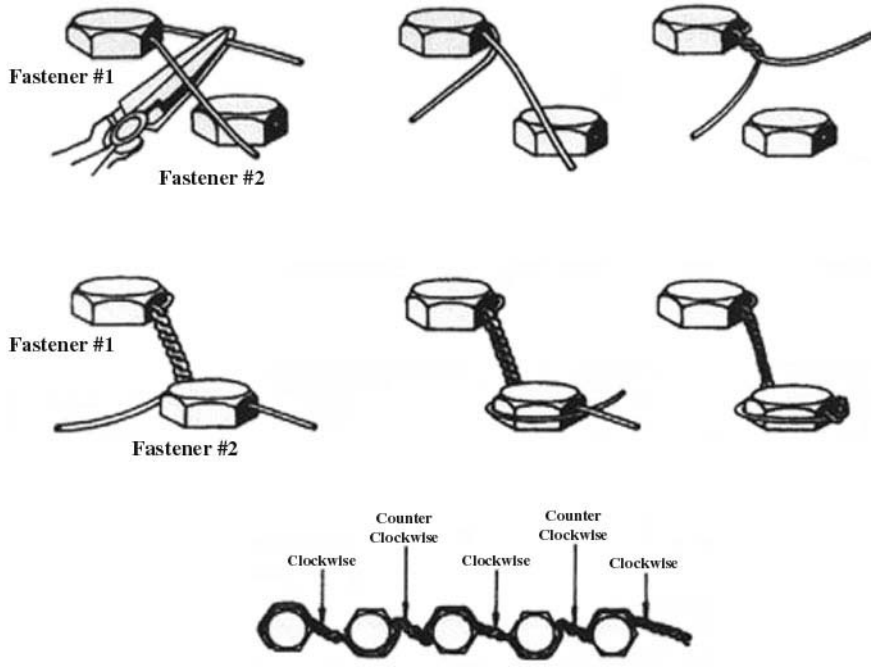

Figure 3: Safety wiring by hand. Follow the same order when using a wiring tool.

(the cut ends of safety wire are quite sharp and are excellent for removing human fur).

If you insist on applying safety wire by hand, here are the steps involved (follow along in Figure 3). Again, begin by pulling the wire through the first fastener. Loop one end of the wire around the head of fastener #1 toward fastener #2, in a direction such that a pull on the twisted wire toward fastener #2 would cause fastener #1 to tighten.

Twist the outer wire under the inner wire, close to fastener #1. Continue twisting the wire clockwise, keeping the two pieces spaced apart to ensure a tight, even twist.

When the twisted pair reaches fastener #2, without slack, insert the wire into its hole in a direction such that fastener #2 cannot loosen without pulling fastener #1 tighter.

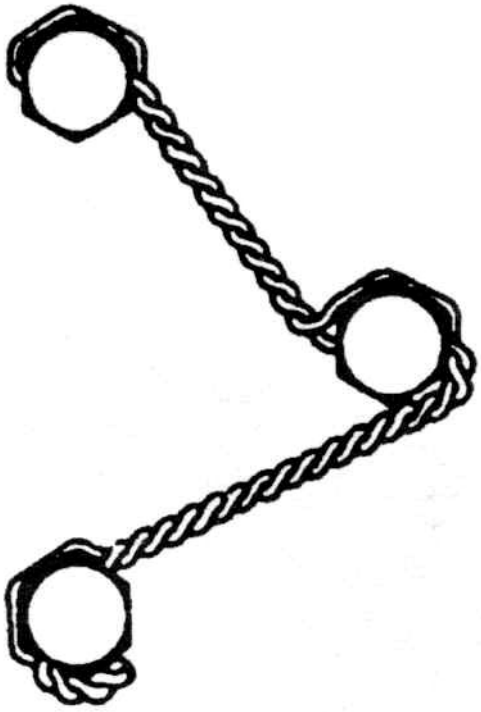

Figure 4: Wiring fasteners out of line.

Meanwhile, bend the wire that does not pass through the hole around the head of fastener #2 and twist the two wires together in a counter clockwise direction. Continue twisting in this direction to form a pigtail with 4 to 6 twists in it. Cut the pigtail off , leaving a minimum of four twists. As above, fold or tuck the twisted end away so that it doesn't become a snag, later on.

Figures 4, 5 and 6 show some examples of how to wire fasteners in special circumstances. Of course, each circumstance deserves to be given some thought to arrive at a good solution for wiring its fasteners but studying these examples may provide you with some ideas how to go about it.

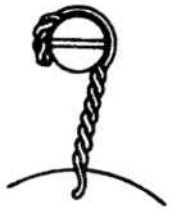

Figure 5: Wiring a fastener to a fixed object.

Figure 7, on the next page, shows how one might use the single wire method to wire together a number of closely spaced (remember, closely spaced means less than two inches) fasteners (in this case in a rectangle).

To reiterate the procedures for safety wiring fasteners, here are some rules of thumb to use when doing so:

- Torque the fasteners to their proper torque setting before safety wiring.
- Don't over-torque or loosen a fastener in order to insert the safety wire or align safety wire holes.

Figure 6: Wiring perpendicular fasteners.

- Use .032" or larger wire for the double twist method on parts drilled .045" or larger. For large bolts, such as 1/2", the .051" or .062" wire should be used, if possible.
- A double strand of .020" wire can be used on parts drilled .045" to .062" to give

greater flexibility during installation, if the spacing between fasteners is less than 2".

- Use the largest diameter wire possible with the single wire method.

Figure 7: The single wire method used on closely spaced fasteners.

- The maximum span of safety wire (between tension points) shall be 6".
- Install the wire so that it will tighten the fastener if pulled.
- Try to install the wire closely around the head of the fastener rather than over it. However, when safety wiring castellated nuts, the wire should be looped over the nut to engage the castellations.
- The wire which is looped around the outside of the fastener must always be routed **under** the wire protruding from the hole (so that the loop will stay down and not cause slack). This often requires the direction of the wrap and the twist of the strands to **reverse** from run to run, or run to pigtail.
- Pull safety wire tight (but not too tight) when twisting it. It should maintain a light tension when secured.
- The number of twists per inch (1 twist = 1/2 complete turn) depends upon the wire diameter:

  .020" to .025" diameter wire = 8-14 twists;
  .032" to .041" diameter wire = 6-11 twists;
  .051" to .060" diameter wire = 4-9 twists.

- Allow 4 to 6 twists on the free end of the wire but never more than 3/4". Bend the free end under or otherwise out of the way to prevent snagging.
- Don't kink, nick or otherwise deform or damage the wire.
- Never overstress the wire or twist it too tightly.

Rotational Forces

And, finally, a word on rotational forces. A friend of mine, upon proofing the first draft of this article, pointed out that I had not mentioned rotational forces, only vibration. What if a fastener is subject to rotational forces such as a bolt that is used as a pin in a rotating joint?

My opinion is that the safety wire is there only for safety, not to be an integral part of the system that keeps the fastener from rotating. So, in cases where there is rotational force on a fastener, there must be some other way of securing it against rotation, such as a castellated nut and cotter pin or elastic stop nut. Then, if you want to add safety wire, have at it.

However, the best way to answer the question about which fasteners to safety wire is to put back exactly what was there when you took things off. Or, for brand new installations, consult an engineer who fully understands the effects of vibration and rotational forces.

Appendix A – Sources of Supply

Malin Co.: Aerospace Lockwire – 5400 Smith Road, Cleveland, OH, 44142, (216)267-9080, www.malinco.com/aerospace/Cannister_Spec.html

Imperial Tools (a division of Stride Tool Inc.): Milbar Safety Wiring Tools – 30333 Emerald Valley Parkway, Glenwillow, OH, 44139, (888)467-8665, (440)247-4600, www.stridetool.com

Sky Geek: Sells Malin Co. Aerospace Lockwire in 1 lb. containers to people like you and I – Styles Logistics, Inc., 79 Styles Way, Sky Acres Airport, Lagrangeville, NY, 12540, (866)464-4368, (845)677-8185, www.skygeek.com/stainless-lockwire.html