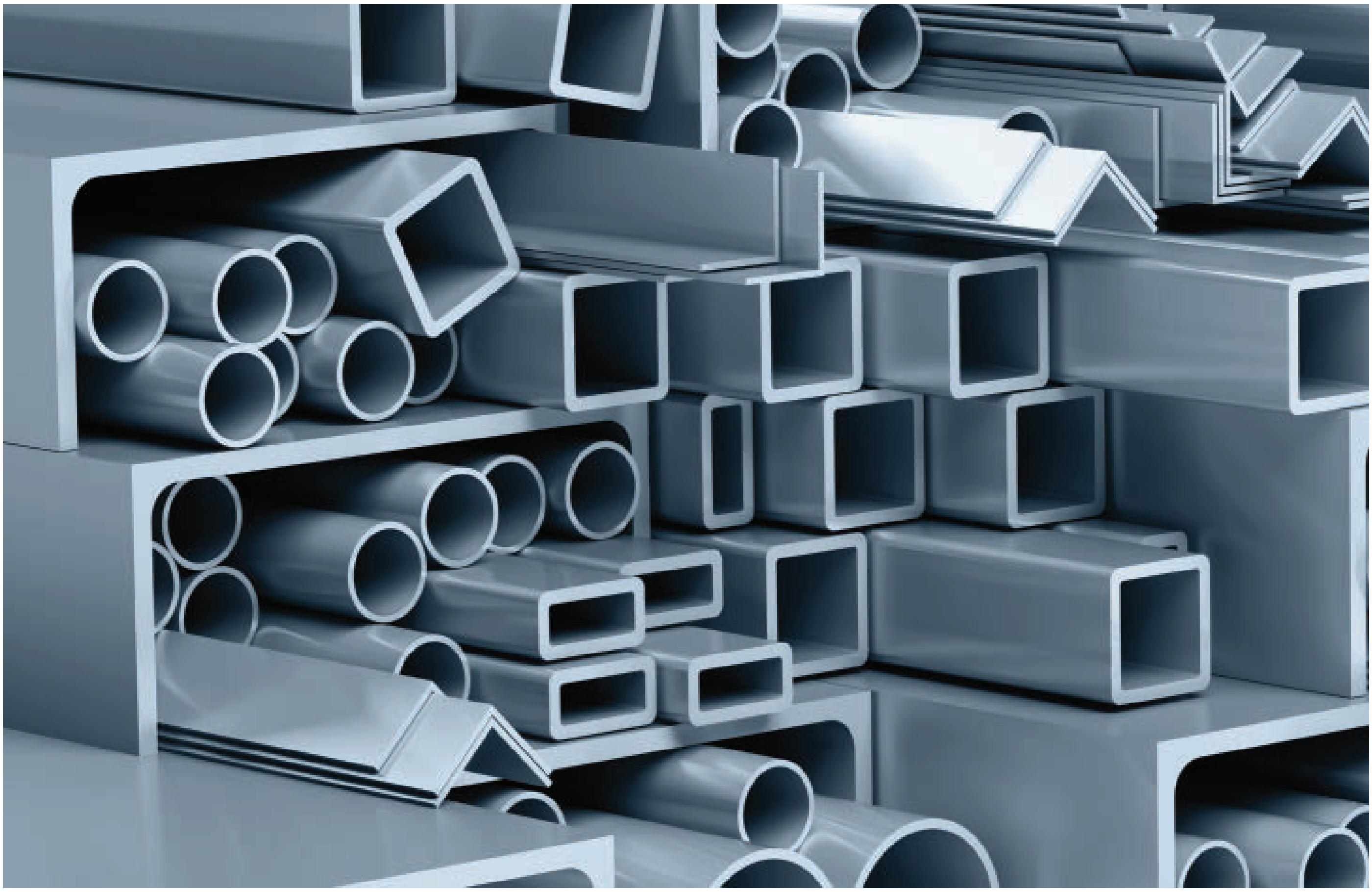
A great debate in the Great Plains

Pros and cons of commercial specifications for tubular products

By Eric Lundin, Editor



Editor's Note: This article was derived from a roundtable discussion conducted at Pipe & Tube Lincoln 2015, Lincoln, Neb., on Sept. 23, 2015. The roundtable participants were John Anton, division manager, Independence Tube Corp.; Ron Bochat, application engineer, Innovo Corp.; Dan Jacobs, vice president of sales, SigmaTEK; Phil Meinczinger, business development manager, Magnetic Analysis Corp.; Brian Havlovic, senior engineer, Kawasaki Motors Mfg. Corp. USA; and Brian Kopack, senior sales engineer, Formtek Inc. The session chairman was Mark Prasek, vice president of sales and marketing for Rafter Equipment Corp.

It's a debate few outside of manufacturing would understand, and one that isn't likely to be settled anytime soon. It's one of the most critical issues between tube and pipe producers and their customers: Are typical commercial specifications good enough?

"The same questions were a concern in the sheet metal industry a couple of decades ago," said Brian Havlovic, senior engineer at Kawasaki Motors Mfg. Corp. USA, Lincoln, Neb. "At that time sheet metal wasn't as flat as it is today. It often had a slight bow or camber to it, and the equipment used at that time could tolerate it. That changed as lasers became more prominent in manufacturing. Laser heads have very little standoff distance, so to prevent the laser head from making contact with the metal's surface, fabricators demanded flatter sheet metal, and the industry complied by finding ways to supply flatter product."

It's a little more difficult—some would say *much* more difficult—to tighten up the tolerances on welded tubular products. Welded tube comes from sheet metal, but the sheet metal goes through a great number of additional processes along the way. First it's coiled, slit to the specified width, then shipped to the tube or pipe mill. There it's uncoiled, formed, and welded. It also goes through a cooling (or quenching) process, sizing, straightening, and cutoff. If the welding process is electric resistance welding (ERW), the product also is forged as it is welded. In other words, the material is subjected to substantial stresses and heat. Because the roll tooling setup varies from one mill to the next, two similar tubes from two different mills probably are different in how they were formed, the amount of weld heat they incurred, and the severity of straightening they needed.

Regardless of the obstacles, tube and pipe fabricators are demanding tighter tolerances and better consistency. Just as the increasing use of laser cutting pushed the sheet metal industry to flatter products decades ago, the increasing use of technology is behind the ongoing desire for more consistency in tubular products. Many manufacturers are dealing with the vocational skills shortage by incorporating more robots and automated systems, technologies that work only when workpieces they pick up, transport, form, and weld have very little dimensional variation. Consistency is the key in getting automated systems to work. For cases in which automated systems *do* work, improving consistency further is necessary for improving throughput.

While the common manufacturing standards were a topic of debate—chiefly ASTM A500 and ASTM A513, which apply to structural and mechanical tubing, respectively—the discussion didn't stay there. Instead, it covered a variety of strategies tube and pipe producers and fabricators can use to make better products.

Three Rules of Tube Production: Prepare, Prepare, Prepare

Every manufacturing process is like a chain—it's only as strong as its weakest link. When making tube, if everything doesn't go just right along the way, the mill operator might be able to compensate, but even so, the tube or pipe quality is likely to suffer. The steel's chemistry and hardness must be consistent from coil to coil, and it must be slit with well-maintained tooling and transported with care so that the coil edges are suitable for welding. Every tool on the mill needs regular inspections and frequent maintenance; every component of the mill, from the infeed table to the Turk's head (straightener), must be aligned; and every setup must be performed the same way, every time, by every operator. No exceptions.

"Consistency is the key," said Brian Kopack, senior sales engineer for Formtek Inc., Cleveland. "If you don't have consistency in the coil chemistry and dimensions, and if you have a 50-year-old mill in a facility with no maintenance department, you're not going to make good tube."

Even when all goes as planned, making tube or pipe by the seam welding process is prone to slight variations. The apex of the seam moves back and forth and can wander laterally, the voltage supplied by the welder varies throughout the day, and the metal's characteristics can vary slightly from one coil to the next. It's not possible to control all of these variables, which is why it's necessary to pay close attention to the variables that can be controlled.

"You need persistent and consistent machine maintenance," said participant Robert Sladky, vice president of tube mill engineering for Roll-Kraft, Mentor, Ohio. "You need good mill integrity—consistency in mill maintenance, tooling maintenance, and setup procedures."

Consistency in mill setup actually does more than help to produce good tube. If the setup is consistent, it's one of the first causes that can be eliminated when problems arise. Also, consistent upstream processes help downstream processes.

"If the weld seam stays in a consistent position, straightening is easier," said Mark Prasek, vice president of sales and marketing for Rafter Equipment Corp., Strongsville, Ohio.

Dealing With the Weld Seam

Depending on the product and the process, the weld seam isn't too difficult to

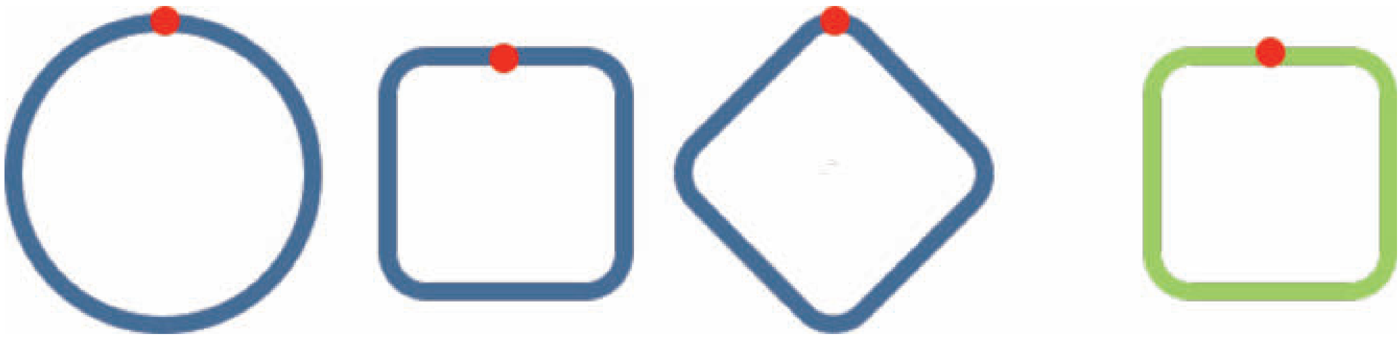


Figure 1
A tube formed round has a weld seam at the 12:00 o'clock location (far left). A subsequent operation on the mill turns this form into a square and leaves the weld seam in the same location. Depending on the roll tooling setup, the weld seam ends up in the center of a side or in a corner. Another option is to form the square directly from the strip; in this case, the weld seam ends up in the center of one side (far right).

deal with. For example, when stainless steel products are made, fusion welding processes such as gas tungsten arc welding (commonly known as tungsten inert gas, or TIG) and laser welding leave a heat-affected zone (HAZ) but little in the way of a weld bead. Participant Bret Molnar, senior technical adviser for Roll-Kraft, mentioned that manufacturers of these products often condition the weld seam with rolls or hammers.

Using ERW to make carbon steel products is a different process altogether. A forging process, ERW causes two weld beads to form, one on the OD and one on the ID. The OD weld bead isn't too difficult to remove, but cutting off the ID weld bead is a challenge. Cutting too little and leaving a small hump on the ID can wreak havoc on downstream fabrication processes; cutting too deep and removing some of the parent material weakens the tube, making it prone to splitting if it goes through a severe forming process later on.

To remove the ID weld bead, producers have several choices. A mandrel that sits inside the tube, equipped with springs to hold the scarfing tool against the ID, is one such tool. Others are hydraulic or cantilevered, but regardless, this is a blind process; it happens inside the tube after it is closed and welded shut, so the mill operator doesn't know if it was successful until the tube exits the cutoff station at the end of the mill.

Tube producers charge extra for this to offset the costs associated with the process, largely the downtime and scrap generated every time a scarfing tool, which is made from carbide and therefore brittle, shatters inside the tube. The mill operator has to stop the line, cut open the tube, retract the toolholder, and replace the tool.

Tips for fabricators:

- It's customary for tube producers to remove most of the weld hump, leaving a slight bulge of about 0.010 in. As the diameter or wall thickness decreases, weld flash removal becomes increasingly difficult. Specifying a very small weld hump, at half the normal tolerance or less, is a challenge to achieve and increases the risk of an undercut.
- Even when the scarfing process goes perfectly, without undercut, the weld seam is still vulnerable to splitting if put through a severe forming process. Because the seam was welded and quenched, it doesn't have nearly as much ductility as the original material. When bending, it's good practice to align the weld seam with the neutral axis. For end forming, annealing can restore some of the ductility to the HAZ, helping to reduce the likelihood of splitting.
- Depending on the ID, it might be necessary to switch to extruded or drawn-over-mandrel tubing. The extrusion process forces hot metal over a die to form the shape, so extrusions don't have a weld seam. The DOM process is used to change the OD, ID, or wall thickness of welded tubing, and annealing between drawing passes helps to reduce the presence of the weld seam. Both products are considered to have tighter tolerances than as-welded products (although an extrusion's wall thickness tends to vary slightly as the mandrel's location varies).

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Tips for producers:

- As laser and digital technologies advance, so do monitoring systems. One manufacturer makes an ERW monitor that measures the weld bead on the OD and uses that data to extrapolate the size of the weld bead on the ID. See Virtual Macro®, www.virtualmacro.com.
- Depending on the tube or pipe diameter, ID flash removal doesn't have to be a blind process. Some systems include an ID camera for large diameters. See SImilcut, www.similcut.com.

• Check the incoming material. One roundtable participant discussed a series of troubleshooting steps to deal with poor fusion and, in some cases, long lengths of tube with no fusion at all. After the mill operators finally got back to making good tube, the problem cropped up again on a different diameter. Eventually the staff traced the problem back to an overly zealous purchasing agent who was trying to save money by buying undersized coils.

"You need perfect strip width to get perfect results," Molnar said.

Forming Nonrounds

Most nonround tubing goes through two forming stages, first to round, then to the final shape. For squares and rectangles, the most common tooling setups form two horizontal sides and two vertical sides; the weld seam ends up right in the middle of one of the sides. For fabricators that need the weld seam elsewhere, an alternate tooling setup locates the weld seam in a corner (see **Figure 1**).

A difficulty is getting a uniform square or rectangle. Often three of the corners have good consistency, but the fourth exhibits a thicker wall (known as a *lazy corner*).

"Theoretically, the material flows evenly into all four corners, but this requires perfectly consistent material," said John Anton, division manager, Independence Tube Corp., Chicago.

In reality, the material isn't perfectly consistent. The original sheet material, as it is rolled in the steel mill, doesn't have a uniform thickness. It's thicker near the center of the sheet, and therefore the individual coils that are slit from the center of the coil are slightly thicker than those slit from the edges. After the material goes through the tube or pipe mill's weld box, the weld zone is harder than the rest of the material. Finally, if a producer needs to know just how well the forming passes do their job, it's possible to install a laser-based measuring system to determine the extent of the tube's ovality before the tube enters the weld box.

Even when every precaution is taken, perfect consistency is elusive. Although every tube producer denies it, tube fabricators often lament that round tube is never round and the hole is never in the middle. A square tube might be nearly flawless, but it's difficult to make a perfect square from an imperfect circle.

Forming the strip into a square or rectangle directly, rather than first forming it round, is another possibility, but this isn't a common process.

"Few mills are set up for this because a mill that forms squares doesn't form rounds well," Prasek said. "Also, products made this way need a slightly different chemistry than round-to-square products. They are worked less, so they are hardened less," he noted.

"It requires more forming stands and tooling, but those costs are amortized over such a large amount of tubing that the per-foot price of the tube is negligible," Kopack said. A benefit to forming a square directly from strip is the ability to punch holes in the strip before forming, if necessary, Kopack added.

Tips for fabricators:

• If you need square or rectangular tubing with holes punched in it or other features, you might want to shop around for a tube producer set up to form squares and rectangles directly from strip. Punching holes before forming is one of the advantages of this process.

• Beware that service centers source tube and pipe products from many suppliers, so inconsistencies in dimensions and hardness are unavoidable.

Tips for producers:

• When sourcing raw material, remember that gauge control is tighter for cold-rolled material than for hot-rolled material.

• Regardless of the forming process, increasing the number of forming passes increases the products' consistency.

Production Negotiations

Fabricators are accustomed to asking their customers questions about bends and end forms. Is zero ovality in the bend zone really necessary? Would a deburred end work as well as a chamfered end? Does a hole location need a location tolerance of ± 0.005 in.? Likewise, some have listened to their customers' concerns and taken these up with the tube producer to work out a solution.

• **Remove or move?** One fabricator reported a request from a customer regarding a part made from rectangular tubing: Remove the ID weld bead from the 10 in. of material closest to the tube end. Working as a go-between, the fabricator learned exactly what the customer needed and what the tube producer could provide. In the end, the OEM didn't really need the ID weld bead eliminated. The issue was a punching operation; the OEM didn't want to punch through the weld seam. In the end, moving it was less expensive than removing it.

Consistent upstream processes help downstream processes.

• **Work around it.** Bending often requires a mandrel to support the tube's shape. If the tube has an ID weld bead, fabricators have two choices: Ask the tube producer to remove it or ask the mandrel supplier to grind out a notch along the mandrel's length, a relief feature, so the mandrel doesn't contact the weld bead. If a fabricator takes the second route, success hinges on consistency. In this case, it's the consistency of the weld seam location.

"Even with a weld seam steering device, the weld seam location varies a little bit," Anton said.

Still, one fabricator reported a successful outcome. It had been purchasing tube with the weld flash removed, but changed to using a mandrel with a relief. The cost of adding the relief feature on the mandrel was more than offset by eliminating the cost of weld bead removal.

It's a matter of learning what the customer really wants and what the tube producer can provide, and finding the best solution. It might be a lot of work, but the results are better working relationships in the supply chain and better products for the customers. TPJ

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