A roundabout look at the process of making hollow structural sections.

# Full CIRCLE (or Square)

STORY AND PHOTOS BY GEOFF WEISENBERGER

**ON APRIL, 27, 2011,** an F-5 tornado ripped through northern Alabama and southern Tennessee, killing more than 100 and devastating several communities.

One of the towns hit was Decatur, Ala., home to one of Independence Tube's hollow structural section (HSS) mills. The tornado destroyed much of the plant, but luckily none of the 25 employees in the facility at the time were hurt.

"There was a Wrangler jeans plant 50 miles away that was hit by a tornado that same day," recalls John Tassone, Independence Tube's marketing manager. "And we found blue jeans on our site."

One year later, the facility was rebuilt and running again. In fact, the rebuild provided the opportunity to increase the mill's round HSS capacity from 14 in. OD (outer diameter) to 16 in. OD. The tragic event also provided unforeseen opportunities for employee development. In the aftermath of the tornado, several Decatur employees stayed busy by helping with demolition, and the company also gave them the opportunity to come to its Marseilles, Ill., and Chicago facilities to work in two-week shifts, even covering all travel and living expenses.

"They learned a lot up here," says Tassone. "They were cross-trained on different jobs, made friends and learned the Independence Tube culture."

**Geoff Weisenberger** (**weisenberger@aisc.org**) is *Modern Steel's* senior editor.

## Down the River

And the Marseilles facility is a good place to learn, as it houses not one but two mills. The first mill was built in 1997 to supplement the company's original Chicago location, and a second, adjacent mill line was added in 2009. (Independence will be opening a second Alabama location this month, in Trinity, to supplement the nearby Decatur plant and produce smaller-diameter products.) The initial Marseilles mill can produce HSS from 4 in. to 10 in. square and 6.625 in. to 12¾ in. (OD) round, with walls from ⅛ in. to ⅝ in. thick. The second mill produces from 2 in. to 4 in. square and 1.66 in. to 5 in. (OD) round, with walls from 0.109 in. to 0.375 in.

While size ranges and logistics differ from location to location, all four facilities produce HSS the same way. It all starts out as steel coil. At Marseilles, coil typically arrives in rolls of up to 45 tons, generally up to 74 in. wide. The facility generally receives its coil via barge, as it is located on the Illinois River, and orders steel from various manufacturers.

▲ Barges, bringing steel from up or down the Illinois River, can pull right up to the plant. The river flooded in 2008, but the plant sits on high enough ground that it wasn't affected.

◀ This steel will become round or rectangular hollow structural sections.

▼ The steel is brought into the facility from the barge via overhead crane.

▲ The steel arrives in rolls of up to 45 tons.

▼ Steel that has been slit is rerolled before being transported to the mill line.

▲ The slitter cuts the steel to the proper width.

▼ The slitter also creates a smoother edge, which facilitates connecting the two edges to form a tube.

▲ This drum creates a buffer between the flattening/butt welding operation and the forming tools.

▼ Steel coils are joined together end-to-end to create an endless ribbon of steel.

◀ Coil travels through one group of tool sets to become round tube, then another group to become square (photos in left column).

▼ The mill contains several sets of tools to gradually form the coil into tube.

The coil is brought into the facility from the barge via overhead crane then awaits its transformation from flat steel to finished structural products. Unlike wide-flange beams, which are cast into dog-bone shapes then gradually hot-rolled into the familiar I-beam profile, HSS is gradually cold-rolled into round shapes—then rectangles or squares as needed.

### Trimming the Fat

First, the mill edges of the coil must be cut off to produce a clean edge for the welding operation and to get the steel to the proper width for the tube it will become. The coil is unraveled and fed into the slitter, where it travels between two rollers with offset blades that edge-trim both sides of the roll; these edge strips are collected and eventually recycled.

Now at the proper width, the coil is ready to be fed into the mill. It first goes through the leveler, a series of rollers that flatten the steel, working out any bumps or waves. But the mill isn't stopped each time a new roll is ready to be fed through. Except for breaks, shift changes, maintenance or when the plant is closed, the mill is constantly running. In other words, the mill doesn't stop for each new coil of steel, but rather the steel has to catch up to the mill. It's much like a relay race: While the runners change, the baton is always in motion throughout the race. As such, the new roll is attached to the one before it, via automated butt welding, to create an endless ribbon of steel.

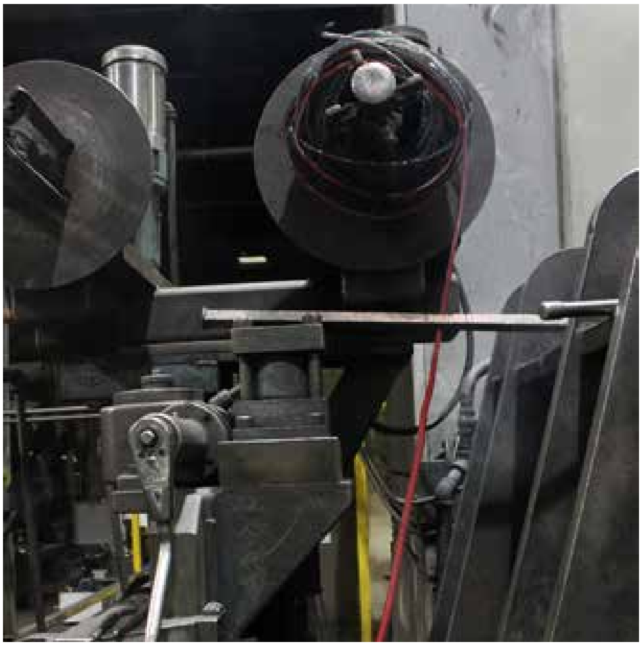
This is made possible by the accumulator, and each mill at the Marseilles facility uses a different type of accumulator. The main mill's accumulator is a large drum, around which the steel is looped, that moves back and forth along a set of tracks at the beginning of the mill and creates a buffer zone or slack in the operation while a new roll is added; there's a similar drum at the other end, beyond the welding operation. Sensors let the operator know how much steel is left in the "queue" and how much time they have to attach the coils before the mill would need to be shut down. And a shutdown means having to bring the entire mill process to a halt, resulting in unnecessary down time, more steel that can't be used as final product and ultimately money.

### Making Tube

From here, the steel goes through the heart of the HSS operation and is gradually formed into a tube. It travels through a series of concave and convex rollers—the number depends on the final product (the batch I watched being made used 11 sets)—that round it further and further into a circle. Throughout the process, the steel is bathed in a mixture of cool-

▲ Tooling can be changed out based on the desired product shape and size.

▼ After being made round but before being made square/rectangular, the edges of the coil are seamed by induction welding to complete the circle.



**AISC Member HSS Producers**

- Atlas Tube: **www.atlastube.com**
- EVRAZ North America: **www.evrazna.com**
- Independence Tube: **www.independencetube.com**
- Steel Ventures LLC DBA Exltube: **www.exltube.com**

▲ After being cut, HSS is routed into the packaging operation.

▼ One end of the bundle is raised to allow excess cooling/lubricant solution to drain.

▲ Tube that doesn't meet the specifications to be sold as a final product is removed from the line following cutting and is eventually recycled.

◀ Residual flash from the forging process is removed to create a smooth seam.

▼ Steel coil is transported from the main mill to the smaller mill via an automated "train" running on tracks between the mills.

The accumulator for the small mill provides the same service as the one for the main mill, though via different means.

Equipment for the small mill is similar to the main one.

A 2-in. square tube is formed.


The tube is marked after squaring and before cutting.

During the cutting operation, the saw attaches to the steel while it cuts it, then releases it.

Slit steel is fed into the accumulator (bottom strand) and released into the mill line (top strand).

ant and lubricant, which regulates temperature and prevents adhesion to the tooling. This mixture is cycled back through the process and is replenished and recycled as necessary, and tooling is switched out based on the desired diameter and also when it reaches the end of its useful life.

At the end of the first set of rollers, the edges are fused together using the induction method. The residual slag or "flash" on the outside of the tube is skimmed off (and collected and recycled) to form a smooth seam. Now a complete circle, the tube is sent through a cooling trough before going through the next set of rollers. If it is to remain round, it only goes through a few more sets to further refine the shape. But tube that is to become rectangular is fed through three more sets of "squaring" rolls that apply precise pressure on all four sides to gradually flatten the steel into the desired shape.

Independence prides itself on the smooth corners of its rectangular shapes, and Tassone notes that the rounding portion of the rolling is just as important as the squaring portion.

"It's essentially feeding a round peg into a square hole," he says. "In order to make a good square, you first need to make a good round."

After shaping, the tube is friction cut—the Marseilles facility produces lengths of 20 ft to 80 ft—using a circular saw; products that need to be shorter than the 20-ft minimum length are cut in a second operation with a band saw. The ever-moving nature of the mill is, of course, addressed at this end as well, and the saw moves with the operation and cuts the steel "on the fly." The saw, mounted to a track, attaches to the moving tube for the cut then detaches and retracts to wait for the next cut.

The smaller mill is similar to the main mill, though the packaging system is slightly different, and the mill line is smaller and tends to use fewer sets of rollers since the products are smaller. The main difference in terms of equipment is the accumulator, which is stationary and looks somewhat like an inverted metal tornado. Essentially, instead of moving to create slack in the steel, the slack is created inside the accumulator itself. The steel is then released from the accumulator into the mill line.

## Packing and Tracking

At this point, the tube is nearly done. After being cut to length, it is stacked for packaging via magnetic cranes, wrapped at three points with metal strips and lifted at one

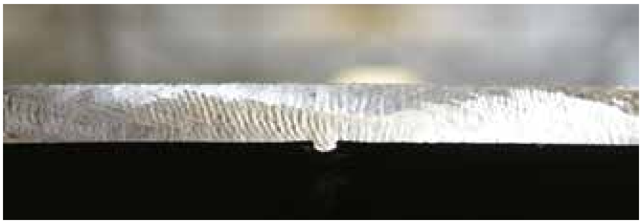
Tube is stacked into bundles.

Metal stripping is applied to the bundles for shipping.

Elongation, tensile strength and Charpy tests are performed on the welds. This piece was measured to see how far it stretched before breaking.

Final product, ready to ship. Steel is bundled and tagged on a per-customer basis.

The bead from the seaming process is left on the inside of the tube, though it can be removed if a customer/designer so desires.



Heading out!

end to drain out the excess cooling/lubricant solution from the inside. Employees perform quick measurements for straightness. (Tube that doesn't make the cut—typically only the first few tubes made whenever the mill is restarted or tube that includes the butt weld from when two rolls are joined—is rerouted and recycled.) It then travels through a machine that sprays each batch with an anti-corrosion solution for transit (galvanizing, paint and other coatings systems are applied by customers on a project-by-project basis), then is routed to storage where it awaits shipping by truck or train. Approximately 75% of product goes to service centers while the other 25% goes to fabricators.

Material is tracked through the mill via RFID and is tagged at three points: upon arrival, after it is slit (because the first tag comes off during slitting) and when it is bundled for shipping (because the second tag comes off during the rolling process).

The facility also includes a testing lab, where tensile, elongation and Charpy testing is performed to verify that each heat of tubing meets the minimum standards of the ASTM specification it was produced to. The lab also has various pieces of equipment for the metallurgist to check the weld integrity of the mill's products.

Of course, Independence is not only interested in producing high-quality HSS, but also in raising the overall awareness of HSS—as early as possible.

"We're trying to get students familiar with HSS while they're in school and let them know that it's an option," Tassone says. "It can be difficult to get an architect or engineer with years of experience to start designing with HSS later in their career. But if you can make the younger generation aware of the benefits of HSS right from the start, they'll be able to implement those benefits in their designs." ■

*For updated information on HSS shape availability, visit **www.aisc.org/steelavailability**. And visit **www.aisc.org/hss** for general information on HSS.*

**A1085**

Independence Tube produces HSS to ASTM A500, ASTM A252, CSA G40.21 (350W) and the newest HSS specification, ASTM A1085. Independence was involved (along with other HSS producers and AISC) in the creation of A1085. This new specification provides enhanced performance to make designing with HSS easier and more efficient for structural engineers. Some of the benefits of the new specification include:

- Tighter material tolerances and a single minimum yield stress of 50 ksi
- Maximum specified yield stress of 70 ksi
- Standard requirement for Charpy V-notch toughness
- Corner radius range