Four Ways to Weld Steel Tanks

The Steel Tank Institute's quality control expert describes the four welding methods commonly used to fabricate steel tanks and methods employed to test the work.

Choosing the right weld:
In the May/June issue of PE&T, Larry O'Shea described the steps that should be taken in the steel tank acquisition process to ensure that the tank's fabrication and welding are adequate ("How to Get Good Steel Tank Fabrication,"). While that article described and illustrated acceptable and unacceptable welds, it did not discuss the welding process itself. In the following article, Larry gets technical on this critical aspect of steel tank fabrication.
Many PE&T readers have seen blue sparks flying from a welder on an overhead bridge. Those who grew up on the farm likely saw the same kind of sparks when farm machinery was being repaired by welding. The advice back then, not to look directly at the source of the sparks—the welding arc—without proper safety glasses, is still great advice. Arc welding produces radiation and may burn your eyes (similar to sunburn).

On the good side, arc welding is the essential process that makes the construction of steel tanks possible. Let's take a quick look at how it works (no safety glasses needed) and then talk about the four different arc welding processes used in steel tank construction.

Figure 1:
Typical Circuit for Shielded Metal Arc Welding

What makes the arc?

Simply put, arc welding is a process in which an electrical arc is created and used as a source of heat to melt and join metals. Arc welding systems consist of: (1)an electrical power source (either AC or DC) equipped with leads for connecting the electricity to the metal being worked on (workpiece); and (2)an electrode holder that is connected to an electrode (or welding rod). When the electrode is held so that it is nearly touching the workpiece, the electricity arcs continuously, creating intense heat that melts the electrode and the workpiece, thus welding them together. Figure 1 illustrates a typical circuit for shielded metal arc welding.

Basic welding processes

Four basic arc welding processes are used in fabricating steel tanks. Each of the four processes will repeatedly produce quality weldments. But they each have weaknesses. Prospective tank buyers should be aware of the different processes.

SMAW (Shielded Metal Arc Welding): Commonly referred to as stick welding, SMAW is the most commonly used welding process today. The equipment and materials are inexpensive, portable and relatively simple to operate even in outdoor conditions.

One drawback to the SMAW process is that it is slow. Because it is a manual process, the operator must stop and replace the consumed electrode approximately every 18 inches. In addition, the operator must remove solidified slag from the surface prior to completion.

Welds made using the SMAW process are readily identifiable by the start/stop markings on the surface of the welds. More surface irregularities are found with this process than with others.

The type of electrode used in the SMAW process has a very significant impact on the mechanical strength of the weld. For example, a jet rod (known for its speed) will not penetrate as easily into the base material, thus the strength of the joint is not as great as other types of electrodes, such as pipe rod.

GMAW (Gas Metal Arc Welding): Also known as Mig welding, the GMAW process uses a solid bare wire to create the arc between the workpiece and the filler material. The wire is fed (usually automatically or semi-automatically) through a welding gun from a spool or reel. A shielding gas protects the weld from contamination from the environment (oxygen). The gas flows through the welding gun/nozzle to the arc.

The GMAW process has a high deposition rate (i.e., the rate at which the electrode melts and gets deposited on the workpiece) and can save time and labor costs. However, because the process uses a shielding gas, it is very susceptible to drafts or wind which might blow the shielding gas away from the arc; thus it is not very well suited for welding outside.

While GMAW welds generally have a good, uniform profile. Mig welding is less forgiving than some of the other processes. A greater risk of lack of fusion exists because the arc doesn’t provide as much heat. Many fabricators will limit its use to thinner gauge steel. Undesirable weld spatter (metal particles expelled during welding that do not form a part of the weld) is generally greater with this process but can be significantly reduced with the proper mixture of shielding gas.

FCAW (Flux Cored Arc Welding): The FCAW process is very similar to Mig welding, although it does not always use a shielding gas. Also, instead of a bare wire, a tubular wire containing granular flux is used. When a self-shielding flux is used, no gas shielding is required. Some wires use a combination of both flux and the shielding gas for improved weld metal properties.

The FCAW process is very popular because of the deep penetrating arc that reduces fusion type discontinuities, and because it has a quick deposition rate. The self-shielding electrode is popular in field applications as well. Like the SMAW process, solidified slag must be removed from the surface of the weldment.

If there is considerable smoke in a plant, the FCAW welding process is probably being used. Although similar to Mig welding, the FCAW process often presents a different kind of problem: slag. Because the tubular wire has flux inside, there is greater opportunity for slag entrapment in the weld. Undercutting (melting away of the base material along the edge of the weld, forming a groove) is very common with this process because of the amount of heat created at the arc.

Figure 2:
Submerged Arc Welding, Photo courtesy of ITEQ Starage Systems, Provo, Utah

SAW (Submerged Arc Welding): SAW is probably one of the most efficient welding processes. The process is automatic and uses a solid wire electrode that is submerged in a granular flux blanket (see Figure 2).

The SAW process is ideal for building up material/overlays and joining thicker materials. Solidified slag must be removed from the surface, but removal is much easier compared to other processes.

While the SAW process produces a very smooth and uniform weld, it also can pose problems. With this automatic process, the tank must be turned at a constant speed and the weld joint fit must be uniform. With other processes (manual or semi-automatic), the welder can make adjustments with the joint geometry. With SAW, the welder cannot see the arc and is limited to only minor adjustments while the unit is in operation. Again, slag entrapment and fusion discontinuities are not uncommon with this process. Because of the amount of heat generated at the arc, it is not uncommon for the operator to burn right through the base metal.

Checking the joint out

Procedure qualification tests are performed to ensure that a welding process produces a quality weld. These include mechanical testing of samples based on applicable welding code requirements. These tests help prevent deficiencies in the techniques, materials or operator skill. Many codes and specifications require such tests not only of the process but also of each welder working on the project.

Underwriters Laboratories of Canada (ULC), for instance, requires each welder or welding operator to be certified under ULC-S601: Standard for Shop Fabricated Steel Aboveground Horizontal Tanks for Flammable and Combustible Liquids).

In conclusion...

Each of the welding processes discussed in this article will repeatedly produce quality weldments. As with any craft, the skill of the welder/welding operator is just as critical as the process used. When comparing the workmanship from one tank fabricator to another, it is important to determine the welding process employed. Obviously, a manual stick weld is not going to look as good as an automatic weld, but it still fulfills the objective. Finally, don't be afraid to get some help. Welding is a highly technical and specialized field; trying to understand what's critical is difficult even for seasoned professionals.

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