

# TechTopics No. 118

## Bolted construction vs. welded construction

Historically, metal-clad switchgear was constructed using welded frames to support the structure. However, the industry has moved away from welded construction to use bolted construction. Siemens was one of the last major firms to abandon welded construction, in the middle 1980s, when stacked switchgear was introduced. Even though welded construction has been obsolete for several decades, we still see specifications inspired by older examples that call for welded construction. This issue of TechTopics discusses Siemens' experiences providing products using both construction methods and the lessons derived from those experiences.

What are the perceived benefits of welded construction versus bolted construction?

Most people would say that welded construction is rugged, indestructible, the image of quality, etc., but that perception is the opposite of reality.

Welded structural assemblies are inherently dimensionally unstable. When metal pieces are welded together, they often move relative to each other. This movement makes it nearly impossible to hold tight dimensional tolerances which is why in most cases critical interfaces on welded assemblies are machined or added after the welding process is complete. As an example, Siemens many years ago manufactured a welded frame that was intended to have a manufacturing tolerance of  $\pm 0.010$  inches (ten thousandths of an inch) over an assembly of roughly 36 inches on a side. Two vertical supports were welded to a rectangular frame with all parts held in a robotic welding fixture to assure precise alignment. During welding, the vertical supports could be observed moving in response to the thermal stresses. In a repeatable, robotic welding configuration, optimized to reduce the amount of movement due to thermal stresses, finished assemblies varied by as much as 0.160 inches – 16 times the limit.

So, every frame was placed on an alignment table and teased into proper alignment (i.e., hammered into place). Finished frames, verified to be within tolerance, were handled in a gentle manner and then placed back onto the alignment table, and were often found to have moved out of tolerance.

The finished frames were then used in further assembly steps and the resulting assembly had to then be individually adjusted to fit into the final assembly and to achieve the desired interchangeability.

After experiencing this for several years, Siemens converted the assembly to a tab and slot bolted assembly, using sheet steel fabricated on numerically controlled machines that produced parts to  $\pm 0.010$  inch tolerance. Results? The parts went together first time every time, the alignment operation was eliminated, the trial fit operation in the final assembly was eliminated, and nagging problems in field installations disappeared.

With a welded assembly, the design must incorporate means to adjust mechanisms and mountings to account for the fact that a welded assembly can be dimensionally unpredictable. Anything that must be adjustable is undesirable because of the expense of performing the adjustments, the expense of fixtures or tools required to enable the adjustment, and the need to instruct the end user concerning the adjustment should it ever be needed.

One issue is that the adjustment seldom needs to be made at the installation but inexperienced maintenance persons or outside maintenance firms often adjust settings that are not out of spec. When this has happened, the manufacturer must have well-experienced service engineers who can analyze a severely misadjusted product, re-zero it, and restore it to proper working condition.

Such a design is a disservice to a user, and extremely costly to a manufacturer.

In summary, how does a welded-structure design measure up?

On many occasions while demonstrating switchgear to a potential purchaser, Siemens has used a circuit breaker of the correct ratings, selected at random, and inserted it into the appropriate switchgear compartment (type GM-SG or GM38) without difficulties. The experience historically with welded assemblies was completely different – often the circuit breaker and/or the cubicle required persuasion before both would mate properly.

The lesson is that quality is predictability, and the predictability of bolted-structural designs was made possible by the revolution that came with the introduction of numerically controlled machinery. These modern machines, along with designs that capitalized on the CNC capabilities, made possible today's products, where quality is designed in, not added afterwards using alignment operations.

Please be aware that all welded construction is not bad. When it comes to assemblies where larger manufacturing tolerances can be accommodated more readily, or when post-welding process (such as machining) are possible in a cost-effective and consistent manner, welded construction is a viable option. For example, the base-frame structures that form the foundations for many power equipment center structures commonly use welded construction.

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