



## Design File

# Watch Out For “Nothin’ Welds”

Practical Ideas for the Design Professional by Duane K. Miller, Sc.D., P.E.

A “nothin’ weld” - now there's a term you won't find in AWS A2.4 *Standard Welding Terms and Definitions*! But designers, fabricators and engineers need to know about “nothin’ welds” since they can lead to disastrous results.

What is a “nothin’ weld?” For the purposes of this discussion, a “nothin’ weld” is one that has essentially no throat, and yet the external, visually discernible characteristics of the connection give all indications that the expected weld, complete with the expected weld throat, has been achieved. Unlike a weld that is undersized or filled with surface-breaking porosity that would alert an inspector to the need for more thorough scrutiny, “nothin’ welds” look just like the intended weld.

The capacity of any weld is a function of the following: length x throat x allowable strength. Regardless of the allowable weld strength or the length of the weld, if the weld throat is zero (or nearly zero) the connection has no load carrying capacity. “Nothin’ welds” have weld throats that approach zero, so the structural or mechanical implications can be disastrous.

Four examples of “nothin’ welds” will be cited, their causes discussed, and the practical means by which they can be avoided will be explained. Finally, an actual case study will be presented.

## T-Joints with Poor Fitup

Under ideal circumstances, the two members that constitute the T-joint should be brought as closely into contact as possible before those members are joined with a fillet weld. Along the length of a T-joint, perfect fit is never possible, and so some small gaps will exist. Larger gaps may be tolerable in certain situations. However, as the size of the gap between the two members increases, and if the fillet weld leg size is kept the same, the actual weld throat decreases. This is illustrated in Figure 1. Taken to the extreme, this gap could approach the same dimension as the fillet weld leg size, creating a “nothin’ weld.” Externally, the weld may look identical to that of a properly prepared joint. Figure 1 shows the increased stress level that results from the applied load on the decreasing throat size. It should cause little surprise when such welds fail in service.

The AWS D1.1-98 Structural Welding Code addresses the issue of fitup in paragraph 5.22.1, which states, “The parts to be joined by fillet welds shall be brought into as close contact as practicable... If the separation is greater than 1/16 in (1.6 mm), the leg of the fillet weld shall be increased by the amount of the root opening, or the contractor shall demonstrate that the required effective throat has been obtained.” This principle is illustrated in the final schematic of Figure 1, and as illustrated by the numbers in the Table, acceptable stress levels can be maintained when the appropriate compensation is made.

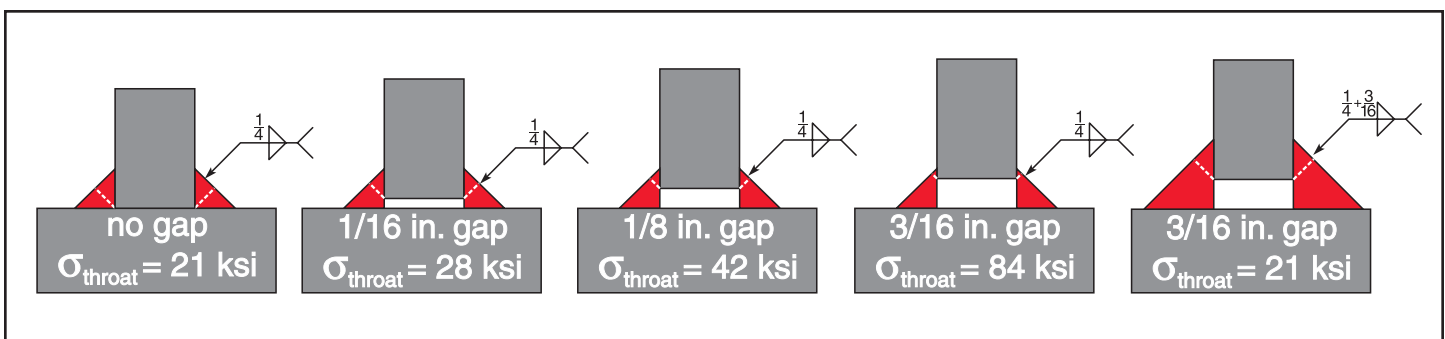


Figure 1. Increasing the root opening of a T-joint without increasing the fillet weld size increases the stress on the throat.

The most straightforward method to avoid this type of “nothin’ weld” is to obtain good fitup. When good fitup cannot be achieved, it is important to note those joints that contain areas of poor fitup so that compensation can be made for these conditions. This requires an effective visual inspection program that includes pre-welding inspection.

## Fillet Welds and Lap Joints

A second example of “nothin’ welds” occurs when fillet welds are put on the edges of lap joints where the member with the vertical edge of the fillet weld is relatively thin, typically less than 3/8 in (10 mm).

While this is less of an issue with the commonly used semi-automatic welding processes of today, welders using SMAW electrodes (with their inherently broader arc) can inadvertently melt away the top edge of the member. This creates an illusion of a full-sized fillet weld equivalent to the thickness of the top plate. In reality, and as illustrated in Figure 2, the resulting weld throat may be much smaller than the designer intended.

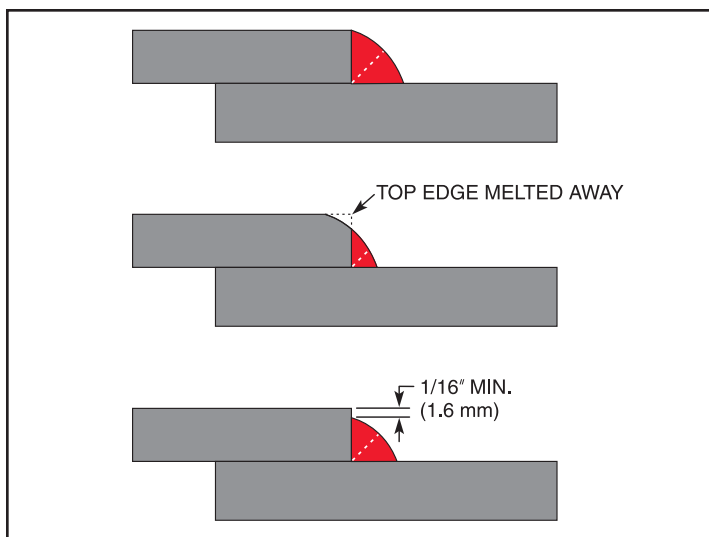


Figure 2. Melting top edge of lap joint can misrepresent actual throat.

The AWS D1.1 Structural Welding Code addresses this by calling for maximum fillet weld sizes on the edges of lapped members as stated in paragraph 2.4.5: “The maximum fillet weld size detailed along edges of material shall be the following: (1) the thickness of the base metal, for metal less than 1/4 in (6.4 mm) thick; (2) 1/16 in (1.6 mm) less than the thickness of base metal, for metal 1/4 in (6.4 mm) or more in thickness...” This is not applied to the thinner members because, from a practical point of view, these welds normally achieve the full throat thickness. The most straight-forward way to avoid the creation of this “nothin’ weld” is to leave the 1/16 in (1.5 mm) unwelded portion above the upper weld toe. Additionally, welders should be taught of the implications of this practice and be discouraged from melting the top edge.

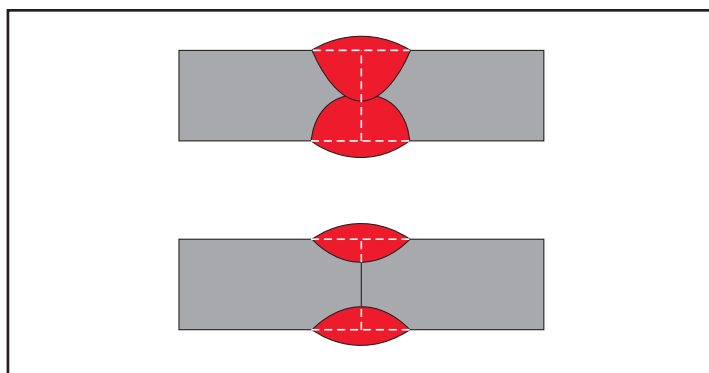


Figure 3. Examples of square edged joints, including the designer's expectation and what actually can be delivered in production.

## Square-Edged Groove Welds

On a square-edged groove weld, the base metal at the joint is not beveled or prepared in any other way. A gap may be provided between the two members to be joined, resulting in a root opening that helps facilitate joint penetration. In other cases, the joint may be butted tight, and joint penetration is fully dependent upon the penetration supplied by the welding process. Figure 3 illustrates how a “nothin’ weld” can occur with square-edged groove welds. While the designer expected a complete joint penetration weld like that in the top illustration, a combination of variables can lead to the partial joint penetration weld shown in the lower example. In the extreme, the strength of the connection may be due only to the surface reinforcement. Yet, the visually discernible weld on the surface cannot be used to gauge the likely degree of penetration that has been achieved.

The D1.1 places fairly severe restrictions on the use of these joint types. For example, prequalified joint details B-P1a, B-P1b and B-P1c are limited to a maximum thickness of 1/4 in. All other thicknesses require some type of joint preparation, whether the intended weld is a complete joint penetration groove weld or partial joint penetration groove weld. For non-D1.1 Code work, or when using non-prequalified joint details, it is possible to successfully make CJP groove welds on materials as heavy as 1 in (25 mm) thick if welded from both sides, even when a square-edged groove weld is employed. However, rigorous control must be placed on the welding procedures used in production, and electrode placement with respect to the joint is critical. Spot checks of production parts are highly recommended to ensure that the production system is sufficiently robust to ensure consistency. Alternately, groove weld details that employ prepared surfaces for vee and beveled groove details, for example, can be employed to avoid this form of a “nothin’ weld.”

## Metal Removal Operations

Sometimes “nothin’ welds” are created by machining or grinding operations that are performed after the weld is made. Often in this situation, a weld is deposited that is fully compliant with the design intent, but a significant portion of the weld throat is reduced by a metal removal process. Overcoming this problem is fairly simple: the designer must

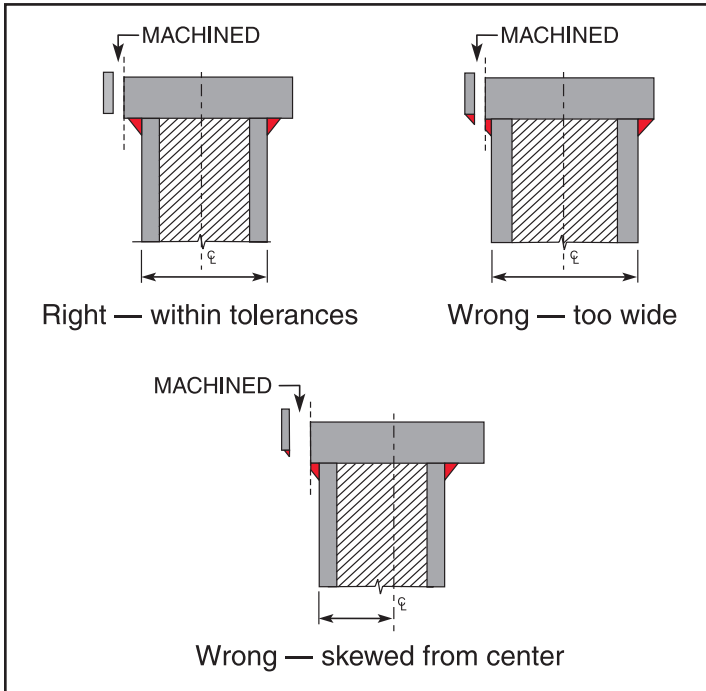


Figure 4. When machining weld metal, tolerances are critical.

consider the final connection, after machining of the part, and make sure that the required weld throat will be maintained in those conditions. It is essential that the designer consider all the tolerances that could accumulate, resulting in maximum metal removal, and verify that even under these conditions, adequate weld throats will be maintained.

Figure 4 illustrates how these problems can arise, and the important role that tolerances play in avoiding the creation of these problems. Perhaps one reason that this occurs is that the typical tolerances associated with many steel welding applications may be in the general magnitude of  $\pm 1/8$  in (3 mm), whereas machining tolerances may be much more rigorously controlled.

## Case Study

This case study is basically an example of the first type of “nothin’ weld” that was described: a fillet weld in a poorly fit joint. What compounded this problem further is that poor fitup was inherent to the detail that was selected. A part was stamped from 3/16 in (4.8 mm) sheet metal, formed into a channel, and assembled into a skewed joint configuration. To minimize cost of material preparation, the end of the inclined member had a 90° edge. Due to forming tolerances, fitup would never be exact and the inclined nature

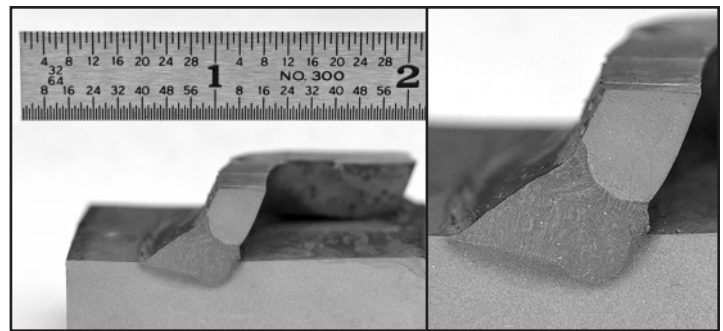


Figure 5. Weld with adequate throat.

of the skewed joint created a narrow included angle. The designer expected a PJP groove weld with a reinforcing fillet weld would be applied. To ensure this, welding procedures were developed that assured adequate penetration as long as the part was welded in the flat position. See Figure 5.

However, during production a “nothin’ weld” was created. Although all the facts will probably never be known, it appears that the welder chose to perform this operation in the horizontal position, minimizing penetration into this groove, yet resulting in a “nothin’ weld” with virtually no throat that was visually indistinguishable from the expected fillet weld. See Figure 6.

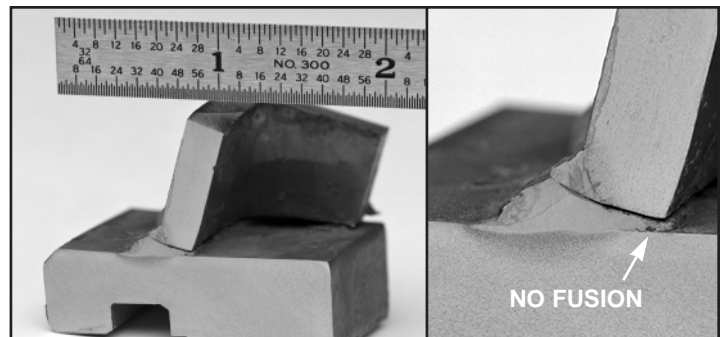


Figure 6. A “nothin’ weld.”

Four of these brackets supported a bearing cartridge that was part of a rotating machine. After several dozen hours of operation, the welds on one bracket failed, followed by failure of the corresponding welds on the other three brackets. When the bearing support was lost, the entire machine was ruined. To overcome this problem, a rigorous in-process inspection and monitoring of the welding operations was initiated to ensure that the welder made the welds in the prescribed position. After-the-fact weld inspection was obviously incapable of detecting this “nothin’ weld.”

## Conclusion

“Nothin’ welds” can be avoided by proactively anticipating the unexpected, and taking specific measures to ensure that the expected weld throat is consistently delivered in the finished product. 