Control Costs by

Avoiding Overwelding

It is important to minimize overwelding in order to reduce costs, distortion, and assembly problems.

UNDERSTANDING WELDING ECONOMICS and the variables that affect those economics is critical. This knowledge can provide you with the information necessary to make the best decisions to positively affect quality and productivity.

Overwelding can have a significant effect on costs because it increases filler metal consumption and your welders' total arc-on time. The following information should help you avoid overwelding.

Factors that Affect Welding Decisions

When deciding which type of weld joint to use, the choice becomes a trade-off between the cost of the weld preparation time for a groove weld vs. the additional deposited weld metal needed to make a fillet weld of equal strength. For sheet metal and light plate thicknesses, the comparison usually favors the use of fillet welds. In heavier plate, the advantage in productivity shifts to groove welds. The transition point usually occurs with fillet welds of less than ⅝ in. to ¾ in. leg size. In some cases it can occur before, depending on an individual company's cost of weld groove preparation.

Once a groove weld has been selected over a fillet weld, the decision whether to use a single-sided weld joint (single bevel or single-V groove) or a double-sided weld joint (double bevel or double-V groove) must be made. As the plate thickness increases, the amount of extra deposited weld metal needed to make a single-sided groove weld will exceed the cost of double-sided joint preparation. Where this changeover point occurs will in part be affected by the company's cost of making weld joint preparations, but in most cases this point occurs in groove welds when the thickness of the metal exceeds 1⅛ in.

Another factor that can affect the requirement to use the least amount of filler metal is the need to control distortion in the welded plates. When welding is done from one side only, the amount of weld metal deposited about the neutral axis of the plate being welded is unbalanced, which can lead to distortion of the material about that axis. In most cases, depositing the same amount of filler metal on each side of the neutral axis will result in the least amount of distortion.

When backgouging is not required (e.g., for a partial-joint-penetration weld), this is achieved by equal groove preparations on both sides. When backgouging is required (e.g., for a complete-joint-penetration weld), this is accomplished by making the first side of welding deeper than the second side. When the backgouging operation is performed from the second side into the root of the first side, the resulting groove on each side will be equivalent. A ⅔ (first side), ⅓ (second side) is often used to achieve this result.

Sources of Overwelding

In any production operation, there are three potential sources of overwelding. The first source is Design Engineering. Since the Design Engineer specifies the fillet weld size or the joint application, this selection becomes the requirement the welders must meet. If the Design Engineer selects a weld that is larger than necessary, then overwelding results because the welders are required to make oversized welds.

The second potential source of overwelding is the welder. Once the Design Engineer specifies the weld size required, the welder must make the weld that size and length. Any weld greater than those amounts results in overwelding.

The third potential source of overwelding is parts fitup. If a weld fillet has a root opening greater than 1/16 in., the welder is required to weld a larger fillet than the engineering print specifies, which results in overwelding. If a groove weld contains an unspecified or larger than specified root opening, or has an included angle greater than specified, overwelding will occur.

Welding supervisors do not have control over Design Engineering, but do exercise supervision over the welders and, to a degree, the fitup. Therefore, the welding supervisor can affect how large a weld is being made.

Figure 1 illustrates the effect that overwelding can have on costs. The examples use a fillet weld for ease of comparison.

An Example for Overwelding

A 3/16-in. fillet weld volume per inch length is 0.0175 in.^{3}, a 1/4-in. fillet weld volume per inch of length is 0.031 in.^{3}. The subtraction of 0.0175 from 0.031 = 0.0135 in.^{3} of deposited metal savings. The 0.0135 when divided by the small fillet weld volume will show the percentage of savings, 0.0135 divided by 0.0175 = 78% volume savings when making a fillet weld to engineering size that is 3/16 in. instead of overwelding the fillet weld 1/4 in.

As shown in Fig. 1, the difference in filler metal volume can range from a 43% to a 124% increase if the weld leg size is larger than the size required by just 1/16 in. This difference can be even greater if the leg size is oversized by more than 1/16 in.

As shown in Fig. 2, having just one leg of the fillet weld oversized can lead to significant overwelding. A further example is the effect on cost of making a 1/4-in. fillet weld with one leg oversized. This overwelding example results in a fillet with one leg 1/4 in. and the other leg 5/16 in. This increases weld metal volume by almost 26%. If the oversized leg is 3/8 in., which can happen with horizontal fillet welds, the increase in weld metal volume will be almost 52%. This results in a cost of overwelding of more than 50% in both filler metal and welder arc time.

At the same time, overwelding can also occur when doing intermittent or partial length fillet welds where the length of fillet weld is specified by the design engineer. If the welder fails to make a fillet weld of this length, but instead makes the weld longer, the additional weld length is also considered as overwelding.

The same logic for overwelding can be applied to groove welding where excessive increase in the groove angle, root opening, or penetration depth above what is specified in the design requirements results in additional filler metal material, as well as taking additional welder time.

If the Design Engineer specified a 3/16-in. fillet weld leg size on an engineering drawing, and the welder made a 5/16-in. weld, this would result in an increase in weld metal volume and, therefore, deposited filler metal weight of 177%. The result, independent of the deposition rate used, would require 177% more arc time per weldment to complete. For example, the welder making a 3/16-in. fillet weld 1 ft long would require 36 s, the same weld with a 5/16-in. fillet weld using the same welding parameters would require 1 min 39 s to complete. A welder could complete approximately 3 ft of weld using a 3/16-in. fillet in the same time that would be required to make a 5/16-in. fillet 1 ft long.

It is obvious that a major reduction in the amount of arc time required to make a length of weld is greatly impacted by the size of the weld being made.

Welding supervisors can do little to impact the weld size designed for the part, except to be aware of its impact and alert the Design Engineer whenever a change in weld size is warranted. Overwelding occurring

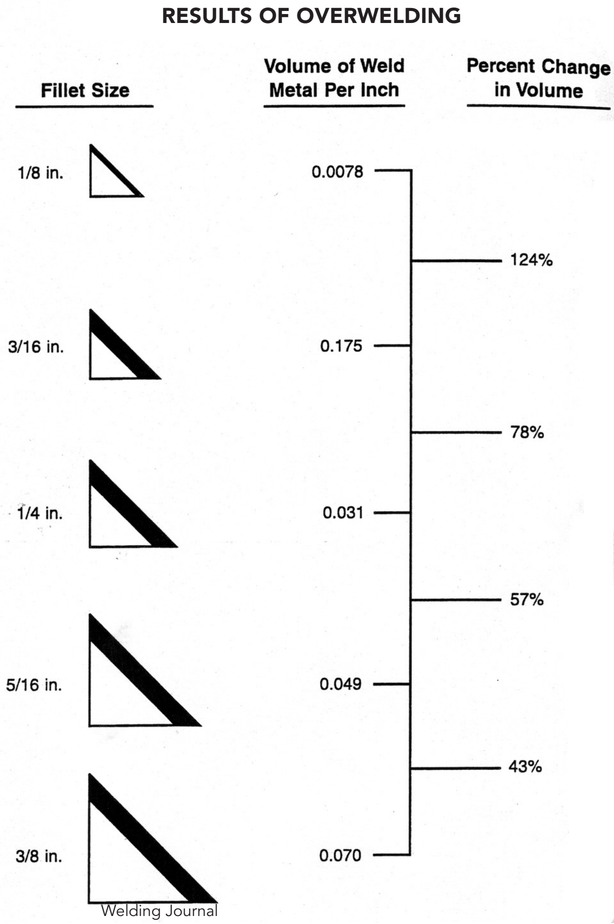
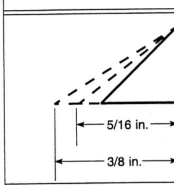
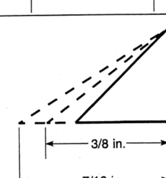
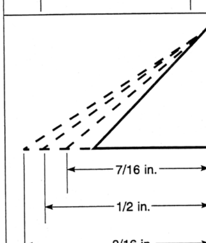


Fig. 1

Fig. 2

	Leg Sizes (in.)	Cubic Inches of Metal per Inch of Weld	Percent Increase (%)
	1/4 in. Leg Sizes "By Specification" 1/4 × 5/16 1/4 × 3/8	0.031 0.039 0.047	Normal +25.8 +51.6
	5/16 in. Leg Sizes "By Specification" 5/16 × 3/8 5/16 × 7/16	0.048 0.059 0.068	Normal +21.9 +41.7
	3/8 in. Leg Sizes "By Specification" 3/8 × 7/16 3/8 × 1/2 3/8 × 9/16	0.071 0.078 0.094 0.106	Normal +15.6 +32.4 +49.3

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due to welder performance and joint fitup is to a degree controllable by the welding supervisor. The supervisor can ensure that the welders periodically check their welds using a fillet weld or weld reinforcement gauge to verify that the welds are made to size. This practice not only prevents overwelding, but also guards against undersized welds that could lead to weld failures or repairs. The supervisor should periodically check the welders' joint fitups to verify that welds are being made to the specified size and length. This type of monitoring can demonstrate the importance of weld sizes if the welders' supervisor takes the time to check them.

An overlooked benefit of reducing overwelding is the effect that using less weld metal has on distortion. One of the hidden problems in welding is the effect distortion has on the outcome of a finished weldment. Distortion can lead to an unsightly appearance of the part, can cause assembly problems, and can also interfere with the operation of the welded assembly in service. All of these conditions will result in time-consuming, costly delays to rework or replace a part that is rendered unusable because of distortion from overwelding. MSC

Overwelding and Distortion Control

An entire chapter of AISC *Steel Design Guide No. 21, Welded Connections—A Primer for Engineers*, is dedicated to the topic of distortion that results from welding and how to control it. The chapter includes an in-depth explanation of the phenomenon of distortion, as well as the following statement regarding how it is affected by overwelding:

> *The importance of specifying welds of the proper size is essential for controlling distortion. Larger-than-necessary welds will naturally result in more distortion. Specification of complete joint penetration (CJP) groove welds "just to be safe" will often result in larger-than-necessary welds, with correspondingly greater distortion. Fortunately, many of the concepts that are useful for obtaining economical welded connections (discussed in Chapter 14 of this Guide) simultaneously reduce the volume of shrinking weld metal, which is what drives distortion.*

Written by Duane Miller, Sc.D., P.E., Design Guide 21 *is available as a free download for AISC members, and for purchase by non-members, at* **www.aisc.org/dg**.

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