Advancements in EWI DeepTIG™ for Higher Productivity GTAW

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Introduction

EWI DeepTIG™ flux was developed on the Navy ManTech Program in the 1990s to increase productivity during gas tungsten arc welding (GTAW) by enabling simplified joint preparations and reduced number of passes. GTAW welds made with EWI DeepTIG are typically produced in a single pass on square groove butt-joints with base material thickness up to 3/8-in thick. The flux is available commercially through EWI's website, and specialized flux formulas are available for carbon steel, stainless steel, and nickel-based alloys. EWI DeepTIG is classified by the American Welding Society as a penetration enhancing flux with many user benefits. Now, a more user-friendly version of the product, EWI DeepTIG wire, is also available and has been validated by work that EWI has performed for the National Shipbuilding Research Program (NSRP) to improve the productivity of pipe welding in U.S. shipyards.

EWI DeepTIG Flux

EWI DeepTIG flux is applied by first mixing it with a carrier such as methanol, painting the solution onto the weld side surfaces of the joint, and then producing the GTAW weld once the solution has dried. EWI DeepTIG contains metallic oxides that change the fluid flow in the weld pool to increase penetration by as much as 300%. Figure 1 shows penetration verses current for bead-on-plate welds produced on 7.7-mm thick nickel-based superalloy plate with and without EWI DeepTIG. The plot shows that for a given current level, the penetration of the GTAW welds produced with the flux were significantly greater than those produced without flux.

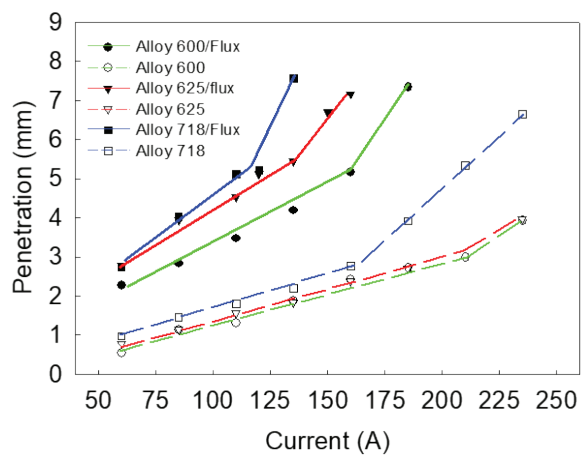


Figure 1. Penetration vs. current for bead-on-plate GTAW welds produced with EWI DeepTIG flux

Macrographs of complete penetration bead-on-plate welds produced on 7.7-mm thick Alloy 718 plate at 3-ipm travel speed with and without EWI DeepTIG are shown in Figure 2. The weld produced without flux required 235A to achieve complete penetration, whereas the weld produced with the flux required only 135A; this represents a 43% decrease in current when using EWI DeepTIG. Referring to the macrograph shown on the right, depending on the application, a cap pass with conventional wire is sometimes needed when base materials that are about 6.4-mm (1/4-in) or thicker are welded with the flux to promote a convex weld cap.

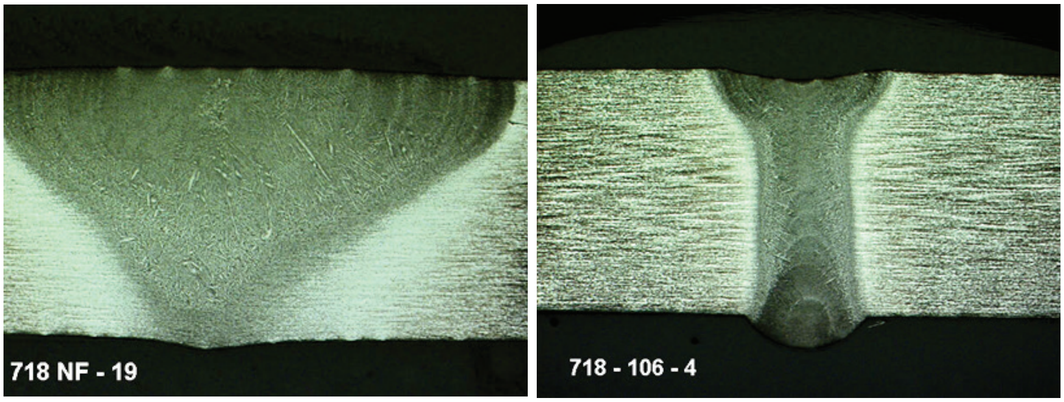
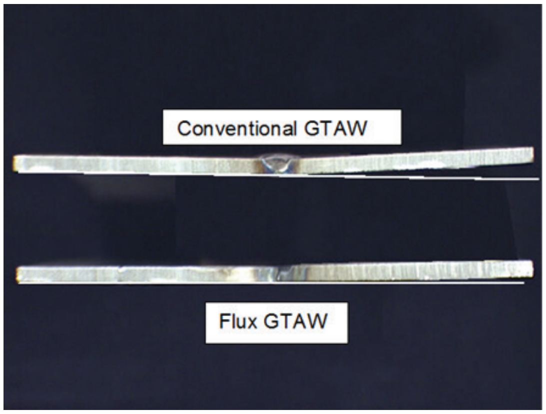


Figure 2.
Macrographs of full penetration bead-on-plate welds produced on 7.7-mm (5/16-in) thick Alloy 718 plate at 3-ipm travel speed with no flux (235A, left) and with EWI DeepTIG flux (135A, right)

EWI DeepTIG also has been shown to reduce distortion when welding thin materials. Both welds shown in Figure 3 were produced using 1.5-mm thick Type 304 stainless steel plate in a square groove butt-joint configuration. Referring to the top photo, the conventional GTAW weld is wide at the top and narrow near the bottom, whereas the GTAW weld produced with the flux has a much more consistent width between the top and the bottom of the weld profile. The weld produced without flux has more angular distortion, which is at least partially related to the steeper gradient in weld width between the top and bottom surfaces of the weld cross-sectional profile.



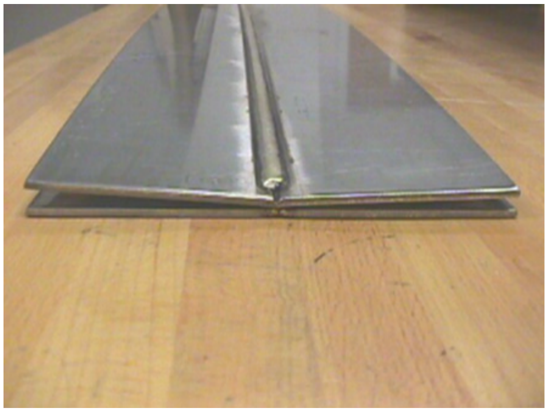


Figure 3. Complete penetration square groove butt-joint welds produced on 1.5-mm thick Type 304 plate with and without EWI DeepTIG flux

EWI DeepTIG flux has been shown to have several benefits when welding thicker materials.

1. <u>Simplification of the joint preparation</u>: Machining cost can be reduced by replacing the complex joint designs used with conventional GTAW with square groove butt-joints. In some cases, the flux can be used with square groove butt-joints that are prepared with saw cutting rather than machining, further reducing fabrication costs.
2. <u>Reduction in the number of passes</u>: EWI DeepTIG can enable single pass, or at most, two pass welds to be produced in material up to 3/8-in thick. As material thickness increases, the number of passes that are required for conventional GTAW also increases, and thus productivity improvements that can be achieved with EWI DeepTIG increase. For example, for conventional GTAW, butt-joints in 0.134-in thick Type 304 stainless steel are typically prepared using a single-side v-groove with three passes required. When EWI DeepTIG flux is used, a square groove butt-joint configuration can be used with only one pass required.
3. <u>Reduced distortion</u>: GTAW welds produced with the flux typically use square groove butt-joint preparations, fewer passes, and have a greater depth to width ratio; therefore, these welds typically have less distortion than conventional welds.

DeepTIG Wire

One of the primary barriers to the widespread use of EWI DeepTIG is the 3-step process of mixing the flux with a solvent, painting the solution onto the base material surface, and waiting for it to dry prior to welding. Now, this barrier can be overcome using a new version of EWI DeepTIG in a cored wire product form that can be used like any other welding filler metal; the advantage is that penetration can be increased 250%-300% compared to conventional welds made with solid wire.

EWI recently completed an NSRP Welding Technology Panel project during which mechanized GTAW welding procedures with 308L EWI DeepTIG wire were developed for producing square groove butt-joints in Type 300 series stainless steel piping for the applications listed in Table 1 below.

Procedures were identified for producing weldments that met all standard procedure qualification requirements specified in NAVSEA Technical Publication S9074-AQ-GIB-010/248 for the following applications:

- 5-in. Schedule 10, Type 304 pipe, 1G-R position (Application No.1)
- 10-in. Schedule 10, Type 316L pipe, 1G-R position (Application No.2)
- 5-in. Schedule 10, Type 304 pipe, 5G position (Application No.4).

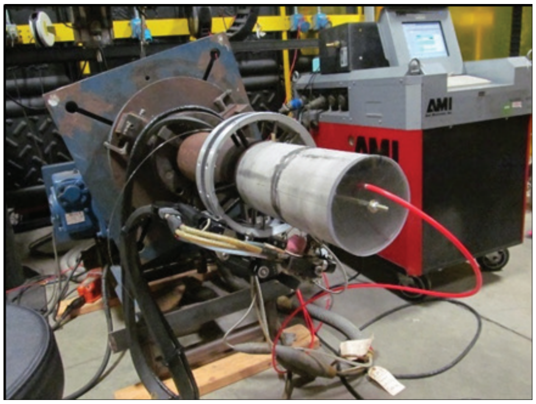
Each of these weldments was produced in a single pass using travel speeds between 5.8 and 6.8-ipm, and abutting edges that were machined. A macrograph and photograph for the procedure qualification (PQR) weldment for the 5-in schedule 10 butt-joint weldment produced in the 5G position are shown in Figure 4. The procedures developed for the 5-in diameter schedule 10, and 10-in diameter schedule 10 butt joint weldments produced in the 1G-R position were successfully demonstrated at two U.S. shipyards.

Procedures were identified for welding the square groove butt joint in 5-in. schedule 40, Type 304 stainless steel pipe in the 1G-R position using two passes. Both passes used a travel speed of 3-ipm. 308L EWI DeepTIG wire was used for the first pass, and conventional ER308L wire was used for the second pass. Complete penetration of the 0.258-in thick square groove butt-joint was accomplished with the first pass. The second pass was a cap pass that was needed to provide a convex weld cap. This weldment met the Class 1 penetrant testing and radiographic testing requirements of MIL-STD-2035A. The weld cap met the Class 1 visual testing requirements of MIL-STD-2035A, however, future modifications to the first pass procedures are needed to reduce root reinforcement by 1/32-in to enable the Class 1 visual testing requirements to be met. Since there is not an immediate need for implementation of this procedure at the participating shipyards, it was not completely developed during the 2017 NSRP Panel project. A photo of this weldment is shown in Figure 5.

Application No.	Joint Type	Pipe Type	Pipe Size	Pipe OD (in.)	Wall Thickness (in)	Welding Position	Torch Positioning
1	Butt joint	304	5-in. Schedule 10	5.563	0.134	1G-R	Mechanized
2	Butt joint	316L	10-in. Schedule 10	10.750	0.165	1G-R	Mechanized
3	Butt joint	304	5-in. Schedule 40	5.563	0.258	1G-R	Mechanized
4	Butt joint	304	5-in. Schedule 10	5.563	0.134	5G	Orbital

Table 1. Applications for which welding procedures using EWI DeepTIG wire were developed

Figure 4. Macrograph for the PQR weldment (right) produced in 5 in. schedule 10 Type 304 stainless steel pipe using 308L EWI DeepTIG wire



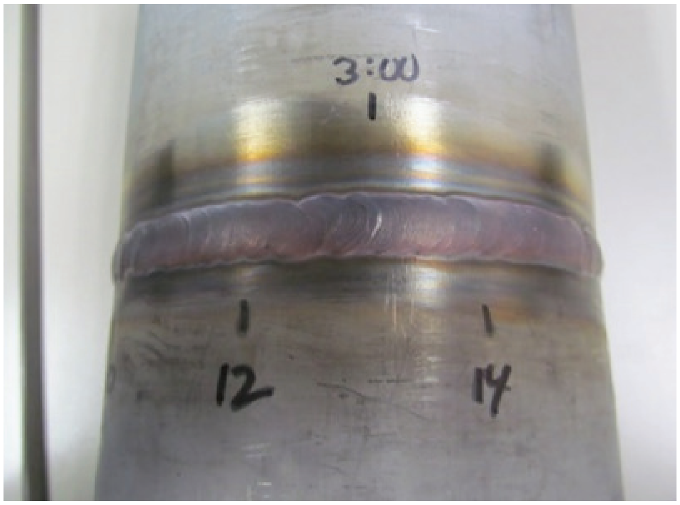


Figure 5. The 5-in. schedule 40 butt joint produced in Type 304 stainless steel pipe in the 1G-R (as-welded) condition

Summary

EWI DeepTIG flux and EWI DeepTIG wire can provide increased productivity and reduced fabrication costs due to the following benefits: 1) penetration can be increased by as much as 300%, 2) number of passes and the heat input per pass can be reduced, 3) simple square groove butt-joints can be used rather than more complex joints, and 4) distortion can be reduced. EWI DeepTIG flux is an established commercially available product that has formulations for carbon steel, stainless steel, and nickel-based alloys. EWI DeepTIG wire offers the advantages of the flux product plus ease of use since it can be used like any other welding filler metal.

***Nick Kapustka**, Senior Engineer in the Arc Welding group at EWI, has built a successful reputation in the field of arc welding, specifically focusing on aluminum, titanium, magnesium, nickel-based alloys, and advanced high-strength steels (AHSS) with broad experience in terms of both industry and technological processes. In 2009 Nick received the McKay-Helm Award from the American Welding Society for his peer-reviewed Welding Journal article on GMAW of AHSS. In addition, he has written more than 60 technical reports for contract work, has authored several papers, and has spoken at numerous conferences. He has co-invented several shielding devices for the GMAW and gas tungsten arc welding (GTAW) of reactive metals.*