# Autogenous Orbital Gas Tungsten Arc Welding Can Increase Pipe Welding Productivity

*Steve Manring, Project Engineer*
*EWI*

## Introduction

Although autogenous orbital gas tungsten arc welding (GTAW) is not a new process for joining pipe and tube, the advantages of the process are not widely known due to its limited use in industry. Autogenous welding is defined by the American Welding Society as "a fusion weld made without filler metal." [1] Autogenous orbital GTAW is capable of producing single pass, complete joint penetration welds on square edge butt joints without using filler metal. This automated process can increase productivity by reducing the welding time required for an applicable piping system to be completed (compared to manual GTAW methods). Majority of the time savings result from the reduction in total number of passes required to complete each weld. Cost reductions are also realized by eliminating the need to prepare beveled groove joints and purchase filler metal.

Implementing technologies that reduce the cost and build time for U.S. ship construction was the primary focus of this project to investigate how autogenous orbital pulsed GTAW could reduce fabrication costs for ship piping systems. The results of the work described in this paper show that autogenous orbital GTAW can reduce pipe welding time by approximately 35% compared to manual welding procedures.

Figure 1: Orbital GTAW Welding a 4 in. Schedule 10 Pipe Specimen in the 5G Position

Figure 2: 1/2 in. Schedule 40 Pipe Specimen Positioned in a Closed-Frame Orbital Welding Head

## Autogenous Orbital Pulsed GTAW Process Capabilities

Type 304L stainless steel is a material commonly used in ship piping systems and many other industrial applications. For this reason, 304L was selected as the primary material for demonstrating the advantages of autogenous orbital pulsed GTAW. The process is equally applicable to other grades of stainless steel, including Types 316, 316L, 321, and 347; as well as carbon steel and nickel alloy pipes and tubes. For this project, square butt joints welded in the horizontal (5G) position were used on pipes ranging from 1/2 to 4 in. nominal pipe size (Figures 1 and 2).

This project confirmed that autogenous orbital pulsed GTAW can efficiently and consistently weld ½ in. Schedule 10 (0.083 in. wall), ½ in. Schedule 40 (0.109 in. wall), 2 in. Schedule 40 (0.154 in. wall), and 4 in. Schedule 10 (0.120 in. wall) Type 304L pipes. For each diameter and wall thickness described above, complete joint penetration welds were verified by radiographic testing and metallurgical examination of weld cross sections (Figure 3). Visual inspection and dye penetrant testing were used to evaluate the weld face and root surfaces. All welds passed inspection per the acceptance criteria listed in the commercial and military standards used for this project (NAVSEA Technical Publication S9074-AR-GIB-010/278, MIL-STD-2035, ASME Pressure Vessel Code Section IX).

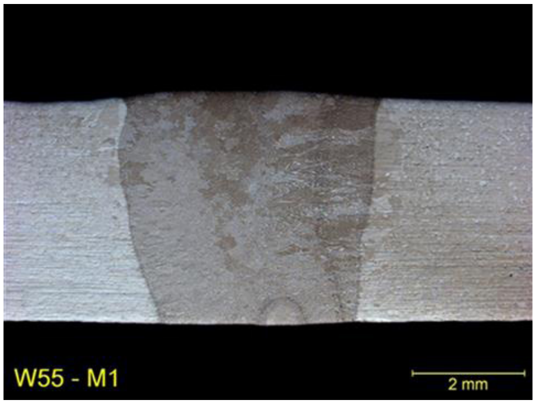


Figure 3: Cross Section of Autogenous Orbital GTA Weld Using 95%Ar-5%H Shielding Gas in 2 in Schedule 40 (0.154 in. wall) Pipe with Zero Root Gap

A 100% argon shielding gas and a 95% argon - 5% hydrogen (95%Ar-5%H) shielding gas was used to produced acceptable autogenous orbital GTAW welds on the 304L pipe sizes tested in this project. However, the weld profile and penetration resulting from the 95%Ar-5%H shielding gas appeared to be slightly more consistent compared to welds made with 100% argon shielding gas. An attempt was made to weld 4 in. Schedule 40 Type 304L pipe with 0.237 in. wall thickness, but acceptable welds were not obtained.

## Process Tolerance to Production Variables

This National Shipyard Research Program (NSRP) project also investigated the tolerance of the autogenous orbital GTAW process to variations in weld joint fit-up conditions that may be encountered in production. Square butt joints were assembled with pre-set root gaps of up to 0.015 in. or a pipe off-set of 0.025 in. Out-of-roundness was also evaluated by producing welds on pipes with as much as 0.025 in. run-out. The wall thickness variations of all pipes welded during this project were within the nominal specification tolerances of plus zero and minus 12.5% of the nominal pipe wall thickness.

The results of this investigation confirmed that the welding parameters used to produce acceptable welds on joints with good fit up were tolerant of the typical variations in pipe wall thickness and joint fit-up conditions that conform to industry practice. This includes root gaps of up to 0.015 in. and pipe off-set or out-of-roundness up to 0.025 in. (Figure 4). While not verified in this project, similar success should be expected on other types and grades of stainless steel as well as carbon steel pipe.

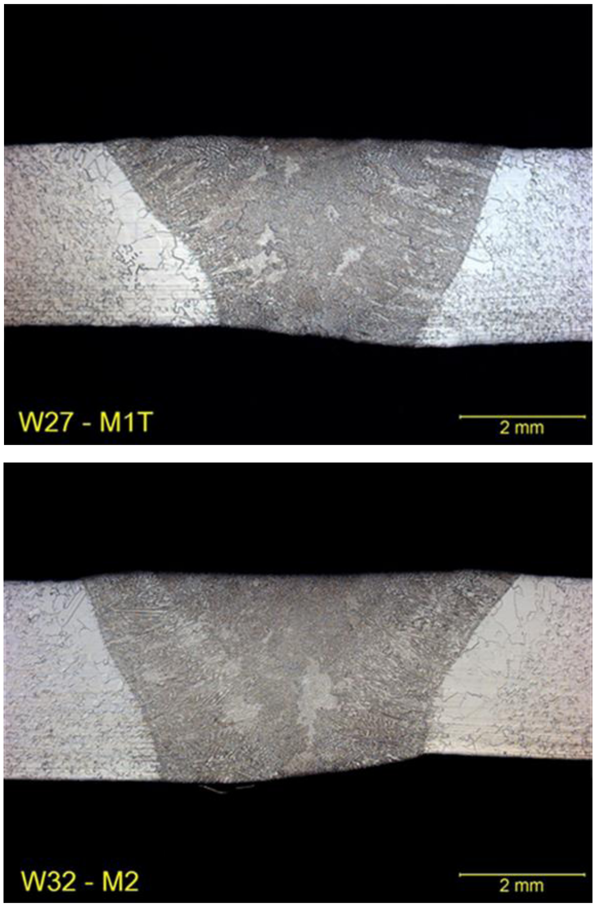


Figure 4: Cross-Section of 4 in. Schedule 10 Weld W27 (left) with Zero Root Gap Weld W32 (right) with 0.015 in. Root Gap Made with the Same Welding Parameters and Argon Shielding Gas

## Process Tolerance to Stainless Steel Sulfur Content

When using the autogenous GTAW process, a variation of the sulfur content in the stainless steel being welded can alter weld penetration if parameter changes are not made. Welds produced on stainless steels with very low sulfur content (less than 0.005 wt. %) may result in shallower penetration as compared to welds produced on stainless steels with higher sulfur content (when using the same welding procedures).

To illustrate the impact of sulfur content on weld penetration, welding trials were performed on two heats of 2 in. Schedule 40 Type 304L pipes. The two heats had sulfur contents of 0.003 weight percent and 0.015 weight percent respectively. The results of these trials showed that although pipes with higher sulfur levels of 0.015 weight percent required slight adjustments to the welding parameters compared to those with low 0.003 weight percent sulfur levels, acceptable welds that met all the inspection requirements were still achievable.

## Autogenous Orbital GTAW Yields High-Quality and Productivity

The autogenous orbital GTAW procedures used during this project were compared to typical manual GTAW pipe welding procedures used to fill V-groove joints. The autogenous orbital GTAW process saves time in preparation of the weld joint and reduces the number of manual welding passes require to fill the joint (from two or three passes required for manual welding to a single pass with the autogenous orbital GTAW process). These process improvements are estimated to save an average of 35% in the total production welding time, which would be a tremendous benefit to any industry that fabricates pipe and tubing.

## Reference

[1] AWS A3.0M/A3.0, Standard Welding Terms and Definitions, American Welding Society, Miami, Florida.

## Acknowledgement

The Autogenous Pipe Welding project was funded by the National Shipbuilding Research Program-Advanced Shipbuilding Enterprise (NSRP-ASE).

***Steve Manring*** *has almost 35 years of welding and materials joining experience, with a focus on orbital and automated welding equipment. His work has included process and parameter development, operator training, equipment integration into production, and process and equipment problem solving. He has further experience with material testing, metallurgical evaluation, and quality control. Currently, he is a project engineer in the Arc Welding team at EWI.*