

## Purge to Protect Stainless-Steel Pipe Welds

*On occasion we get questions from our members who would like to use backing flux in lieu of purging when making welds on stainless steel or other corrosion resistant materials. The following describes an experiment conducted by NCPWB Consultant, Walter Sperko, where he had a colleague make stainless steel butt welds without any protection of the root of the weld, with inert gas backing, with backing flux and with flux-coated wire.*

### Backing Flux – An Alternative To Purging

Why not use backing flux instead of purging stainless steel pipe? Purging piping is expensive and time-consuming; however, some method of preventing oxidation of the weld root surface is necessary because the weld surface will be rough and covered with a heavy black oxide if it is not protected from the oxygen in the air by something. See Figure 1.

### Purge Gas and Backing Fluxes Fight Off Oxygen

Purge gas must flow through the pipe long enough to displace the oxygen to a low enough concentration that the level of discoloration is acceptable to the end user. With a gas flow of 50 ft<sup>3</sup>/hr., purge time can range from 30 seconds per foot of pipe for 3-inch pipe to 90 minutes per foot of 48-inch pipe. (see *Table on purge-gas flow times*). Purge dams will reduce the volume to be purged, and that reduces time and the volume of gas needed. Contractors should verify that the oxygen in the pipe is less than necessary to achieve the level of discoloration that the contractor and the customer have agreed on based on PFI Standard ES-50. See Figure 2.

Fabricators have successfully used backing flux to protect the weld root surface from oxidation as an economic alternative to purge gas. Fluxes come as fine granules that the welder mixes with alcohol to form a thick paste. The welder applies the paste to the inside surfaces of the pipe at the edges of the bevel. The solvent evaporates quickly and the flux sticks to the pipe surface. The heat from welding melts the flux and the molten flux floats over the weld pool surface protecting the weld pool from the oxygen in the air. Contractors have also use flux coated or large, specially made flux cored wire to weld root passes in piping without using a backing gas. The flux on or inside these filler metals provides a layer of flux over the weld pool just like paste flux, protecting it from the oxygen in the atmosphere.

To compare the results of welding with various backing conditions, Larry Peterson (Peterson Welding, Clemmons, N.C.) and the NCPWB consultant used Type 304 NPS 3 Schedule 40 pipe coupons. Test welds were made with an argon backing, with backing flux, with flux coated filler metal and, for baseline comparison, with the weld root surface boldly exposed to the air.

### And the Winner Is...

Without any root side protection, Peterson struggled to obtain penetration; he had to “work” the weld pool. In contrast, root passes made with backing gas, with backing flux, and with flux-coated wire fused smoothly and easily into the joint. The root side surfaces were fully penetrated, smooth and uniform. The flux on the coated wire would occasionally pop off before melting into the weld pool. Both types of backing fluxes bubbled up through the weld pool, disturbing the arc plasma somewhat. The weld deposited with inert gas purge was smooth and uniform, with slightly golden in color with a thin blue coloring on the heat-affected zone.

The gold coloring was caused by a bit of oxygen present in the pipe during welding. The blue was caused by surface contamination, probably residual cutting fluid on the pipe surface. Both adhered tightly to the weld surface. The welds made with paste flux and coated wire oxidized some when the second pass was deposited. That contrasted

with the welds made with purge gas: the weld interior surface did not discolor further by the heat from subsequent passes.

As was expected, welding with the root of the weld boldly exposed to the air left the rough surface that was heavily oxidized as shown in Figure 1. In contrast, the weld metal flowed easily with backing flux, with flux coated wire and with argon purging, enabling the Larry to achieve full penetration easily . However, welds made with flux left behind residual slag on the inside surface of the pipe. As the test coupons cooled, some of the slag flaked off. The remaining slag could not be removed with a wire brush; use of slag hammer proved only somewhat successful. The flux-coated wire left less slag than the paste flux.

## **Conclusion**

The only way to ensure that the inside surfaces of welds made in stainless steel or any other corrosion resistant material are free of contamination and excessive oxides that may cause corrosion of the pipe is to use inert backing gas that displaces the oxygen in of the pipe sufficiently that an acceptable level of discoloration is achieved.

Use of backing fluxes and flux-coated and flux cored wire improves quality of root side welds in stainless steel pipe when compared to welding with the root surface exposed to the air. The flux allows tack and root pass welds to fuse into the weld easily they make it possible to get a good root pass surface contour. However, these products leave residual slag on the interior surface of the pipe, and that may cause issues with contamination of the product that will flow through the pipe. Residual slag on the inside of a pipe weld can lead to pitting and crevice corrosion, especially in water-wetted applications. Residual slag may not cause problems in applications such as in elevated temperature service or transportation of petroleum products, strong acids and caustics.

Contractors should make their customers aware that residual slag will be present on the interior surface of the pipe if root passes are welded using flux rather than inert gas purging.

**TABLE 1**

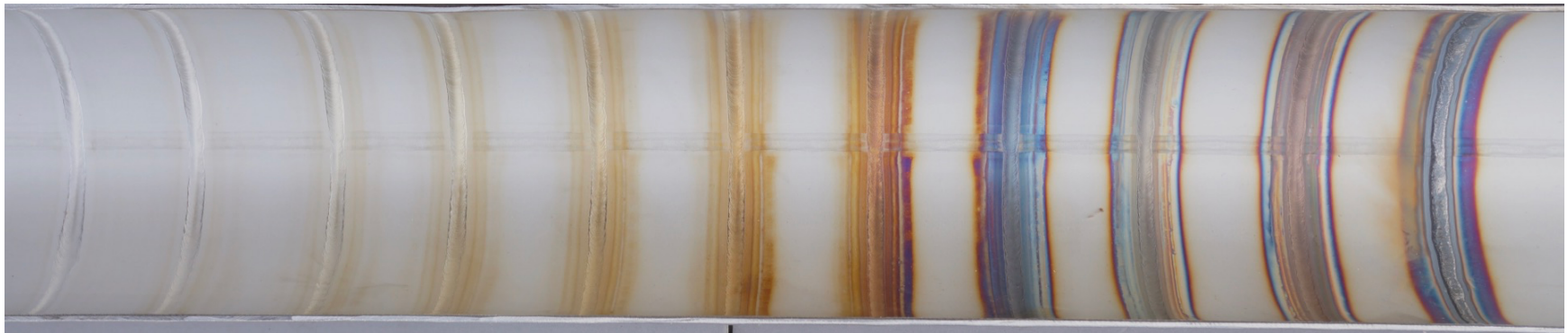
<b>PURGE-GAS FLOW TIMES VARY WITH PIPE SIZE</b> Gas-flow rate of 50ft <sup>3</sup> /hr. with six volume changes			
<b>Nominal pipe size (NPS)</b>	<b>Purge time, min., per foot of pipe</b>	<b>Nominal pipe size (NPS)</b>	<b>Purge time, min. per foot of pipe</b>
3 and smaller	0.5	16	10
3-5	1.0	18	12
6	1.5	20	16
8	2.5	24	23
10	4.0	30	35
12	5.5	36	51
14	7.5	48	90

**FIGURE 1**



This photograph shows the root side of a weld that was made using GTAW open root with the root side exposed to air. Note the coarse, irregular surface.

**FIGURE 2:**  
**Weld Discoloration Levels on the Inside of 304L Tube**



ID: 1      2      3      4      5      6      7.      8      9      10      11

Weld discoloration chart from PFI ES-50. Reproduced with the permission of the Pipe Fabrication Institute.