

Purge to Protect Stainless-Steel Pipe Welds

A weld test compares quality of root-pass gas-tungsten-arc welds in stainless-steel pipe when employing purge gas, backing flux, and flux-coated filler metals to prevent weld-backside oxidation.

Can't you use backing flux instead of argon purging?" Fabricators of pipe frequently hear this question from contractors installing stainless-steel piping. Purging to protect the root side of stainless-steel pipe weldments, or any pipe weldment of corrosion-resistant alloy, can be an expensive and time-consuming task. But welding the pipe requires the fabricator to use some method of preventing oxygen contamination of the weld root. If not, the weld surface will be coarse and rough, covered with a heavy black oxide layer, and it may exhibit excessive concavity and incomplete penetration. Use of backing fluxes or flux-coated welding wire may prove an economical alternative; however they leave a residual flux and slag on the pipe inner surface that, when the piping is in service, can contaminate the process stream or damage equipment. The residue may also cause pitting and crevice corrosion of the pipe.

Purge gas, backing fluxes fight off oxygen

Purging stainless-steel pipe with argon (or nitrogen for 300-series alloys with less than 10 percent nickel) requires the purge gas to flow long enough to displace the air from the pipe and create an atmosphere of less than 1 percent oxygen. Use of purge dams, which reduce the volume to be purged, minimizes the amount of purge gas needed and the purge time. With a gas flow of 50 ft³/min, purge time can range from 30 seconds per foot of pipe for 3-inch pipe and smaller to 90 minutes per foot of 48-inch pipe. The inside surface of a completed weld on properly purged stainless-steel pipe will be smooth, even, and uniform. It

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may exhibit thin black deposits at the outer edges of the heat-affected zone (HAZ), but the weld metal should be free of black oxides. Slight discoloration—a golden hue to the weld—indicates a bit of oxygen remained in the pipe during welding. This thin and tightly adherent oxide layer generally does not affect weld corrosion resistance, and is usually acceptable.

Fabricators turn to backing flux to protect weld backsides as an economic alternative to purge gas. Fluxes come as fine powder that the fabricator mixes with a solvent such as alcohol to form a thick mud. The welder applies the mud to the inside surfaces of the pipe at the edges of the joint bevel.

When heated by welding, the flux melts and floats over the weld-pool surface; the solvent evaporates quickly and leaves no residue. Another alternative is use of a flux-coated weld-filler wire that delivers a protective layer of flux over the weld.

To compare the results of welding with a backing flux and use of purge gas, Larry Peterson, Peterson Welding (Clemmons, N.C.), and I prepared gas-tungsten-arc-welded GTAW Type 304 stainless-steel pipe coupons, NPS 3 Schedule 40 (3.5-inch o.d., 0.216-inch wall thickness). Test weldments were made with an inert backing shield; backing flux; a flux-coated filler metal; and without root-side protection. Refer to the photos to view effects on weld quality of each procedure.

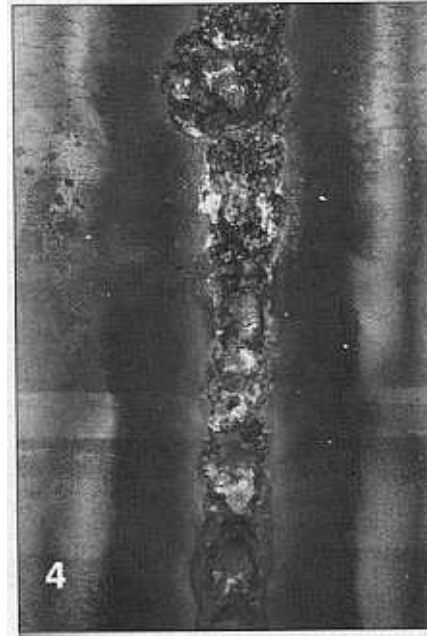
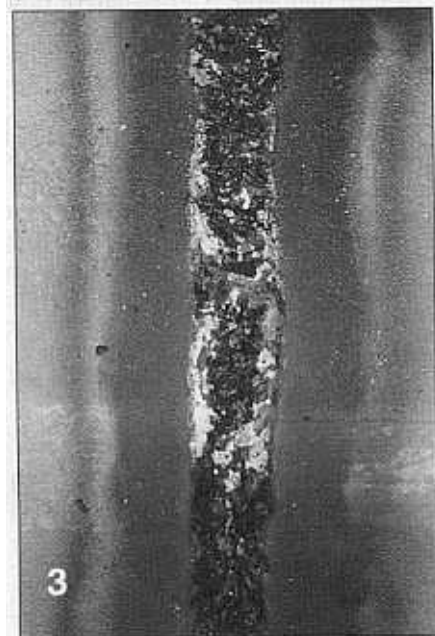
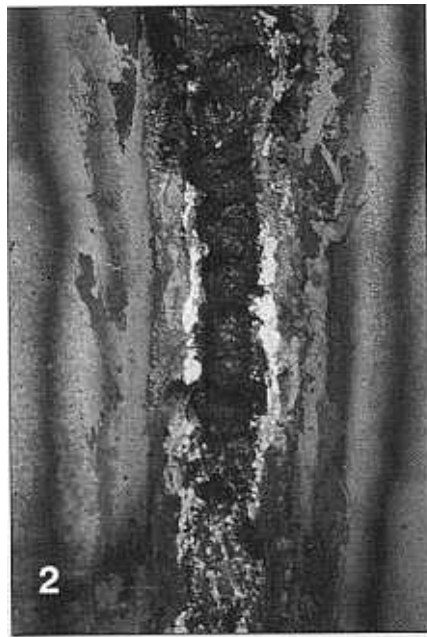
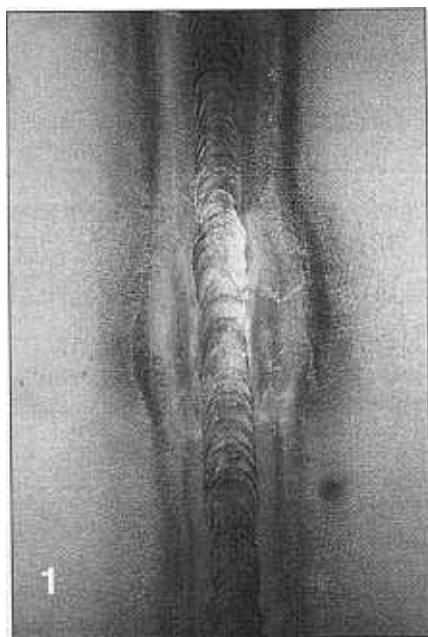
And the winner is ...

Welding without root-side protection, as Peterson welded he struggled to obtain good pipe-wall fusion. Root-pass welds made with backing gas,

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PURGE-GAS FLOW TIMES VARY WITH PIPE SIZE— Gas-flow rate of 50 ft ³ /HR with six volume changes.			
Nominal pipe size (NPS)	Purge time, min., per foot of pipe	Nominal pipe size (NPS)	Purge time, min., per foot of pipe
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





These photos show the root side of gas-tungsten-arc welds deposited from one side on stainless-steel pipe. From top left (1), deposit made with inert-gas backing is smooth and even, without oxides; (2) weld back-shielded with flux exhibits residual flux and slag on and near the weld; (3) the root side of a two-pass weld using backing flux shows that the second pass has disrupted the residual slag, leaving a cleaner weld surface; (4) and use of a flux-coated filler wire results in a small amount of slag covering the weld and heavy oxidation of the base metal next to the weld.

backing flux, and flux-coated wire fused smoothly and easily, although the flux on the coated wire would occasionally pop off of the wire before melting into the weld pool, and some slag would float on the weld pool. Both types of backing fluxes used tended to bubble up through the puddle, disturbing the arc plasma. The weld de-

posited with inert-gas purge was smooth and uniform, with slight golden and thin blue discoloration on the weld and HAZ, and brown discoloration at the edge of the HAZ. The gold and blue layers, caused by a bit of oxygen present in the pipe during welding, tightly adhered to the weldment; the brown layer, which probably

formed due to decomposition of machining fluids remaining in the pipe after bevelling, easily flaked off. While the root pass of all of the welds receiving some method of backing easily fused, the second pass oxidized the root-side surface when backing with flux and when welding with coated wire. Only when depositing the second pass with purge gas protecting the root-side surface did the inside surface remain unoxidized by the heat of subsequent passes.

As was expected, welding without backing left rough-surfaced heavily oxidized welds plagued with cavities.

Use of backing fluxes and flux-coated wire eases wetting of the weld metal and base metal, enabling the welder to easily achieve full penetration. However, welding left behind a residual slag fused to the inside surface of the pipe over the weld and HAZ. As the test coupons cooled, some of the residue—flux and slag, a hard ceramic oxide—flaked off in chunks. The remaining residue proved tough to remove—water spray and hand-wire brushing failed, and use of a slag hammer proved only somewhat successful. The flux-coated wire left less of a slag than did use of backing fluxes.

Residual slag that adheres to the inside of a pipe weld can lead to corrosion under the slag, including pitting and crevice corrosion. Applications where the slag may not cause problems include elevated-temperature sites where electrolytic corrosion is of no concern, transportation of noncorrosive products, and handling of strong acids and other aggressive products. Strong acids may even dissolve and dislodge the residue, leaving a clean corrosion-resistant surface.

Conclusions

Use of backing fluxes and flux-coated wire improves quality of root-side welds in stainless-steel pipe when compared to welding without backing. The flux causes tack and root-pass welds to fuse easily and fully. However, piping-system designers should not approve use of these products without first determining the effects of the residue left behind.

The only way to ensure that the inside surfaces of welds made in stainless steel or any other corrosion-resistant material is free of contamination and excessive oxides that may cause corrosion of the pipe is to deliver a shield of an inert backing gas that sufficiently displaces the oxygen from the inside of the pipe. ■



Typical weld in stainless steel made
without backing gas