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Achieving a Corrosion-Free Weld Surface on Pipelines

BY JULIE HOLMQUIST

Pipeline construction is a good example of a situation where it is difficult to keep weld surfaces clean. Pipeline segments often have to sit outdoors for extended periods of time and can easily rust if not protected.

Learn all about water-based coatings and biobased rust removal alternatives to grinding

A clean metal surface is critical to achieving a good weld. Welders must clean off grime and then grind off any rust present prior to welding. Often, protective coatings also need to be ground off to avoid interfering with weld strength.

Although good surface prep is vital to the quality of the final weld, grinding or other forms of abrasive blasting take extra time and labor. In some situations, these activities may be limited by the environment (e.g., a remote area). Mechanical rust removal can also create irregularities, raising its own questions about weld integrity (Ref. 1). Fortunately, there are other ways to deal with the problem of rusty weld surfaces. These alternatives are worth investigating because of their potential to make surface prep easier and allow welders to focus on their main job of welding.

Recently, two water-based coatings were studied to see if they would provide corrosion protection and could be welded over without compromising weld strength. If the coatings were to prove adequate for each concern, they could greatly increase welding speed and convenience by minimizing the amount of surface prep required. Rust removal using an organic acid was also performed and documented to demonstrate a viable alternative to using harsh chemicals for rust removal when grinding or blasting is not preferred or feasible.

Corrosion Protection with Water-Based Coatings

Pipeline construction is a good example of a situation where it is difficult to keep weld surfaces clean (see lead photo). Pipeline segments often have to sit outdoors for extended periods of time and can easily rust if not protected. This creates extra work for the welder who has to mechanically remove rust from pipeline ends before welding the segments.

Protective coatings are one strategy for keeping welded surfaces, such as pipe ends, corrosion free before welding. However, it is often recommended these coatings be removed before

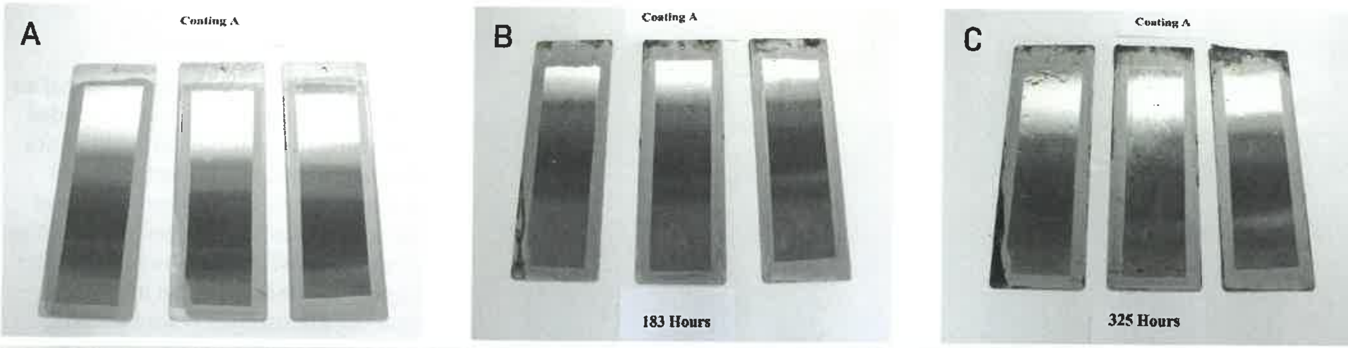

Fig. 1 — A — Coating A before; B, C — after salt spray testing.

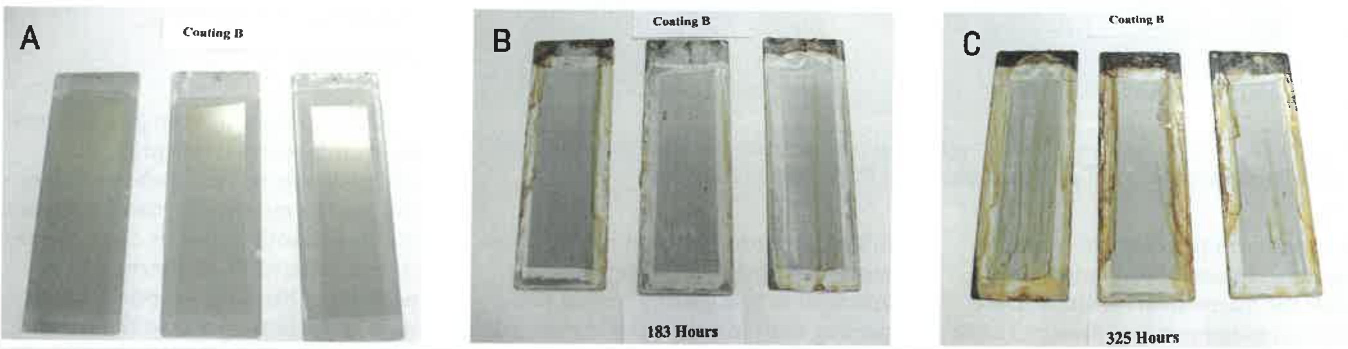

Fig. 2 — A — Coating B before; B, C — after salt spray testing.

welding because they can cause contamination or interfere with the welding process or weld integrity. This makes coating somewhat counterproductive, unless a coating is chosen that is considered weldable (although this classification itself has been debated), because it leads back to the need for the welder to grind the surface off.

The key is to find coating options that offer good protection and can either be welded through or easily removed.

Exploring Two Examples

Two water-based coatings, referred to here as coatings A and B, have shown potential for simplifying this problem and providing a viable alternative to corrosion-inhibitor coatings that rely on heavy metals such as zinc or chromate. Coatings A and B contain organic corrosion inhibitors that form a protective molecular layer along the contours of the metal and are said to inhibit microcorrosion because of their smaller particle size relative to heavy metals (Ref. 2).

Coating A is a clear, water-based permanent coating that can provide protection at very low dry film thickness (DFT). It does not negatively impact surface appearance.

Coating B is a removable coating that also protects at low DFT. It is relatively clear when dry, with a slight waxy, whitish appearance when wet. It is relatively easy to remove using a standard alkaline cleaner; however, this is not always required.

Test Conditions

Coatings A and B were tested in ASTM B117 salt spray conditions to provide a general idea of their protective abilities against corrosion (Ref. 3). The standard accelerates corrosion on metal test panels by exposing them to a constant saltwater mist at 35°C (95°F) and approximately 100% relative humidity. In these conditions, an unprotected new steel panel will severely rust within 24 h.

Although there is no exact method for equating hours in salt spray with real-life weathering outdoors, the test gives a general idea of how the coating will perform under severe conditions. If a coating provides protection in ASTM B117 conditions, it is to be expected the coating will also provide protection for a much longer period in outdoor conditions that do not include constant salt spray.

Coatings A and B were applied to three carbon steel panels, at 5 mils wet film thickness, which translated to 1.5 mils DFT — Figs. 1, 2.

The edges of the panels were dipped in wax to minimize corrosion on edges, which have less protection or are not coated at all. The panels were placed in a salt spray chamber and periodically removed for visual documentation. After 325 h of testing, the panels were in relatively good condition on the main coated parts, with some small rust spots that would be relatively easy to brush away when preparing a weld surface. Panels protected with coating B were relatively free from corrosion on the majority of the main panel coated area. Two of the panels did have an overall rusty appearance, but this was due mainly to rusty stains that had dripped down from the rusty edges and over the coating. The rusty edges presented a stark contrast to the main bodies of the panels that had been protected, overall, by the coatings.

Following Two Paths

Practical application of these coatings for protection in the field could follow two paths.

The ideal would be to inhibit corrosion from the start by applying a permanent coating, such as coating A, to

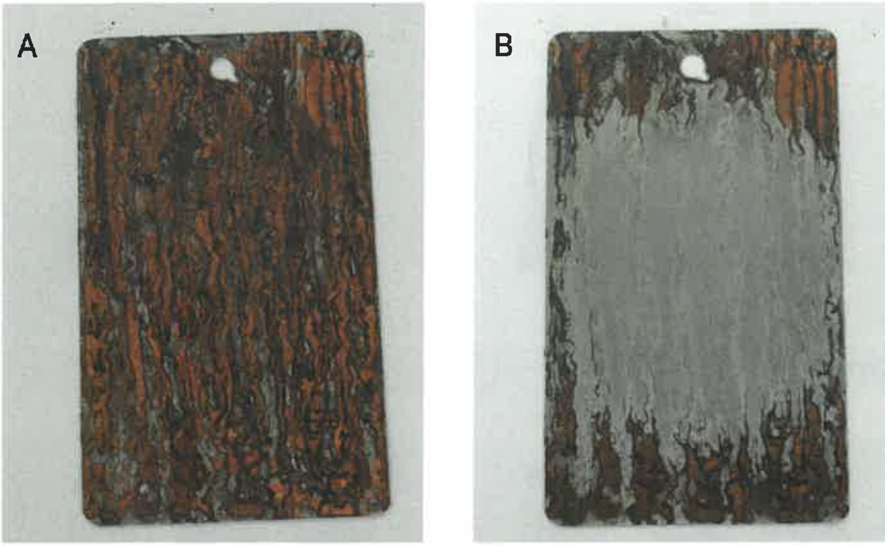

Fig. 3 — A — Rusty panel before; B — after rust removal with an organic-acid-based remover. Rust removal gel was only applied to the center of the panel.

the metal components (for example, pipeline segment ends) before they leave the manufacturing site and are exposed to temperature swings, fluctuating humidity, precipitation, or other harsh elements. The goal would be to keep the surface corrosion free and ideally only require minimal cleaning to wipe off dust or grime that might accumulate on the coated surface.

A removable or temporary coating, such as coating B, would be more suitable for protection applied farther down the process line. For example, preservation professionals working in a pipeline laydown yard where they have to restore and/or preserve assets for an extended period of time before installation could apply coating B to protect the ends of pipeline segments until it is time to weld them. When it comes time for installation, the welders could easily clean off the coating with an alkaline rinse, leaving behind a clean surface on which to weld. In some cases, it may be acceptable to weld directly over coating B.

Weld Joint Strength Testing

There is generally a concern about how welding over a coating may impact the strength of the weld, since the coating, in a sense, acts as another surface contaminant. This may even lead to the decision to grind off the coating itself to provide a clean weld surface. Knowing it could be a major advantage to welders to benefit from a corrosion-inhibitor coating without having to remove it, a professional engineer arranged to test coatings A and B regarding their impact on weld strength (Ref. 1). If the coatings were to not show a negative impact on weld strength, they could potentially provide the protection needed while eliminating the time and hassle required for mechanical cleaning of the surfaces.

Details of the Experiment

To perform the test, several 4-in. (100-mm) pipe segments were coated with clear permanent coating A, removable coating B, or not coated at all (control samples). These coated pieces were then welded by twos to make six total test pieces, with two specimens (test coupons) in each category. Pipe segments of 0.250 in. (6.4 mm) thick (Schedule 40) and 0.500 in. (12.7 mm) thick (Schedule 80) were tested for each category. An independent, certified ASME welder performed the welding according to the ASME Section IX code using shielded metal arc welding.

After coating and welding, the test coupons were sent for metallography and mechanical property testing. The coated pipes surpassed tensile strength requirements for A53B material testing (48,000 lb/in.^{2} minimum for Grade A and 60,000 lb/in.^{2} minimum for Grade B). All tensile results were near or above 70,000 lb/in.^{2} failure (the lowest being the control at 66,779 lb/in.^{2} failure). Both metallographic and mechanical testing showed similar results on coated vs. uncoated pipes.

Positive Outcome

Based on results, the professional engineer who ordered the test concluded that using the coatings "on weld joints does not negatively impact the weld geometry or mechanical properties of the weld." He also reasoned the coatings would help reduce the amount of other foreign substances on the metal, and cleaning the surfaces before welding would only require wiping grime off with a material such as alcohol.

Organic Acid Rust Removal

Although coatings can give welders an advantage in surface prep, there will inevitably be times when welders still have to remove corrosion for one reason or another. In this case, chemical rust removal is an alternative to grinding or blasting, especially when options are limited due to the welding location or environment.

There are a variety of harsh chemicals, such as phosphoric acid, that can do the task, but there are also safer options that are less corrosive. For example, effective rust removal has been demonstrated time and again with an organic acid enhanced with flash corrosion inhibitors. This material offers environmental and safety advantages compared to other chemicals on the market because of its less acidic pH and its high biobased content derived from a common food industry ingredient. A gel version of this rust remover was used in a laboratory demo in March 2019 (Ref. 4) to show the potential for rust removal on weld surfaces, such as pipeline ends, that may be vertical out in the field. The gel is able to cling to vertical surfaces, enabling it to be left for a period of time to penetrate and loosen the rust.

During the test, the rust removal gel was applied to a severely rusted panel and left to sit for 12–15 min — Figs. 3, 4. The panel was wiped off with a paper towel, then rinsed in water with less than 5% concentration of an alkaline cleaner containing flash rust inhibitors. Due to the severity of the rust, another application of the gel was required for about 15 min. This time, a scrub pad provided extra abrasion to help remove the rust before once again rinsing the panel in the cleaning solution. The metal was stained but clean.

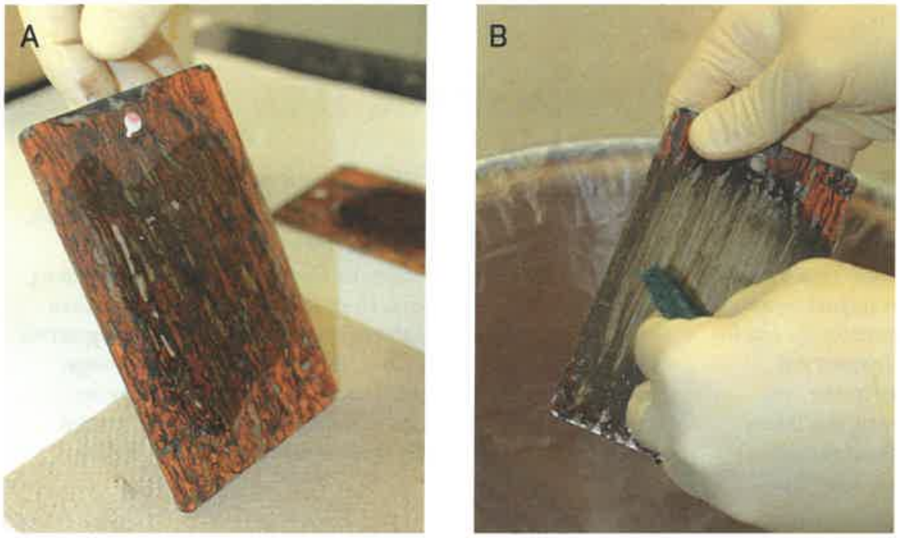

Fig. 4 — A — Organic acid rust remover gel clinging to a vertical surface; B — using a scrub pad to remove rust after a second application.

Conclusion

Grinding and blasting are not the only ways to prepare a rust-free weld surface. Organic acid rust removal and/or the use of water-based corrosion-inhibitor coatings that are weldable or easy to remove present other viable options for welders to explore. These have the potential to increase convenience and reduce labor for welding prep on areas vulnerable to rust. Additional testing and field use of these coatings and materials will be helpful to the industry in further evaluating the benefits of these strategies for simplifying surface prep to achieve corrosion-free weld surfaces. WJ

Acknowledgments

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Figures 1–4 are courtesy of Cortec.