

Liquid Metal Embrittlement of Austenitic Stainless Steel When Welded to Galvanized Steel

To preclude liquid metal embrittlement cracking of austenitic stainless steel welded to galvanized steel, the zinc coating must be scrupulously removed from the joint area prior to welding

BY R. M. BRUSCATO

ABSTRACT. Liquid metal embrittlement (LME) cracking can be readily induced in austenitic stainless steels by molten zinc when that steel is welded to galvanized carbon steel. Evidence is presented which shows that zinc-induced LME cracks up to about ¼ in. (6.35 mm) deep in the base metal have been produced during the welding of stainless to zinc-coated steel, and it is estimated that under conditions of minimal preweld cleaning, cracks up to ⅜ in. (9.5 mm) may be produced. Consequently, to preclude cracking of the stainless steel, either the zinc must be scrupulously removed from the joint area prior to welding or a mechanical joint must be utilized when stainless steel is joined to galvanized steel.

Introduction

Because of its excellent corrosion resistance, austenitic stainless steel has found widespread use in the paper industry. Stainless steel paper-making equipment includes pressure vessels, storage tanks, piping, hoppers, bins, chutes and structural components. For virtually all of these applications, attachments are welded to the outside surfaces of the equipment. Attachments can include access platforms, catwalks, stiffeners, column supports, stairways and pipe hangers. Galvanized carbon steel is often specified for these attachments.

The reasons for utilizing galvanized

carbon steel are many and varied. This material has good corrosion resistance in the paper mill environment. It is, essentially, a maintenance-free material providing a good color match when attached to stainless steel, and is readily available in many configurations, sizes and shapes. Finally, there have been instances where an erector has substituted galvanized carbon steel attachments as a "premium material" to upgrade his work for a valued customer.

Other materials utilized for attachments to stainless steel are perceived as having drawbacks. Plain carbon steel rusts and is particularly unsightly in contact with stainless steel. Painted carbon steel tends to become an ongoing maintenance problem. Stainless steel is appreciably more expensive.

Recently, a problem was encountered where 27 zinc-plated washers were welded to a 304L stainless steel

pressure vessel. Using very small welds, an insulation contractor had welded the 2-in. (51-mm) washers to the surface of the vessel. The washers were attachment devices to mount and hold insulation in place against the vessel wall. Penetrant inspection of the welds revealed cracking. After removal of the washers and weld, the cracking was found to run ⅛ to ⅜ in. (3 to 5 mm) deep into the stainless steel plate material at every weld location. Considering that the welding of galvanized steel to stainless steel is a common practice, the depth and widespread nature of this cracking was surprising. Consequently, an investigation was undertaken to better define and understand the ramifications of welding galvanized steel to stainless steel.

Liquid Metal Embrittlement Cracking of Austenitic Stainless Steel by Zinc

Two types of interactions between molten zinc and austenitic stainless steel have been reported (Ref. 1). Molten zinc slowly erodes unstressed 300 series stainless steel at 785° to 1058°F (419° to 570°C) penetrating (diffusing) primarily along the grain boundaries in a relatively slow manner. This phenomenon has been designated Type I embrittlement.

Type II embrittlement occurs in stainless steel above 1380°F (750°C) when it is stressed and exposed to molten zinc. It is characterized by extremely rapid crack propagation perpendicular to the applied stress. This phenomenon is de-

KEY WORDS

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