

A CASE STUDY-CAUSTIC GOUGING OF BOILER TUBES

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ABSTRACT

Caustic corrosion also referred to as “Caustic attack” or “Caustic gouging” generally results from the fouled heat transfer surfaces on boiler tubes and due to the presence of sodium hydroxide in the boiler water. Once the caustic concentrations reached a certain level the caustic attack occurs and results in irregular wall thinning or gouging of the tube water side surface. The damage progresses through the tube wall until it ruptures. Such caustic corrosion failure was observed in one tube from a utility’s boiler. This paper presents the laboratory metallurgical analysis of the failed tube including welds and the process fluids and its effects on the caustic corrosion. The laboratory analysis includes chemical analysis, scale deposit analysis, metallography, and hardness tests.

Keywords: Caustic corrosion, boilers, high temperature corrosion, tubes, failure analysis

INTRODUCTION

Caustic corrosion is sometimes referred to as “caustic attack or “caustic gouging.” Corrosion of this type may result from (1) internally fouled heat transfer surfaces and the presence of sodium hydroxide in the boiler water; and (2) concentrated solutions of alkali where the normal washing of the tube metal ID is restricted after Departure from Nucleate Boiling (DNB), i.e., when the steam bubble release exceeds the rinsing rate.¹⁻²

Failures due to caustic attack are characterized by metal loss. The damage progresses to failure when the tube wall thins to a point where rupture occurs locally. The microstructure does not change, and the tube metal generally retains its ductility.

Once local caustic concentrations are reached such that caustic attack occurs, the corrosion can proceed to failure in a relatively short time. Caustic corrosion results in irregular wall thinning or gouging of the tube water side surface. Areas subjected to caustic attack typically show smooth, rolling contours surrounded by encrusted boiler water solids and a crystalline dense oxide.³⁻⁵ The oxides, however, are not protective. Particles of metallic copper may also be embedded in the deposit layer.⁶⁻⁷

A failure investigation was performed on tube sections removed from a utility boiler. The carbon steel tube sections are 76.0 mm outside diameter (OD) and 4.50 mm wall thickness, and the tubes were produced in accordance with ASME approved materials SA-178 requirements.

Failure analysis was performed on two water wall tubes including visual examination, energy dispersive X-ray spectroscopy (EDS) analysis, X-Ray diffraction (XRD) analysis, metallography, Vickers hardness tests, and chemical analysis by optical emission spectroscopy (OES) analysis to determine the mechanism which led to the tube ruptures or perforations. Results of the analyses are summarized in this paper.

FAILURE ANALYSIS

Visual Examination

Both tube ID surfaces showed an unusual amount of ID scale deposits.

Perforation and a groove pattern adjacent to a repair patch weld was observed in one tube (Tube #1). Figure 1 shows the OD and ID surface of Tube #1. Reddish brown, dark and white colored deposits were observed on the ID surface.

Several groove patterns at or adjacent to the repair patch weld root were observed on ID surface of Tube #2. Figure 2 shows the OD and ID surface of Tube #2. Reddish brown corrosion deposits were observed on the ID surface of Tube #2.

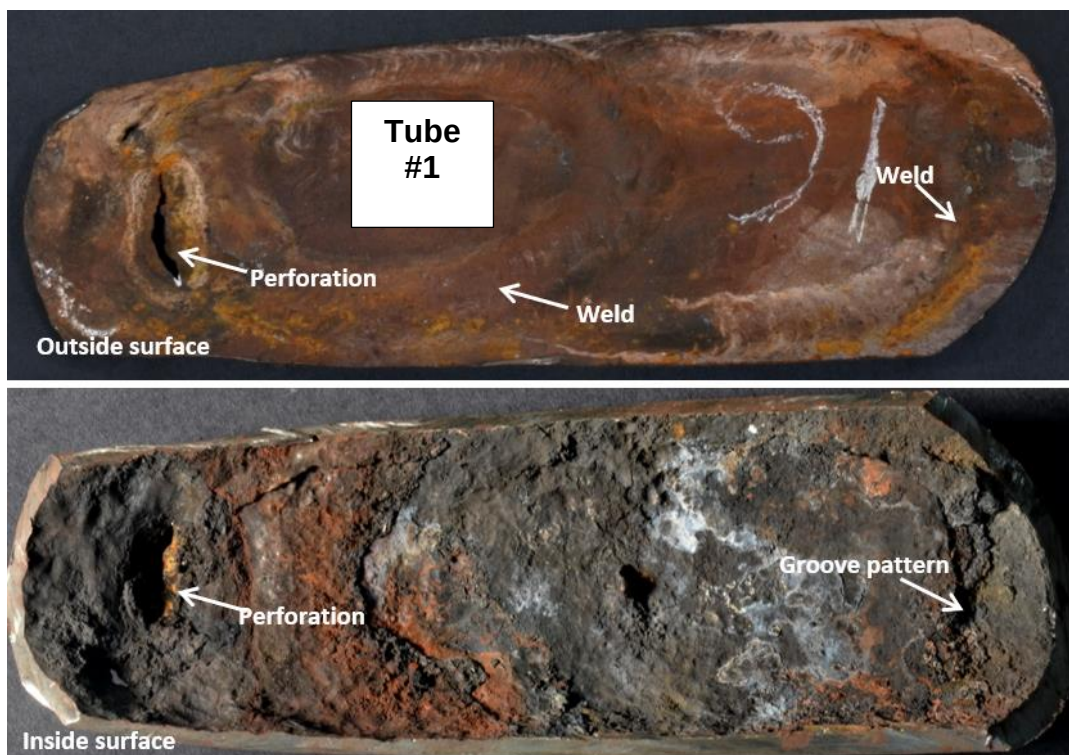


Figure 1: Outside and inside surfaces of tube #1 showing perforation at patch weld.

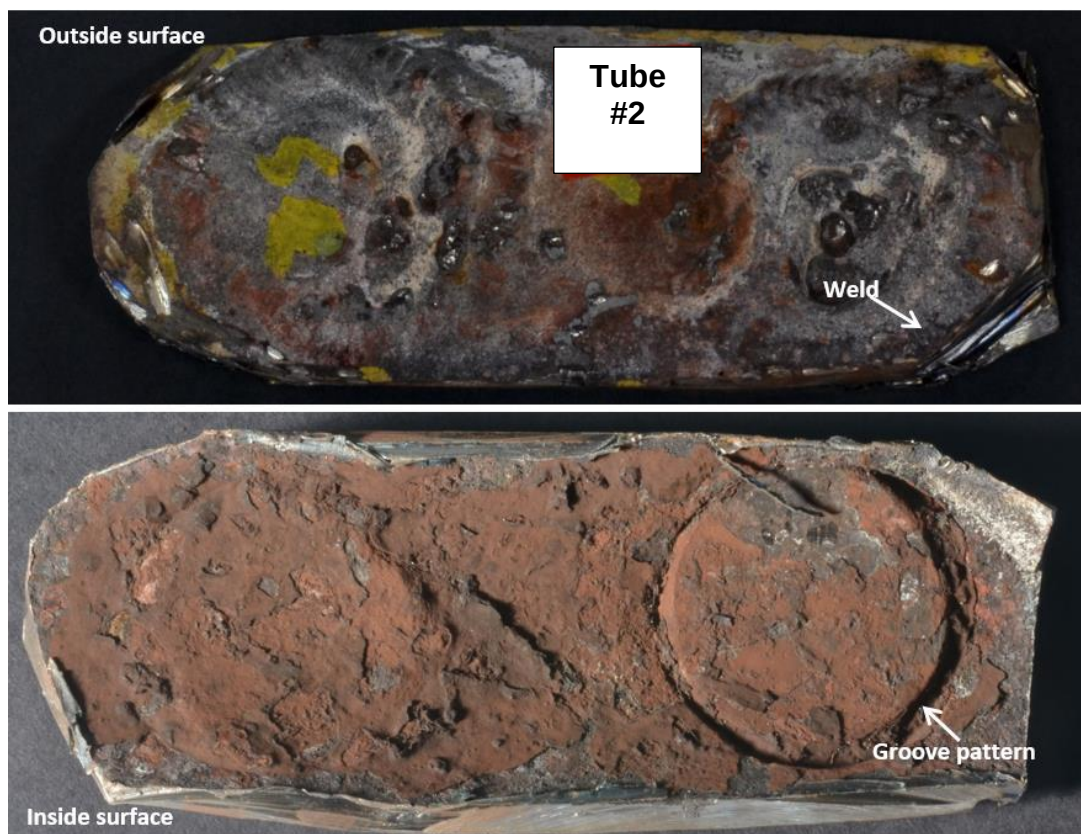


Figure 2: Outside and inside surfaces of boiler tube #2. The tube inside surface exhibited groove patterns at repair patch weld root.