Pipe Thinning and Rupture

SAFETY ALERT WARNING

Plant Service Bulletin

Purpose

This plant service bulletin is a **SAFETY ALERT** that advises boiler owners and operators of the need to inspect condensate and feedwater piping, attemperation/desuperheater piping, and other auxiliary and branch piping where conditions conducive to flow accelerated corrosion may persist.

Problem

Internal thinning and subsequent rupture of carbon steel piping located outside the boiler setting remains a serious safety concern. B&W is aware of failures in recent years. Thinning generally occurs over months or years of operation. Ruptures can occur unexpectedly and close to work areas and walkways. Figure 1 is a photograph of a failure that fatally injured nearby workers.

Background

Extensive research has lead to an improved understanding of the failure mechanism. Pipe walls are thinned by localized dissolution of iron from the piping into flowing water. This is commonly referred to as flow accelerated corrosion. Steel is normally protected from corrosion by a surface layer of iron oxide. Thinning occurs where locally corrosive conditions destroy this normally protective oxide. For example, local chemical conditions may be sufficiently oxidizing to form soluble Fe^{++} ions but not oxidizing enough to form or maintain Fe^{+++} ions needed for protective oxide formation.

Conditions known to accelerate thinning include:

- Low pH
- Excessive oxygen scavenger
- Flow impingement on pipe walls
- Intermediate temperatures (250 to 400F or 120 to 200C), but thinning can occur at any feedwater temperature
- Chemicals (such as chelants) that increase iron solubility
- Thermal decomposition of organic chemicals

Figure 1: Rupture of a six-inch (152.4 mm) feedwater pipe in an area thinned by internal corrosion.

Recommendations

To assure continued integrity of all boiler feedwater and similar piping, it must be periodically inspected for internal corrosion and wall thinning. Any thinned areas must be identified and replaced before they become a safety hazard.

Boilers should be placed on a systematically managed inspection program. This is especially true where water pH is less than 9.5, where chelant treatment is employed, or where there has been prior evidence of pipe or steam drum internal wastage. Particular attention should be paid to areas

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in and immediately downstream of chemical (especially chelant or polymer) feed locations, bends, valves, tees, and wherever pipe geometry is likely to disturb flow and increase flow impingement against pipe walls. If thinning is found at any location, the entire piping system should be inspected.

Inspection methods

Ultrasonic thickness testing can be used to locate defective areas. Testing should include a grid pattern around the full circumference in any suspected areas because corrosion or thinning may be very localized. Where wall thickness cannot be measured in inaccessible areas, the internal surfaces should be visually examined using fiber optics or remote cameras as necessary. Because of localized flow effects, corroded areas have a roughened or pockmarked appearance, which can normally be seen using low angle lighting.

Replacement materials

Where internal wall thinning has occurred, the affected pipe should be replaced with more corrosion resistant low-alloy chromium-bearing steel. Chromium extends the range of conditions under which surface oxide remains protective. Type SA-335 Grade P2 steel containing 0.5% chromium is much more resistant to attack than chromium-free carbon steel. Higher chromium P12 (1Cr-0.5Mo), P11 (1.25Cr-0.5Mo-Si), and especially P22 (2.25Cr-1Mo) steels are even more resistant.

Chemistry control

Even where thinned piping has been or will be replaced with higher chromium steel, the corrosiveness of the water should be moderated. Ask your chemical treatment specialist to assure that your water treatment program minimizes the potential for flow accelerated corrosion. Oxygen scavenger feed rates should be based on residual oxygen, so that the residual scavenger concentration is minimal. Where chelants are used, chelant feed rate must be based on water hardness, not on residual free chelant concentration in the boiler water. The boiler water available chelant concentration should be minimal. B&W recommends that feedwater pH be no less than 8.8 for copper-bearing cycles and no less than 9.3 for copper-free cycles. Higher pH values (about 9.6) are preferable. Exceptions include high-pressure utility boilers that employ very high purity feedwater with oxygenated feedwater treatment.

Support

Contact B&W Field Service Engineering through your local district service office to coordinate your inspection and repair efforts and to answer any questions.

Additional reading

"Flow-Accelerated Corrosion in Power Plants," Electric Power Research Institute, TRE-106611-R1, Palo Alto, California, 1998.

"The Effect of Erosion-Corrosion on Power Plant Piping," by S. Bush, Proceedings of Fifty-Ninth General Meeting, National Board of Boiler and Pressure Vessel Inspectors, Columbus, Ohio, 1990.

"The Central Electricity Generating Board Single-Phase Erosion-Corrosion Research Program," by A. Bates, G. Bignold, and others, *Nuclear Energy*, December 1986, Pages 361-370.

"Corrosion of Steel in EDTA," by J. Palmer and P. Boden, *British Corrosion Journal*, Volume 27, No.4, 1992, Pages 305-309.

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