Creep Fatigue and Ligament Cracking of 1-1/4 Cr-1/2 Mo-Si (T11 and P11) Pressure Parts

Purpose

Plant Service Bulletin PSB-1 was issued May 2, 1983 to provide awareness of creep swelling and ligament cracking of 1-1/4 Cr-1/2 Mo-Si (SA213-T11 and SA335-P11) Pressure Parts.

Since initial issue of PSB-1 in 1983, inspection recommendations and techniques have been updated, and the ASME Code has been revised. PSB-1A provides this updated information.

Problem

Certain tubing, piping and headers of 1-1/4 Cr-1/2 Mo-Si (SA213-T11 and SA335-P11), operating at 975°F and higher in boilers designed to pre-1965 ASME code revisions may be experiencing damage due to creep fatigue resulting in problems such as ligament cracking. This problem may occur on any boiler designed to the pre-1965 ASME code, regardless of the manufacturer.

During this time frame, the ASME Code allowable stresses for 1-1/4 Cr-1/2 Mo-Si (T11 and P11) were based on a relatively small data base. During 1965 a larger data base became available and allowable stresses for this alloy were significantly reduced in the Summer 1965 addenda to the ASME Code. With the 1989 addenda to the ASME Code, these stresses were further reduced at certain temperatures. See Figure 1 for these revisions.

For simple geometries such as piping, the failure sequence may consist of minor swelling and crack initiation at high stress points. Complex geometries such as headers are more likely to experience failures as a result of creep fatigue. The complex mechanisms found to cause cracks in headers are a result of cyclic thermal stress coupled with creep. This creep fatigue occurs at the tube stub bore hole penetrations into the header, can be very localized, and is not necessarily accompanied by a measurable swelling. Cracks that start along the bore hole will eventually propagate through the wall. If undetected, the first signs of the problem will be the occurrence of leaks at the tube stub-to-header welds, at which time the header may already be at its end of life. (See Figure 2).

Warning

Failure to inspect and make necessary repairs or replacement of components found damaged could result in tube, pipe, or header failures. Failures or

(Continued on reverse side)

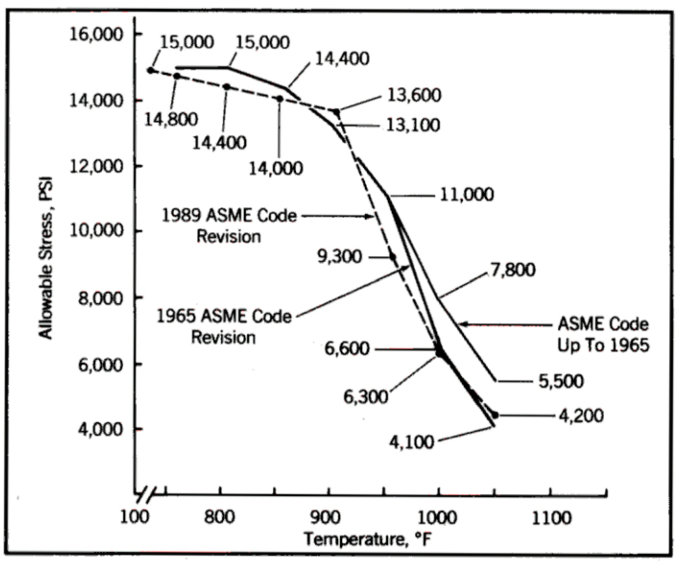

Figure 1 *Allowable stress versus temperature for 1-1/4 Cr-1/2 Mo-Si.*

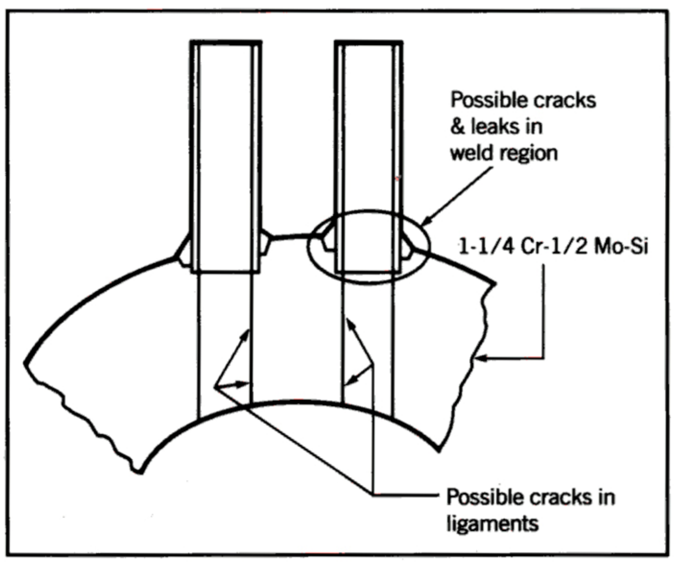

Figure 2 *Typical header.*

excessive leakage may overpressurize casing enclosures and result in casing failure and personnel injury.

Recommendations

Creep damage can be caused by extended component service above 975°F and creep fatigue can be caused by numerous short temperature excursions above the design temperature range. While a check of plant records may indicate periods of extended operation above 975°F, it may not properly identify all temperature excursions (typically associated with a cycling unit). Inspection is, therefore, the most desired method of problem identification.

Due to the nature of creep fatigue failures, the swelling that precedes a failure is normally not obvious. Thus, a proper inspection of pressure parts using a systematic plan is essential. This plan should include the following:

1. Internal fluorescent dye penetrant examinations of tube bores followed by deep penetrating eddy current sizing of cracks
2. External dye-penetrant testing of critical areas
3. Replications of select areas
4. Swelling measurements

Items 1 and 3 are new techniques developed since 1983. Figure 3 shows how a tube bore hole examination is accomplished.

Exfoliation and cracking of high temperature oxides can hide or mask ligament cracks. Thus, it is **very critical** to remove these hard tightly adhering surface oxides from the tube hole region before conducting the internal dye-penetrant examination. A fiber optics or video probe examination is **inadequate** to locate cracking unless these oxides are removed. Also, early warning of potential header failures can be provided by radiographic detection of cracks.

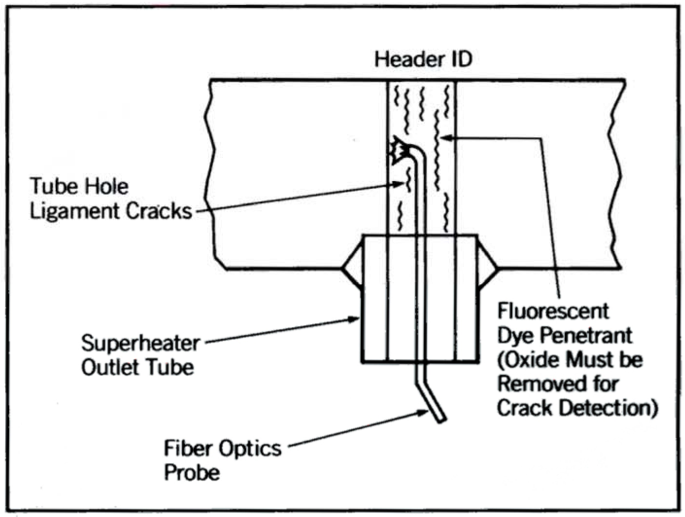

Figure 3 *Typical tube bore hole examination.*

If cracking has occurred, or if the percentage change in diameter is greater than 1% (2% for piping), replacement with a redesigned component based on the current ASME Code allowable stresses must be considered. Even less diametrical strain can be indicative of end of life if most of the damage was due to fatigue and not creep. Thus, it is not recommended to rely solely on swell measurements to determine header condition.

B&W Support

If you have any questions or desire assistance in doing these inspections, please contact your local Babcock & Wilcox Field Service Engineering office.

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