DAVID N. FRENCH, INC., METALLURGISTS
ONE LANCASTER ROAD
NORTHBOROUGH, MASSACHUSETTS 01532
TEL: (508) 393-3635
FAX: (508) 393-3914

SUMMER 1992 VOL. IX, No. 2

A VIEW FROM THE PENTHOUSE: USEFUL INFORMATION FOR THE WORLD OF BOILERS

STRESS CORROSION CRACKING

Stress-corrosion cracking can be defined as the brittle failure of an alloy stressed in tension below the yield point and simultaneously exposed to a specific corroding environment to which the metal is sensitive. The most common occurrences of this type of failure within the boiler are in carbon steels in concentrated hydroxide and austenitic stainless steels in the presence of chlorides.

There are three components necessary to cause stress-corrosion cracking: 1) a tensile stress. The stress may be either a residual stress from cold work or an applied stress from the service. Usually there is a threshold value below which stress-corrosion cracking will not occur. Compressive stresses will not cause stress-corrosion cracking; 2) a chemical species. The corrodant is specific for a particular alloy, and each alloy has unique species that promote stress-corrosion cracking; and 3) the metallurgy. That is the alloy under consideration.

Historically speaking, the first systematic stress-corrosion cracking investigations were in the last half of the nineteenth century. Deep-drawn or cold-work brass was introduced for use in cartridge cases in large quantities. Cartridge brass was failing in a brittle fashion with such frequency that the phenomenon was given the special term "season cracking". By the close of the century, the necessary role of residual stresses was identified and so well known that stress-relief heat treatments for cold-formed products had been developed. Indeed, chemical tests were available to verify the heat treatment; acidified mercurous nitrate will cause mercury cracking and was used for assurance of a proper stress-relief heat treatment.

At this same time, ammonia was found to cause stress-corrosion cracking in cartridge brass. Thus the second requirement was identified, a specific corrosive species. By inference the third criteria was established, in this case, cartridge brass, the particular alloy under study.

By this time, the end of the 19th century, steam boilers were used to generate electricity. Cracking of riveted boiler drums was another example of stress-corrosion cracking and an indication that the problem was not unique to cartridge brass.

The cracking of carbon steel used in riveted boiler drums was such a problem that stress-corrosion cracking monitors were developed. These devices would indicate when the conditions would be ripe for this kind of failure.

At that time, sodium hydroxide was used as the chemical of choice for pH control. Leaking rivet holes or riveted joints would concentrate the hydroxide at the steam leaks, and the cracks would develop. The conditions for caustic cracking are concentrated hydroxide, appropriate tensile stress, and elevated temperature. Now that the conditions that cause cracking are understood, the frequency of occurrence is rare. For the most part, rolled tube joints are the most likely source today.

Other alloys that are known to suffer stress-corrosion cracking are: zirconium in iodine environments, titanium in nitric acid and nitrogen tetroxide, magnesium and aluminum alloys in atmospheric moisture, and steel in concentrated sodium nitrate.

Figure 1 shows an example of stress-corrosion cracking - caustic cracking - in an SA-106 Grade B pipe.

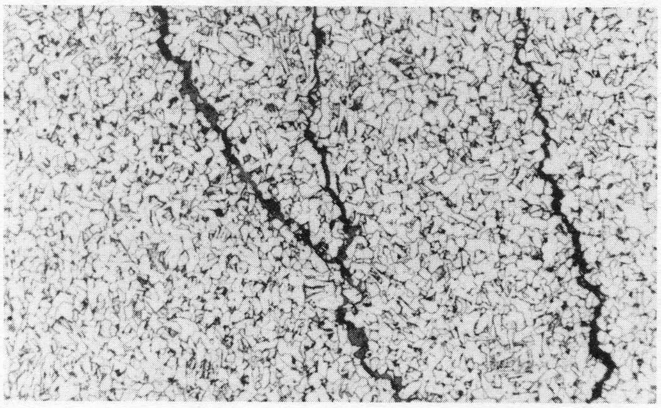

Figure 1. SA-106-B. 200x

Figure 2 shows the stress-corrosion cracking in a 304H stainless-steel superheater.

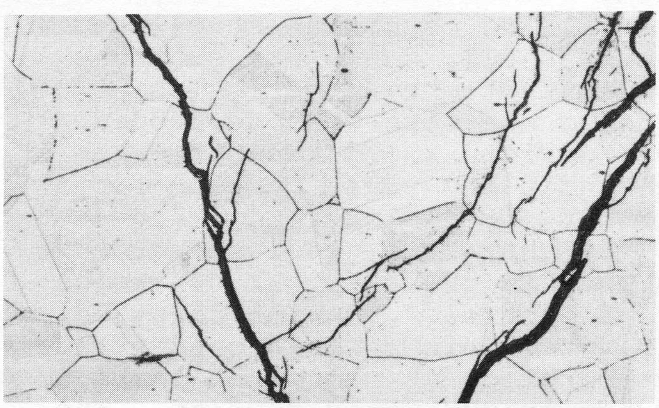

Figure 2. 304H. 200x

Cracks are usually transgranular (that is, the cracks cut across or through the grains) and are branched, but can be intergranular (that is, the cracks follow the grain boundaries) under certain conditions, and may not be branched, depending on the detailed state of stress in front of the advancing crack. Stress-corrosion cracking failures are always macroscopically brittle in appearance; that is, thick-edged with no obvious ductility.

Figure 3. 304. 200x

Figure 3 presents a cross section through a 304 feedwater-heater tube that failed by stress-corrosion cracking. The austenite grains contain no evidence of any deformation, slip, or excessive twinning, a completely brittle fracture.

NAMES OF OTHERS WHO MIGHT LIKE TO RECEIVE OUR NEWSLETTER:

NAME:____________________ COMPANY:____________________

ADDRESS:____

SUGGESTED TOPICS FOR DISCUSSION:____________________________