Protective shields solve condenser inlet-end erosion/corrosion problem

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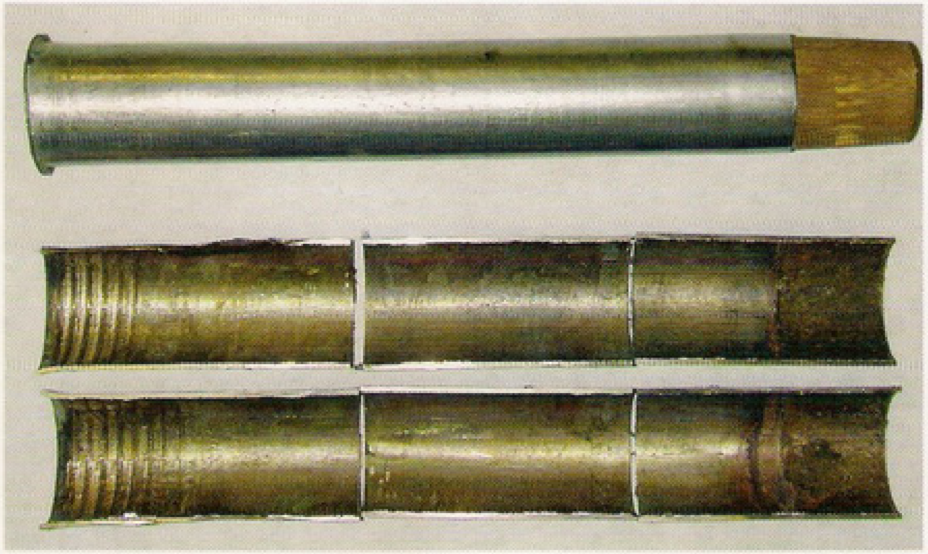
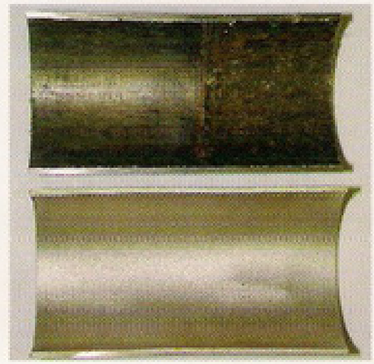


1. Condenser tube inlet where the AL6X shield had been installed is at the bottom. Note that the wooden plug could not be removed from the insert when it was extracted from the tube (top of photo)



2. Tube inlet surface with shield removed shows oxide downstream of where the shield ended (top). After abrasive blast cleaning (bottom), tube shows no evidence of exit-end corrosion after 22 years

In 1982, a West Coast powerplant experienced leaks near the inlet ends of 90/10 copper/nickel tubes in its seawater-cooled condenser at the rate of one per week. Leaks in the 1 in. × 20 BWG tubes, rolled into a Muntz metal tubesheet, were attributed to inlet-end erosion/corrosion. Zinc waste plates provided cathodic protection until 2000 when an impressed-current system was installed as an environmental upgrade.

Statistical analysis supported the need for immediate corrective action and three alternative solutions were considered:

- Retube the condenser.
- Install inlet-end protective shields.
- Epoxy coat the inlet ends of the tubes.

Here's how engineers evaluated each of the options:

Retubing, although considered the most reliable fix, was much more expensive than the alternatives—nearly six and a half times the cost for sleeve inserts and eight an a third times that for the epoxy coating. Also, a four-week outage was required.

Metal shields offered several advantages: affordable (only slightly more expensive than epoxy), ability to accommodate the metal and brush scrapers used periodically to maintain condenser performance, and a week outage at most to do the work (could be done online with half the unit out of service). However, industry experience indicated that improper cathodic protection could result in localized pitting of the base tube immediately downstream of where the shield ends.

Plastic shields were not considered a viable option because industry experience was not favorable for long-term restoration (expected life ranged from two to 10 years). Also, the thickness of the insert would reduce tube ID by about 35% and inhibit the tube cleaning process. Another disadvantage is that plastic liners tend to loosen and work free of the tube over time (they are glued to the tube base metal, not expanded into it like metal inserts). Finally, the US Navy was, at that time, in the process of removing all plastic inlet sleeves on its main ship condensers because of poor performance.

Epoxy offered a cost advantage and required only about a week's downtime to accomplish the work. But long-term reliability was questioned because of coating brittleness and the potential for pin-hole leaks. Another concern was that the use of mechanical scrapers to clean the condenser tubes might damage the coating.

The decision

All condenser tube samples pulled prior to 1982 exhibited little or no damage in areas other than the inlet end after more than 14 years of service. The same was true for other units at the station, some with up to 20 years of service. Because the causes of the degradation were isolated to a specific section of the condenser, engineers thought that AL6X inlet shields would be effective in getting a proper seal between tube and tubesheet and eliminate the erosion problem.

Belief was that with properly maintained cathodic protection and a tube ID cleanliness program, the shields would not cause any harmful side effects to the tubes or tubesheet. The evaluation team expected that the service life of the inserts would approach, possibly exceed, the 14 years it took for the erosion/corrosion mechanisms to cause leaks in the base metal. Project payback was estimated at about nine months.

Fast forward to the plant's 2004 maintenance outage, when a specimen was removed from a plugged tube to determine the cause of a leak that had occurred earlier. Diagnosis: The leak was caused by through-wall damage from steam impingement that had occurred near the exit end of the condenser tube.

This failure investigation offered the opportunity to review the 22-year performance history of the tube inserts. Inspection of the tube section that contained the sleeve insert confirmed that the sleeves were continuing to perform as intended (Fig 1). One of the concerns of the inspection team was the performance of the new cathodic protection system installed four years earlier. They found no evidence of erosion or corrosion at the exit end of the shield, where the potential for galvanic corrosion is highest (Fig 2).