BLRBAC MATERIALS AND WELDING SUBCOMMITTEE BULLETIN

1.6 COPPER INDUCED CRACKING IN BOILER TUBES

1.6.1 Introduction

Copper-induced cracking in boiler tubes is a type of liquid metal embrittlement failure that occurs when copper is melted during the welding process and penetrates the steel in the weld heat affected zone of the base metal. This may be from tube butt welds or from weld repairs made to inadvertent tube damage where copper has been deposited. The melted copper is concentrated along the grain boundaries of the steel resulting in a reduction of the tube's mechanical properties (ductility, fracture toughness). The resulting mode of failure is intergranular cracking.

1.6.2 Sources of Contamination

Sources of copper contamination include the following:

- Contact with copper tips from wire feeders during the welding process
- Contact with copper nozzles for the delivery of shielding gas
- Copper tooling abrading the surface of the tube
- Copper deposit accumulation on the waterside surface of the tube.
- Energized copper wire arc strike
- Copper backing bars used as a heat sink source during welding of thick-walled steel material (this is not typically used in Recovery Boiler Welding)

Aqueous copper sulfate solution appears to be an unlikely source for copper contamination of welds, but proper cleaning (flap wheel ID and OD) should still be done to assure proper base metal cleanliness for welding.

1.6.3 Prevention

- The best method is to prevent molten copper from coming into contact with the susceptible base material during welding.
- Avoid using copper tools that could abrade and contaminate the surface of the base material
- Copper tips and nozzles can be replaced with tips or nozzles that are chromium plated, ceramic or which have Teflon sleeves, etc.
- Copper fixtures can be replaced with aluminum or nickel plated fixtures
- Buff the ID and OD of the tubes at weld locations to ensure removal of possible copper deposits before welding. Flap wheels are preffered since wire wheel power brushing have been known to smear the metal and contaminants.

1.6.4 Evaluation

Suspected contamination of copper is not readily detectable unless there is sufficient residual stress present to initiate cracking shortly after welding. If cracking is immediate, dye penetrant or Magnetic Particle testing can be used to detect cracking. The only definitive method of identification is destructive, metallographic examination.

If copper contamination is suspected, it is recommended that the affected portion of the tube should be replaced.

Hydrostatic testing alone has not proven sufficient to rule out the presence or potential of cracking from copper contamination.

1.6.5 Welding

During the welding process, there should be a competent welding inspector onsite to witness the welding as it is being performed per the recommendations in the General Welding Forward.

Due to the increased use of sublet shops and the loss of experienced personnel, education as to the risks of copper contamination must be imparted to all shops, and adequate QA/QC included.

1.6.6 Weld Process

1.6.6.1 Repair

If copper contamination is suspected or detected, the only effective method of repair is complete removal of the affected area. Sufficient base material should be removed to ensure that the entire contamination has been completely removed. Depending on the severity, and the ability to ensure complete removal of the copper contamination, tube replacement may be the required option.

1.6.7 Final Inspection

Dye penetrant examination (PT) or Magnetic Particle Testing (MT) can be used to evaluate the repair area.

If the repair is on a coextruded or weld overlaid tube, the inspection of the carbon steel base metal should be made prior to restoring the corrosion protection layer.

For guidelines on the weld finish of a weld build-up, hydro testing, and documentation, see Section 2.3.5,6,&7, Repair of Pressure Part Boundary Materials in Tubes.

1.6.8 References

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2. W. F. Savage, E. P. Nippes and M. C. Mushal, Copper-Contamination Cracking in the Weld Heat-Affected Zone
3. James J. Dillon, Paul B. Desch, Tammy S. Lai, The Nalco Guide to Boiler Failure Analysis p 41 – 42

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