TIP 0402-30

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Inspection for cracking of composite tubes in black liquor recovery boilers

Scope

This Technical Information Paper (TIP) provides guidelines and procedures that may be used to identify cracks that form in composite tubes of black liquor recovery boilers during service. The document addresses inspection frequency, boiler preparation and tube cleaning for inspection, critical inspection locations or features, nondestructive testing (NDT) methods, and inspection personnel qualifications. It does not discuss the interpretation of inspection data, nor does it consider inspection and quality assurance requirements for new or replacement construction. These guidelines are not intended to supersede or replace jurisdictional and regulatory requirements.

Safety precautions

Personnel safety and industrial hygiene should be ensured by compliance with established confined space entry procedures and all mill safety and lockout procedures. Ventilation, scaffolding, and personal protection must be in compliance with jurisdictional requirements.

This TIP may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Material Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this technical information paper, the user should determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, should follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

Background information

Composite tubes are commonly specified as corrosion-resistant replacements for carbon steel tubes in recovery boiler floors, walls and occasionally in superheaters. The most commonly used tubes are co-extruded with a 304L (UNS30403) stainless steel outer layer over an SA-210 carbon steel inner core. Composite tubes with proprietary variants of 310 stainless steel (UNS 31000), Alloy 825 (UNS N08825) and Alloy 625 (UNS N06625) outer layers have also been used in recovery boilers. An alternative to co-extrusion is to apply these, or similar, alloys as a weld overlay onto a carbon steel tube. Generally, all of these alloys have superior resistance to corrosion and sulphidation in recovery boiler environments compared to the carbon steel tubes they replace, but cracking has occurred in composite tubes and in membranes or other attachments welded to composite tubes.

Composite tubes made from 304L stainless steel or equivalent are by far the most susceptible to in-service cracking. Cracks have been reported in both Alloy 825 and Alloy 625 composite tubes, but are less severe, and occur much less frequently. Extensive cracking has been observed on the composite tubes and membranes in boiler floors. Cracks have also been found in spout opening tubes, tubes that form air port openings and wall tubes near the bed. Cracks have been found in the alloy cladding of the tube, and in the membrane between tubes. Membrane cracks can extend into the tube through membrane welds and welded attachments. Depending on the location in the boiler, and other specific circumstances, the cracking may be a consequence of stress corrosion cracking, fatigue, or a combination of both.

The scope of inspection for cracking is based on the results of visual examination, existing mill and contractor experience, and reports from other mills. The detection threshold for cracks is strongly dependent on boiler preparation and the procedures used for inspection. If the procedures are not optimised, cracks may not be detected. Fine, narrow cracks in composite tubes are particularly difficult to detect during inspections. Even well qualified, technicians have reported difficulties in finding cracks using standard procedures. Failure to identify cracking can lead to uncertainty in repair/replace decision-making. The purpose of this TIP is to provide information on where to find cracks in composite tubes and on techniques that have proven successful in locating cracks. Users are referred to the references for more information about the nature of cracking, and photographs of typical cracks in recovery boilers.

Inspection frequency

The time required to initiate and propagate cracks in composite tubes depends on the metallurgy of the composite tube and varies for each boiler, and by location in the boiler. Cracks in 304L composite floor tubes have propagated to detectable size in only a few months. Similarly, cracks have formed in 304L composite tubes that make up primary air port openings in less than six months operation. When determining the frequency of inspection, owner/operators should take into account the past boiler history of cracking, as well as general industry experience with that type and age of boiler. A thorough inspection of crack-susceptible areas is of value as a baseline when composite tubes are inspected for the first time. Inspections are commonly done during major scheduled outages and the inspection interval may be adjusted based on results of previous inspections.

Boiler preparation

A clean boiler facilitates the inspection of composite tubes for cracking. When preparing the boiler for inspection, it is highly desirable that the char bed be completely burned out before the boiler is shut down. Leaving a char bed will extend the cool down time and can add significantly to the amount of time and work required to clean the floor. In addition, the presence of a significant smelt bed may prevent adequate cooling of floor tubes prior to starting a water wash. Water washing of inadequately cooled tubes has been identified as a likely cause of composite floor tube cracking.

In units with sloped floors, complete burnout of the char bed will leave the floor tubes exposed and ready for final tube surface preparation and inspection. In units with decanting hearths, the remnant smelt pool must be removed over the areas to be inspected

Complete burnout of the char bed requires special attention by the operators starting at least one shift prior to shutting down the boiler. Raising liquor temperature and pressure and lowering the angle of the liquor guns to raise the temperature in the lower furnace typically accomplish initial burndown of the bed. Final burnout is done with burners firing auxiliary fuel. For the burners to be effective, the primary air should be shut off to allow the bed to burn down completely.

Much of the remaining smelt on the boiler floor, and that which is adherent to walls, is usually removed during water washing. If the smelt bed is not removed, using auxiliary burners to dry the furnace after water washing is thought to significantly increase the risk of initiating cracks on any floor tubes under remnants of the smelt bed.

Surfaces need to be clean of deposits and debris before they can be inspected. More extensive cleaning of the tubes may be required for specific NDT procedures.

Wall tubes: Water washing may leave crystalline salt deposits on tubes. These must be removed prior to examination. If frozen smelt remains (for example, in air port openings) it must also be removed where it impedes inspection. Many boilers are dried after water washing by oil firing, which leaves a greasy residue on the tube surfaces. This residue must also be removed as a first step in surface preparation.

Floor tubes: It is easier to expose composite tube floors in boilers with sloped floors than in decanting boilers. In decanting boilers, trenches are sometimes dug through the bed to expose areas of the composite tube. Severe damage can be done to the tubes if jackhammers are indiscriminately employed for removing frozen smelt or refractory. Particular care is required in boilers where "staghorns" were welded onto the membranes in an attempt to hold a frozen smelt layer in place. Smelt pumps have been used to remove molten smelt from the floor in decanting floor boilers before the boiler is shut down.

APPENDIX

Qualifications of nondestructive testing (NDT) personnel

1. NDT inspection personnel should be trained and certified in each NDT inspection method used to inspect the boiler. Practices used to certify the inspection personnel should be reviewed by the owner/operator to ensure that they comply with regulatory requirements, and with the needs of the job. Some owner/operators further require inspection personnel to demonstrate proficiency in locating specific types of defects in on-site test panels before allowing them to engage in inspections. In the United States and Canada, inspection personnel should be certified in accordance with either:

> SNT-TC-1A (American Society for Nondestructive Testing). (Address: ASNT, 1711 Arlingate Lane, P.O. Box 28518, Columbus, OH 43228, Phone 614-274-6003).
> CGSB (Canadian General Standards Board). (Address: CGSB, Ottawa, Ontario, Canada K1A 1G6, Phone 819-994-5373).

2. Personnel certification records should be available to the mill representative for review before the inspection.
3. Written inspection procedures for all NDT should be available to the mill representative for review.

Owner/operators may require additional information and documentation regarding specific experience of personnel performing this test work.

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