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Guideline for evaluating quality of boiler tube butt welds with ultrasonic testing

Scope and purpose

This document is intended to provide technical guidance to mills and providers of ultrasonic testing (UT) of welds in tubes in recovery and power boilers. UT of welds is done to find flaws that could cause a weld-related leak. *Weld quality criteria must be defined by the mill.*

A supplementary goal of the document is to encourage use of UT in appropriate circumstances.

This document applies to welds in tubes less than 4-in. OD and wall thickness less than 0.5 in. This TIP also can be used for UT of welds in small diameter piping. Tubes can be carbon steel, stainless steel or any combination thereof, including composite (layered) tubes.

This document describes procedures and requirements to qualify equipment and technicians for this type of UT.

When using this procedure, the mill should:

1. Define the weld quality acceptance criteria.
2. Provide physical standards for technician skill testing and equipment calibration. (Arrangements are usually made for the NDT contractor to provide a calibration standard.)
3. Verify the UT technician's skill and competency prior to field testing of welds.

Safety precautions

No special personnel safety precautions are required for doing tasks directly described in this TIP. Follow mill safety procedures for work in and around recovery and power boilers.

Why the UT method is acceptable

There is no ASME Code requirement for inspecting welds in this range of tube dimensions. The intent of UT is to find flaws that may lead to leaks or undermine the weld's strength, such as cracks, inclusions, voids, etc. *Acceptance criteria for weld quality and action resulting from non-conformance must be specified by the mill.*

BLRBAC accepts UT of tube butt weld quality as equivalent to radiographic testing (RT) – see Reference 1. Section I of the ASME Boiler and Pressure Vessel Code requires UT of butt welds in lieu of RT when RT cannot meet certain geometric unsharpness limits. ASME Code Case 2235, *Use of Ultrasonic Examination in Lieu of Radiography*, describes application of UT for examination of welds. – see Reference 2.

Quality of tube butt welds is generally defined by Section I, Power Boilers, ASME Code, part PW. Part PW-52, lists “acceptance standards for ultrasonic examination” of circumferential welds in tubes, pipes and headers. A table in PW-35 is helpful in setting acceptability criteria for excessive weld reinforcement inside the tube, (“push through”) - a contributing factor to tube failure due to flow disruption, especially in floor tubes.

Practical considerations

- Differences in UT and RT technologies give them different sensitivities for detecting flaws in welds. UT is less likely than RT to detect rounded features like pores but UT is more likely to find planar flaws like lack of fusion or inadequate penetration. RT is more likely to find planar flaws aligned with the radiation beam. Because of this, acceptance criteria for RT and UT should be explicitly defined and may differ.
- UT results generated as described in this document are not presented in a permanent image format. UT basically detects each flaw independently and relies on the UT technician’s skill to instantly interpret its significance and record its size and location.
- Probe manipulation requirements can hinder UT of butt welds at tube tangent points on membrane panel walls, depending on tube spacing and technician access. Inspecting the weld at the tube tangent point also is a concern with the elliptical RT technique. (See Reference 3)
- UT of tube welds does not require worker evacuation (it can be done with the welder present) and results are instantly available as testing is performed. By contrast, RT radiation safety standards normally require worker evacuation in a sizeable zone around any exposed source – “safety zone” size depends on the strength of the radiation source and radiation shielding from structures and equipment. It typically takes at a few hours to set up for and obtain RT images, excluding time for processing and reading the film.

Recommended testing protocols

A process for gaining practical benefits of UT and obtaining some RT images is to use UT as a “screening test”. This involves doing UT to select for subsequent RT welds that do not pass the UT test. Butt welds are first visually inspected (VT), then tested using UT. Locations of flaws detected with UT should be clearly marked on the tube and an accompanying diagram to optimize follow-up RT.

Two testing protocols are available, at the mill’s discretion, after detecting flaws with UT.

- Change to RT:* The need for repair and final weld quality can be based solely on RT acceptance criteria. Resulting radiographs are permanent film images of welds that did not meet the UT acceptance criteria and are either accepted per RT criteria or are repaired and radiographically tested at least once more.
- Stick with UT:* Repairs can be re-inspected with UT where the repair was made until they pass UT acceptance criteria. Problematic weld repair can be facilitated with RT. Welds that must be repaired more than twice to pass UT testing should be replaced (even though this adds another butt weld).

Figure 1 shows these alternative paths, starting with a weld that passes VT and including a defect repair.