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# Guideline for obtaining high quality radiographic testing of butt welds in boiler tubes

## Scope and purpose

This document is meant to provide technical guidance to mills and qualified providers of radiography testing (RT) services in obtaining high quality RT images when inspecting tube welds in recovery and power boilers. RT of tube welds is accepted by the Black Liquor Recovery Boiler Advisory Committee (BLRBAC).

This document applies to butt welds in tubes up to 4-in. OD with wall thickness less than 0.5 in. This document also can apply for small diameter piping. Tubes can be carbon steel, stainless steel or any combination thereof, including composite (layered) tubes. RT is suitable for new construction and repair welds in the shop or in the boiler.

The guidelines in this document apply equally to RT of tube butt welds by the “elliptical” and “contact” techniques, illustrated herein. A subordinate goal of the document is to describe advantages the contact technique offers over the elliptical technique in appropriate circumstances.

Qualification requirements for people who obtain and interpret RT images are described. Image quality requirements are described but *acceptance criteria for weld quality are not given and must be defined by the mill.*

## Safety precautions

This document discusses RT work commonly carried out on boiler tubes in pulp and paper mills. Two safety issues should be adequately addressed:

- Federal and state regulations for radiation safety must be precisely followed by the contractor and technicians doing the nondestructive testing. (The TIP provides more information on this.)
- Safety precautions normally required in pulp and paper mills for safe work practices, confined space entry and personnel protection should be followed.

## Certification of technicians

A crucial part of obtaining high quality RT is to ensure that technicians performing RT are properly trained and certified. Both the U.S. and Canada have strict regulations governing radiation safety issued by national, state/provincial and sometimes local jurisdictional agencies. The film or image interpreter also should be adequately qualified. In view of this, personnel certifications are normally required as follows:

### *RT technician*

The RT service contractor should provide documentation of valid certification for all RT technicians on the job.

In the U.S., a “Certified Radiographer” meets requirements of ASNT-SNT-TC-1A or the Nuclear Regulatory Commission (NRC) Appendix A to 10 CFR Part 34 – “Radiographer Certification”. An RT technician in Canada must be certified as a “Certified Exposure/Device Operator” and have CGSB 48.9712 certification.

NRC and some jurisdictions stipulate that work shall be done by an “RT crew” consisting of two certified radiographers; other jurisdictions permit a certified radiographer to work with a trained assistant.

#### *Film/ image interpreter*

Film (image) interpreters shall be certified in RT to ASNT Level II or Level III in the U.S and to equivalent certification in Canada. (Some mills have third-party review of film interpretations to ensure both RT image quality and weld quality meet requirements, especially when mill-specific weld quality standards are used and when the RT contractor works for the welding contractor and not for the mill.)

### **Pre-RT requirements**

#### *Code and weld quality considerations*

The RT contractor must have good working knowledge of relevant jurisdictional code requirements. ASME Boiler & Pressure Vessel Code, Section I, *Rules for Construction of Power Boilers*, exempts tubes of the sizes covered by this document from RT and it is not required by any construction or repair codes in N. America. Nevertheless, RT inspection is one method recommended by the Black Liquor Recovery Boiler Advisory Committee (BLRBAC) for evaluating the quality of boiler tube butt welds.

**NOTE 1:** BLRBAC views ultrasonic testing (UT) of welds as equivalent to RT. (Ref. TAPPI TIP 0402-31)

The purpose of RT inspection is to find flaws that may lead to leaks or undermine the strength of the welds, such as cracks, inclusions, voids, etc., *acceptance criteria for weld quality and action resulting from non-conformance must be specified by the mill.*

Even though tubes this size are exempted from RT in the ASME Code, weld-quality requirements in Section I, Parts PW-34, PW-35, PW-41 may be adapted by a mill for use with this RT method. A table in PW-35 is useful in establishing acceptance criteria for excessive reinforcement (push through) inside the tube, which is a known contributing factor to tube failures, especially in floor tubes.

Normal practice for recovery boilers is to RT 100% (full length) of 100% (called 100-100 scope) of “critical” butt welds (so-called 100-100 scope) - those located where a leak could put water into the smelt bed. Less intensive RT scopes like 50-50 or 50-20 are totally acceptable in power boilers and non-critical recovery boiler locations: with appropriate test scope expansion if problems are found.

#### *Test qualification and calibration standards*

Testing standards are needed to confirm the RT procedure sensitivity and are essential for qualifying equipment and technicians. Testing standards should be developed with butt welds in tubes of the same material, diameter and thickness expected during the examination. Synthetic flaws in the testing standards can test the RT technician’s ability to use the written RT procedure to reliably detect and evaluate the flaws.

For this type of inspection, it is recommended to make the calibration standard from an actual panel consisting of several tubes. A circumferential (cross-cut) notch and an axial notch, 0.10t deep, should be made in the external and internal surfaces, offset so as not to overlap. An 0.10 in. diam., 0.5t deep, blind-drilled hole should also be located in the weld.

The internal surface of the weld standard should incorporate examples of acceptable and excessive weld reinforcement. In all cases, test standards for qualification and equipment calibration must be designed with flaws that accurately simulate the mill’s weld quality requirements.

Test coupons from welder qualification by RT can serve as test standards for RT technician proficiency testing. Testing and calibration standards should be kept in good condition and used for their intended use only.

*Written procedures*

For every job the RT contractor should provide a *written* copy of the RT procedure, in accordance with ASME Code, Section V, Article 2. The procedure description should include a diagram showing relative placement of the radiation source, the film and the image quality indicator (IQI)

**Appendix A** shows two techniques suitable for RT of butt welds in boiler tubes. The contact technique is especially well suited for “100-100” and “100-50” inspection of multiple welds in rows in wall and floor panels.

*Radiation safety*

Procedures for demarcating the perimeter of and strictly controlling personnel access into radiation safety zones must be clearly defined and strictly enforced on every RT job. The RT contractor should know and ensure full compliance with the mill’s personnel safety and emergency procedures.

*Film and report handling and archiving*

The mill should contractually specify ahead of time, how and by whom all reports, radiographs and exposed film are to be submitted, handled, filed and archived.

**Film identification and marking**

Every RT film/image shall be identified - using lead (Pb) figures, flashed I.D.s, or other suitable permanent markings - with the following data:

- a. Date of RT.
- b. RT contractor ID, job or contract number
- c. Weld ID
- d. Repair designation (R-1, R-2, etc., for first, second, etc. repair).

Location markers on the film image must accurately correspond to location markers on the weld.

When 100% of the weld length is required, it should be readily apparent from the film image that this has been achieved. (Diagraming the RT exposure setup on image reader sheets can help the reader verify this.)

**Image quality and resolution (sensitivity)**

*Image quality indicator (IQI) or penetrameter*

Each exposure shall contain an image quality indicator (IQI), also called a penetrameter or “penny”. The IQI can be the hole or wire type, manufactured and identified in accordance with requirements (or alternates allowed) in Section V, Article 2 Part T-233.

The IQI number must be clearly legible on the RT image. The RT technique shall be sensitive enough to adequately display the specified hole or wire dimension in the IQI image.

*Density, artifacts or blemishes*

The density of the RT image must reveal significant flaws that may be present. Transmitted density through the weld image shall meet the requirements of ASME Section V, Article 2.

Images shall not contain physical, chemical, or other artifacts or blemishes that interfere with reading of the image and evaluating apparent discontinuities in areas of interest. Prohibited artifacts and blemishes include:

- a. Processing defects such as fogging, streaks, watermarks or chemical stains.