# In-service application of EMAT in Boiler Water Wall Tubes ancdHigh Temperature Components

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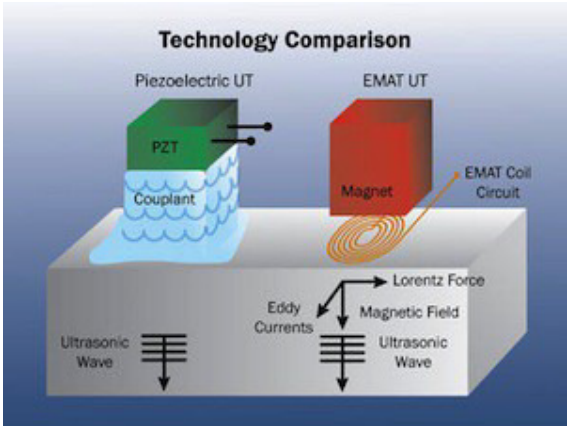
This article describes the application of electromagnetic acoustic transducer forthickness mapping of boiler water wall tubes and high temperature pipelines used in various industries. Althoughconventional UT spot thickness gaging is widely used in industries such as oil and gas, power, petrochemical, Pharmaceutical plants etc., this paper will give an idea about the importance of mapping entire tubes/pipes and its advantages .This article also describes the use of Medium Range Ultrasonic Testing (MRUT) by EMAT forquick detection of wall lossfor later verification by thickness mapping to find out the integrity of the pipelines

Keywords: Tubular inspection, water wall tube inspection, in-service inspection by EMAT, high temperature thickness gaging/mapping

**Introduction**

EMAT or Electro Magnetic Acoustic Transducer is an Ultrasonic Testing (UT) technique that generates the sound in the part inspected instead of the transducer.




An EMAT induces ultrasonic waves into a test object with two interacting magnetic fields. A relatively high frequency (RF) field generated by electrical coils interacts with a low frequency or static field generated by magnets to generate a Lorentz force in a manner similar to an electric motor.

This disturbance is transferred to the lattice of the material, producing an elastic wave. In a reciprocal process, the interaction of elastic waves in the presence of a magnetic field induces currents in the receiving EMAT coil circuit.

For ferromagnetic conductors, magnetostriction produces additional stresses that enhance the signals to much higher levels than could be obtained by the Lorentz force alone. Various types of waves can be generated using different combinations of RF coils and magnets.

**Application**

1. **High Temperature thickness gaging**

High temperature thickness gaging is the most demanding applications for preventing unplanned shutdowns. It is always a challenge for maintenance personnel to identify/anticipate the failures. As on today most of the failure occurs in piping systems are caused by corrosion and erosion that result in wall thinning. A periodic NDT inspection is often required by the plants to check the integrity of the piping's.

For high temperature components, each time an inspection is performed, the productivity of the plant is reduced, resulting in a significant loss of money. However piezoelectric probes are available for high temperature thickness gaging application it got lot of limitations as well. In this case EMAT based transducer are the significantplayer to resolve the problems.

**Gadgets:**

The **temate® PowerBox H**is a hand-held, battery operated ultrasonic instrument capable of generating spikes and tone bursts up to 1200V or 8kW of peak power in frequencies ranging from 100kHz to 6MHz. The equipment can be used in pulse-echo and pitch-catch operation.

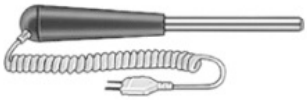

The instrument can generate nearly any type of wave mode used for several applications such as

- Normal Beam (0º)-Shear Horizontal and Longitudinal.
- Angled Beam (0º to 90º); Shear Horizontal and Shear Vertical.
- Guided waves (90º); Rayleigh (surface), Shear Horizontal and Lamb.

A thermocouple port comes with the instrument enables the application of high temperature thickness measurement.

As EMAT has the unique advantage of generating ultrasound inside the material, measuring thickness on the coated/painted and rough surface with a liftoff of 3 to 4mm.This lift off and dry inspection enables flaw and corrosion detection from -30ºC to 650ºC without any couplants.

A complete thickness measurement kit consist of Power Box H, thermocouple, probe holder and a sensor consist of amagnet and a RF coil,



thermocouple

Magnet

Sensor holder


**Benefits over Conventional UT**

| Sr.no | Conventional UT | EMAT |
|---|---|---|
| 1 | Need of Different delay shoes for different temperature | No additional accessories such as delay shoes are required |
| 2 | Couplants:<br>• Different types of couplants need to be selected based on temperature.<br>• In this case identifying the temperature requires Separate tool<br>• Possibilities of surface contamination<br>• Need to remove the dried couplant from the probe for next reading | Couplant free inspection |

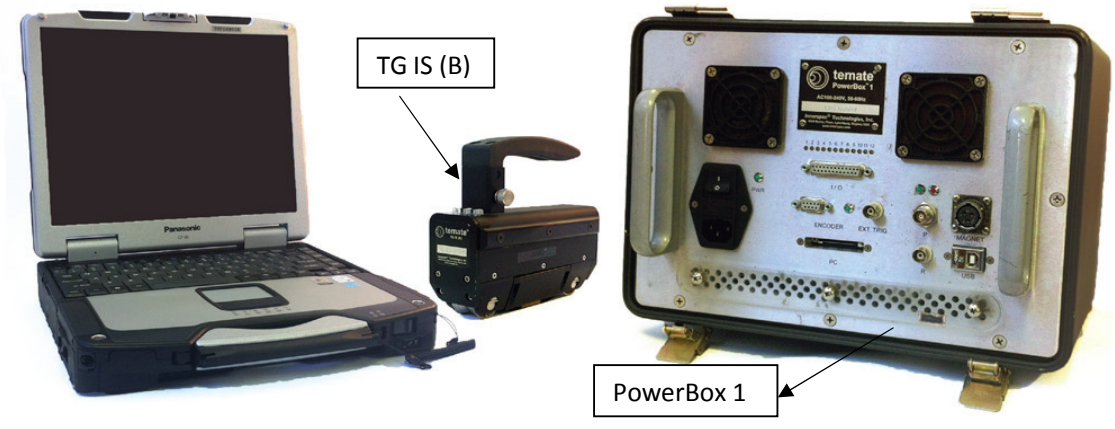
| | | |
|---|---|---|
| 3 | Special probes shall be used up to a maximum temperature of 450 degree C with precautions | High temperature sensor can operates up to 650 degree C with 4-5 s intervals. Continuous B-scan mapping is possible at 200 degree C |
| 4 | coating surface hiders the ultrasound penetration | coating will not affect the ultrasound penetration |
| 5 | surface preparation: Requires good surface cleaning | Comparatively less surface preparation and works on uneven surface up to an extent. |
| 6 | Inspection speed reduced drastically due to practical problems such ascouplant evaporation, improper probe contact, surface preparation and comparatively human errors are more due to fatigue. | Less operating time per point |

## 2. Boiler water/furnace wall tube inspection TG IS(B)

[1]The temate® TG-IS(B) is a portable system designed for rapid tube inspection to measure wall loss, Hydrogen damage, caustic gauging, and similar types of defects in boiler tubes. The Electric Power Research Institute (EPRI), Babcock & Wilcox (B&W) and McDermott Technologies, Inc. (MTI) developed the former version of TG IS (B) called FST-GAGE® for boiler tube inspection in early 90s.

The temate® TG-IS (B) runs with Inner-spec's temate® PowerBox 1 instrument, a premium ultrasonic system designed for techniques that require high-speed and high-power such as EMAT, dry-coupled piezoelectric, and air-coupled ultrasound in different wave modes for flaw inspection, thickness, and material property. The instrument includes an intelligent processor with integrated digitizers and broadband receivers. Operation and data management is performed using an external laptop that includes the temate® TG-IS (B) software for scanning and reporting results.

A built-in magnet-pulser provides the ability to use electromagnetic probes such as TG IS (B) used for scanningferromagnetic materialswithout adhering to the surface,



The proprietary pitch-catch EMAT design oftemate® TG-IS (B) is a proven tool can accurately measure the remaining wall on tubes from 2.5mm to 12.5mm thick for the tubes OD greater than 22mm. The system is capable of providing a complete and accurate map of a boiler showing both defects, remaining wall on every tube scanned even when the walls are non-parallel or heavily pitted. Based on the amplitude loss alarms the system also enables the operator to detect HCC.

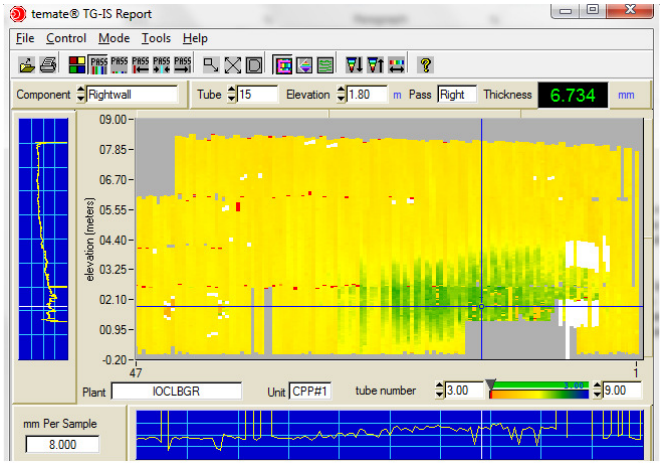



Figure 2 shows the example for mapping of a utility boiler tubes, The TG IS (B) reporting software maps the entire tubes thickness information in color codes from Red, yellow and blue color. The red indicates the lower thickness and blue indicates the maximum thickness

The region in green shows the increasing thickness on the particular region due to heavy hard scale deposition in the ID of the tubes. Secondly the top most region tubes closest to super heater areas seems to have more wall loss comparatively.

**Fig-2**

Prior to the development of this system, testing of boiler tubes was primarily limited to spot checks of wall thinning using conventional ultrasonic thickness gauges during outages. This resulted in only a small fraction of the tube wall area being tested. With temate® TG-IS (B), if necessary, scan the entire furnace to know the overall furnace tube conditions at different elevations to detect thinning and variety of other boiler tube failure mechanisms

**Advantages:**

- Chances of missing a defective region is very less when compared to conventional spot thickness gauging.
- Couplant free inspection with minimum surface preparation
- Gives thickness information with +/-0.127mm accuracy which is very sensitive in comparison with other electromagnetic techniques such as LFET,RFET available for furnace tubes
- Enables the Retracing of the same spot with elevation information for the forthcoming shutdowns to measure degradation rates.
- Comparison of overall furnace walls conditions becomes easier with C scan maps to identify the most critical areas which are about to fail.
- Amplitude information enables HCC detection.
- Thickness measurement is possible on tubes having heavily pitted non parallel walls

### 3. Corrosion detection

The guided wave ultrasonic testing is the widely used technique for detection of corrosion and other discontinuities in pipelines. The temate® MRUT (Medium Range Ultrasonic Testing) uses EMAT technology to generate high frequency guided waves from 100 kHz to 1MHz to detect corrosion, cracks and discontinuities on exposed tubes, gas lines, oil pipelines and storage tanks

Thesystem uses high-power Electro Magnetic Acoustic Transducer (EMAT) technology to perform 100% scanning by manual and automatic scanners at speeds of up to 150mm/s. The inspection can be performed on rough and corroded surfaces and when covered with thin wraps and coatings (<3mm).

Although MRUT can be used for various components, for pipeline inspection its constructional features enables the corrosion detection more flexible by axial scanning and circumferential scanning methods.

**Axial Scanning** Separate transmitter and receiver in through-transmission configuration send sound around the tube or across a plate to measure attenuation and/or velocity changes in the signal due to corrosion, cracks or other defects. Ideal for inspection under supports when the top of the tube is accessible or to inspect large spans of exposed pipe or tank walls at fast speeds.

Axial Scanning (Through Transmission) detects:

- 25mm x 20% wall smooth corrosion, 10% for perpendicular cracks.
- Cross sectional area - 1.4% of 14" pipe / 3.3% of 4".
- 0.125mm (0.005") surface defect detection.

**Circumferential Scanning** Single or dual sensors send guided waves along a tube or a plate and measure reflections from any corrosion and defects up to 5m in front of the sensors. Ideal for inspection of air-to-soil interfaces and any tubes and plates where there is no direct access to the area inspected. Circumferential

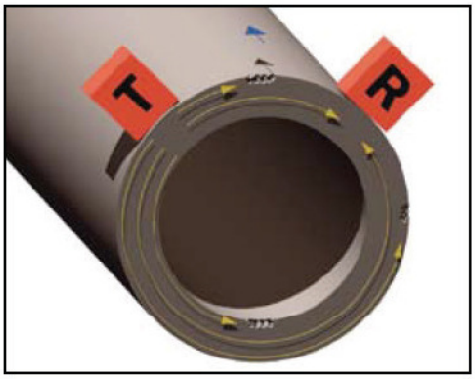



Figure 1: Axial scan method

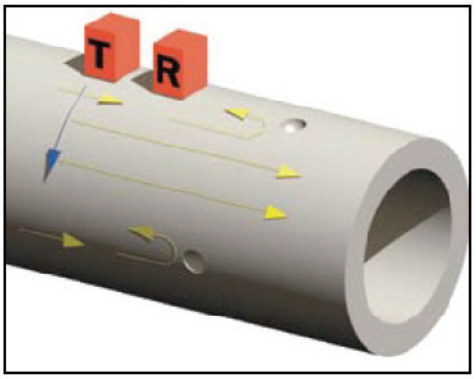



Figure 2: Circumferential scan method

Scanning (Reflection) detects 25mm x 30% wall smooth corrosion, 0.1m to 5 m coverage.

With the use of higher frequencies and a shorter range, this technique detects isolated pitting and wall loss with up to 10 times better resolution than Long Range UT systems with minimal or no dead zone.

**Conclusion:**

EMATs arethe proven technology with added advantage of piezo transducers.The dry couplant feature of EMAT can cater various application such as high temperature thickness gauging, flaw detection, corrosion mapping etc.with higher inspection rate with good integrity

**References**

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