General Information about Guided Wave Testing (GWT)

Why Use Guided Wave Testing

Guided Wave Ultrasonic Inspection or Guided Wave Testing (GWT) uses a Wavemaker Pipe Screening System to send 'guided' ultrasonic sound waves along lengths of pipes to screen for corrosion or cracks. Conventional ultrasonic testing such as thickness gauging uses bulk waves and only tests the region of structure immediately below the transducer. Therefore, it is an extremely slow process to scan a large structure and it is frequently necessary to resort to testing at a grid of points and hoping that they are representative of the whole structure. However, even this strategy breaks down when part of the structure is inaccessible because it is either buried or covered in insulation.

It is much more attractive to be able to screen a large area of structure from a single transducer location, and this is possible using guided waves which propagate along the structure. The Wavemaker system uses special arrays of transducer elements, referred to as rings, which fit around the pipe under test. After a ring has been fitted around a pipe, the operator uses the Wavemaker system to perform a single test that screens a number of metres of pipe on either side of the test location. **The length of pipe that can be effectively screened on either side of the test location in a single test depends on numerous factors and typically ranges from several tens of metres for pipes in good condition down to a few metres for pipes in poor condition or with certain types of coatings.**

How Guided Wave Testing Works

In order to understand how the Wavemaker system works, the whole ring of transducer elements may be regarded as behaving like a conventional ultrasonic transducer operating in pulse-echo mode. The ring sends out a burst of ultrasonic guided waves and then listens to signals that are reflected back. Figure (a) shows a schematic diagram of the ring of the Wavemaker system operating on a typical pipe that contains an assortment of features around the test location. A schematic of the corresponding results are shown in Figure (b).

The Wavemaker system is composed of three primary components, labelled in Figure (a) as the transducer ring, the Wavemaker instrument, and the controlling computer. The transducer rings are specific to a certain pipe size. They use either springs or air pressure to dry-couple piezoelectric transducer elements to the pipe being inspected. Internal circuitry allows each transducer ring (and therefore the diameter of the pipe being tested) to be automatically detected by the electronics. All of the signal generation and detection is housed in the Wavemaker instrument, which operates from an internal rechargeable battery and is connected to a standard laptop PC via a USB or serial connection. The control of the instrument as well as the signal processing and report sheet generation is done via the Wavemaker WavePro software.

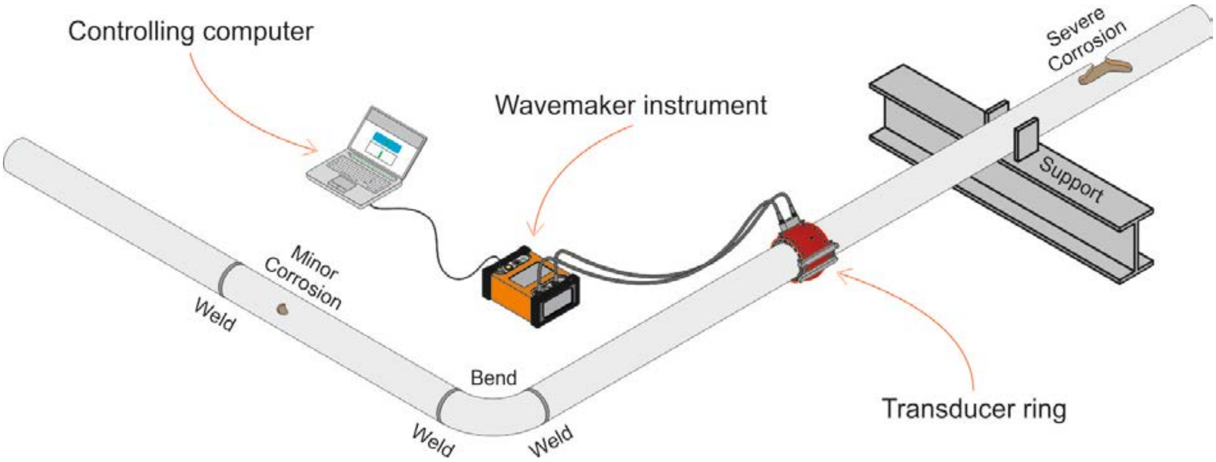

Figure (a), typical GWT equipment setup

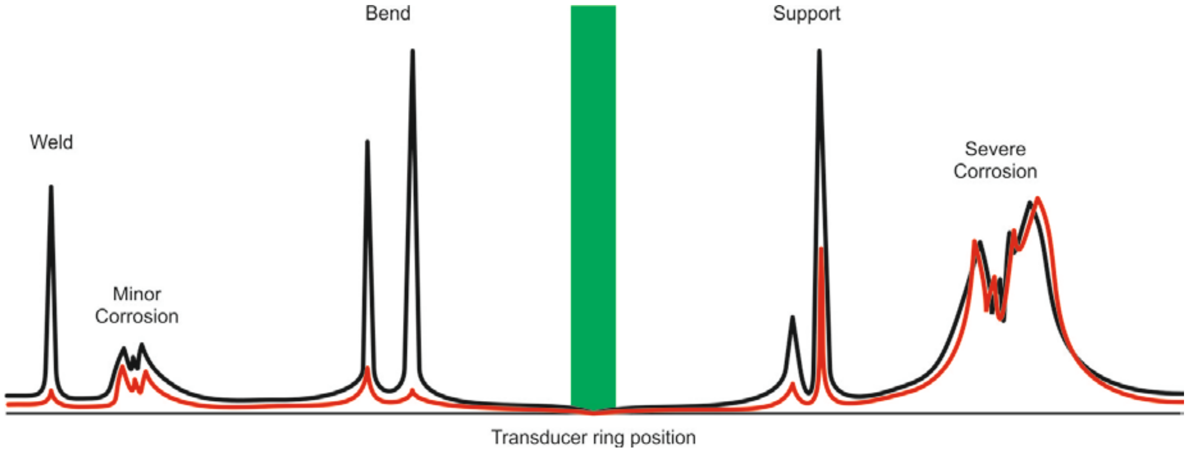

Figure (b), typical data obtained from GWT testing – relates to setup shown in Figure (a)

Performing Guided Wave Testing

The configuration of the equipment and the choice of transducer rings varies depending on such features as the pipe diameter, pipe condition, coatings, type of supports, and suspected type of defect. To obtain optimum results, the GWT inspector will ordinarily complete a checklist in co-operation with the client on a pre-inspection site visit. If available, isometric drawings are very helpful especially for reporting the location of suspected corrosion.

In general very little surface preparation is required for testing using this technique because the operating frequency is quite low. The transducers are able to couple directly through paint, thin layers of epoxy, or a small amount of general corrosion. However, if there is any flaking paint or corrosion, this should be scrapped off. In addition, **if there is any thick (generally greater than 1mm) coating, this needs to be removed over an area at least 300mm long.** In order to inspect the pipelines that are insulated, the insulation must be removed over a small area, which is typically one metre long. The area where the insulation should be removed is usually marked on the pipe by the GWT inspector at a site visit. The transducer rings must be able to contact the pipe wall around the entire circumference of the pipe. Therefore, any heat tracing or wire that is attached to the pipe should be released, leaving a minimum of 200mm between pipe wall and the wire/heating pipe.

Sensitivity of Guided Wave Testing

Guided Wave Testing (GWT) utilises a range of frequencies as a combined 'regime' so as to enhance feature differentiation and maximise analysis clarity. Resultant from this, the sensitivity of inspection becomes a relative concept and as such is difficult to quantify explicitly.

Furthermore, **many performance related parameters, including the level at which a 'call' can be made concerning the nature of a detected feature, are heavily dependent on the general condition of the pipe.** On a pipe that is very clean, corrosion or any other type of defect/discontinuity much smaller than a defined 'standard' detection value (in terms of pipe wall cross-sectional area) could be identified. However, on a pipe that is generally corroded, it may be difficult to locate areas of more severe corrosion unless they correspond to a much higher percentage loss than the normal call level. Thus, **the detection threshold for features/defects/discontinuities is dependent upon the general condition of the piping; detection requirements should be discussed with the GWT inspector at the pre-inspection visit.**

Typically, where the amplitude of the reflection from a discontinuity of declared minimum sensitivity level is 6dB above the noise floor (determined by the level of coherent noise at the point and time of inspection), the detection threshold limit (with 95% probability of detection) is defined. Thus, **under standard analysis protocols the detection threshold for any given inspection represents a 5% cross-sectional change in pipe wall material** (for which a 95% probability of detection exists).

Interpretation of cross-sectional change in terms of pipe wall material loss (or gain) is a dependent quantity derived from multi-element quantitative and qualitative analysis and thus is not defined as a base unit against which guided wave inspection sensitivity or detection probability is measured. Analysis of signal composition at a point of detected cross-sectional change within gathered inspection data does however enable a GWT inspector to interpret the circumferential extent (location/distribution around the pipe) of the feature. From this signal analysis it is possible to provide an approximation of material loss (or gain) – generally listed within a 10% tolerance band (e.g. 20-30% pipe wall loss).