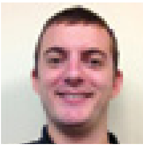
GUIDED WAVE MONITORING: A NEW TREND FOR IMPROVED SENSITIVITY AND COVERAGE IN BURIED AND CASED PIPING



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Guided Wave Testing (GWT) is a relatively young and rapidly evolving Non-Destructive Evaluation (NDE) method primarily used for the inspection of piping. In its infancy, the results from a guided wave test were displayed in a very basic amplitude versus distance plot that allowed the inspector to extract qualitative information about the relative size and axial location of potential areas of corrosion. The advent of the guided wave focusing technique brought with it the ability to determine the approximate circumferential location of these areas of corrosion and even to generate a three-dimensional image of the inspected area of the pipe, showing amplitude and axial and circumferential positions, all on a single display. This provided a new means for determining the criticality of detected corrosion indications.

More recently, a new guided wave technology and trend is emerging for the long-term condition monitoring of piping, referred to as Guided Wave Monitoring (GWM). GWM represents a paradigm shift in the way we apply guided wave technology and is characterized by the use of permanently installed guided wave sensors for continuous monitoring or cyclical re-inspection of a component. Among other significant benefits, this technology will allow for improved penetration power and sensitivity over traditional GWT for buried and cased piping applications. These benefits are discussed next, along with a description of several of the available technologies and potential applications for GWM.

GUIDED WAVE MONITORING

GWM differs from GWT in that a guided wave transducer collar is permanently installed on the piping segment of interest. A baseline data set is acquired at the time of installation to which all subsequent data sets may be compared and analyzed for changes in the component. The permanently-installed sensors are ideal for installation on piping in excavations, high-radiation areas, difficult-to-access areas, or on critical components.

SEVERAL OF THE PRIMARY BENEFITS OF GWM OVER GWT INCLUDE:

- Ability to re-inspect as often as desired without direct access to the component.
- Improved sensitivity/ coverage through the removal of coherent noise.
- Improved sensitivity to corrosion at structural features (e.g. supports, welds, flanges).
- Increased productivity as there is no need to apply/ remove the transducer collar.
- Simplified interpretation through time-progression processing of data.
- Added prognostic capabilities through data trending.
- Conducive to condition-based, rather than time-based, maintenance.

MEF COLLARS

Magnetoelastic Focusing (MeF) collars, developed by FBS, Inc., utilize the magnetostrictive effect to efficiently generate and receive guided waves. The MeF collar is the first commercially-available collar of its kind to incorporate phased-array and passive focusing capabilities. The magnetostrictive effect is a property of ferromagnetic materials by which the material changes shape in the presence of an applied magnetic field and vice versa. MeF collars are well-suited for permanently-installed applications as they have a low profile and operate most efficiently when permanently bonded to the pipe prior to use.

gPIMS COLLARS

Guided Ultrasonics, Ltd. (GUL) currently offers permanently-installed monitoring systems (PIMS), consisting of piezoelectric guided wave testing collars that are permanently installed on the piping segment of interest. After installation of the collar, the tool leads can be located in a convenient location where the inspector can return to the site and recollect data at will without the need for direct access to the piping segment.

OPTIMIZING PERMANENT INSTALLATIONS

Piping segments are routinely excavated for External Corrosion Direct Assessment (ECDA) and Internal Corrosion Direct Assessment (ICDA) examinations. This is an opportune time to install a GWM collar.

GWM is a form of Structural Health Monitoring (SHM). SHM, in many cases, is easier to execute than NDT and can often provide more information. The essence of this advantage lies in the fact that GWM produces multiple data sets that represent a timeline of the condition of the piping segment. In contrast, GWT requires that the assessment of the piping segment be done from a single data set. Furthermore, GWM provides enhanced sensitivity because it is possible to isolate a particular indication in the data and monitor its progression over time. This data trending approach facilitates the estimation of indication growth rates, subsequently enabling a condition-based maintenance approach in place of a time-based approach.

Coherent noise, often resulting from the inspection process itself, is problematic in GWT because it can produce false indications; however, GWM enables the use of signal processing techniques, such as the simple subtraction of successive data sets, that make it possible to remove this coherent noise and subsequently highlight changes in the piping segment of interest. This time-lapse inspection approach is advantageous as flaws, such as corrosion and cracks, tend to grow over time, while structural features, such as welds and supports, tend to provide a stable response. GWM can therefore be utilized as a simple means to identify areas of active corrosion at or near structural features such as welds, flanges, and supports.

The adoption of GWM and permanently-installed collars has the potential to drastically increase productivity and minimize future inspection costs. As an example, GWT of buried piping is time-consuming and costly as the component must be excavated, protective coatings usually must be removed, the excavation must be made safe for entry, GWT personnel that are trained in excavation safety and entry must travel to the site (with a considerable amount of equipment) and perform the GWT examination, and finally, the component must be recoated and reburied after the inspections. The placement of permanently-installed collars in this situation would facilitate future guided wave inspections of the buried component without the need to re-excavate, thus significantly reducing the time and cost associated with the inspection process.

In comparison to that of GWT, data interpretation with GWM has the potential to be much simpler. With GWM, the existence of baseline data and subsequent data sets enables the statistical and feature-based analysis of the data sets, data-trending, and prognostic capabilities, which may potentially allow for the estimation of the remaining useful life of a structure or component. For example, indications from cracks or corrosion can be isolated and analyzed with each subsequent data acquisition, allowing valuable information about the size and/or growth of the indication to be extracted for more reliable failure analysis and prognostics.

Currently, NDT and maintenance activities are most commonly planned on a time-based recurring schedule with pre-determined inspection intervals that may not take into consideration the actual condition of the specific component of interest. GWM can initiate a transition from time-based maintenance to condition-based maintenance, which can provide more substantive information for making decisions regarding the re-inspection and/or replacement of a specific component and can raise early warning signs that a structure or component is nearing failure. A condition-based maintenance approach can also provide a means to obtain the maximum usable life of a specific component prior to its replacement.

CONCLUSIONS

The imminent paradigm shift from GWT to GWM has the potential to reduce the complexity, cost, and time associated with guided wave inspection of buried and/or cased piping. Furthermore, the added signal processing capabilities afforded by the GWM approach provide significant potential for improved sensitivity and penetration power in these applications.