Pipeline Pigging Part 2: In-Line Inspection for Metal Loss

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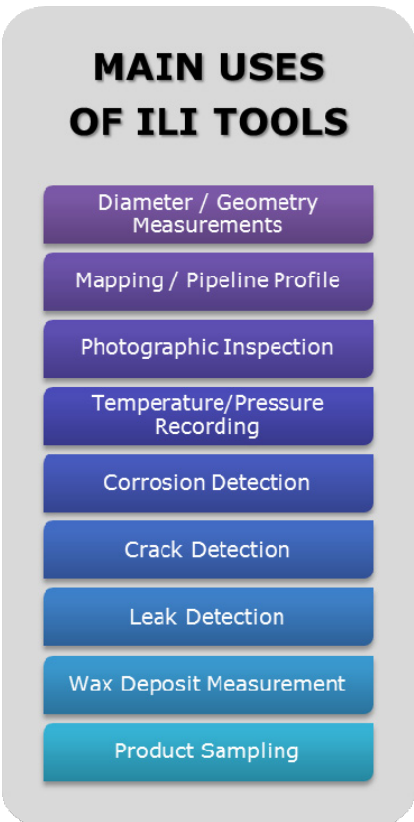

Figure 1: Main Uses of ILI Tools

As mentioned in Part 1, pigs are devices that travel through the pipeline and can be used for cleaning or maintenance purposes (utility pigs) as well as for gathering information about the condition, features and integrity of a pipeline (intelligent pigs).

Intelligent pigs are designed to identify different features or abnormalities as they travel through the pipe. Figure 1 briefly lists the functionalities for which intelligent pigs are commonly used. API 1160 and NACE RP0102 provide guidelines for selecting the appropriate tool for a given purpose. In this paper, the most commonly used In-Line Inspection (ILI) techniques, methodology and limitations applicable to detecting metal loss and wall thickness measurements are presented.

Magnetic and Electromagnetic Techniques

There are two types of tools commonly used for inspections of liquid pipelines; Magnetic Flux Leakage (MFL) and transverse MFL, also known as Transverse Flux Inspection (TFI).

The MFL is based on magnetizing the pipe wall by using a temporarily applied magnetic field in the axial direction. Magnetic flux distribution is dependent on the wall geometry and the variations (imperfection or metal loss), which cause changes in magnetic flux distribution resulting in "leaks" outside of the pipe wall. Flux leakage decreases with decreasing depth and width of the defect. The amplitude, length, and direction of the leaks are collected by sensors placed on the body of the pigs and analyzed to identify the nature of disruptions.

Transverse MFL utilizes either permanent magnets or electromagnets. When the transverse (circumferential) magnetic field is applied, as in TFI, longitudinally oriented defects such as cracks, lack of fusion in the longitudinal weld seam, and stress corrosion cracking can be identified.

In the case of the eddy current method, the magnetic flux is induced to the pipe in the by use of a coil generating alternating magnetic fields. The distortion is created when there is a flaw which causes a change in eddy current. The associated impedance in the coil are measured to identify the type of flaw or material condition. Eddy current can be used to overcome the wall thickness limitations of magnetic flux.

The available tools can be customized to the given requirements for a pipeline. The detection threshold for the depth of an anomaly varies depending on pipe type and diameter as well as the tool used; however, it is typically between 5% - 15% of the nominal wall thickness. Available tool sizes, in general, range from 6 to 56 inches. Typical specifications for defect identification for a high resolution MFL tool are presented in Figure 2, where WT represents the wall thickness.

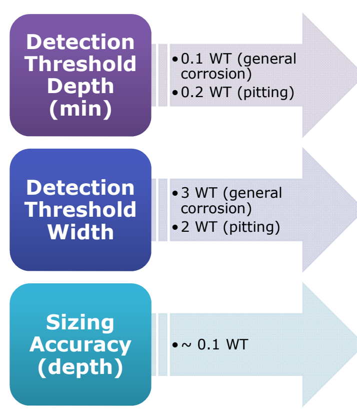

Figure 2: Typical Detection Capability And Defect Classification

Ultrasonic Testing (UT) Techniques

UT uses ultrasonic waves generated by transducers placed circumferentially around the pig body. The waves are transmitted through the pipe wall and reflected from the front and back surfaces of the pipe or from defects in the pipe.

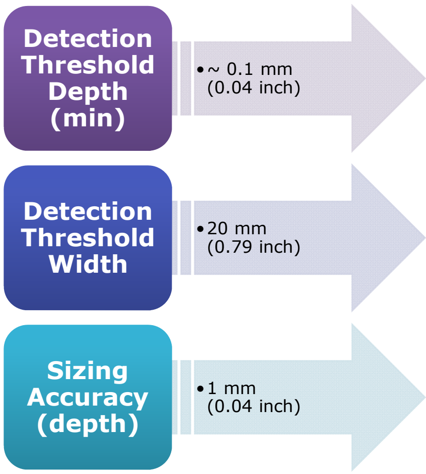

Figure 3: Typical Defect Specification For UT Wall Thickness Measurement Tools

The ultrasonic signal, reflected at the inner and outer surface and at the flaws, is emitted by the sensors. Because the time of arrival for the signals from different surfaces is recorded with respect to the initial pulse of ultrasound, the data is used as a direct measurement of the wall thickness.

The number of transducers used, the pipe diameter, and the pig traveling speed determine the resolution that can be achieved. For maximum traveling speeds of 1 m/s (3.3 ft/s), resolution of about 1% of the wall thickness is achieved. Speeds higher than 1.5 m/s (5 ft/s) can lead to loss of coverage.

Ultrasonic pigs are available for a large range of pipe diameters (150 to 1,000 mm or 6 to 39 in). A certain number of transducers, depending on the pipe diameter, are used to give the required resolution for defect identification. The longitudinal resolution depends on the pig traveling speed.

The data can be interpreted in terms of thickness of the pipe, identifying the defect as external or internal. This, however, is significantly dependent on the data quality which, in addition to the number of transducers and travelling speed, can be affected by other factors such as wall thickness and surface roughness.

Typically, for large-diameter pipelines, two inspections are performed. The first inspection uses equally-spaced transducers around the pipe circumference to perform an overall inspection of the pipe. The second inspection staggers the transducers to perform a detailed inspection of the area between 5 and 7 o'clock. This allows us to evaluate the area in which the most severe internal corrosion is likely to occur in liquid pipelines.

Benefits & Limitations

To summarize, the benefits and limitations of the two most widely used ILI tools are presented in Table 1.

Tool	Benefits	Limitations
MFL	• Used in both liquid and gas pipelines. • Detect and locate internal and external pipeline imperfections, defects, and corrosion. • Monitor changes in a pipeline condition over time.	• Planar defects can be difficult to detect. • Crack and longitudinal type defects or anomalies are not always reliably detected. • Small diameter pipes with extra-heavy walls are sometimes difficult to inspect because of low magnetic flux density availability. • Reduced resolution for pipe sections with thick walls. • Data loss due to velocity excursions can be a limiting factor for the tools used in gas lines if the pressure is not high enough.
UT	• Direct measurement of wall thickness and defect depth. • High accuracy of wall thickness and depth measurements (1% of wall thickness). • Differentiation between internal and external defects.	• Require a homogeneous liquid in the pipe. • Circumferential coverage is dependent on the number of transducers and the pipe size. The gap between transducers increases as line size decreases. • Axial coverage is dependent on the travel speed. • Very sensitive to the cleanliness of the internal pipe surface. • Uniform travel speed is necessary for best results.

Table 1: Summary of Benefits and Limitations of MFL and UT Tools

Reference

1. Managing System Integrity for Hazardous Liquid Pipelines. API 1160. Nov, 2001.
2. In-line Inspection of Pipelines. NACE RP0102. Jan, 2002.
3. Titratsoo, J., *Pipeline Pigging & Integrity Technology, 3rd Edition. Houston, TX. 2003.*

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