

Paper No.
16884



Field Experience on Why Pipeline In-Line Inspections (ILI) Fail

Ito L. Akra, Mohammad S. Hamaqi, Tawfiq I. Hathloul, Abdullah F. Almakini, Abdulaziz A. Naim

Saudi Aramco
Northern Area Technical Support Department
Juaymah Admin Building, Ras Tanura
Saudi Arabia

ABSTRACT

Pipeline in-line inspection (ILI) is a reliable technique to evaluate and assess the integrity of pipelines. Multiple technologies are currently deployed for ILI. The most widely used include; Magnetic Flux leakage (MFL), Ultrasonic (UT), Electromagnetic Acoustic Transducer (EMAT) and Eddy Current (EC). ILI is used to identify different anomalies and defects, to prevent pipeline leaks or ruptures that will result in production loss and/or adverse environmental impact. Extensive planning is required before running an ILI tool in a pipeline. Even with extensive and rigorous planning between pipeline owners/operators and the ILI vendors, some ILI runs fail. This paper will discuss field experience as to why some pipeline ILI runs fail. It will also discuss key factors to consider during pre-planning and preparation, to minimize the potential for ILI failure. Several of these factors include understanding all pipeline physical parameters, compliance with ILI vendor tool operational limits; such as magnetization capability, velocity, differential pressure and temperature requirements, and compliance with sound operational practices for launching and receiving of ILI tools. It is essential to identify the root cause(s) of an ILI failure to avoid reoccurrence.

Keywords: Inline Inspection (ILI), Magnetic Flux Leakage (MFL), Ultrasonic (UT), Electromagnetic Acoustic Transducer (EMAT), Eddy Current (EC), Pipeline Failure, Velocity, Temperature, Magnetization, Pre-Planning, Differential Pressure (DP).

INTRODUCTION

Since the first pipelines began to fail, operators have wanted to find out why; what condition the remainder of the pipeline might be in, and was the problem going to occur in other pipelines? Initially, there were very few methods available to assess the integrity of an in-service pipeline. Basically, the only option was to fill the line with water and pressurized it, to see if the line would “hold” the pressure, as an indication of presumed integrity. This often proved unsatisfactory, as the line would be pressurized shown not to leak while under pressure, and then would leak again several days, weeks, or months later. The actual condition of the pipeline or extent of the original problem; were not effectively determined.

Eventually; more complex mechanical evaluation devices, either tethered or free swimming, were pulled or propelled through the pipeline in an attempt to identify the location where wall thickness; and mechanical integrity had been reduced. These devices have developed significantly with time and are now known collectively as intelligent pig/scrapper, instrument pig/scrapper or inline inspection (ILI) tools.

In-line Inspection (ILI)

ILI tools utilize a number of different inspection technologies; with magnetic flux leakage (MFL), ultrasonic (UT), electromagnetic acoustic transducer (EMAT), and eddy current (EC) being the most widespread use. These technologies provide full 360-degree coverage and condition determination of both the internal and external surfaces for the entire length of the pipeline being inspected. These tools are widely available in the marketplace and are typically the most economical to run. Pipeline ILIs are still costly; both in terms of the equipment/service provision and logistical preparations that may be required to ready the line for an inspection survey. Discussing the root cause(s) of pipeline ILI failure is essential to avoid incurring the high costs of having to perform a rerun inspection. The paper will discuss various circumstances and reasons under which an ILI survey may fail. It will also point out that in the vast majority of the circumstance, ILI failures can be prevented by good pre-planning and preparation. Aspects in this area would include; understanding all the true physical parameters of the specific pipeline, compliance with vendor tool operational limits particularly regarding, magnetization capability, velocity, and temperature requirements, and compliance with sound operational practices for launching and receiving an ILI tool.

When running ILI tools, there are a number of parameters that must be assessed and confirmed, both prior to and during an inspection, to increase the probability that the inspection will be a success. These various parameters can be divided into three broad categories; physical, process and operational.

PARAMETERS FOR IN-LINE INSPECTION (ILI)

PHYSICAL PARAMETERS

Pipeline physical parameters having the most impact on the successful passage and on the consequent collection of inspection data by an ILI tool include; diameter, whether it is constant or varies, and pipe wall thickness, which impacts pipe internal diameter, both in straight sections and in bends, and the bend radius of fabricated bends.

Diameter

Ideally, pipelines should be a single nominal pipe diameter for their entire length. There are tools on the market that can negotiate a diameter difference of 1, 2 and occasionally 3 nominal pipe diameter differences. Most ILI service vendors will have an inventory of the more typical multiple diameter tools; for example, 16 x 18, 20/22 x 24, 32 x 36 inches and with adequate time may be able to modify tools to offer other ranges or slightly expand the capability of available tools. Some tools can be utilized with a larger differential; for example, 28 x 42 inch, but these types of tools are typically purpose-built to be used in a specific pipeline and have limited industry-wide appeal. These specialized tools are expensive to build and require significant lead time to develop.

Issues arise when pipelines are being inspected for the first time and there are unknown diameter changes within the line. Attempting to run a 24-inch tool, in a pipeline that contains unknown or unrecorded sections of 20-inch line pipe, will not be successful. The running, in advance of scrapers/pigs equipped with gauge plates, or some form of manual or electronic caliper tool that has a broader diameter passage characteristic, is the best method to prevent ILI failure due to diameter mismatches. This is specifically important where a given line is being inspected for the first time. In that circumstance, and particularly if a line is old; it is better to consider available data as inaccurate at best.

Pipe Wall Thickness

The wall thickness of the line pipe to be inspected; impacts the accuracy of data collected in several aspects. For MFL tools, the thicker the pipe, the more difficult it is to saturate with a magnetic field; as such, MFL tools, dependent on their diameter, typically have a maximum wall thickness that can be inspected. Different ILI vendors may have a different capability to magnetize heavier wall thickness pipe. Some ILI vendors have the capability of inspecting pipe wall thickness up to 1.65inches (41.9mm). The capability of inspecting a heavy wall pipe thickness has to be confirmed by the ILI vendor before running the ILI tool. Under most circumstances, an MFL tool will be configured to ensure full magnetization of the main pipeline wall thickness; the heavier wall section, i.e., fittings, may not be magnetized sufficiently to ensure full inspection. Increasing wall thickness also decreases pipe internal diameter, which can restrict tool passage. Tools will pass through heavier wall pipe in straight sections than they will in bends; therefore, it must be known where an increased wall thickness occurs. Running of a mechanical gauging scraper with gauge and

bend plates will provide this information in addition to the diameter information. Figure 1 shows a gauging scraper with a bend plate in the middle and gauge plate at the front. Bend plates are sized to pass the anticipated or larger bend radii without deflection but will be deformed by a smaller radius. Gauge plates for ILI passage are specific to the tool to be used; as such they will have a greater diameter than a construction gauge plate, which is sized for all plus tolerances on the thickest fitting installed. The Plus on the fitting make the fitting thicker thus reducing the internal diameter. Constriction gauge plates are sized below the minimum ID for the entire pipeline. This means the will be much smaller than an ILI plate sized for 93 to 95% of nominal ID.

While plate-based mechanical gauging scrapers may be easier to run; i.e., they are a routine cleaning scraper, they are limited in the information that they provide. For example, if a plate is received deformed it is deformed to that maximum. It is not known if one or more excursions caused that deformation. The physical distance along the line at which the single or multiple deformations occurred is not known. Remediation, in terms of restriction removal, is not possible on this information alone. Electronic gauging tools provide information across the entire line; therefore, may be a better option if there are significant gaps in the existing physical data for the pipeline. If the plates are received undamaged, barring issues with subsequent valve mispositioning and flow rate excursions, a gauge plate scraper run immediately in advance of an ILI tool, the passage of the ILI tool without damage would be anticipated. As was the case with pipe diameter, prior knowledge of actual wall thickness or confirmation of wall thickness variation ahead of the ILI survey will increase the probability of a successful run. If tools are run without verification, data may not be collected or in severe cases, the inspection tool may become lodged in the pipeline. Figure 2 shows the consequences of running a gauging tool in a pipeline which was 14-inch in diameter, where the valve was not fully opened. Running the ILI tool without the gauging run would have resulted in the tool being stuck in the pipeline and would have required a shutdown for removal. It is important to stress that all gauging and ILI tools be equipped with appropriate locators, either electromagnetic or acoustic, to identify the physical location of the device should it stop along the line.

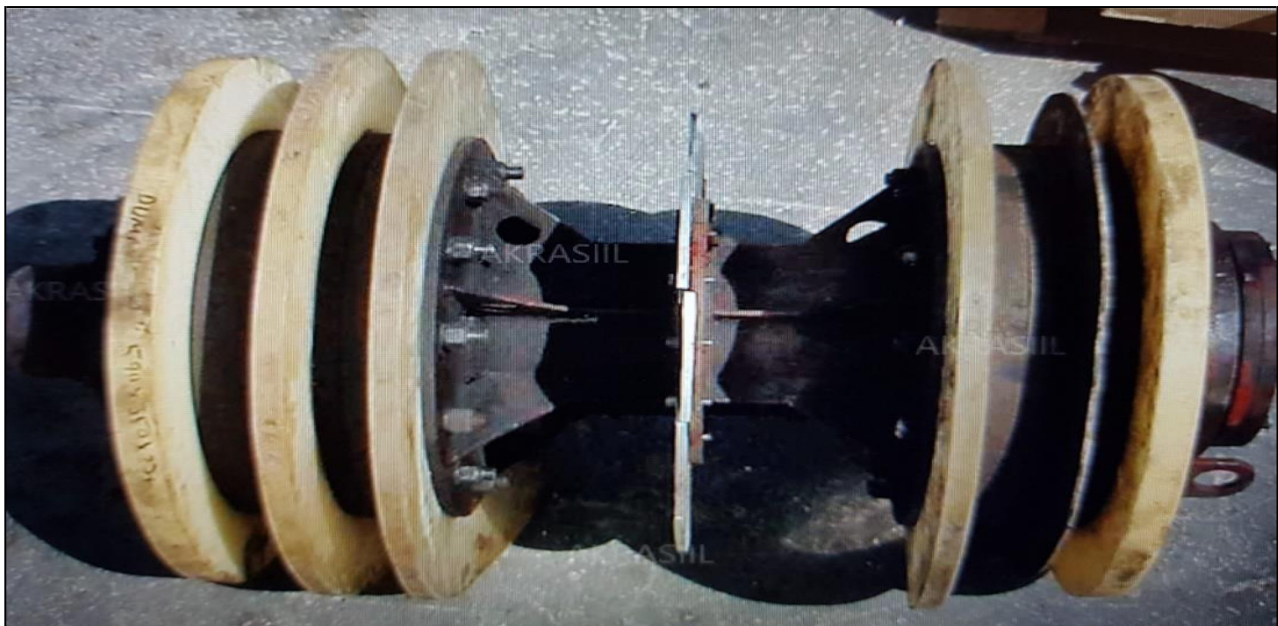


Figure 1: Gauging Scraper with bend plate in the middle and gauge plate at the front



Figure 2: Gauge plate after passing through 14inch diameter pipeline damage due to half open valve

Bend Radius

The majority of pipelines contain bends; these bends can be pre-formed or created during installation by “roping” the pipe in a very large radius without the need to permanently deform any given pipe joint. Rope bends are easy to negotiate, as they are made from the base pipe. Pre-formed bends may be made from the line pipe, but will typically be formed from heavier wall materials to accommodate the wall thinning, which occurs on the outer ligament of the bend. Pre-formed bends are made available with industry common radii. Typical bends are 1D, 1.5D, 3D, and 5D and for smaller diameter 10D and 15D bends are used; with D being the nominal pipe diameter. As such, for 24-inch nominal pipe, on the center of the bend, a 1.5D bend will have a radius of 36 inches and a 3D bend will have a radius of 72 inches, see Figure 3 below.

Figure 4 shows two different radius bends installed on a platform. Additionally, in Figure 1, the centrally mounted slotted plate is a bend plate designed to determine if the bend of a tighter radius than anticipated has been installed.

As a caution; in older pipelines, bends may have been installed by mitering the line pipe. The pipe is cut on an angle and then rewelded to itself, offset to the original orientation to create the bend. In the extreme; a 90-degree angle can be produced; which looks like the corner of a picture frame.