IN-LINE INSPECTION OF NEW PIPELINES

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Abstract

In-Line Inspection (ILI) of pipelines is usually only of interest to operators of older pipelines with known integrity problems. In the recent years it has become more and more common to also inspect new pipelines right before they are commissioned for service. This is not so much done for the purpose of detecting corrosion. Corrosion and other operating related flaws are not anticipated in newly laid pipelines. However, the non-destructive testing that usually takes place after several years of operation will be an in-line inspection. It has turned out to be very valuable to have a similar survey carried out at the very beginning, so later inspections can always refer to initial results. It can easily be found out, whether changes have taken place or not. In addition the In-Line inspection can also be a quality control of the manufacturing process. Although the pipeline and its parts are thoroughly tested throughout the manufacturing process, the ILI is a measurement different from previous inspections and shows the final result. The benefits of a baseline survey will be discussed with special regard to ultrasonic inspection (UT). It is explained why UT inspection is especially suitable for this purpose.

Introduction

Before a pipeline goes into operation it has been tested in many different ways and in a lot of different circumstances. Not only is the line tested for its pressure containment ability– typically by a hydrotest. All components are thoroughly tested in the process of production. Even the material itself, the steel plates are usually tested in the mill for various flaws, like non-metallic inclusions and laminations. Already at this first step in the lifetime of a pipeline quality standards describe what flaws are permissible. The inspection right after the rolling process it often done using ultrasonic technology. Figure 1 shows a steel mill in which a steel plate is tested for flaws using ultrasonic sensors. The sensors are attached from below and are visible in the lower part of the picture.

After the steel material is delivered to a pipe mill, the plates are bended into a pipe and welded. Weld beads and edges may be trimmed, depending on the pipe type. A new testing is required to prove the quality of the pipe. At minimum the welds are tested for weld flaws like lack of fusion or slag. Often an additional testing of the whole volume is carried out for wall thickness and internal flaws in axial and circumferential orientation. The weld area is tested for laminations. These tests are also done using UT. In the case of ERW-welded pipes the weld test is also done with eddy current method.

Once the steel pipe itself is manufactured it will be coated with a protective polymer coating. This coating is also tested for thickness and adhesion and insulating capabilities.

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Figure 1: Steel is produced that will later on be delivered to a pipe mill to become a pipe for an oil or gas pipeline. Testing is performed to meet certain quality standards.

On the pipeline construction site the pipe will be welded together. The girth welds are tested using ultrasonic and radiographic methods. Most construction regulations demand that records of the testing are to be archived. It has, however, been quite difficult to routinely retrieve this information and match it with later in-line inspection results.

The Benefit of a base-line survey

Once a new line is ready to go in operation, a thought on problems of corrosion and cracking susceptibility is usually avoided. These problems should not occur if the line is properly handled. However, after some time, all lines will show some effect of aging. Strictly speaking, if the effectiveness of the cathodic protection (CP) is proven, corrosion can be ruled out and ILI would not be required. It is a fact, that effective CP is not trivial [1] and that corrosion is often found, where it should not be [2]. ILI has been invented for this reason. While CP surveillance (the integral part of what is nowadays called Direct Assessment) is rather an indirect proof of pipeline integrity, the results of an in-line inspection show the presence or absence of defects directly. Once defects have been found, the question often is: "Do we have manufacturing related defects or active corrosion". In some cases this can be answered from the latest measurement alone. In all other cases there is no more conclusive method than comparing the present finding with the initial pipeline condition as it has been put into operation.

Another benefit of a baseline survey lies in the fact that, despite the multitude of inspections that have been carried out, defects may still exist. ILI technology today is so reliable, that parameters are found violating the pipeline construction standards. If the complaint is filed before the commissioning of the pipeline, manufacturers could still be hold responsible. Especially the wall thickness of seamless pipes is much better tested by internal pigs than by any other means. Often wall thickness values are found that do not exceed the required minimum wall thickness. These are usually reported in ILI reports as wall thickness variation. Once the pipeline is in operation, nobody can prove that a wall thickness deviation has always been in the line or has newly developed.

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Results of high resolution UT-wall thickness inspection

The ultrasonic wall thickness inspection method has turned out to be the most appropriate method for base-line inspections. This has different reasons.

- The alternative would be an MFL-inspection. MFL is very sensitive to abrupt changes in wall thickness and yields a quantitative value on the loss of metal. In new pipelines, however, the question is rather to have a quantitative measure on the absolute value of sound pipe wall. This will allow to find sections were a gradual decrease in wall thickness may fall short of the nominal wall thickness and thus constitute a problem. The absolute wall thickness measure of MFL is inaccurate, such that a reference to an as-build pipe tally is required in the data analysis of MFL inspections.
- Ultrasonic inspection will find lamination type flaws. These flaws do not represent defects that compromise the integrity of the pipeline. However, when carrying out repairs that include welding, these spots should be known. Since these flaws are manufacturing related[1], it is sufficient to find them once, and then keep the records.
- Intelligent pig run intervals can be as long as 10 years. In the quickly developing field of in-line inspection this is a very long time. It is not likely that the later inspection is done under the same circumstances as before. An absolute measurement, as in UT, has the big advantage of being free of interpretation and reinterpretation. The value of the once gained information will stay regardless of future inspection technology. As will be shown in the next section, 11 year old data has successfully been used as a basis for defect comparison. This is somewhat different from MFL-Data. Since this data needs to be interpreted, the favored method of interpretation may have changed.

Thus only the UT inspection results will truly give a reference for future inspections. Some sample data screenshots shall demonstrate this.

For a better understanding some terms are explained. The term resolution is often misunderstood. The wall thickness is of course measured as a discrete digitized value. The resolution yields information about the discretization error or in other words, "How large is the step between two digits?" Traditional tools had a resolution of 0.2 mm for the wall thickness measurement (the stand-off was usually even worse). The new generation has a resolution of down to 0.06 mm. The improvements are due to changes in the AD-conversion of the signal. With the higher resolution the profile is seen with more detail as the sample in Figure 2 demonstrates. The depth measure is not necessarily different. For defect assessment procedures using the so-called River Bottom Profile the results are potentially affected.

[1] Similar operating related defects exist as well, like Hydrogen induced cracking.

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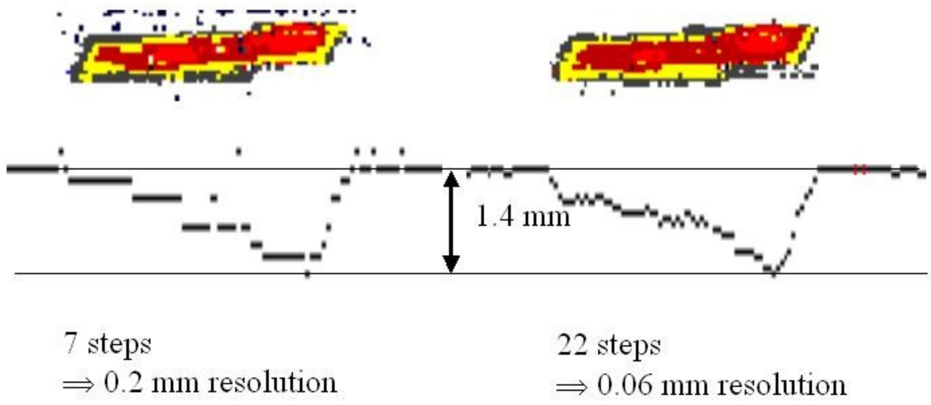

Figure 2: Depiction of a metal loss defect measured with different resolution.

Another term that is important in UT inspection data is the compression window. In order to efficiently store the data, areas of pipe surface with no change in wall thickness are stored with a single value, the mean nominal wall thickness. All measurements that are within this window are reduced to this value. Values outside of this window are all stored individually. Obviously the smaller the compression window the more subtle variations of the wall thickness will still be observed, while the amount of data on the storage devices increases respectively. The center of the compression window will be adapted to the nominal wall thickness in certain time intervals. The size of the compression window is a parameter that can be set on the tool before launch. In seamless pipe the tool operators will set the window size to larger values than in welded pipe. Figure 3 shows the effect of a change in the compression window. In the upper picture the window is set to 1 mm, in the lower to 0 mm (i.e. all data points are stored individually). The size and shape of the defect is affected. The corresponding profiles are seen in the lower part.

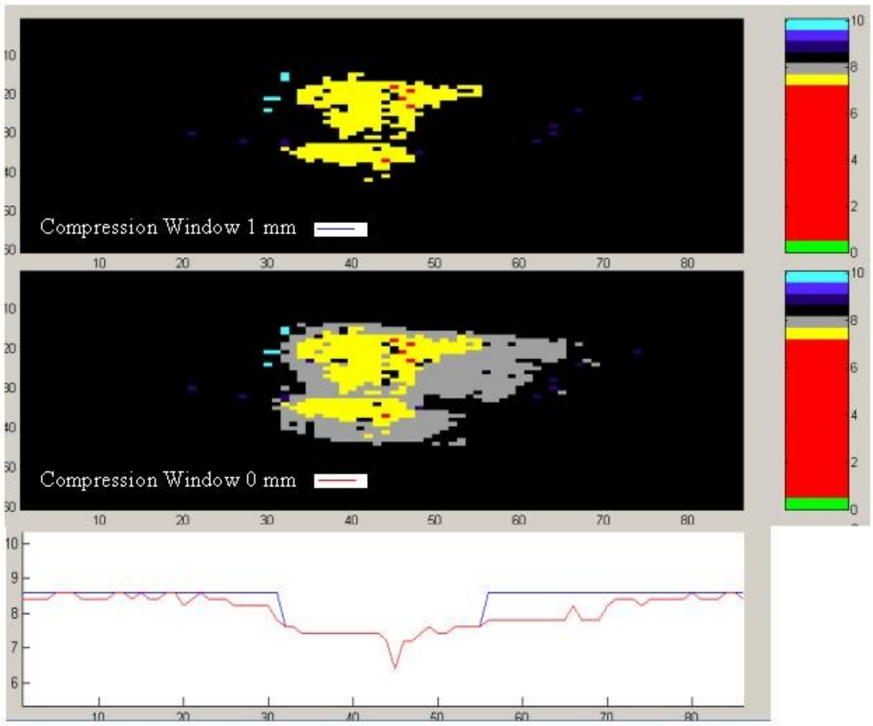

Figure 3: The compression window will affect how shallow deviation from the nominal wall thickness will be stored in the data.

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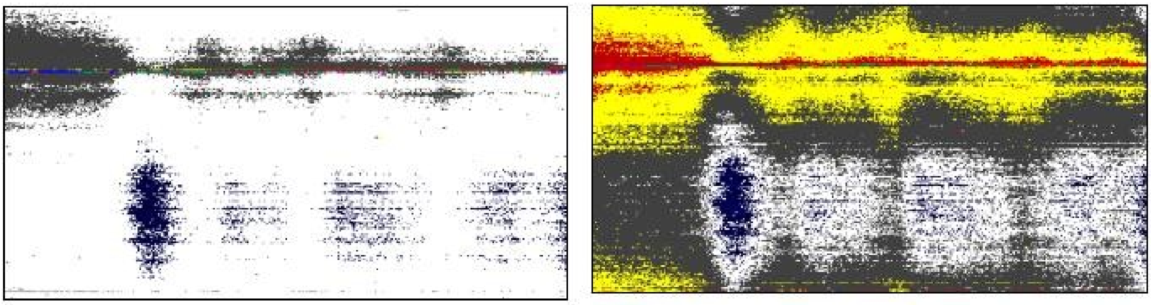
With both of these parameters there is always a trade-off between precise measurement and restrictions in tool speed and range. For a baseline survey the precise measurement is definitely desired. This would require a compression window of 0 mm and the full resolution. The range of the tool under these conditions is reduced compared to the regular data sheet. The optimum values thus depend on the actual situation. In Figure 4 a sample section of pipe wall not affected by metal loss is shown. In both cases the compression window is zero. The resolution in the part on the left is at 0.2 mm and on the right at 0.06 mm. There is an astonishing degree of detail in the variation of wall thickness visible. Note that this pipe is long seam welded, with the weld in the upper part of the picture. For seamless pipe wall thickness variations can always be observed. The difference between the maximum and the minimum wall thickness in the picture is only 0.45 mm. There is an obvious thinning near the weld. This is typical for older pipes and originates from the rolling process (called a camber). A longitudinal pattern originating from the rolling process is also visible due to a small chatter.



Resolution 0.2 mm
No compression window

Resolution 0.06 mm
No compression window

Figure 4: Sound pipe wall without compression and with different levels of resolution. Interesting features become visible that are usually not observed in an inspection for corrosion.

Run Comparison and corrosion growth

Active corrosion is usually an unexpected occurrence, because cathodic protection and inhibition should prevent any metal loss of this kind. However, it is a fact, that corrosion does occur at some point in the lifetime of the pipeline. When discovered by the means of ILI, the question on why it has occurred and whether the conditions are still favorable for corrosion will arise. Of course, the conditions for corrosion are not tested by ILI, but rather the fact that it is there. Calculations on corrosion growth rate, based on theoretical models [3] have rarely been employed, because the conditions may vary so drastically.

The calculation of the corrosion growth rate based on ILI-Inspection data usually consists of different steps. First the features are identified that correspond to each other. Now it is an important information if a feature has already been detected in the as-build pipeline or if the steel has been flawless. Next the difference in depth or remaining wall thickness between the two is calculated. In seamless pipe the local wall thickness shows considerable variations. To assume that the wall thickness has been at the nominal value before

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corrosion started, is an oversimplification. In a final step the degree of reliability of the conclusion is assessed. Because of the uncertainty of the ILI measurement it is not possible to consider the slightest change in wall thickness as a given fact. The more accurate the measurement is, the more reliable is the conclusion.

Conclusions

Processes of quality control and quality assurance are definitely further advanced today as compared to several decades ago. Still today a process of aging and hence deterioration of fitness for purpose of new pipelines should not be neglected. Taking into account that during the lifetime of the pipeline ILI will become an important means of integrity assessment, a baseline survey can turn out to be a very valuable information basis. From this basis decision making later on will be more reliably and inference can be replaced by evidence.

References

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[3] CO_2 Corrosion growth rate model, NORSOK M-506 (1998),

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