

Ultrasonic inspection technology

Stephen R Cox and David A Harman, SGS PfiNDE, Inc., USA, discuss the use of ultrasonics for measuring sludge and sediment levels in pipelines.

In 2013, during routine cleaning operations with a pigging tool, a pipeline company encountered a blockage in one of their pipelines. As the pipeline transported a sediment-containing hydrocarbon product, the company wanted to ensure that the blockage was removed in a timely, economical and environmentally safe manner. After considering several technologies, the company chose SGS PfiNDE's ultrasonic inspection technology as the best solution to solve the unique challenge and discovered that ultrasonic inspection technology can be employed for more than just high-end weld investigations.

Project operation

In early 2013, SGS PfiNDE received a call from a client pipeline company that transports a light hydrocarbon product with entrained particulate and sediment through a 150 mile section of pipeline in Minnesota. The company encountered a challenge when, after cleaning the first 20 mile section of the pipeline, the cleaning tool became blocked by what was determined to be the excessive buildup of sediment. Due to the large amount of sediment in this particular line, the tool had gathered enough sludge to completely stop any further progress of the cleaning pig.

Although the company knew the approximate location of the pigging tool used to clean the pipeline, the engineers faced three challenges: firstly, they needed to know the amount and characteristics of the sediment blockage;

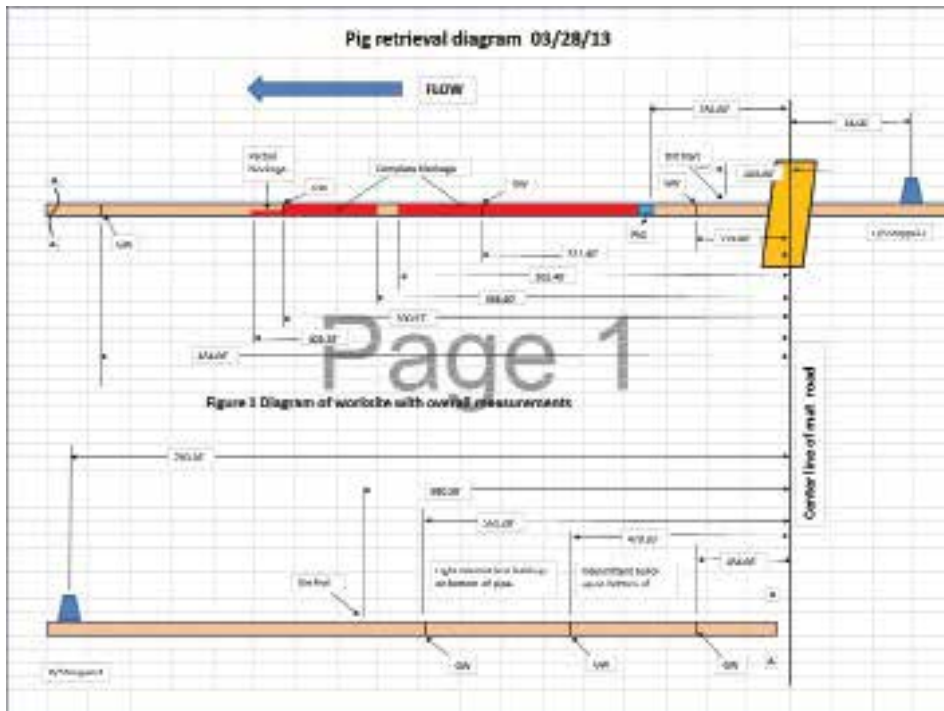


Figure 1. Diagram of worksite with overall measurements.

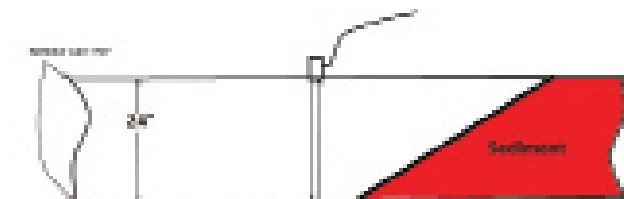


Figure 2. Use of ultrasonics to verify liquid levels and locate large deposits of particulate or sediment.

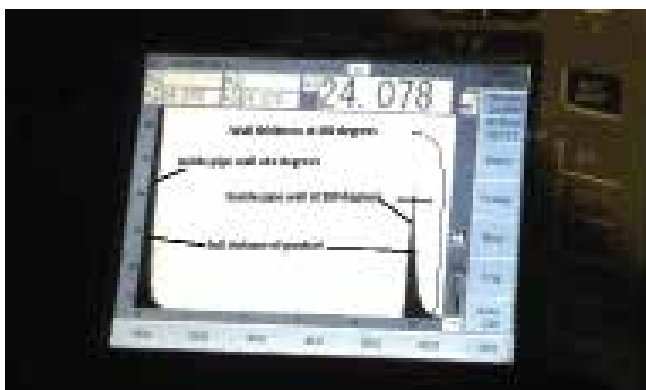


Figure 3. Description of screen signals.

secondly, they needed to know the location of the blockage in relation to the stopple tees; and thirdly, they needed to isolate and contain the sediment, determine the sludge level and ensure that the tool could not only be removed, but that when the line was put back in service, the company would have no further issues with flow. The diagram shown in Figure 1 was created by SGS technicians in the field as part of the final report.

Initially, the use of X-ray technology to solve the blockage issues was discussed. However, due to the diameter of the pipe and the fact that it was full of sediment and product, the parties agreed that the use of X-ray technology would prevent them from meeting their timeline goals. Furthermore, they would not receive all of the information needed to solve their problem. After further discussions, and review of available technologies, it was determined that a technique could be developed using ultrasonic inspection technologies to determine the location of the blockage, the amount of sediment in the line, its true length and other characteristics necessary to facilitate an expedited repair and return to service.

Ultrasonic inspection technology

Ultrasonic inspection technologies require only a single technician with minimal equipment – results are displayed in microseconds, are readily available for interpretation and the technology does not pose a safety hazard. Radiographic imaging requires multiple personnel with extensive equipment requirements, takes several minutes for each shot along multiple-foot sections of the pipeline (with additional time required for film development prior to interpretation of the results) and poses a safety hazard to all nearby personnel. Since the transducer can transmit and receive sound through the entire volume of materials, with an ultrasonic inspection system, a single transducer is connected to the ultrasonic instrument and is used to take measurements from any location with access to the outside surface on the circumference of the pipe (Figure 2).

SGS staff traveled to a rural area of Minnesota and, using pipeline rights-of-way, arrived at the approximate location of the blockage. To begin the project, SGS inspection personnel first helped determine the exact location of the pigging tool. Once the tool was located, work was immediately started to determine the extent of the blockage and the level of the sludge.

SGS inspection technicians determined that the use of an ultrasonic scope that allowed the user to manually set the material velocity, as opposed to data logger equipment with pre-set velocity values, was required due to the unique problems encountered by the varying velocities of the steel pipe, sludge and fluid. The equipment selected allowed the inspectors to drop the velocity down to that of water, which is considerably lower than that of carbon steel. SGS inspection technicians also used a low frequency, 2.25 MHz transducer, which allowed significant penetration through the pipe, the fluid and the blockage.

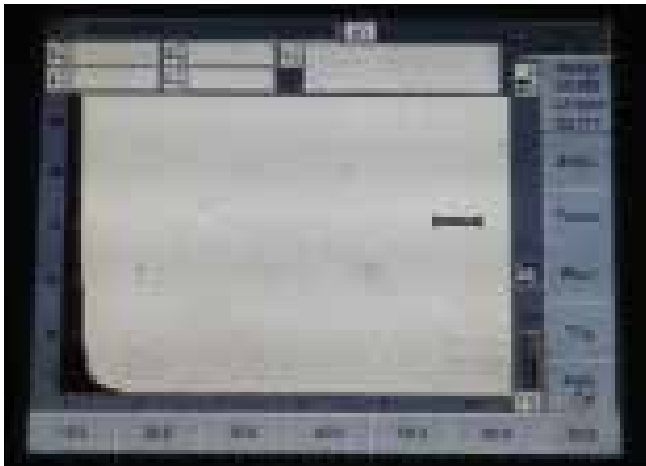


Figure 4. Screen presentation: pipeline full of sediment.



Figure 5. 150' of pipeline removed from service due to sediment levels.



Figure 6. Cross section of pipe showing extent of blockage.

SGS inspection technicians knew that the velocity of the steel used in the pipeline was 0.230 in./ μ s (0.230×10^5). In addition, technicians knew that the velocity of water (as opposed to oil) is approximately a quarter of that of steel, or 0.053 in./ μ s (0.053×10^5). As a result, the inspection technicians initially set the velocity on the ultrasonic scope to water. Once the ultrasonic system was coupled to the pipe, and the pipeline diameter of 24 in. was taken into account, the technician made the necessary adjustments in velocity settings to match the known distance from the top outside surface to the known distance of the inside bottom surface (Figure 2). This adjustment brought the velocity setting closer to the true velocity of the petroleum product in the pipeline, which normally ranges from 0.05 - 0.055 in./ μ s ($0.05 - 0.055 \times 10^5$).

When inducing sound into the top of the pipe, at a location upstream of the impacted pigging tool that was clear of sediment, the technician was able to transmit ultrasonic signals through the wall thickness of pipe and the entire volume of product in the line, and receive a return signal from the bottom of the inside pipe wall (180°). Additionally, the technician was able to transmit ultrasonic signals through the entire volume of the bottom wall thickness (Figures 3 and 4).

Utilising ultrasonic inspection technology, SGS inspection technicians were able to obtain a full-volume reading. Ultrasonic readings were taken along the entire section of pipeline containing the sediment around the circumference, enabling technicians to plot out the exact location of the sediment and determine the volume.

After final interpretation of the inspection results, it was determined that approximately 150 ft of pipeline was solidly impacted with sediment buildup (Figure 5). Based on the results, the pipeline company was able to develop a strategy to effectively and efficiently cut and remove the specific section of the impacted pipeline (Figure 6).

The repair plan, developed as a result of the ultrasonic inspection data collected, permitted the removal of the pipeline section containing the blockage and the impacted pigging tool well within the stopple tees, thereby stopping the flow of the liquid product before the operation. Additionally, the pipeline company was able to remove all of the sediment blockage and buildup, reducing any further issues that may have resulted from partial removal, while at the same time preventing any product leakage that would have posed serious environmental issues. Finally, the removed section was replaced and after the successful completion of testing, normal pipeline operations resumed.

Conclusion

Typically, pipeline companies only consider ultrasonic inspection technologies, such as shear wave, phased array, FAST and TOFD, for use in high-end weld investigations, and while looking for cracks, dents and internal defects. Used properly, by a fully trained, skilled technician, ultrasonic testing is appropriate for finding discontinuities below the surface of the material, such as internal corrosion, manufacturing flaws in pipeline materials and flaws in welds. However, with today's generation of ultrasonic technology, inspection techniques can be developed to provide safe and virtually instantaneous

results that can be used quickly, efficiently and economically obtain additional information such as fluid levels and checking for the presence of sludge, as well as many other instances where, traditionally, a more costly and time-consuming technique such as radiographic inspections would have to be utilised.

Events such as those described above prove that each situation or issue provides a unique set of challenges in ultrasonic inspection to overcome and when properly utilised, ultrasonic inspection can often be a viable alternative to X-ray or destructive testing.

Pipeline companies would be well served to consider the wide range of possibilities where ultrasonic testing services could potentially be utilised and determine if ultrasonic inspection applications are appropriate for a specific situation or procedure. 