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SIDE-SCANNING: STREAMLINING COLLECTION AND ANALYSIS OF INSPECTION DATA

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Video inspection crawlers are remotely operated vehicles that carry a robotically-articulated camera head hundreds—even thousands—of feet down pipelines as small in diameter as a softball. Video inspection crawlers help identify structural defects and construction features in pipes, and can also find infiltration, roots and other operational defects. Crawlers capture rich visual data in a manner independent of operator judgment, and then provide data in a standardized format, such as NASSCO's Pipeline Assessment Certification Program (PACP) for efficient review and analysis. This information about pipe condition is crucial to plant managers who plan maintenance within a limited budget and minimize downtime.

Introducing Side-Scanning.

Side-scanning relies on the proven inspection crawler platform to gather visual data from within a pipe. However, it implements digital image processing technology to deliver richer visual information in a format that is easier to analyze. Side-scanning also relies on software to manipulate video frames into a flat digital scan. This scan resembles a long mural or scroll, and it bears an image whose length corresponds to the length of the pipe, and whose height represents the full circumference of the pipe, from 0 to 360 degrees. These scans capture a level of detail far greater than conventional video, and present it in a format that is easier to review and analyze. Rather than sit through hours of inspection video, an analyst can view an entire length of pipe at one time, quickly pinpointing problem areas and making annotations and measurements directly on them.

Review is aided by special client software, where a thumbnail version of the entire scan (*resembling a film strip*; see Figure 1) allows quick navigation to a specific region of the pipe scan. When an area of the thumbnail is clicked, a detailed view of that region appears in the analysis pane, with the corresponding down-pipe view beside it. In these panes, the analyst can scroll the view down the pipe and back and zoom in on specific regions for further analysis. Drawing and annotation tools allow the analyst to mark-up the scan, identifying pipe features, highlighting regions of interest and concern, and posing questions to subsequent reviewers.

The Technology of Side-Scanning.

Side-scans are created in real-time by a quick-moving crawler. The crawler itself requires only three special features:

- A fish-eye camera lens that provides an ultra-wide view (FOV greater than 180 degrees).
- Diffuse wide-angle lighting.
- A wheel encoder for exact measurement of camera movement.

As the crawler advances down a line, the encoder fires a signal every time the wheel rotates 50 degrees, corresponding to 1 inch of forward motion. (Measurements here are hypothetical; wheel rotation and scan intervals will vary based on equipment). With each signal from the encoder, the video camera captures a single video frame and transmits it back to the crawler Camera Control Unit (CCU).

The CCU relays the frame to a back-end computer, which digitizes it and extracts a ring of pixels corresponding to a 1-inch ring of pipe. Using a mathematical algorithm, the computer slices this ring at the top and unfolds it into a rectangle. As these rectangles are created from each subsequent video

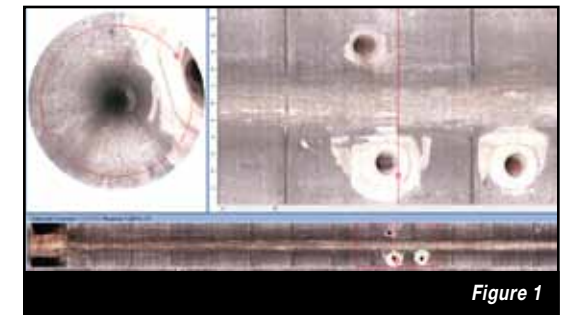


Figure 1

frame, they are stitched together into a complete sidewall scan. Building a good scan requires ample and even illumination, a camera view that's centered in the pipe, and minimal terrain variation.

Typical Side-Scanning Workflow.

Side-scanning greatly improves the speed at which inspections can be performed because the operator's sole responsibility is to pilot the crawler through the line, with analysis of the visual data left to professionals best qualified to review. For this reason, there is no need to slow down at problem areas or articulate the camera to gain a better view; stop and backtrack when a potential problem flashes by onscreen; or second-guess perceived anomalies. All of these observations are captured in rich detail for post-inspection analysis, and captured at a pace that makes side-scanning far more productive than traditional crawler inspection.

This same productivity carries over to the analysis phase, where professionals representing multiple disciplines (metallurgists, structural engineers, process chemists) can quickly survey scans using client software. Presented with a single image of the entire pipe interior, an analyst quickly scans for areas of interest, zooms in for greater scrutiny, and annotates the image directly. Measurement tools allow precise quantification of observations—crack length, fracture width, tap diameter, and corrosion surface area—to name just a few. Other inspection data gathered by the crawler, such as inclination and temperature, can be plotted directly below (and in direct correlation with) the scan.

Side-scanning review takes a fraction of the time as video from a crawler, and reduces time the operator takes to investigate problem areas, including cueing, jogging and pausing the footage. Digitization of visual data also allows rapid analysis and robust annotation, allowing an engineer operator to overlay archival scans to determine the speed of pipe deterioration, providing crucial information to identify common pipe features such as joints and taps and make sound maintenance decisions overall.