

# **TRACERCO DISCOVERY™ – SUBSEA CT (COMPUTED TOMOGRAPHY) HELPS TO OPTIMISE YOUR OPERATIONAL PIGGING CAMPAIGN AND VERIFY ILI RESULTS: TECHNOLOGY FOR PIPELINE INTEGRITY AND FLOW ASSURANCE VISUALISATION**

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## **Abstract**

Tracerco has developed a new non-intrusive external inspection technology for ultra-deep water subsea pipelines. The inspection application specifically measures both integrity and flow assurance issues within various types of pipelines that would include PiP (pipe-in-pipe), coated pipelines, piggable, un-piggable, pipe bundles and risers.

Discovery™ is a field proven technology that provides high resolution wall integrity data plus detection of hydrates, asphaltene, wax, scale and other deposits for flow assurance purposes with quantitative results. This technology is ROV deployed and the inspection is carried out from the outside of the pipeline. It is the only non-invasive technology capable of inspecting non-piggable or difficult to pig coated pipelines without the need to remove and replace the pipe's protective coating. This revolutionary system also allows for the inspection of PIP systems with near millimeter anomaly detection and accuracy of both internal and external walls. It provides a 360 degree high resolution scans in real time with immediate results provided allowing for instant assessment of the pipeline conditions. As well as being applicable to the inspection of unpiggable pipelines, Discovery™ is also an ideal technology for verification of detected defects sizing post-ILI campaigns of coated and PiP systems. Until now, this has not been possible for PiP systems or without removing the protective coating on single walled pipelines.

The presentation will provide examples of the technology development, examples of recent field project results, and a description of this new cutting edge technology that finally fulfills a key industry need to help solve some of the most challenging subsea pipeline integrity and flow assurance challenges.

### **Discovery™ – Subsea CT**

Discovery™ is a revolutionary inspection technique that uses CT (computed tomography) technology to allow the online inspection of subsea pipelines from the outside without removing the protective coating. Discovery™ has been created for flow assurance and integrity specialists concerned with subsea pipelines, providing high resolution images of pipeline contents and pipe wall thickness, enabling pipeline integrity flaws and flow assurance conditions to be accurately visualized. Discovery™ enables the effectiveness of remedial action to be verified.

Discovery™ is operated by a ROV when scanning subsea pipelines (see **Figure 1**). Discovery™ is rated for use at 10,000ft sea depth and can be deployed on piggable and unpiggable pipelines, online, without any interruption to production or the need for pipeline modifications.

Discovery™ is proven in field. For example, Discovery™ has been deployed to survey an unpiggable pipeline system in Gulf of Mexico to determine the condition of the pipelines at each scan location, with respect to pipeline integrity and flow assurance at predetermined locations. The pipelines consisted of coated single wall jumpers and pipe-in-pipe flowlines of various diameters. The survey involved deploying Discovery™ at over 200 locations and at depths ranging between 2900 and 4400 feet of sea water.

### **Benefits of CT (computed tomography)**

CT technology is the only non-invasive technology capable of inspection subsea coated pipelines without the need for the coatings or marine growth to be removed. CT technology enables:

- Flow assurance specialists to obtain an accurate characterization of pipeline deposits and confirm what they are (such as hydrate, wax, asphaltene, and scale).
- Integrity engineers to have an externally deployed reliable method of accurately measuring defects and the remaining wall thickness of any type of pipeline.

The benefits of CT technology for subsea pipelines are:

- High resolution tomographic images of the pipeline contents and wall thickness to 1mm resolution.
- Production can continue and normal operations are not affected.
- Coating does not need to be removed.
- Suitable for gas, liquid, or multiphase flow.
- Suitable for inspection of rigid and flexible lines, including pipe-in-pipe and pipe bundles.
- Real-time communications allow instant assessment of pipeline conditions
- Verification of the effectiveness remedial actions.
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## Pipeline simulations

Prior to deployment, Discovery™ is tested with various materials to simulate the densities of the expected flowline contents and with various combinations to verify that Discovery™ is capable of determining the wall thickness for pipeline integrity and contents for flow assurance.

Flow assurance tests can also include the following:

- Tests to determine small gas channel openings in blocked pipelines to assess the possibility of gas communication between different sections.
- Tests to detect gas pressure differences in blocked pipeline channels to assess gas communications (high and low pressure) between sections of pipelines.

To determine small gas channel openings in blocked pipelines, Discovery™ is setup to scan a test pipeline, as shown in **Figure 2**, with six holes to represent gas channels in a pipeline blocked with asphaltene or wax. The diameters of the holes ranged from 0.25 to 2.2 inches. Figure 3 shows the density maps after two and 10 revolutions. After 10 revolutions, all the gas channels are clearly visible.

To detect gas pressure differences in blocked pipeline channels, Discovery™ is setup to scan a pipe-in-pipe system, as shown in Figure 4, with four rods made of materials with densities to represent gas with hydrostatic pressures of approximately 1770psi and 2500psi. Although Discovery™ requires several revolutions to produce high resolution density maps, operators were able determine gas pockets in wax or asphaltene after just a single revolution as shown in Figure 5. Figure 5 compares the density map from a single revolution (30 second scan) to the density map from 20 revolutions (10 minute scan) of the carrier spool and rods shown in Figure 5.

Discovery™ has also been used successfully on insulated pipes with piggyback lines. For example, Figure 6 shows a five-layer PP (polypropylene) pipe with a piggyback line fitted with a bobbin that allows Discovery™ to clamp on to the pipeline system. The resulting scan clearly shows that the pipeline integrity can be determined.

Flow assurance and pipeline integrity tests show that:

- For pipeline integrity, operators are confident of measuring defects down to 2mm x 2mm.
- For flow assurance, operators are confident of the following:
  - Measuring density differentials of 0.5g/cm<sup>3</sup>
  - Detecting gas pockets in wax or asphaltene after one single revolution
  - Accurately measuring the density of gas pockets after 10 minutes (20 revolutions).

Also, the maximum perceivable clarity is obtained with scans with durations within 15 minutes (30 revolutions) and no noticeable improvements are observed for scans up to 30 minutes.

## Flow assurance

For flow assurance, Discovery™ uses a water equivalent density to produce two-dimensional density maps of the flowline contents. The density maps enable operators to evaluate the contents and deposits types. The expected deposit types include:

- Wax (0.8g/cm<sup>3</sup>)
- Hydrate (0.9 to 0.96g/cm<sup>3</sup>)
- Asphaltene (1.1g/cm<sup>3</sup>)
- Scale (1.92 to 2.65g/cm<sup>3</sup>).

For evaluating the contents of flowlines, the density maps typically use a density scale between  $0\text{g/cm}^3$  and  $2\text{g/cm}^3$ . For example, Figure 7 shows a density map of a pipe-in-pipe system with a high density material filling about 60% of the bore and a low density material covering about 40%, and Figure 8 shows a density map of a pipe-in-pipe system with asphaltene deposits.

The low density materials expected in the flowlines were:

- Gas ( $0.05$  to  $0.20\text{g/cm}^3$  depending on the pressure)
- Condensate ( $0.70$  to  $0.80\text{g/cm}^3$  depending on the pressure)
- Oil ( $0.70$  to  $0.80\text{g/cm}^3$ ).

However, for evaluating build-up, density maps typically use a scale between  $0\text{g/cm}^3$  and  $3.8\text{g/cm}^3$  in order to separate the color of the scale from that of the pipe walls. For example, Figure 9 shows the area averaged density of each band (A), as well as the percentage of the bore that this density band covers (B). For example, in the image below the build-up (or scale) between  $1.97\text{g/cm}^3$  and  $3.8\text{g/cm}^3$  has an average density of  $2.68\text{g/cm}^3$  and covers approximately 30% of the bore.

Discovery™ enables the sizing and locating the extent of pipeline deposits. Deposits can be characterized so that the different deposit types (wax, hydrate, asphaltene, and scale) are differentiated. Discovery™ provides results that enable efficient remediation and cleaning campaigns to be planned.

### **Pipeline integrity**

For pipe integrity, Discovery™ uses a steel equivalent density to produce density maps and wall thickness plots.

Wall thickness plots detail the wall thickness as a function of angle around the pipe and enables the wall thickness to be measured to within an accuracy of 1mm. To assist evaluation, wall thickness plots also include the mean wall thickness and the spread in wall thickness. For example, Figure 10 shows a typical wall thickness plot where the wall thickness, shown as a green line, is a function of angle around the pipe. The mean wall thickness is the horizontal line and the spread in thickness is the vertical line. Density maps clearly show the pipeline walls and help operators to identify defects. Figure 11 shows the density maps annotated with the wall thickness measurements.

Figure 12 shows the wall thickness measurement for a section of a pipe-in-pipe system that is within the allowable tolerance (green line) and the wall thickness measurement for a section that is outside the allowable tolerance (red line). The section outside the allowable tolerance is clearly visible on the density map.

## **Discovery™ summary**

Discovery™ key characteristics:

- Fully Operational and Field Proven – TRL 7
- DNV RP-A203 Certified
- No need to remove any type of coatings.
- Provides detailed images of all pipe walls and contents.
- Reduce costs on remediation campaigns. Fully characterize the location, amount and types of deposits prior to remediation.
- Reduce overall integrity costs and lifetime extension costs:
  - Non-intrusive
  - No interruption or risk to production
  - No coating removal/replacement
  - For pipe-in-pipe systems, confirm integrity of outer and inner pipeline from the outside.

Figures

Figure 1 –Discovery™ with ROV deployment

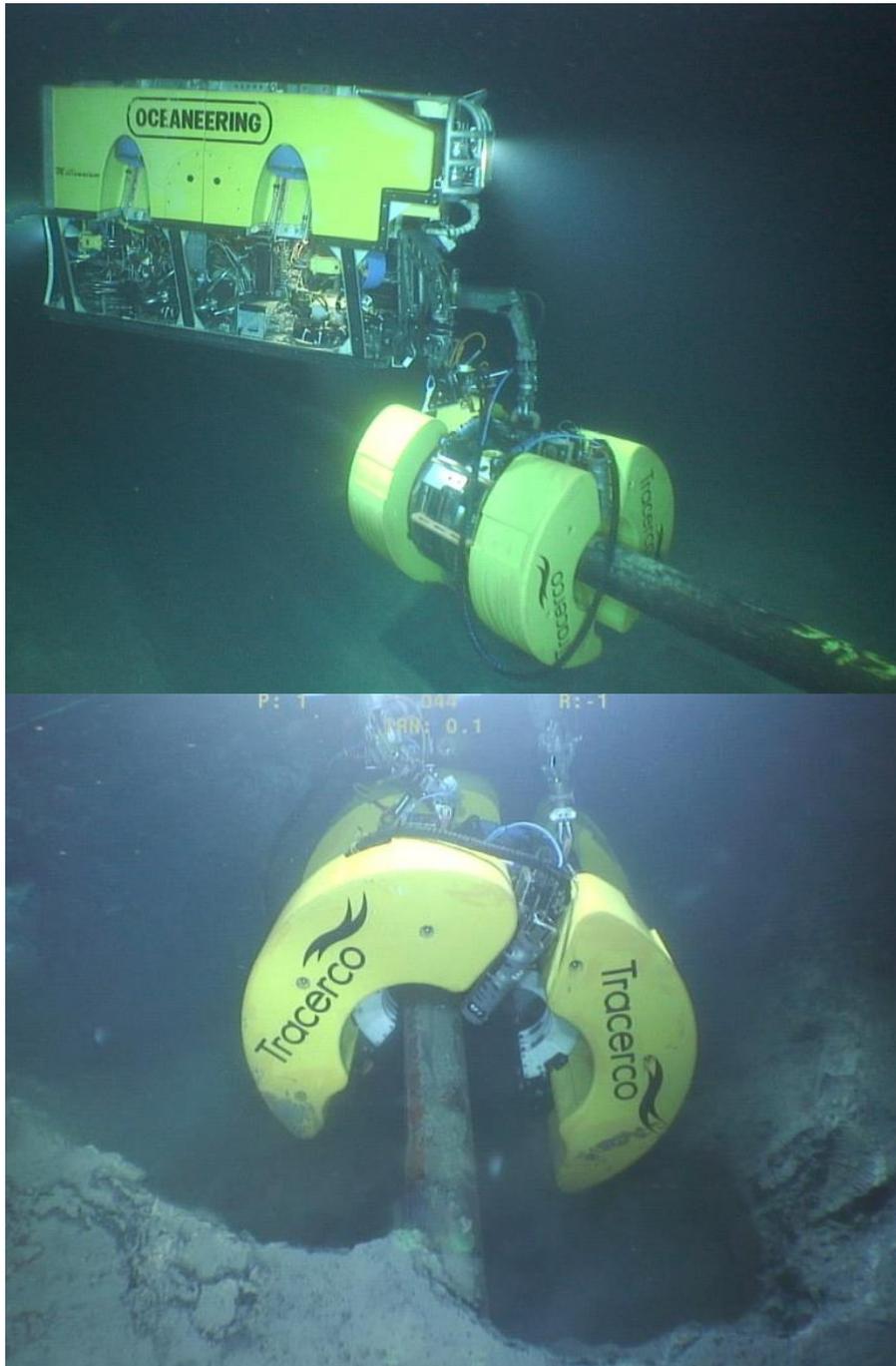


Figure 2 – Six-hole test pipe to detect small gas channel openings in blocked pipelines

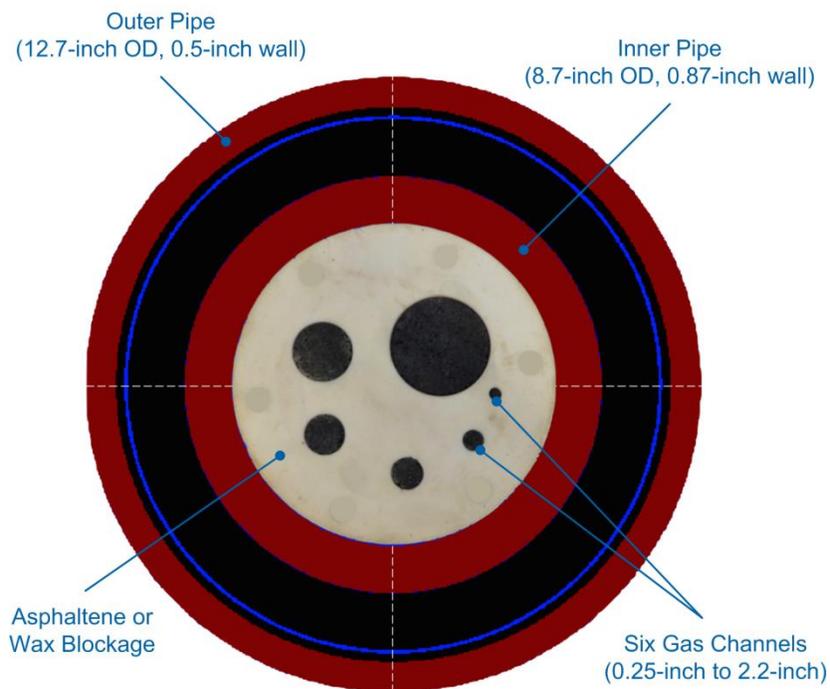
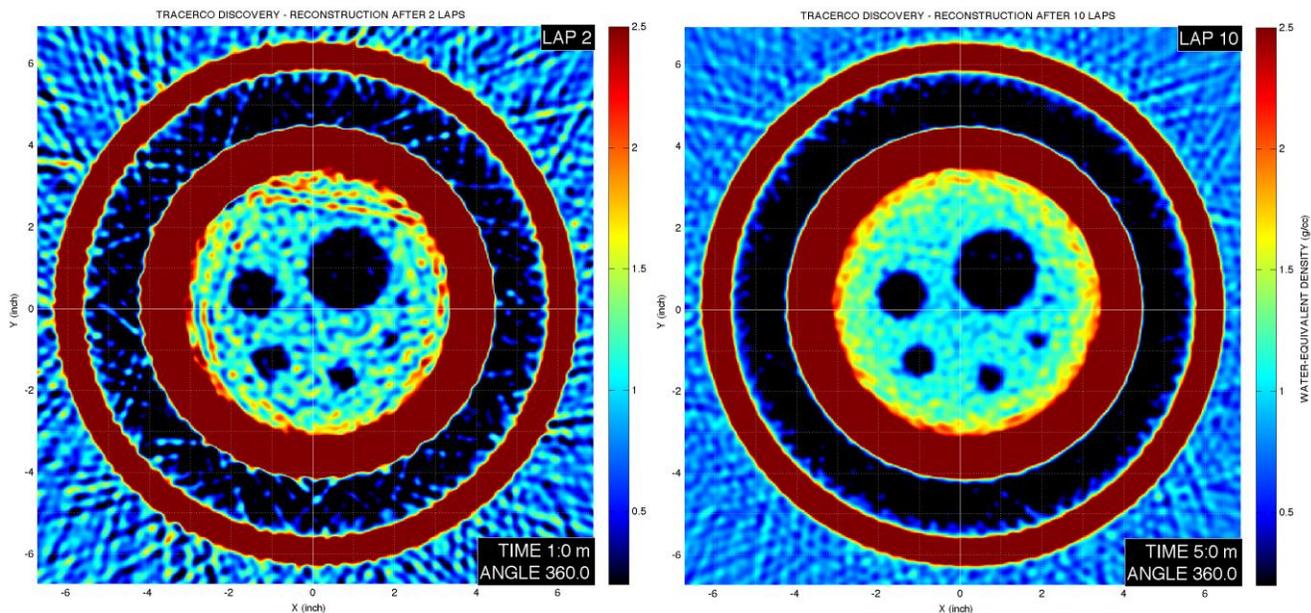


Figure 3 – Density maps of the six-hole test after 2 revolutions (left) and 10 revolutions (right)



**Figure 4 – Carrier spool and rods used in testing**



Figure 5 – Density maps after 1 revolution (left) and 20 revolutions (right)

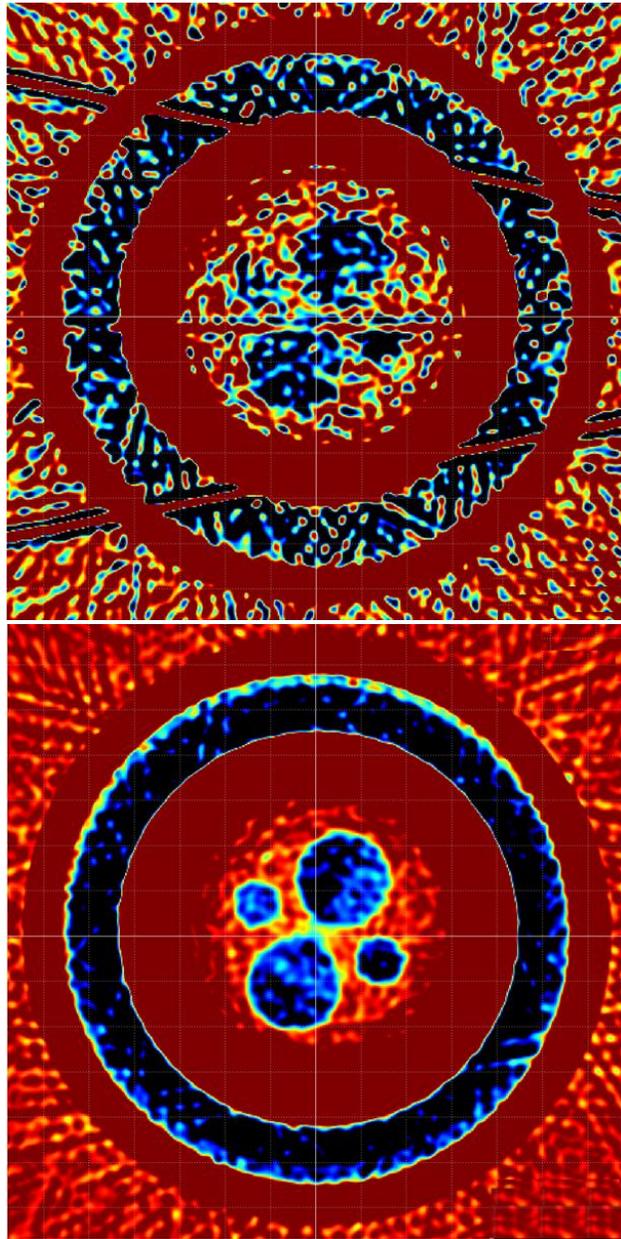
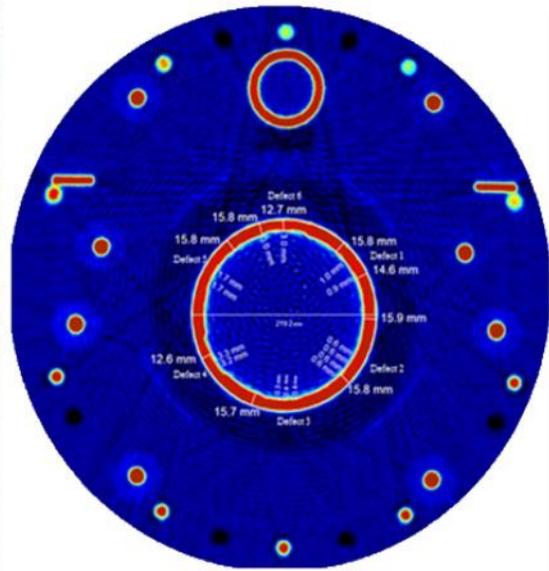


Figure 6 – Five layer PP insulated pipe with piggyback line



**Figure 7 – Flow assurance density map**

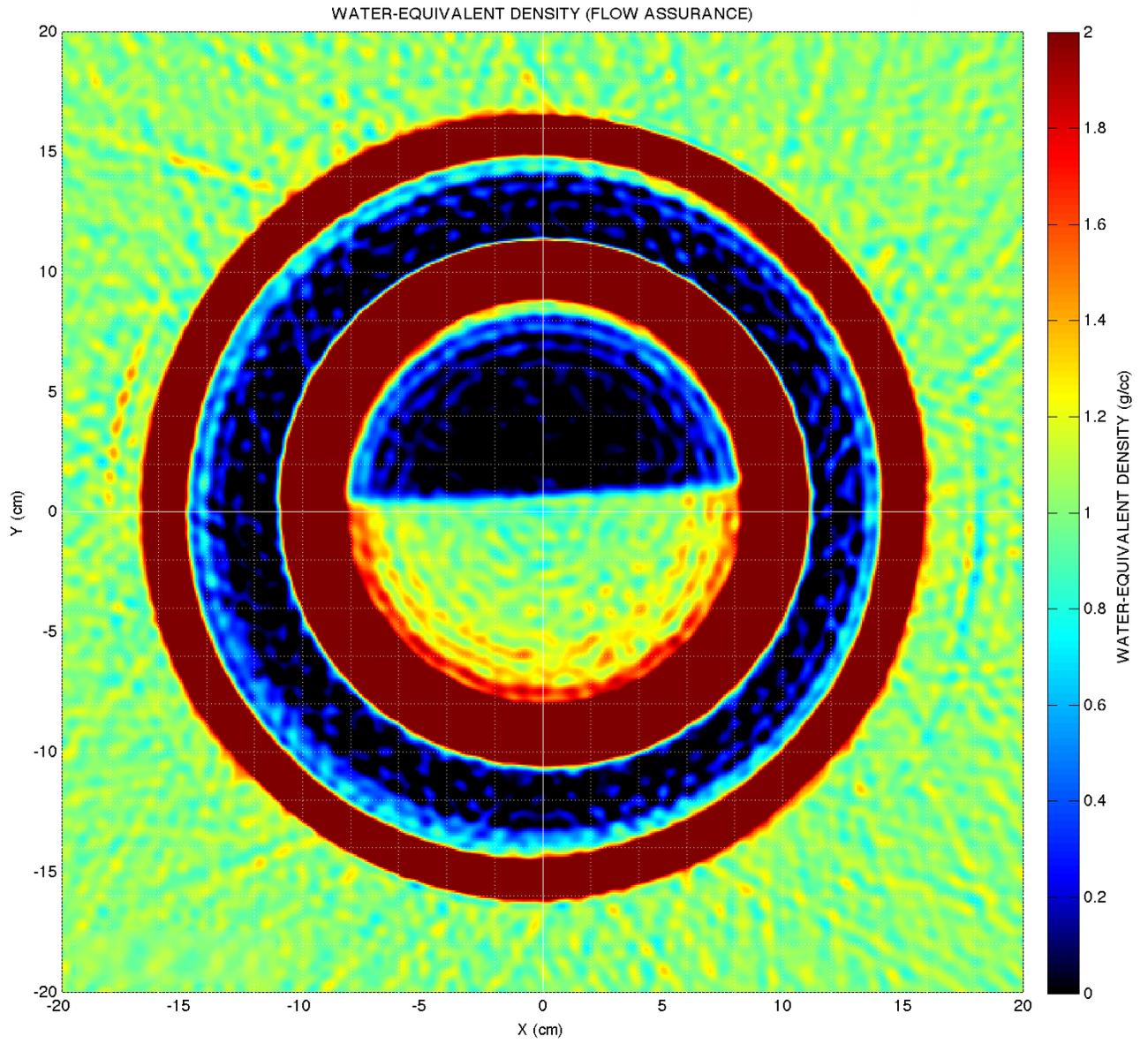


Figure 8 – Flow assurance density map with asphaltene deposits

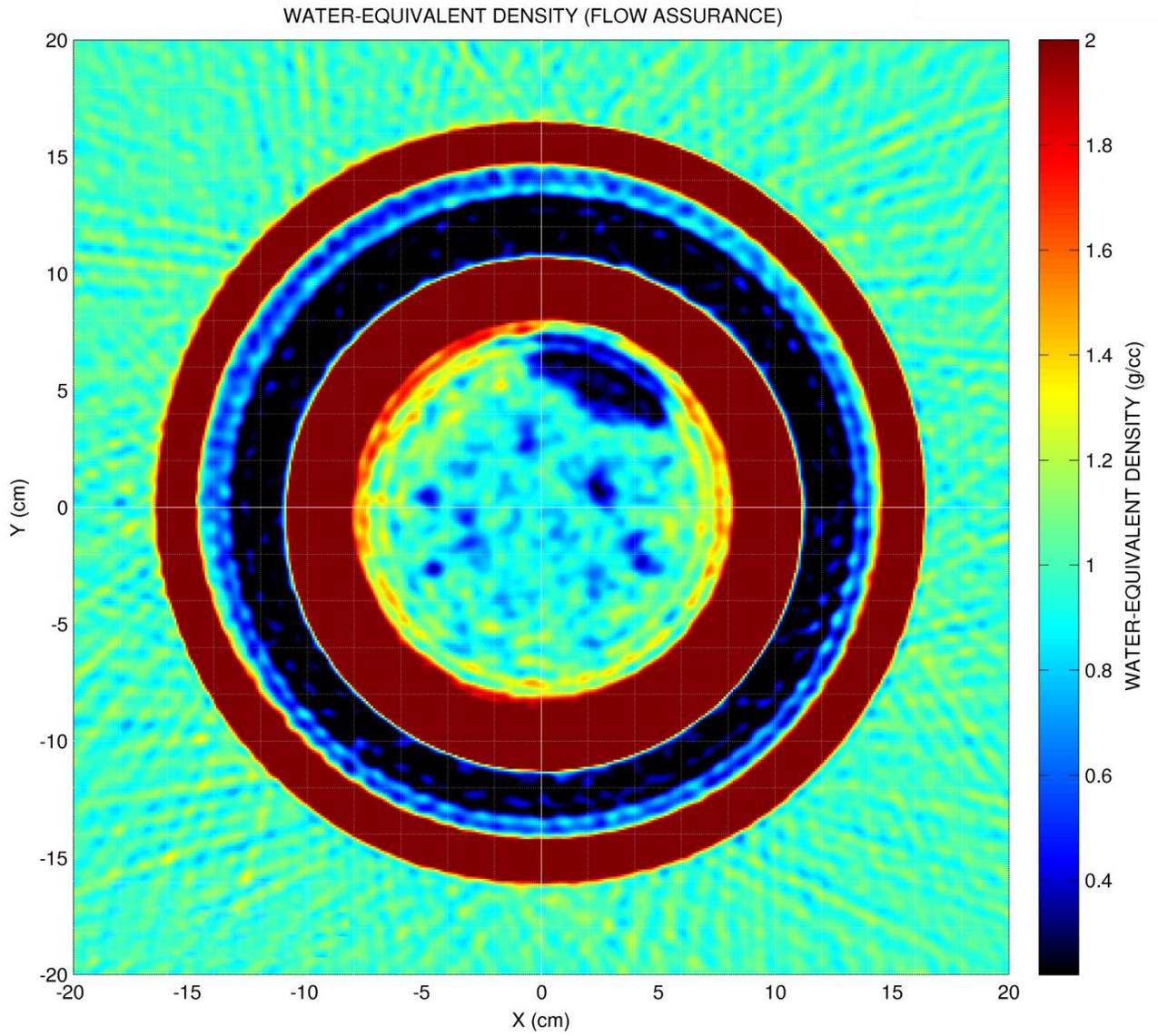
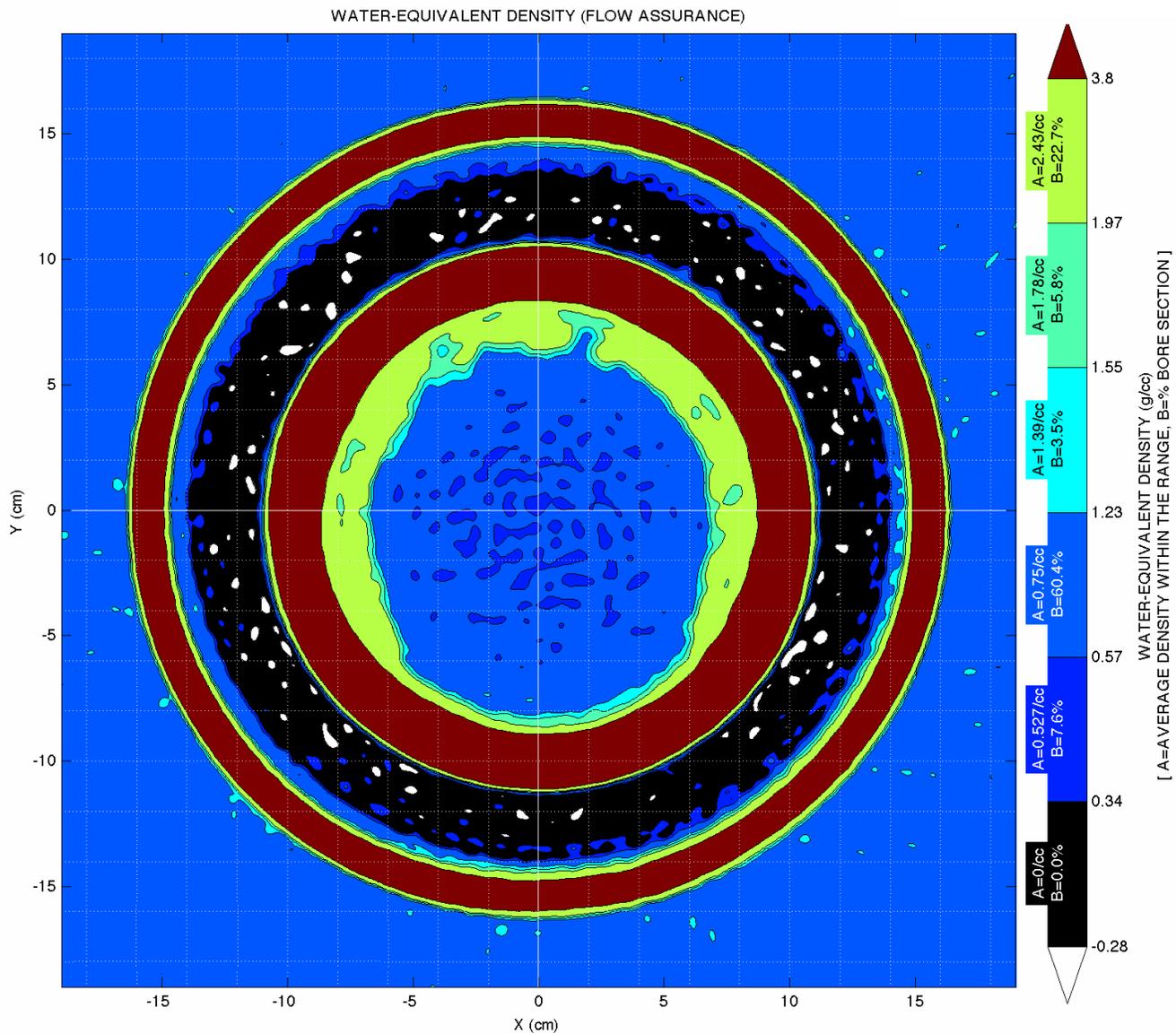
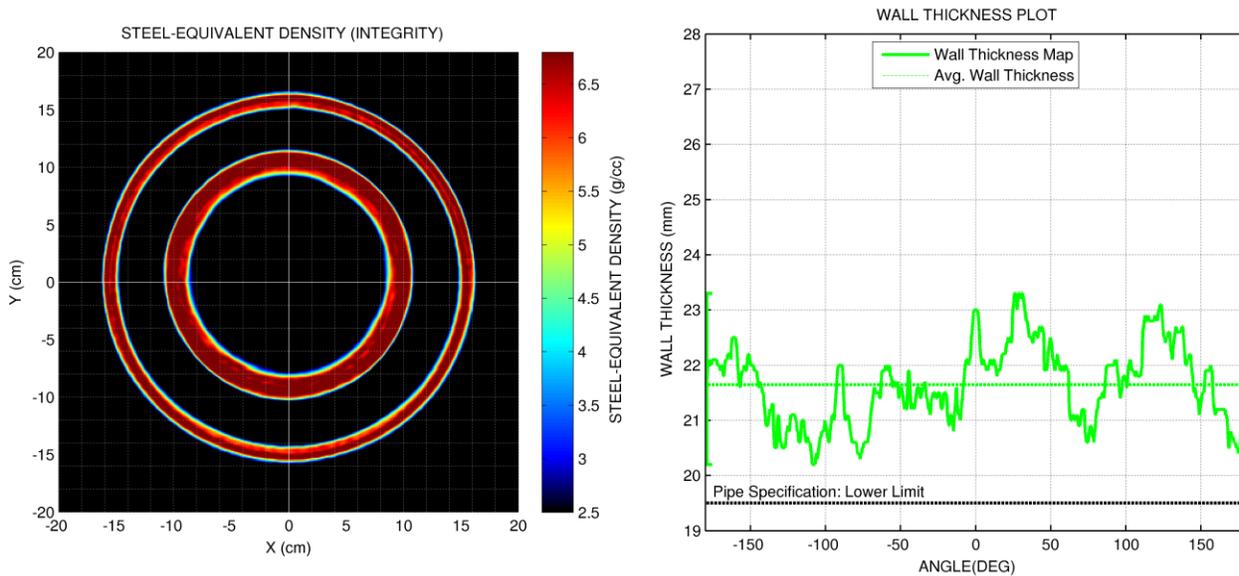


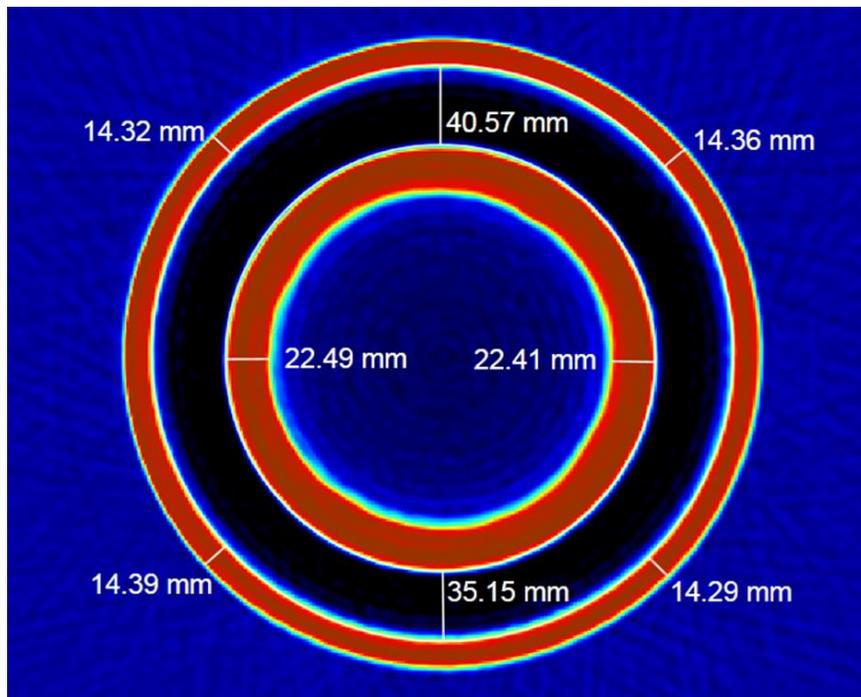
Figure 9 – Flow assurance build-up



**Figure 10 – Pipeline integrity of a pipe-in-pipe flowline**



**Figure 11 – Pipeline integrity results**



**Figure 12 – Wall thickness measurements**

