Robotic Online Storage Tank Floor Inspection Services
Storage Tank Floor Condition Assessment Without Taking Tanks Out of Service

- Eliminate the high cost of tank downtime
- Greatly reduce VOC emissions
- Eliminate the need for temporary product storage
- No cleaning required (high sludge levels may require mixing)
- Increase personnel safety by avoiding confined space entry

Above-ground Storage Tank floor inspections are primarily driven by API 653 requirements. Traditional floor inspections are performed manually, requiring storage tanks to be taken out-of-service, cleaned, and degassed to allow workers to enter the confined space. These tank turnarounds create vapor clouds, create unique safety risks, and are extremely costly due to both prepping the tank for human occupation and the opportunity cost of being unavailable for use.

Diakont provides comprehensive storage tank floor inspection services using a robotic crawler called the Stingray, which is safely deployed into above ground storage tanks while they remain filled and operational. Using a combination of non-destructive examination (NDE) sensors housed within an explosion-proof enclosure, Stingray inspection systems supply complete inspection coverage in accordance with API 653 requirements.

Online tank floor inspections can be conducted more often than manual inspections which allows operators to prioritize tanks for turnarounds and extend inspection intervals through risk-based inspections. This inspection technology is also crucial for gaining information on newly-acquired assets with limited documentation.
The Stingray system is a robotic crawler-type tool, connected to a control station with an umbilical cable. The robot and umbilical cable are purged and pressurized with dry nitrogen. The system is certified to operate in Class 1, Division 1 environments, where ignitable concentrations of flammable gas or vapors exist under normal operating conditions.

Diakont’s Stingray inspection system is equipped with multiple NDE sensors to assess the storage tank floor integrity. The Stingray provides the two complementary inspection methodologies of MFL and UT that can be run simultaneously. MFL is a robust sensor that can detect anomalies in almost any surface condition and the UT inspection has high accuracy measurement capabilities for characterizing any flaws detected. A higher confidence can also be obtained with detection by both NDE systems.

- **Magnetic flux leakage (MFL)** – The Stingray system is equipped with 64 Hall effect MFL sensors. This MFL system has a rotating magnetic assembly that facilitates turning off the magnetic field by cancellation. The Stingray is also equipped with 4 Eddy Current sensors that are used to measure liftoff of sensor housing.

- **Ultrasonic testing (UT)** – The Stingray system is outfitted with high accuracy UT sensors to measure floor thickness and assess anomaly size and depth. The UT module has 96 sensors positioned in an array of 4 staggered rows to provide 100% inspection coverage. In addition to measuring the floor plate thickness, the UT sensors are able to determine the thickness of any coating that may be present.

The Stingray system is also equipped with 3D imaging sonar which performs XYZ scans of the tank floor and internals to build a map of the entire accessible floor. The sonar also provides navigation and obstacle avoidance support when tank floor sediment prevents the onboard cameras from receiving clear images.

**NDE Specifications**

Stingray system detects and measures anomalies listed in API 653 Appendix G with the following accuracy:

**UT thickness accuracy**
- Uncoated floor: ± 0.02 inches
- Coated floor: (≤ 0.1 inch) - ± 0.03 inches

**MFL thickness accuracy**
- Heavily corroded floor: ± 0.2 T
- Disbonded coating: ± 0.2 T
Safety

Personnel and process safety are Diakont’s primary focuses when conducting storage tank floor inspections. All of Diakont’s inspection personnel are OSHA 10/30 certified, Basic Plus trained, RSO trained, trained in first aid/CPR/AED, and are equipped with proper PPE and SCBA equipment.

Before turning on any equipment, Diakont inspection technicians ground the field office, robotic equipment, tank, and generator. Diakont technicians go above and beyond API safety standards to eliminate static electrical hazards on the ground and the tank roof.

Storage Tank Roof Integrity

Diakont takes many considerations into account when analyzing roof integrity, such as the type of roof (single or double layer), product in the tank, past repairs and maintenance, and potential H₂S corrosion on the underside. Roof integrity needs to be ensured prior to placing any equipment or personnel on the roof. This can be performed through a UT inspection on the roof and using planks for support. Diakont develops contingency plans based on the roof integrity analysis, leveraging the crane to bear the load during deployment and retrieval, and building scaffolding for the robot and inspection personnel, if necessary.
Control of VOC Vapor Release

Diakont’s Robot Deployment Procedure is designed to keep vapor emissions as low as reasonably achievable. To meet this goal, the hatch is only opened once during the initial launch, and again at the conclusion of the inspection to retrieve the robot. Diakont achieves this by inspecting the tank floor in 24-hour shifts, in order to minimize the time the temporary hatch is in place. Diakont field crews follow the below procedure during the launch:

• Manway bolts are changed prior to removal of hatch
• Personnel removing the hatch do so upwind of the manway
• SCBA is worn by all personnel on tank roof’s containing certain products, and are equipped with personal 4-gas detectors
• Designated person is on stand-by with an IR Infrared Thermometer Gun to watch for vapor release
• Once permanent hatch is removed, a flat temporary hatch, outfitted with a sealing gasket, is immediately placed over the opening
• Stingray and deployment tripod with sealing gasket are lowered just above the flat temporary hatch
• Flat hatch is removed, and the deployment tripod is immediately lowered over the opening and secured to the manway
• Tripod hatch is opened, and the robot is lowered into the tank via a manual winch
• Once the robot is completely below the manway edge, the hatch is closed
• There is an opening in the center of the tripod hatch, which seals around the umbilical, while at the same time allowing the umbilical to move through the opening without losing seal
Once onsite at the tank facility, Diakont technicians deploy a mobile diagnostic lab to a safe location near the storage tank. Technicians check all grounding, then power on the equipment on the ground for a complete function test and calibration. To verify the Stingray NDE sensor calibration, Diakont technicians use a verification test plate of the same thickness as the storage tank floor (including built-in anomalies in accordance with API 653 standards). After verifying system functionality and sensor calibration, Diakont technicians load the Stingray tool into the deployment tripod. Diakont technicians use a crane to lift the deployment tripod and Stingray tool to the tank roof. Technicians remove the manway and take extra precautions to limit vapor release while lowering the Stingray into the tank.

Diakont technicians lower the Stingray tool to the tank floor and configure the on-board sonar navigation. Diakont technicians then drive the Stingray tool to the edge of the first floor plate and scan the entire tank floor plate by plate. Each plate and the annular ring are scanned using MFL and UT, creating a comprehensive NDE map of the tank floor. Two Diakont technicians operate the Stingray system; a robot operator and an NDE technician. The NDE technician monitors the sensor data in real-time. If any large anomalies are discovered, the technicians can go back and rescan to characterize the defect on location.
Tool Retrieval

After scanning the entire tank floor, Diakont technicians drive the Stingray tool back to the initial position beneath the manway and hand-crank the tool back to the roof. The deployment tripod vapor seals are in place during the entire process until the last three feet when removing the tool.

Diakont technicians hand crank the tool out of the storage tank, paying careful attention to minimize VOCs and manage all hazardous material. All equipment removed from the tank is sealed in a hazardous material berm, placed into spill top boxes, and removed from the tank roof for decontamination.

Hazardous Product Containment

Diakont’s Robot Retrieval Procedure is designed to ensure that no hazardous product is spilled on the roof or the ground. Prior to retrieving the robot, containment berms are set in place around the manway, which are able to fully contain the entire robot, tripod, and umbilical. Every piece of equipment with hazardous material is then lifted off the roof (sealed within the containment/berm material) and into a containment box on the ground, to be taken to a clean pad or wash bay equipped to handle hazardous material. In certain cases, decontamination personnel and equipment will be on site as a contingency plan in case of a spill or leak, or in cases where a wash bay is not available.

Final Reporting

Immediately following the inspection, Diakont Level III NDE data experts thoroughly review the MFL and UT sensor data at Diakont’s office. All inspection NDE sensor software is available for customer review and digital floor maps are stored for benchmarking purposes.