



TANK INSPECTION AND CALIBRATION WITH 3D LASER SCANNING

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INTRODUCTION

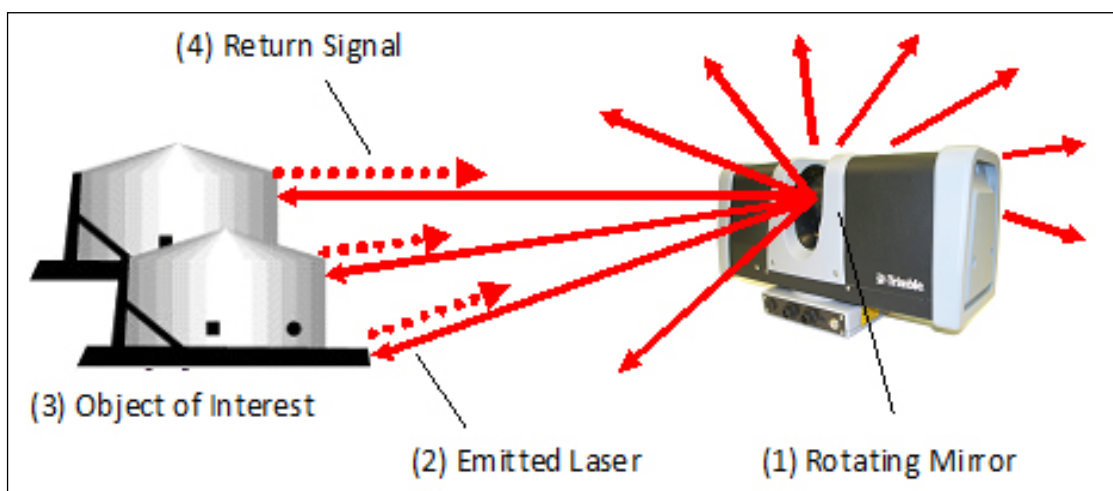
3D laser scanning technologies can capture a vast array of three-dimensional positions (X, Y, and Z coordinates or points) that provide factual information about assets. For large scale storage tanks and barges, 3D laser scanners capture accurate position information that can be used to identify true shape, geometry, deformation, and locations of interior structures.

Traditionally, this process is completed using a survey total station or a simple measuring tape. While these techniques provide the necessary position information, they are generally time intensive when multiple measurements are required, and when using a measuring tape are prone measurement errors. 3D scanning alleviates these deficiencies by capturing thousands of points in the same time it takes to capture ten points with a total station.

HOW 3D SCANNING TECHNOLOGY WORKS

3D laser scanners use similar technology to total stations. Distance and angle measurements determine a 3D position (X, Y, and Z coordinate). However, the distance measurement technology in a 3D scanner is very different; distances can be measured at the rate of 100,000+ points per second as opposed to 1 point per second—it's like comparing the power of a Ferrari sports car to a single horse.

3D scanners collect millions of points by using a laser and high speed mirror assembly. Typically, high-speed scanners rotate a central mirror (1) vertically while a laser light source is directed onto the mirror. The light is reflected off the mirror, in a controlled method, away from the scanner (2) where it ultimately encounters an object of interest (3). A portion of the light is reflected back off the object of interest to the scanner, termed the return signal (4).



Internal sensors and processors then either measure the number of wavelengths between the emitted light and the return signal (phase-based technology) or measure the time taken from when the light was emitted to when the return signal comes back (time-of-flight technology). A distance to the object can be determined using these measurements and the inherent characteristic of the laser light source. The distance is combined with the precisely measured horizontal and vertical angles within the scanner to determine the exact 3D coordinates of the point where the light was returned from the object of interest. The technology allows for thousands and up to 1 million points to be precisely measured each second. The end result is a collection of millions of 3D points, commonly called a “*point cloud*”, which provides a precise representation of the scene.



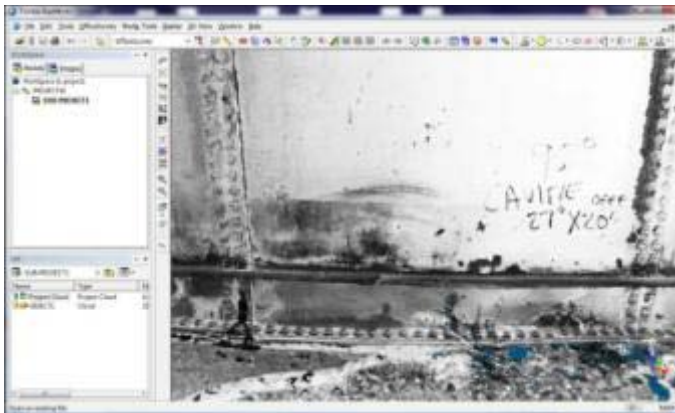
TANK APPLICATIONS

3D laser scanners can capture very accurate, factual information in a short period of time. Captured data is then analyzed either in the office or on a mobile computer to provide:

- Simple coordinates of objects
- Length measurements and diameters
- Angular or tilt information
- Shape information, such as roundness of objects
- Area/volume measurements
- Deformation, or change, in objects over time

In addition to the geometric information, the 3D point cloud also provides a visual representation of the scanned object due to the large density of measurements that are obtained. Some scanners can also capture images to further enhance the collected data. This visual information provides a factual record of areas inspected, being monitored, or for quality reporting of work undertaken.

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Many of these measurements from 3D scanners can be used to provide additional information for tank applications, such as:

- Inspection
- Design/modification projects
- Deformation monitoring
- Containment dike analysis
- Volume calibration

The technology does not provide a practical technique to measure tank shell thicknesses; technologies such as ultrasonic are best suited for this type of analysis. However, the data does complement shell thickness devices by providing a link to the tank location and a method to visual problem areas.

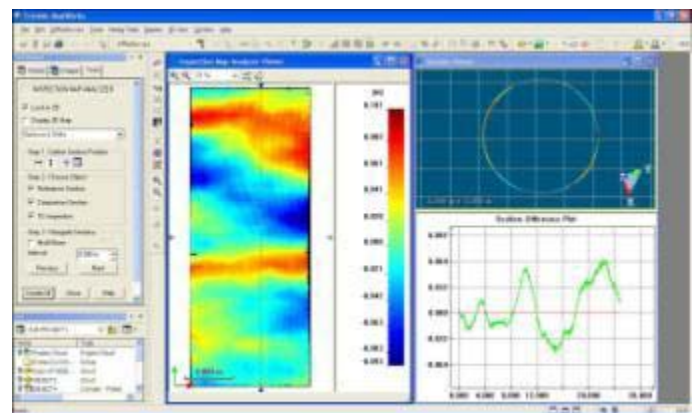
INSPECTION

For general tank inspections, 3D scanners provide a technology to quickly capture high accuracy and high density positional information that complements other measurements used to evaluate the conditions of tanks. The positional information enables

inspectors to not only locate areas of interest, but to also visualize the entire tank structure. Direct measurements, such as position and size of defects, as well as more detailed analysis of tank roundness and tilt can be quickly obtained. Loaded with a comprehensive data set, tank inspectors can be better equipped to assess and verify changes to the tank, saving time and ensuring quality of services.

DESIGN

For structural design projects or tank modifications, such as replacing a roof or seals, the true shape and condition of the tank can be critical for ensuring that the design fits the existing conditions; hence reducing costly delays or rework. 3D laser scanning provides a way to quickly and accurately obtain the existing condition information. The exact roundness of a tank can be easily determined to ensure that roof fabrication or seal selections match the existing structure. Alternatively, the information can be used to identify areas to be corrected for roundness and to verify repairs before fabrication.



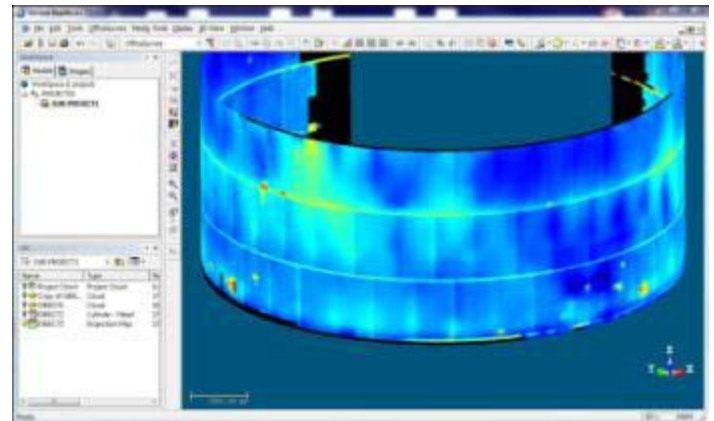
The time to modify or add ancillary structures can also be streamlined by accurately designing from a true representation of the existing conditions. For example, scanning a tank interior during an out-of-service inspection provides the factual information needed to locate or to obtain measurements of:

- vapor control/fire prevention systems
- roof supports
- deadwood
- valves and manholes

This information can be utilized for current or future design projects by simply interrogating the scanned data on a computer to obtain the required measurements. The rich data avoids the need to re-enter the tank to take further measurements, which enables design projects to proceed without waiting for the next out-of-service inspection.

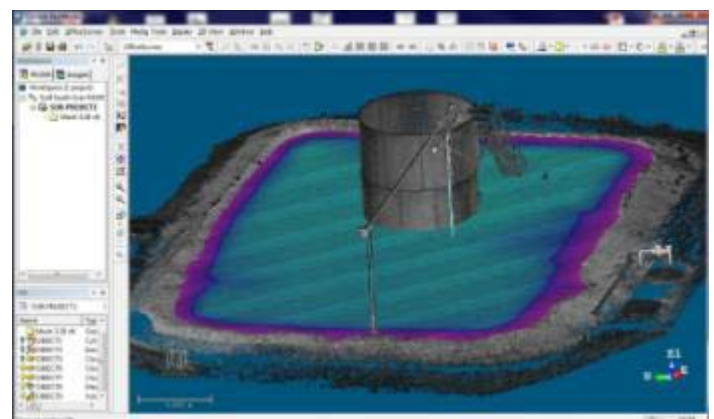
DEFORMATION

While tank thicknesses are effective for the monitoring of structural integrity, positions obtained from 3D laser scanners can be used to complement thickness measurements by analyzing the deformation or movement of the tank over time. Comparisons of millions of points between two scans over an extended period can highlight areas where change has occurred. Closer inspection or repairs could then be undertaken on the specific areas of concern to avoid costly failures and potential loss of assets.



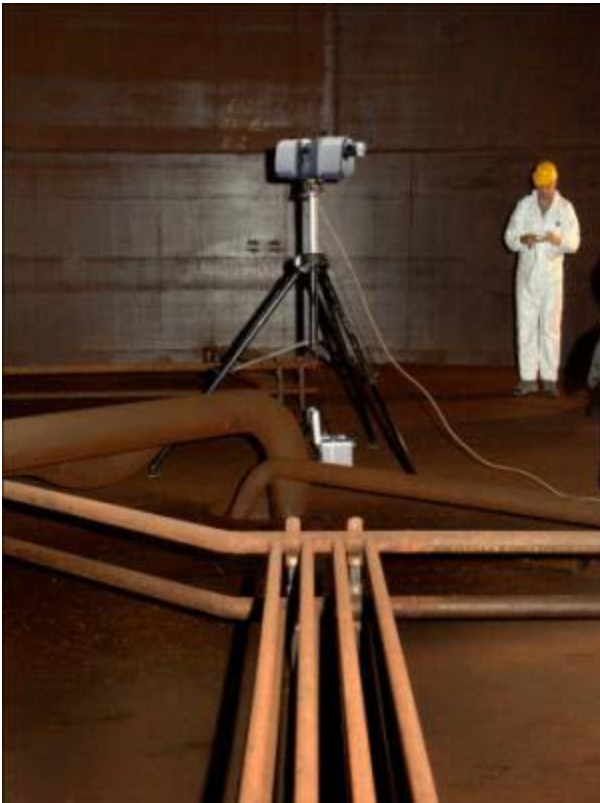
CONTAINMENT DIKE ANALYSIS

Scanning tank exteriors and surrounding containment areas provides accurate and visual information that would normally take up to ten times longer with a total station or leveling device. The end result is a comprehensive data set that can be used to obtain direct measurements and volumes to ensure containment dikes satisfy regulatory requirements. Areas of potential concern or failure can be quickly identified and quantified to reduce repair time.



CALIBRATION

In addition to tank inspection applications, 3D laser scanners can also be used for tank calibration—creation of accurate filling tables. In contrast to traditional methods of strapping or measuring with a total station, the technique involves placing the 3D scanner inside the tank, while out of service, to capture the tank interior. Data for both the tank floor and sump and filling volume are recorded in a single operation, and an estimation of tank thicknesses is not required as the internal cavity is directly measured.



Trimble established the application of 3D scanning for tank calibration in conjunction with the Physikalisch-

Technischen Bundesanstalt (the German national metrology Institute, PTB) in Braunschweig, Germany. The PTB demands a measurement uncertainty below 0.5% and has certified the solution of the Trimble CX 3D laser scanner and accompanying software to meet the legal requirements of measurement in Germany. The accuracy and speed of measurement provide direct benefit for tank calibration including:

- Reduced data collection time – less time in the tank interior
- Reduced labor costs
- Higher accuracy and more comprehensive data – protect transactional losses
- No need for liquid sump volume determination – less environmental costs

SUMMARY

3D laser scanning enables inspection companies to collect a large amount of accurate position data in a very short time. The data provides rich information to visualize and analyze tanks in great detail for efficient inspection and maintenance.

For more information, go to www.trimble.com/plant.

AUTHOR

Tim Lemmon is a market manager for Trimble in the Power, Process, and Plant Division. He has been with Trimble for over 11 years in a variety of engineering and marketing roles, specializing in positioning solutions and technologies. He holds a BS and MS in

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