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Determine of Losses Storage Tank by Geodetic Measurements

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Abstract: It is important to fully determine the actual geometric parameters during operation and the need for their repair by a method developed based on the results of three-dimensional, ground laser scanning measurements, to avoid damage and damage, and to prevent serious economic, environmental, and social consequences. The methodology for measuring storage tanks using three-dimensional ground laser scanning technology includes requirements for reducing measurement errors, reducing the influence of external factors on the accuracy of results, and reducing work time. It includes: measure the tilt of the storage tank from the ideal position of the tool, calculate the actual geometric shape, reducing the impact of external factors on the results (metric properties of the object, instrument errors, methodological errors, instrument errors), it is possible to reduce the measurement time of checking a 25 m^3 storage tank by 50-80% with the accuracy of the ground laser scanner. Various methods for determining the structure, deformation, and geometric parameters of storage tanks are based on technologies, data collection methods, measurement methods, comparison methods, and mathematical modeling methods. Microsoft Excel and Word were used to integrate research data and data, Faro Scene was used to check and process storage tank measurement data, and Trimble realworks, Tanks, and LupoScan software were used to create a three-dimensional model of the surface of the storage tank and to study changes in geometric parameters.

Keyword: Determine, Storage Tank, Measurement, Deviation

1. Introduction

Measurement data should be linked to the local interpolation system to monitor changes in the geometry of the storage tank over time. For this, the GNSS antenna can be installed on the scanner and the position of the instrument can be determined correctly. It can be mounted on a known offset point, perform tool checks and adjustments, measure scanner height, enter scanner location point and mark coordinates, or pre-forecast these offsets to the tool.

In recent years, countries around the world have focused on extending the life of steel storage tanks that have expired. It is impossible to solve the problem of ensuring the safety and reliability of their use without conducting theoretical and experimental research on the stability and strength of storage tank elements, determining the reality of changes in the geometry of storage tanks, developing new methods and technologies. Therefore, measurement and testing of underground horizontal cylinder tanks is being carried out using ground laser scanning technology.

2. Determine the Deviation of the Fuel Tank by Geodetic Measurements

An effective way to model the structure of a storage tank is to use well-selected discrete control points located on the outer surface at various levels to provide detailed information on the tank's properties when properly placed. Any movement of the position of the control point (and therefore the deformation of the structure) will preserve the position of the same point over time, making measurements at certain time intervals and allowing comparison of the direct displacement of the point. The number and location of control points depends on the shape of the structure, but the accuracy of the location of the change depends on the method of data collection and the accuracy of the instrument used.[13]

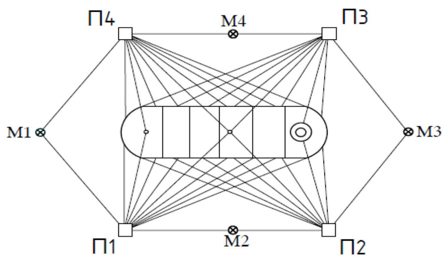

Figure 1. *Diagram of a geodetic network with an electronic tachometer.*

To create a system for monitoring the geometric parameters of the storage tank, the deformation control scheme consists of measurements from several selected control points around the storage tank. Geodetic instruments are placed on these control points and observations are made to calculate the displacement of the control points on the surface of the container. [7] These control points are placed at equal distances on the surface of the tank. Control points must be constant throughout the observation period (monitoring period). The measuring devices used for deformation monitoring depend on the application, the method chosen, and the measurement interval. Deformation control is aimed at defining the transition between two epochs. It is most relevant for controlling the deformation of petroleum products and structures such as reservoir storage tanks and dams.[6] Therefore, the control of structural deformation and various external dynamic responses is important for the reliability of the structure and the cost-effectiveness of the artificial structure [9].

The object of the research is a horizontal horizontal steel tank with a capacity of 50 m^3. The oil and its products are stored vertically, horizontally, dropwise steel tanks and reinforced concrete vessels. The oil and its products are stored vertically, horizontally, dropwise steel tanks and reinforced concrete vessels.[3]

Oil and its oil under high pressure and their products are volatile, fire and explosion proof, and have special properties of electrification, so they have different storage functions. [1]

To determine the geometry of the fuel tank or to measure deviations, deformations, and capacitances, the geodetic positioning network was created using a high-precision geodetic measuring tool and the control points were recorded on the surface of the tank from the base points (Figure 1). [2]

Deviations from the reference plane, perpendicular to the axis of the tank, and deviations of the points along the perpendicular to the actual surfaces of the bottoms of the tank are determined by the formula: [5]

$$\vartheta_j^{\Pi} = L_j^{\Pi} - L^{\Pi} \qquad (1)$$

$$\vartheta_j^{3} = L_j^{3} - L^{3}$$

The deviations of storage tanks of the reservoir SHTS-1 and SHTS-2 with a capacity of 50 m^3 located in Bayanzurkh district were measured by 2 repeated measurements for 2016, 2017, 2018 and 2019, and the results are summarized by the arithmetic average (table 1).

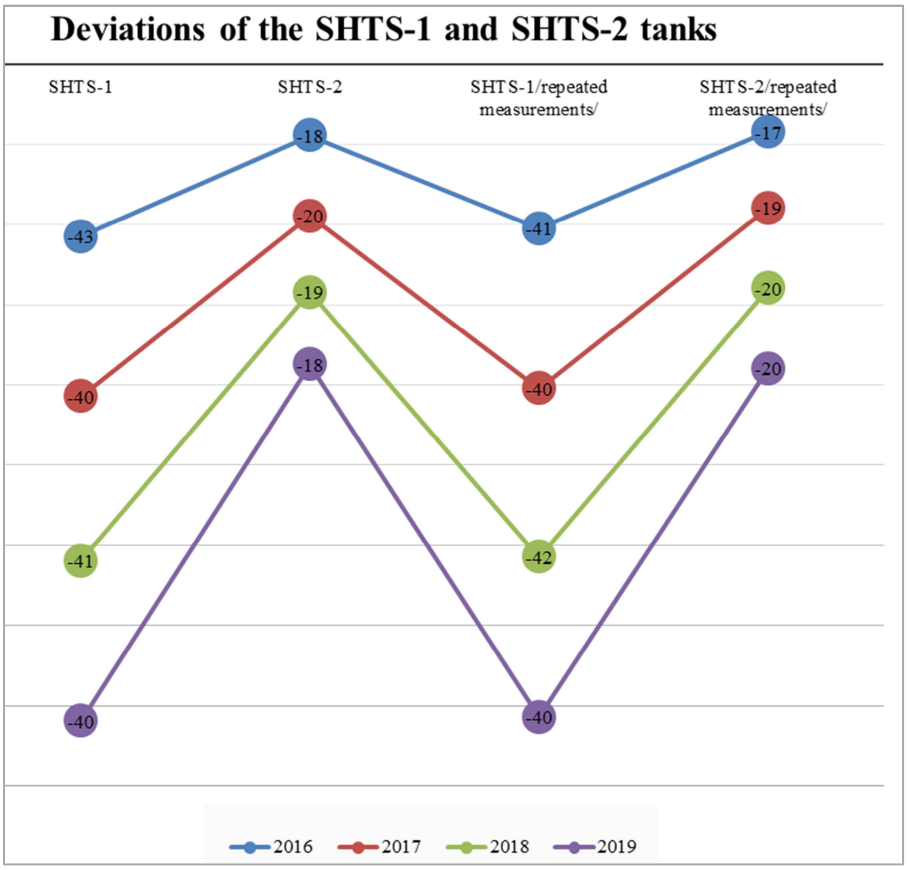

Figure 2. *Deviation from the standard sizes of the SHTS-1 and SHTS-2 tanks.*

***Table 1.** The deviation values of the storage tanks.*

№	Name of place of measurement	Tank №	Tank capacity	The location of the tank	Deviation / mm /			
					2016	2017	2018	2019
1	Bayanzurkh	01	50	hidden	-43	-40	-41	-40
		02	50	hidden	-18	-20	-19	-18
2	Bayanzurkh / repeated measurement /	01	50	hidden	-41	-40	-42	-40
		02	50	hidden	-17	-19	-20	-20

3. Determine the Capacity of the Fuel Tank by Geodetic Measurements

Determine the capacity of the storage tank, a laser scanner was placed inside the backup tank and the distances between the stops P1, P2, and P3 were calculated to be 6.1mm / 10m, and the stops were measured using the M1, M2, M3, M4, M5, M6 tags or spheres (Figure 3). [4]

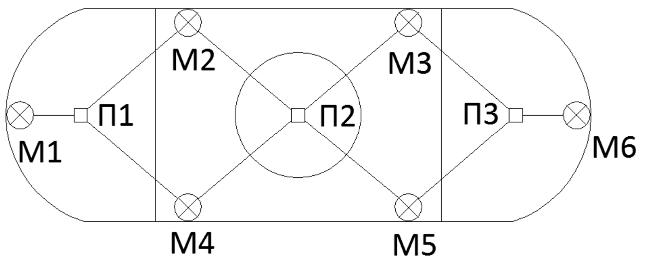

***Figure 3.** Schematic diagram of the inside of the backup tank with a laser scanner.*

The position of the control points was measured with an accuracy of 5mm-1cm and the error was determined by comparing the intervals over time (Table 2).[8]

The position of points indicated on the surface of the using geodetic control points was determined by the formula:

$$X_1 = \frac{X_A cot\alpha_B + X_B cot\alpha_A + Y_A - Y_B}{Cot\alpha_B + Cot\alpha_A} \quad (2)$$

$$Y_1 = \frac{Y_A cot\alpha_B + Y_B cot\alpha_A + X_A - X_B}{Cot\alpha_B + Cot\alpha_A}$$

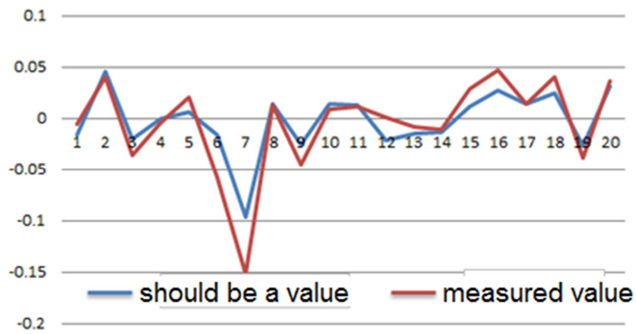

***Figure 4.** Transition values of measurement points.*

***Table 2.** Location of storage tank control points.*

Stations point	φ(0)	X_i	Y_i	$X_i(0)$	$Y_i(0)$	ΔX_i	ΔY_i
1	18	325103.304	148734.500	325103.320	148734.490	-0.016	0.010
2	36	325114.486	148729.925	325114.440	148729.930	0.046	-0.005
3	54	325123.840	148721.794	325123.860	148721.810	-0.020	-0.016
4	72	325129.769	148711.957	325129.770	148711.960	-0.001	-0.003
5	90	325132.586	148700.395	325132.580	148700.380	0.006	0.015
6	108	325131.674	148688.458	325131.690	148688.500	-0.016	-0.042
7	126	325127.104	148677.404	325127.200	148677.460	-0.096	-0.056
8	144	325119.604	148668.559	325119.590	148668.560	0.014	-0.001
9	162	325109.164	148662.061	325109.190	148662.080	-0.026	-0.019
10	180	325097.484	148659.285	325097.470	148659.290	0.014	-0.005
11	198	325085.603	148660.238	325085.590	148660.240	0.013	-0.002
12	216	325074.539	148664.812	325074.560	148664.790	-0.021	0.022
13	234	325065.475	148672.537	325065.490	148672.530	-0.015	0.007
14	252	325059.236	148682.723	325059.250	148682.720	-0.014	0.003
15	270	325056.462	148694.306	325056.450	148694.290	0.012	0.016
16	288	325057.347	148706.000	325057.320	148705.980	0.027	0.020
17	306	325061.934	148717.250	325061.920	148717.250	0.014	0.000
18	324	325069.714	148726.376	325069.690	148726.360	0.024	0.016
19	342	325079.833	148732.569	325079.860	148732.580	-0.027	-0.011
20	0	325091.491	148735.395	325091.460	148735.390	0.031	0.005

The transition values of the measurement points are plotted.

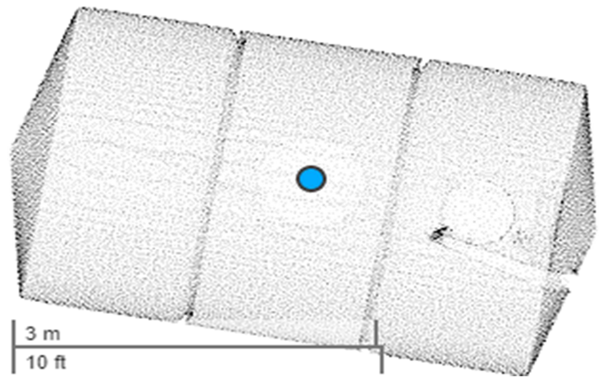

Figure 5. SHTS-1 tank surface point cloud /Faro Scene/.

Based on the results of ground laser scanning of SHTS-1, a three-dimensional point-integrated model of the surface of the storage tank wall is obtained in the integrated system of transformations compared to the original scanning station. The results of the measurement work are shown in figure 5.

Based on the fixed data processing method of land laser scanner, the deviation of the vertical line forming the wall of the tank was determined based on the one-point model of the surface of the tank wall. [12] According to the results of the measurements, as well as the comparison of the data measured using a laser scanner, and the analysis of the data of the storage tank, the maximum deviation from the vertical line of the wall is 48.6mm, and the minimum deviation is 0mm. The deviation values are shown in table 2.

Table 3. Measurement results of the vertical deflection of the walls of the SHTS-1 storage tank.

№	Deviation of the 1st vertical line			Deviation of the 2nd vertical line			Deviation of the 3rd vertical line			Deviation of the 4th vertical line		
	Laser scanning мм	Total station мм	diff мм	Laser scanning мм	Total station мм	diff мм	Laser scanning мм	Total station мм	diff мм	Laser scanning мм	Total station мм	diff мм
1	0.8	-8.4	7.6	10	6.6	3.4	-12.9	-2	10.9	1.3	0	1.3
2	-3.6	-12.3	8.7	18.3	13.2	5.1	-9	-6	3	0.4	0	0.4
3	-5.7	-13.9	8.2	34.5	27.8	6.7	-18.5	-14	4.5	6.3	5	1.3
4	-10.3	-18.2	7.9	43.1	40.3	2.8	-8.4	-8	0.4	16.6	15	1.6
5	-12.8	-17.5	4.7	48.6	49.9	1.3	-10.4	-11	0.6	13.3	10	3.3

Note: "-" sign means the deviation of the wall of the container from the vertical position is the concavity, "+" sign – indicates a bulge.

Figure 6 shows the results of simulating the deformation state of the storage tank wall during operation, taking into account the real space location and the real geometry.[11]

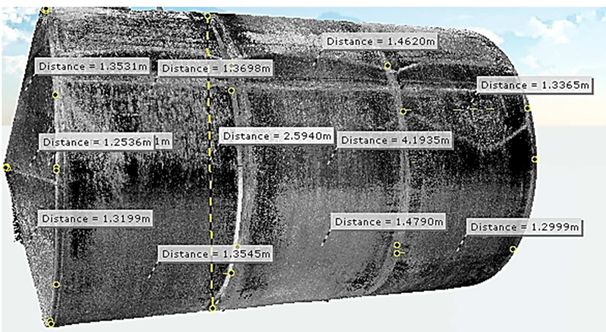

Figure 6. Geometric dimensions of the SHTS-1 storage tank.

The maximum value of the deformation in the wall of the SHTS-1 storage tank is 6.3 mm, and the minimum value is - 3.9 mm.

The picture below shows the surface of the SHTS-1 storage tank covered by a laser scanner with a set of points.

When compiling the SHTS-1 tank metering data and determining the volume by volume program, the volume of the first section is 10.8 m^3, the volume of the second part is 27.6 m^3, the volume of the third part is 11.1 m^3, or the total volume of the storage tank is 49.5 m^3.

The volume of the SHTS-2 tank is 11.6 m^3, the volume of the second part is 25.1 m^3, the volume of the third part is 13.1 m^3, and the volume of the storage tank is 49.8 m^3.

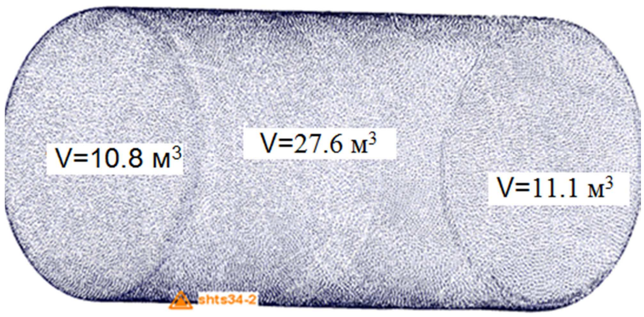

Figure 7. Scanned volume of the storage tank.

4. Conclusion

The following conclusion is made after measuring the storage tank using ground laser scanning technology. [10] It includes:

1) calculate the actual deviation from the ideal position of the tank to the spatial position of the tank wall and the actual geometric shape;
2) reducing the influence of external factors on the results (metric properties of the object, working climatic conditions, etc.);
3) reduction of inspection time for all standard size containers to 1 hour.
4) suitable for analyzing the deformation of the three-dimensional model of the storage tank using the method developed by the method of angular and linear section.

The research carried out a selection of underground steel cylinders of the same type and performance with the same measurement and determined the loss of fuel storage capacity.[14-16] These include:

1) The deviations of the horizontal horizontal cylindrical tank from the ShTS-1 are 2-3 mm, with a loss of 49.5 m^3 or 0.5 m^3 of the original volume.
2) The deviations of the horizontal horizontal cylindrical tank from the ShTS-2 are 1-2 mm with a loss of 49.8 m^3 or 0.2 m^3 of the original volume.

Most importantly, the loss of fuel tank capacity is influenced by the error of the tank length and width, as well as the deviation. Studies show that increasing the slope can lead to a loss in capacitance. It is also recommended to familiarize yourself with the technical and assembly documents of the tank, check the technical condition of the outer surface of the reservoir or its deformation, the degree of iron defects and the thickness of the paint lumps.

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