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## Modern Technologies for Oil Quantity Measurement in Tanks

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### Abstract

This paper discusses the problems of accounting for the amount of oil in tanks. Various types of oil storage tanks, as well as instruments for controlling its amount, are analysed. Based on the studies conducted, the most suitable level gauges for use in various types of oil tanks were identified.

Although visual inspection may be a priority, automatic level meters have several advantages. Using inexpensive level gauges and switches, be they capacitive, magnetic, optical or mechanical, it is possible to send signals to generate either a supplying order (filling the tank) or a work order for replenishment. At a more advanced level, they can be configured to activate a pump that will automatically replenish the oil stock.

Other depth type level gauges using acoustic technology to determine the exact level of oil and oil product are available. The applied level switches must have some damping to avoid constantly fluctuating level changes due to system operation.

When an automatic tank volume recorder is used, the system may give an alarm about a sudden change in fluid volume. Using an automatic level indicator, the system can be designed to send a signal to computer maintenance control software to indicate the amount of fluid added.

### Keywords

*Tank Farm, Tank, Quantity Metering, Level Gauge, RAPTOR, TRL / 2 System.*

### Introduction

Today, oil level monitoring in tanks is very important. Without these data, it is impossible to take into account the amount of oil in the reservoirs. The amount of oil in the tanks is determined by the volume occupied by it in the tank. To quickly and accurately determine the volume of oil depending on its level (innage level), pre-compiled calibration (metering) tables for each type of tanks are used. The tanks are calibrated using various methods: by measuring vessels, by pouring and draining pre-measured volumes of water (for small tanks); with the help of volumetric meters measuring the amount of poured water while measuring the level in the calibrated tank, and measuring the geometric dimensions of the tank. A method is chosen taking into account the volume of tanks and the necessary accuracy.

In this regard, the work considers various systems for monitoring the oil level in reservoirs that are used today, and the best option is selected. The types of tanks for the placement and storage of oil are also considered.

### Methods

A tank farm is a group (s) of tanks intended for the reception, storage and pumping out of oil and located in a territory limited along the perimeter by a bunding or enclosing wall with ground tanks, and roads or fire-prevention passageways with underground tanks.

A tank is a vessel where oil products are stored. Tanks are one of the main facilities of oil depots and are intended for the storage of oil products and the production of certain technological operations. [1].

The purpose of the tanks is to receive, store and dispense various liquids (such as water, crude oil, lubricating oils, gasoline, kerosene, etc.) and gaseous media. [1].

Tanks can be classified according to various criteria, for example: in relation to ground level; the value of excess pressure; on technological operations; by design.

In relation to ground level, tanks can be:

- underground;
- above-ground.

In terms of excess pressure:

- low pressure tanks in which the overpressure differs little from atmospheric pressure ( $pH < 0.002$  MPa)
- pressure vessels ( $pH > 0.002$  MPa);

For technological operations:

- storage tanks for low-viscosity oils and petroleum products;
- storage tanks for high viscosity oils and petroleum products;
- suction clarifier tanks;
- tanks of special designs for storing oil and oil products with high saturated vapour pressure;

By design:

- vertical steel cylindrical tanks with conical and spherical roofs, horizontal cylindrical tanks with flat and spatial bottoms, and drop-shaped, and spherical;

- reinforced concrete reservoirs (vertical and horizontal cylindrical, rectangular and trench).

A vertical tank (RVS) is a usually steel structure (Fig. 1) in the form of a cylinder with a bottom and a roof (therefore, they are also called cylindrical tanks). Various units of equipment should be installed on the roof of a tank: breathing valves, fixed and gage hatches, level controller and lightning rods. In the lower part, pipelines are connected, and a manhole is installed. In order to prevent the emergency product flood, reservoirs are fenced with an earth mound (embankment). For ease of maintenance, the tanks are equipped with fenced platforms and an external steel staircase. All structures must have an anti-corrosion coating (two layers of GF-021 primer and PF-115 enamel coating). [1].

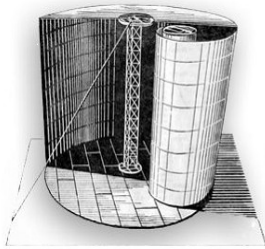


Figure 1: RVS.

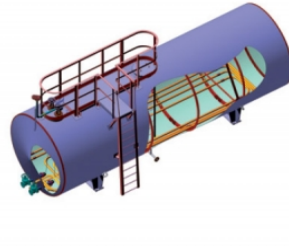


Figure 2: RGS.

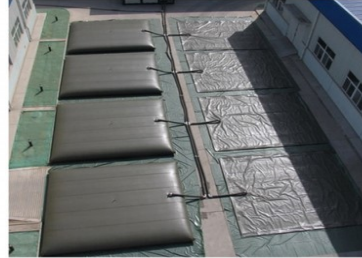


Figure 3: Soft Tanks

Steel horizontal tanks (RGS) are designed for stationary storage of liquids: water, oil, oil products, as well as process mixtures and other liquids with a density of up to  $1.3 \text{ t / m}^3$ .

A RGS reservoir is a steel structure in the form of a cylinder with two flat, conical or spherical bottoms (Fig. 2). In order to make such reservoir more robust, its sidewalls are reinforced with stiffening rings. Bottoms and walls can be reinforced with stiffeners [3].

Ball tanks are reservoirs of spherical shape. They are intended for storage at elevated pressure (more than 0.25 MPa) of liquefied petroleum gases and petroleum products.

The main element of ball tanks is a shell assembled from petals of double steepness. They are factory fabricated. Petals are welded together automatically using welding manipulators, which provide the greatest mechanization of the ball tanks manufacturing process, achieving high quality welds and high installation performance. The ball tank shells rest on several columns welded directly to the tank body; the columns transmit pressure to the concrete foundation. For greater rigidity, the columns can be interconnected by a system of braces [4].

In the drop-shaped tanks, there are no stiffeners and a support ring inside the tank, and the shell rests in the equator zone upon 20 supports (columns), which are mounted on a reinforced concrete support ring. A drop-shaped shell has a thickness above the equator of 5 mm, below - 6 mm. [1].

There are also soft tanks (Fig. 3). This is a fairly new product, which is becoming more widespread. Their use is relevant in various industries, in both small and large factories, by individuals, in the army, in special services, during emergency and rescue operations. Their advantage is that they are not subject to corrosion under the influence of aggressive substances.

Soft tanks are used for temporary storage of virtually any liquids: oil products, water, sludge, alcohol, and other liquids. They are made in the form of pillows [6] and have high tightness which is guaranteed by high quality joints of the polymer material.

However, as in other cases, there are problems with their operation.

- In order to achieve maximum tank capacity and at the same time reduce the risk of spills and overflows, a comprehensive implementation of new technological solutions for measuring and monitoring the level of the product is necessary.
- To improve the quality of measuring the level of the product in tanks, specialists need to apply various methods that improve the quality of the instrument readings. Non-contact or waveguide radars are widely used.

### Methods

- Integrated Technologies
- Vibration Level Switches
- Wireless connection
- Emergency Protection Systems (EPS)

### Results

The use of modern technologies for measuring and monitoring the liquid level is a reliable protection against emergencies. Accurate measurement of fluid levels in tanks plays a significant role in inventory management and environmental protection.

To measure the level in tanks, plant engineers widely use non-contact or waveguide radars. The principle of their operation allows the accuracy and reliability of measurements to increase, while reducing maintenance costs. It is based on the propagation of a microwave nanosecond radar pulse down their probes. When a radar pulse reaches the surface of the medium being measured, part of the energy is reflected in the opposite direction.

Level gauges allow the time to measure it would take for pulses to reach the surface of the medium and be reflected in the opposite direction, after which the built-in microprocessor accurately calculates the distance to the surface of the medium using time-domain reflectometry technology.

The latest level measuring instruments meet all the mentioned requirements, increase the reliability and accuracy of measurements, notify about their technical condition, and also allow measurements that were previously impossible.

The TRL / 2 system is designed for conducting stock accounting of oil and oil products and constant monitoring of the state of the tank farm [7]. The TRL / 2 system provides:

- 1) Level, temperature, pressure measurement for the product;
- 2) Measuring the height of the bottom water level;
- 3) Limit level alarms when filling, and upon product leaks during storage;
- 4) Calculation of a given volume, the required density and mass of the product in the tank based on the measurement results of the product parameters with errors that meet the requirements of GOST R 8.595-2002.

The existing Raptor information and measurement system for commercial metering and management of tank farms is a further development of the TankRadar TRL / 2 system.

The Raptor is a flexible system with the ability to easily change its configuration based on the use of standard communication protocols. This system provides full control not only of the state of the tank farms, but also of the product parameters in the tanks, as well as the calculation of the volume and mass of oil and oil products in tanks of any type: under pressure and without overpressure, with a fixed or floating roof, in vertical or horizontal cylindrical and spherical tanks [8].

#### **Radar Level Meters**

RAPTOR radar level gauges provide level measurement with the highest accuracy and have sufficient reliability due to the fact that they do not have moving parts, although only an antenna or a small sensitive element is inside the tank.

The Raptor system provides the measurement and calculation of product parameters in tanks for the subsequent provision of the following operations:

- monitoring the general condition of the tank farm;
- calculating the volume and mass of the product in the tank itself;
- control over execution of acceptance and shipment operations;
- detection of possible product leaks from various types of tanks;
- prevention of overfilling upon reaching the permissible level of tanks;
- operational control over the presence or absence of the product itself in the tanks.

The Raptor system can be equipped and configured to measure the following product parameters in tanks:

- level and speed of level measurement;
- multipoint temperature measurements to calculate average temperature
- hydrostatic pressure of the product and overpressure in the gas space;
- bottom water level.

The TRL/2 system employs such radar level gauges as TankRadar REX and TankRadar with various types of antennas depending on the measurement conditions. The level gauges are continuously irradiating frequency-modulated HF oscillations and have the highest measurement accuracy. Radar level gauges can be used in tanks for various purposes and types of structures.

1. PRO Series Level Gauges are designed for process tanks with internal structures or mixers.
2. RTG3900REX Series Level Gauges are designed for commercial tanks that require product level measurement with particularly high accuracy.
3. RTG3930REX parabolic antenna level gauges are used on fixed-roof tanks to measure the level of oil and oil products.
4. RTG3950REX level gauges are installed in guide tubes in tanks with a pontoon or floating roof.
5. RTG3960REX level gauges are installed in tanks with liquefied gases under pressure. These level gauges are equipped with ball valves and control devices allowing automatically take into account a signal propagation speed change in the gas space of the tank depending on the product grade.

RNL / RNT level alarms are used to protect tanks from overflow. The advantage of these level gauges is the availability of their operability automatic control function [9].

#### **Summary**

Depending on the storage method, the specifics of loading and unloading operations for oil and oil products and their properties, it is possible to use various methods of accounting for the amount that is defined in the instruction on the procedure for receipt, storage, release and accounting of oil and oil products at oil depots, filling stations and gas stations of the system. The paper discusses the problems that exist today and considers the modernization of radar level gauges.

#### **Conclusion**

At present, however, little studied is the problem of assessing the reliability of oil reservoirs both at different stages of their life cycle and during operation.

When assessing the level of reliability of tanks in operation, the most effective is the expression of this value in terms of the quality of their service.

For a comprehensive study of the problem of ensuring and maintaining the reliability and safety of tanks, it is necessary to develop models and methods with which we can identify and evaluate ways to ensure the reliability of tanks at different stages of storage life cycle with a sufficient degree of accuracy.

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