# ANALYSIS OF THE FEATURES OF EXISTING AND PERSPECTIVE METHODS OF METROLOGICAL VERIFICATION (CALIBRATION) OF LEVEL GAUGES

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**Abstract.** The primary purpose of this scientific article is to analyze existing and potential methods of metrological verification (calibration) of level gauges used for accurate metering of oil products in tanks of various types and purposes. This study will consider their key features, advantages, and disadvantages, as well as prospects for development and improvement, considering modern technological advances and requirements of industry standards.

**Key words:** level gauge, level measurement system, calibration method.

## 1. Introduction

In today's world, companies exporting and importing oil and oil products use many modern oil product accounting systems. Ukraine is no exception. Moreover, the requirement to have a level measurement system, a level gauge, at a gas station or a fuel and lubricant warehouse is enshrined in law. In order to combat the "black market of petroleum products", our country has introduced amendments to the Tax Code of Ukraine [1]. As a result, no point of accounting, storage, or sale of petroleum products can legally operate without such a metering system as a level gauge.

Level gauge – a fuel level meter in a tank (hereinafter referred to as a level gauge, definition from the Tax Code) is a legally regulated measuring instrument designed to measure the fuel level, which calculates the fuel volume in the tank according to the tank's graduation table.

The level measurement system (level gauge) is a legally regulated measuring instrument, which is included in the list of legally regulated measuring instruments by the Cabinet of Ministers Resolution of June 4, 2015, No. 374 "On approval of the list of categories of legally regulated measuring instruments subject to periodic verification" [2].

## 2. Issues

In order to ensure uniformity of measurements in the field of oil products metering, in 2009, the interstate standard MPU 236/03-2009 "Complexes of technical means for metering oil products in tanks" (hereinafter – MPU 236) was introduced [3]. Given the technological progress and growing requirements for metering accuracy, there is an objective need to modernize the existing methods of metrological verification of level gauges, a key element of the above-mentioned metering systems.

Therefore, the primary stage of scientific research is a detailed study of the functional purpose of level gauges, analysis of their design features, and determination of the main metrological characteristics that directly affect the accuracy of oil product volume metering in tanks.

## 3. Overview of the level measurement system (level gauge), its structure and metrological characteristics (Fig. 1)

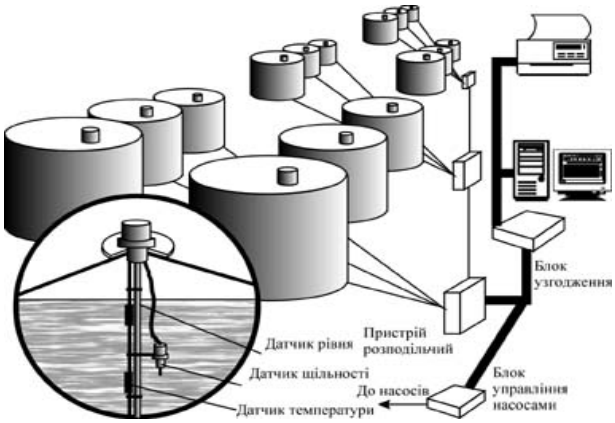


*Fig. 1. Schematic representation of a level measurement system (level gauge) with information transfer to a PC at the point of accounting or sale*


*Fig. 2. Probe and information console of the level sensor*

**Table.** Main metrological parameters of level measurement systems

| | |
|---|---|
| Operating range of level measurement (depending on the probe length) | 0–18 m |
| Maximum permissible basic error of level measurement | ± 1 mm |
| Maximum permissible basic error of measuring the average product temperature, not more than | |
| in the range of –20...+55 °C | ±0.5 °C |
| Units of measurement | mm, °C |

The level sensor consists of a probe that performs the measurement and a console that receives and processes the signal from the probe and displays it on the console display (Fig. 2).

The main metrological parameters that most level measurement systems (level gauges) can measure are shown in Table.

There are also many auxiliary parameters, such as the level of make-up water or others [2]. All the parameters of a modern level measurement system can be modified depending on the needs of the customer or operator.

## 4. Research methods

Further research raises the question of the metrological verification of level gauges. What regulatory documents regulate this process, and how can it be improved?

First of all, let us look at the current regulatory framework. The main document regulating the calibration of level gauges for tank oil products is the interstate standard MPU 236/03-2009 "Complexes of technical means for oil products metering in tanks". However, due to the considerable time interval since its approval in 2009 and in order to update the regulatory requirements, new national standards were developed and put into effect: DSTU 9204:2022 "Metrology. Level gauges. Method of verification at the place of operation" [4] and DSTU 9205:2022 "Metrology. Level gauges. Calibration method by simulation" [5]. Although the new DSTUs have not yet canceled the validity of MPU 236/03-2009, their analysis allows us to identify potential areas for optimizing the verification procedure for level gauges.

One of the key differences between the new DSTU 9204 and DSTU 9205 is a clear distinction between verification methods depending on the place of its implementation: on-site and in the laboratory. In contrast, in MPU 236/03-2009, there is a certain combination of both methods, which can complicate the work of specialists due to the need for fragmentary processing of documentation to obtain relevant information. The new standards provide greater convenience and clarity due to the structured presentation of requirements for each verification method separately.

Regarding the conditions of verification, MPU 236 sets the following ranges for the environment: air temperature from 10 to 30 °C, relative humidity from 30 to 80 %, and atmospheric pressure from 84 to 106 kPa. In turn, DSTU 9205 regulates only the temperature in the laboratory within the range of 20 ± 5 °C. The exclusion of the humidity and atmospheric pressure requirements for laboratory conditions is reasonable, since these parameters do not significantly impact the verification of level gauges in a controlled laboratory environment, and their measurement requires additional time.

An important aspect is the requirements for accuracy and uncertainty of measurement standards and auxiliary equipment. The equipment list for both verification methods is extended in IPU 236, making it challenging to identify the necessary means, especially for inexperienced personnel. Instead, DSTU 9204 and DSTU 9205 contain a more specific list of measurement standards with clearly defined requirements for their accuracy. An example is the comparison of requirements for a reference level gauge:

MPU 236: A set of technical means for accounting for petroleum products in tanks (level gauge), certified as a working standard, measuring range (height reproduction) of liquid level from 0 to 4 m, limits of permissible absolute error of level measurements ± 0.5 mm, temperature measuring range from 0 to 40 °C, limits of permissible absolute error of temperature measurements ± 0.2 °C.

DSTU 9204: Level sensor, $U$ = 0.33 mm or Ultrasonic level sensor, $U$ = 1.0 mm (where $U$ is the uncertainty).

As can be seen from the comparison, the new methodologies set more concise and specific requirements for measurement standards, including the measurement uncertainty. This is an important innovation, since uncertainty is a key characteristic of measurement standard calibration that provides reasonable confidence in the reliability of the results.

The analysis of the section "Verification" in MPU 236 and the new DSTUs shows that specialists with practical experience were involved in developing the latter. The relevant sections in DSTU 9204 and DSTU 9205 are characterized by consistency, conciseness, and consideration of all necessary operations to ensure reliable verification results. An important change is a clear definition of the requirements for the verification result – the limit of the permissible absolute error of the level gauge, which is ±4 mm for verification at the place of operation and ±1 mm for verification in the laboratory. In MPU 236, such requirements were absent, which made it difficult to assess the suitability of the level gauge. It

should be noted that these are international requirements for the accuracy of level measurement systems [6], which are studied and practically applied in the complex construction of a system for measuring oil products in tanks. This indicates a movement towards harmonizing standards and requirements to ensure international uniformity of measurements.

It should be noted that DSTU 9204 allows using ultrasonic level gauges as standards. However, practical experience in the field verification of ultrasonic level gauges has revealed a potential problem of unstable operation when the liquid level changes abruptly, especially if foam is on its surface. Foam can create obstacles to the ultrasonic signal, leading to measurement errors or even the level gauge shutting down or restarting. Therefore, verification organizations need to carefully consider the choice of an ultrasonic level gauge as a reference, taking into account the potential risks associated with the conditions of its use.

The section "Processing of results" in the new verification methods remained without significant changes, which is logical, since the principle of processing the obtained data has not undergone any fundamental changes.

At the same time, the section "Registration of verification results" in DSTU 9204 and DSTU 9205 has become more structured and regulates the procedure for filling out the verification report. The protocol form is a logical continuation of the previous sections, providing clear documentation of all verification stages and their results.

## 5. Conclusions

The comparative analysis of existing and prospective methodologies for metrological verification of level gauges revealed significant progress towards simplifying and unifying this process by introducing national standards DSTU 9204:2022 and DSTU 9205:2022. Thanks to clearer regulations on the equipment used, the reference base, and the sequence of procedures, the new methods help to improve the accuracy of measurements and strengthen confidence in the results of metrological control.

The study results of the peculiarities of existing and prospective verification methods of level gauges emphasize the dynamic development of metrological support in this area. The introduction of DSTU 9204 and DSTU 9205 confirms this progress, aimed at optimizing the verification procedure and increasing its metrological reliability. However, for further optimization and progress in this area, the following measures are necessary:

– intensification of research and development activities in the development and implementation of the latest methods of liquid level measurement;

– development and integration of specialized software to automate the processing and analysis of verification results;

– active promotion of new regulatory documents among specialized professionals and promotion of their widespread practical application;

– introducing modern methods of level gauge calibration as a key condition for ensuring transparency and improving the efficiency of the oil market in Ukraine.

To summarize, the analysis shows that the new national standards DSTU 9204 and DSTU 9205 are characterized by increased convenience and clarity for specialists involved in verifying level gauges. Due to their clear structure and specific requirements, a significant reduction in the likelihood of errors during metrological procedures is expected. Implementing these standards is an important step towards improving the quality of level gauge calibration services and ensuring strict compliance with the requirements of the current legislation in the metrology and technical regulation field.

## Conflict of Interest

The authors declare re no financial or other potential conflicts of interest regarding this work.

### References

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[2] Resolution of the Cabinet of Ministers of June 4, 2015 No. 374 "On approval of the list of categories of legally regulated measuring instruments subject to periodic verification".

[3] Verification Methodology MPU 236/03-2009. Complexes of technical means for accounting for petroleum products in tanks.

[4] DSTU-9204:2022 Metrolohiia. Rivnemiry. Metodyka povirky na mistsi eksplyatatsij.

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