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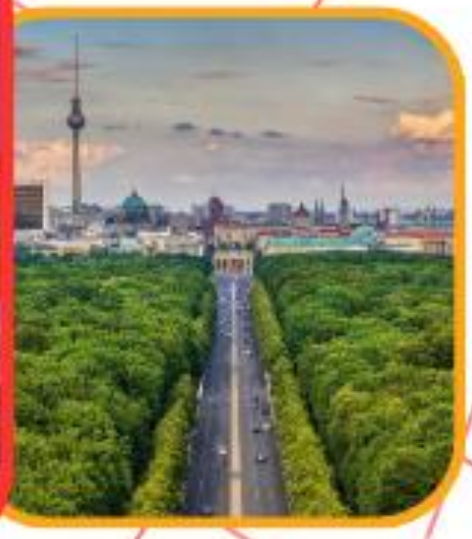

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IMPROVEMENT OF THE PROCESS OF MAINTENANCE OF GAS BALLON VEHICLES BASED ON AN AUTOMATED CONTROL SYSTEM

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Annotation: This article highlights the issues of improving the service maintenance system based on automated control during the operation of gas-cylinder vehicles. The proposed approach is aimed at organizing service processes in a centralized and digitalized manner, assessing the technical condition in real time, and reducing the human factor during operation. The use of radio wave identification tools in the automated control system is justified as a means of increasing the efficiency of the service process.

Keywords: operation, maintenance, service system, automated control, security.

In existing maintenance systems, a significant portion of control processes relies on the human factor [1-4]. This situation can lead to incorrect recording of technical data, the use of cylinders with expired technical testing periods, as well as violations of current technical regulations and safety requirements. The main factors affecting safety during the operation of gas-cylinder vehicles are summarized, including the technical condition of the cylinder, gas leakage, pressure and temperature fluctuations, malfunctions in the electrical system, and the human factor.

Analysis of these factors and the current maintenance process shows that manual control methods do not fully ensure the possibility of timely detection of hidden defects and reduce the level of operational safety. Therefore, the improvement of the GBA maintenance process based on an automated technical control system is an urgent scientific and practical task [5].

Table 1

Main factors affecting safety in the operation of gas-cylinder vehicles [6]

No	Factors affecting security	Description	Risk level
1.	Ballon Technical Condition	Crack, corrosion, expired	High
2.	Gas leakage	Hose, valve, coupling	Very high
3.	Gas pressure	Change of norm	Moderately high
4.	Temperature	Increased pressure	Average
5.	Reducer	Membrane, valve error	High
6.	Electrical system	Fire hazard	High
7.	Human factor	Error and negligence	Very high

Within the framework of this study, a new automated system for monitoring the maintenance of gas-cylinder vehicles was developed. The main purpose of the proposed system is contactless identification of gas cylinders, assessment of their operational condition in real time, and activation of automatic limiting mechanisms in cases of non-compliance with technical regulations. This approach minimizes human intervention in maintenance processes, increases control accuracy, and significantly improves the level of safety in the operation of gas-cylinder vehicles [7].

The general structure of the developed system consists of an identification module operating on the basis of radio wave transmissions, a technical control and decision-making block, and a centralized information database. The gas cylinder is marked with the tag **Radiowave Identification (RFID)** , which serves as the sole identifier throughout the entire operation period of the cylinder. The **RFID** tag stores the date of manufacture of the cylinder, the duration of the technical test, the certificate number, and the permissible operating parameters. This information is automatically read at maintenance points and gas stations [8].

As a result of data processing, the system refers to the decision-making unit. In this unit, it is determined whether the condition of the gas cylinder complies with technical regulations and safety requirements. If all parameters meet the established standards, maintenance or gas filling is permitted by the system. In this case, the process is automatically continued, and the corresponding data is entered into the database.

If, as a result of the verification, at least one parameter does not meet the specified technical requirements, the system automatically launches the restriction mode. In this case, the gas filling or maintenance process is blocked, and a violation of safety requirements is prevented. This decision is also recorded in the database and stored for further analysis.

An important advantage of the system is that all examinations are conducted in a contactless manner, and the influence of the human factor is minimized. As a result, the level of safety in the operation of gas-cylinder vehicles increases, maintenance processes become more transparent, and the possibility of preventing accidents is created.

The newly developed control system differs from previous analogues in the following aspects:

- Fully automated control - the ability to collect and process data without human intervention.
- Real-time monitoring - continuous recording of data on the temperature, pressure, and condition of the cylinder.
- Energy saving - passive RFID tags and low-power sensors increase system efficiency.
- Integrated security system - the system works in conjunction with the GBA's electrical and mechanical protection modules.

Using this system, the GBA maintenance process is carried out in the following stages (Table 3) [9-15].

1. The balloon's serial number already exists.
2. The RFID EPC code belongs to the RFID Label attached to the balloon.
3. The body number refers to the vehicle in which the test gas cylinder is installed or is installed.
4. At the time of state registration of the test site, the identification number assigned to it already exists.
5. If the test is successful, OK, otherwise NOT OK is written.
6. The current date and time will be recorded automatically.
7. The expiration date is recorded.

- An UHF RFID Reader and antenna will be installed on the section.
- A Tampered RFID Label is attached to the gas cylinder being tested at the hydro-test site. This type of bottom is distinguished from others by the fact that it becomes unusable when pulled out. As a result, falsification is prevented.
- The system checks the Access Password of the UHF RFID Label before writing the above information to the server. This is also necessary to prevent falsification.

This system, along with increasing GBA security, increases the productivity of service centers by 25-30%, reduces human error, and allows for electronic control. Experimental analyses show that RFID tags can withstand heat up to 60^0C, humidity up to 95%, and wind speeds of up to 10 m/s. This ensures stable system operation under maintenance conditions.

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