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ANALYSIS OF THE APPLICATION OF MODERN MEANS OF DETECTION AND MEASUREMENT OF CARBON MONOXIDE WHEN USING ALTERNATIVE SOURCES OF ELECTRICITY SUPPLY DURING THE WAR IN UKRAINE

The article examines the impact of carbon monoxide on the human body, as well as the necessity of its detection and measurement. Carbon monoxide poisoning is very dangerous for human health and is accompanied by negative consequences and requires the implementation of new means of its timely detection and measurement. The article identifies the main sources of carbon monoxide, as well as assesses its impact on public health. The choice of modern means of detecting and measuring carbon monoxide is an important and necessary component of protecting people in modern realities. The work examines and analyzes the technical capabilities of modern capabilities of determining the level of carbon monoxide, defines the main models of carbon monoxide detectors, and also classifies and systematizes the peculiarities of their operation. The most convenient and practical portable carbon monoxide sensor. It does not require stationary installation. This is especially important in closed rooms, where carbon monoxide poisoning can occur instantly. The article analyzes literary sources in the field of the main types of alternative energy sources used in Ukraine during emergency and planned blackouts, as well as the dangers associated with them. The influence of dangerous and harmful factors affecting the human body during the use of these devices is considered: power banks, generators, batteries and inverters. The analysis of scientific research on ensuring safety when using alternative energy sources in domestic premises, private and multi-story buildings, factories, underground passages and storages was performed. The features of each type of modern signaling devices are analyzed. Recommendations are provided for the selection of modern means of detecting and measuring carbon monoxide.

Keywords: carbon monoxide, gas alarm, protection, danger, poisoning, war, generator.

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АНАЛІЗ ЗАСТОСУВАННЯ СУЧАСНИХ ЗАСОБІВ ВИЯВЛЕННЯ І ВИМІРУ ЧАДНОГО ГАЗУ ПРИ ВИКОРИСТАННІ АЛЬТЕРНАТИВНИХ ДЖЕРЕЛ ЕЛЕКТРОПОСТАЧАННЯ ПІД ЧАС ВІЙНИ В УКРАЇНІ

В роботі розглядається вплив чадного газу на організм людини, а також необхідність застосування засобів його виявлення і виміру. Отруєння чадним газом є дуже небезпечним для здоров'я людини та супроводжується негативними наслідками і потребує впровадження нових засобів його своєчасного виявлення і виміру. В статті визначено основні джерела чадного газу, а також оцінено його вплив на здоров'я населення. Вибір сучасних засобів виявлення і виміру чадного газу є важливою і необхідною складовою щодо захисту людей в сучасних реаліях. В роботі розглянуто та проаналізовано технічні можливості сучасних засобів визначення рівня чадного газу, визначені основні моделі сигналізаторів чадного газу, а також класифіковані та систематизовані особливості їх роботи. Найбільш зручний і практичний переносний датчик чадного газу. Він не вимагає стаціонарної установки. Особливо це важливо в закритих приміщеннях, де отруєння чадним газом може наступити миттєво. У статті проведений аналіз літературних джерел в області основних видів альтернативних джерел енергії, які використовують в Україні під час аварійних та планових відключень світла, а також небезпек, які з ними пов'язані. Розглядається вплив небезпечних та шкідливих чинників, які вражають організм людини під час користування цими приладами: повербанки, генератори, акумулятори та інвертори. Виконано аналіз наукових досліджень щодо забезпечення безпеки при використанні альтернативних джерел енергії в побутових приміщеннях, приватних та багатоповерхових будинках, на підприємствах, у підземних переходах та сховищах. Проаналізовані особливості кожного типу сучасних сигналізаторів. Надані рекомендації щодо вибору сучасних засобів виявлення і виміру чадного газу.

Ключові слова: чадний газ, сигналізатор, захист, небезпека, отруєння, війна, генератор.

Introduction. From the very first hours after the invasion, Russian troops have been massively shelling not only Ukrainian cities and towns, but also trying to destroy critical energy infrastructure facilities: high-voltage networks, transformer substations, control centers, as well as directly power plants, including renewable energy facilities. In general, after nuclear energy facilities and power lines, renewable energy power plants became the second priority of destruction for the Russian invaders [1]. Therefore, there was a need for additional alternative sources of energy, both for factories and for ordinary users.

Until recently, many did not even think about what it is, and today alternative energy sources could be found literally at every step. Ukrainians buy not only the usual power banks, but also install generators, batteries and inverters in houses and even apartments.

At the same time, many people ignore the safety rules using such devices. They could harm not only the owners of the units, but also anyone around them, as it creates a real danger. The main health hazard comes from the combustion products which are produced during operation – carbon dioxide or carbon monoxide

Analysis of recent research and publications. The relevance of this topic is due to the growing number of carbon monoxide poisonings due to constant power outages caused by military actions on the territory of Ukraine, solving the problem of its impact on people's health.

In Lviv in January 2021, the number of cases of carbon monoxide poisoning doubled compared to January 2020. In 2021, there were 30 cases, 10 of them among children. In 2020, significantly less. In January 2021 – 2 deaths. There were none in 2020 [2, 3].

In 10 months of 2022, 72 patients with signs of carbon monoxide poisoning came to the Lviv Regional

Clinical Hospital. 61 patients, during stay in the admission and diagnostic departments, received hyperbaric oxygenation and after stabilization of the condition were discharged home. Three patients were referred to the cardiology department because they had concomitant cardiovascular diseases, and two more needed a stay in the intensive care unit. The remaining patients had mild symptoms.

In total, since the beginning of the year, 75 cases of carbon monoxide poisoning have been recorded in Lviv region; 174 people were injured (including 56 children), 13 of them died (including 3 children). [4]. In December 2022, eighteen residents of the Ivano-Frankivsk region were poisoned by carbon monoxide, five of whom were children.

In January 2023, 23 people from the Ivano-Frankivsk region were poisoned by carbon monoxide. Including 9 children [5]. During two winter months in Ukraine: (December 2022 and January 2023), more than 800 cases of carbon monoxide poisoning were recorded [6]. Against the backdrop of power outages in Ukraine, the number of people who have been poisoned by carbon monoxide and died as a result of such poisoning increases. The biggest number of such cases were recorded in Lviv, Kyiv, Dnipropetrovsk, and Kharkiv regions [7]. If there were an access to fresh air and gas analyzers – this would not have happened. Each generator produces, on average, the amount of carbon monoxide equivalent to 450 cars. It has no smell and color, so it is strictly forbidden to place the installation in a living room.

Formulation of the problem. The current situation in Ukraine with the war unleashed by the Russian authorities has proven that the use of alternative energy sources is a vital necessity. They play a very important role in preserving the life and health of the population during attacks on critical infrastructure, but at the same time they are also a source of danger. The analysis of this situation showed that it is necessary to pay attention to solving the following problems:

- identify the main sources of carbon monoxide;
- assess the impact of carbon monoxide on public health;
- analyze and classify the means of detection and measurement of carbon monoxide in domestic premises, private and multi-story buildings, at factories, in underground passages, storage facilities;
- provide recommendations on the selection of modern means of detection and measurement of carbon monoxide.

The goal of the work. Determination of sources of danger of carbon monoxide and analysis of the main means of detection and measurement of carbon monoxide for the protection of the population, and determination of the most effective of these means.

Research materials and methods. Analytical review of scientific publications and databases of international safety standards.

Presenting main material. Carbon monoxide is a product of incomplete combustion of carbon. If there is no access to oxygen in the room or there is faulty ventilation, then CO can accumulate in the room and cause people to be poisoned.

Symptoms of carbon monoxide poisoning include: headache, dizziness, fatigue, breathing difficulties, shortness of breath, dry cough, nausea and vomiting, feeling of fatigue, dizziness and confusion, convulsions, loss of consciousness [8]. The presence of high concentrations of carbon monoxide in the air can cause both acute and chronic poisoning. Even low concentrations of CO (0.1%) in the air can lead to exhaustion, when a person, even after noticing the danger, is no longer able to save himself; loss of consciousness occurs, and as a result – death. In the human body there are red blood cells – erythrocytes, their function is to transport oxygen, which occurs due to the content of hemoglobin in the erythrocyte. The danger of carbon monoxide is that it is closely related to hemoglobin. And when it enters the body, it replaces hemoglobin and forms a compound – carboxyhemoglobin. Instead of oxygen, carbon monoxide is transported, and thus adequate gas exchange and oxygen saturation of tissues does not occur, poisoning of the body occurs [9, 10]. The gas is invisible - it has no color, smell and taste, so it is impossible to realize whether it is accumulating in the room. There are special devices – carbon monoxide detectors that detect carbon monoxide in the air. This is actually the only way to know that gas is building up.

In general, according to the US Consumer Product Safety Commission, between 2005 and 2017 in the country, more than 900 people died from carbon monoxide poisoning associated with portable generators, more than 15 thousand people went to emergency departments for the same reason [11]. Our fellow citizens also have similar experience. Studies show that carbon monoxide poisoning from portable generators can actually take more lives than natural disasters.

Even a few days or weeks after poisoning, there is a risk of developing psychoneurological diseases. However, a dangerous dose of carbon monoxide can be obtained not only from the generator, but also from other devices that work on fuel. Therefore, there is a great need for timely detection and measurement of carbon monoxide concentration. For this purpose, carbon monoxide detectors are used to protect people from exposure to carbon monoxide. There are wired and wireless alarms on the market of Ukraine [12]. Wireless gas leak detectors are usually much more expensive than wired stationary ones. Every day, gas alarms are becoming more and more popular, and there are reasons for this. Since the gas is colorless and odorless, an alarm is installed in the places of its possible formation, which will warn in advance about the potential danger. Different gases have different weights, so the location of the gas leak sensor must take this into account. Given that carbon monoxide is lighter than air, the gas alarm should be placed closer to the ceiling. The carbon monoxide sensor detects the excess of the permissible limits of carbon monoxide content and displays the result on the LCD display. Carbon monoxide sensors from different manufacturers are supplemented with sound and light alarms [13]. Exceeding CO is

indexed by a sound and light red-blue signal. The higher the concentration of carbon monoxide, the more intense the warning sound (from intermittent to continuous). The most convenient and practical portable carbon monoxide sensor. It does not require stationary installation. This is especially important in closed rooms, where carbon monoxide poisoning can occur instantly. The main models of carbon monoxide detectors were analyzed by cost and type of gas (Table 1).

It is also necessary to take into account the features of each type of modern signaling devices (Table 2) [14].

Some generator models are also equipped with automatic shut-off valves that are activated when the carbon monoxide content reaches a certain threshold in the confined space.

Table 1. Models of carbon monoxide detectors

No	Model	Type of gases	Price, UAH (as of February 15, 2022)
1	Fuers White (JKD6021)	carbon monoxide	450,00
2	eMastiff (carbon monooxide – CO)	carbon monoxide	523,00
3	AQUA-WORLD XC-04	carbon monoxide	576,00
4	Security Strong JKD512-com	carbon monoxide and smoke	850,00
5	Gas alarm MAXI GROUP MAXI/C	methane or propane-butane and carbon monoxide	960,00
6	Straj S50BK	methane and carbon monoxide	1120,00
7	Straj S51A3K	methane and carbon monoxide	1210,00
8	Straj S50A3K	methane and carbon monoxide	1280,00
9	Gas alarm MAXI GROUP MAXI+K	methane or propane-butane and carbon monoxide	1300,00
10	Straj S51A3K(E)	methane and carbon monoxide	1325,00
11	Straj S51A2K	methane and carbon monoxide	1400,00
12	Straj S51A2K(E)	methane and carbon monoxide	1450,00
13	Ross СГБ-1-2	methane and carbon monoxide	1465,00
14	Straj S50A2K	methane and carbon monoxide	1470,00
15	Gas alarm Leleka-2 КСГ-IP-АС	methane and carbon monoxide	1499,00
16	Straj S50A2K(E)	methane and carbon monoxide	1525,00
17	Ross SGB-1-2B	methane and carbon monoxide	1957,00
18	Ross SGB-1-7	methane and carbon monoxide	2063,00
19	Ross SGB-1-7Б	methane and carbon monoxide	2455,00
20	Ross 2S50A4Q	methane and carbon monoxide	3100,00

Table 2. Features of the operation of carbon monoxide detectors

No	Feature	Explanation
1	Signal type	The best carbon monoxide detector has Smart control. All indicators are displayed on a smartphone or tablet. A signal about the threat of a gas leak will always appear on the mobile phone screen in time.
2	Management method	The smart- sensor will send a signal to the phone. In the settings of such devices, there are other functions – to start ventilation and a backup hood, to shut off the gas supply, to give a signal to the emergency service. Those gas leak detectors that do not have Smart control give a loud sound or light signal, some models have a flashing red light and a sound at the same time. In a properly functioning sensor, the signal strength increases if the risk of carbon monoxide poisoning increases.
3	Coverage area	This characteristic is always indicated in the instructions. The “weakest” devices sense gas on an area of 20–25 m^2. But they are easy to install, so they are ideal for a small room, garage basement and tent. In a large house, they are placed near stoves and fireplaces at the level of a meter from the floor. The most powerful indicators are relevant in private houses, at factories, in underground passages, warehouses.
4	Possibility of testing	It is always possible to check the carbon monoxide detector for serviceability.
5	Service life of indicators	This indicator is up to 10 years and depends on the manufacturer and the price of the device. The more expensive the detector, the longer it lasts. The cheapest sensors have a short service life – about 3 years.

Among the various types of storage batteries, special attention should be paid to the operation of automotive lead-acid power sources for domestic purposes.

First of all, this concerns the charging of car batteries, which is allowed only in a separate, non-residential, ventilated room.

Because different types of car batteries can release sulfur gas, hydrogen arsenic (arsine), hydrogen antimony (stybin), hydrogen chloride and other dangerous gases when charging.

It is better to charge such a battery in the garage or on the balcony. Otherwise, deadly toxins will definitely enter the body.

A car battery causes real harm to health in an apartment. The device emits hydrogen during charging. Also, an explosion can occur in the house due to the use of the device, if these gases - hydrogen and oxygen - are released in the presence of a spark.

In addition, it is strictly forbidden to connect any device whose power exceeds the rated power of the inverter to the car battery through the inverter.

This applies to most types of large-capacity household appliances, including refrigerators, room heaters, gas boilers, microwave ovens, washing machines, ovens, etc.

In the case of connecting high-power devices, the car battery can quickly become unusable, it can leak toxic electrolyte, which can also easily catch fire.

Conclusions.

1. Use only certified equipment as alternative energy sources;

2. Use generators only outdoors, at a distance of at least six meters from windows and doors;

3. If possible, do not use the generator continuously for more than three hours, be sure to turn it off for at least 30 minutes after three hours;

4. When using the generator as a protective device, a fire extinguisher is required;

5. To refuel the generator, use only high-quality fuel, different types of which cannot be mixed with each other;

6. Limit access to the generator for children;

7. Do not refuel the generator while it is running;

8. Be sure to install a carbon monoxide detector.

The choice of modern means of detecting and measuring carbon monoxide is an important and necessary component of protecting people in modern realities. The alarm must be reliable in operation and accurate in measurement. When using alternative means of energy supply, it is mandatory to install a carbon monoxide alarm, you can choose any model that is suitable for the price policy.

When choosing carbon monoxide detectors, one should take into account the model that would meet the stated tasks of gas leak control and controlled parameters of the air environment, taking into account first of all the reliability of the warning system and ease of use.

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