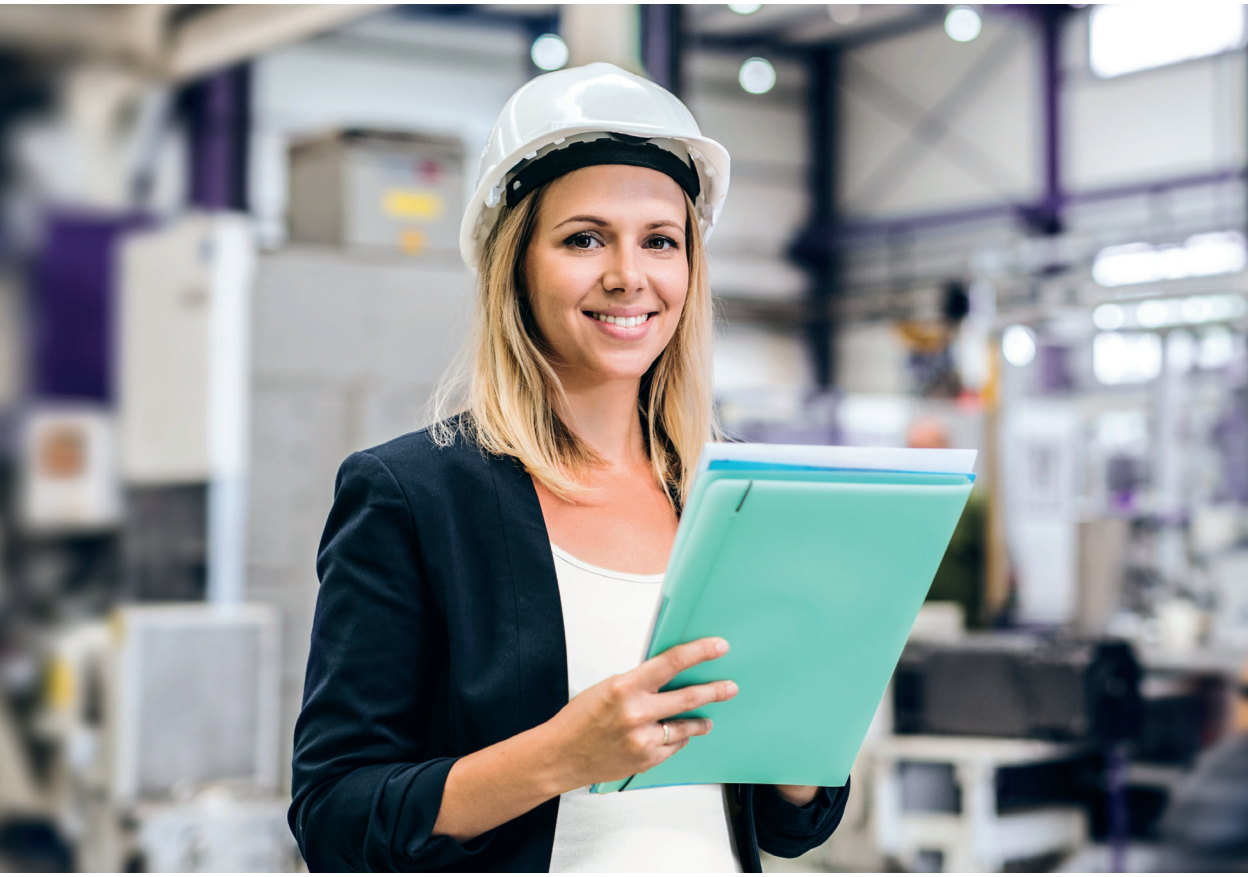
Kultura bezpieczeństwa

– dobre praktyki BHP

redakcja naukowa
MACIEJ PUCHAŁA



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KULTURA BEZPIECZEŃSTWA – DOBRE PRAKTYKI BHP

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Redakcja naukowa

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KATOWICE 2021

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SPIS TREŚCI

Marek Roszak, Tatiana Karkoszka, Ewa Jonda, Anna Kiljan, Aneta Kania, Monika Spilka, Piotr Sakiewicz

Bezpieczeństwo pracy a zagrożenia pandemiczne – rozwiązania systemowe i ich wpływ na ciągłość działania organizacji 7

Teresa Myjak

Organizacyjne czynniki wspierające równowagę praca-życie z moderującym wpływem sytuacji pandemicznej 37

Agata Krystosik-Gromadzińska

Bezpieczeństwo pracy marynarzy podczas pandemii Covid-19 49

Elżbieta Tarczoń

Problemy bezpieczeństwa pracy w sektorze opieki zdrowotnej 73

Małgorzata Tarczoń

Przyczyny występowania zjawiska stresu zawodowego wśród pracowników służby bezpieczeństwa i higieny pracy – wyniki badań własnych..... 97

Marcin Krause, Jolanta Malinowska-Borowska

Kompetencje pracowników służby bezpieczeństwa i higieny pracy – założenia oceny i doskonalenia 113

Krzysztof Słota

Przewietrzanie tuneli podczas ich drążenia w aspekcie poprawy bezpieczeństwa i zmiany przepisów dotyczących najwyższych dopuszczalnych stężeń gazów – studium przypadku 127

Anna Morcinek-Słota

Ocena ryzyka zdrowotnego związanego z zapyleniem na stanowisku sekcyjnego w kopalni węgla kamiennego 139

Zbigniew Słota
Założenia i wytyczne do dokumentacji bezpieczeństwa dla wyrobisk wykorzystywanych w celach turystycznych i rekreacyjnych w odniesieniu do nowego prawa geologicznego i górniczego 157

Grzegorz Walczyk, Wojciech Pakieła, Marek Roszak
Zagrożenia dotyczące bezpieczeństwa pracy w procesie spawania ferrytycznych stali nierdzewnych 173

Przemysław Widliński, Teresa Musioł, Marcin Krause
Adaptacja metody NPW V 5.1 do oceny postawy podczas pracy na stanowisku kosiarza w Zakładzie Zieleni i Małej Architektury HORTUS w Siemianowicach Śląskich 185

Krzysztof Niczyporuk, Marek Roszak
Wpływ opakowań na bezpieczeństwo użytkownika 203

Marcin Krause
Inżynieria bezpieczeństwa jako obszar nauki i kształcenia – stan aktualny oraz szanse i zagrożenia 217

Olena Bryhada
Features of labor safety during the operation of sewer networks 231

Olena Bryhada

FEATURES OF LABOUR SAFETY DURING THE OPERATION OF SEWER NETWORKS

Summary
The maintenance of drainage facilities during emergency repair or maintenance work is an important part of the life support of urbanized areas. The greatest danger during the operation and repair of sewer systems is posed by poisonous gases formed in sewers – hydrogen sulfide, methane, carbon monoxide, etc. Workers in sewer facilities must strictly adhere to occupational safety measures to avoid poisoning by harmful gases and death. However, as practice shows, during planned and emergency recovery work in sewer networks, fatal accidents occur worldwide every year. The paper characterizes the gassiness of sewer collectors in Kharkiv on the concentration of hydrogen sulfide and the danger of gas emissions from sewer shafts and wells for the urban environment. The main reasons influencing the state of injuries on sewerage networks include non-use or absence of personal protective equipment, safety and protective equipment, the unsatisfactory condition of ventilation systems in sewerage facilities; unsatisfactory organization of repair and emergency works on sewer structures, non-compliance with the requirements of labour protection instructions and performance of works with gross violations of occupational safety requirements; lack of training sessions at water supply and sewer enterprises, etc. To reduce injuries at sewer facilities, water supply and sewer workers should be provided with special means of communication, and in some cases, "personal alarms" to give a signal in case of immobilization. As means of individual protection, it is better to use not gas masks and oxygen respirators of various designs.

Keywords: work safety, sewage networks, injuries, sewage gases, work safety, sewage networks, injuries, sewage gases

Every year in Ukraine, during works in closed spaces (well chambers, collectors, sewer networks), there are injuries at water supply and sewer facilities, including fatal ones. People die due to lack of oxygen, poisoning by harmful substances. More than 80% of accidents in wells are due to the at least one poisonous gas. The causes of accidents are usually related to

violations of occupational safety requirements during work, underestimating the danger of workers in such places, failure to use personal protective equipment.

Poisoning by gases contained in the atmosphere of sewers in 50% of cases is fatal. Poisoning is received by workers of water utilities, checking the serviceability of pipelines or eliminating accidents, and bystanders and children who were inspired by gases and could not get out.

Gaseous emissions from sewer networks create environmental tensions in the surrounding urban areas. They pose a threat to public health, as the concentration of several sulfur-containing compounds of hydrogen sulfide, sulfur dioxide, mercaptan, dimethyl sulfide (DMS) exceeds the maximum allowable concentration for populated areas and working area [1, 2].

In order to obtain average indicators, probabilistic and statistical processing of data on the content of gases in the reservoirs of different areas of Kharkiv (Table 1). According to the data, the largest excess of maximum permissible concentrations is observed for sulfur-containing compounds--hydrogen sulfide and DMS [1-4].

Table 1. Chemical composition of the atmosphere of sewer collectors of the city of Kharkiv [4]

Compound	Concentration	Multiplicity of exceeding the maximum allowable concentration of the working area
CO, mg/m^3	0-25	1,4
CO_2, vol. %	0,1-3,5	-
CH_4, vol. %	0,2-6,0	0
H_2S, mg/m^3	0-300	30
SO_2, mg/m^3	5-10	0,5-1,5
NH_3, mg/m^3	0-5	0-0,4

Hydrogen sulfide (H_2S) – is one of the primary priority air pollutants. It is a colourless gas with a sharp characteristic odour, noticeable even in small concentrations. However, in high concentrations due to paralysis of the olfactory nerve, the smell of hydrogen sulfide is not felt, which is a potential danger to life. Hydrogen sulfide acts on the central nervous system, oxidative processes and blood, reducing the ability of blood to be saturated with oxygen [5]. In table 2 presents the symptoms of hydrogen sulfide poisoning and their consequences.

Table 2. Symptoms of hydrogensulfide poisoning [5]

Concentration H_2S, ppm	Symptoms of hydrogen sulfide poisoning and their consequences
0,01-0,3	odour threshold (highly variable)
1-5	Moderate offensive odor, may be associated with nausea, tearing of the eyes, headaches, or loss of sleep with prolonged exposure; healthy young male participants experience no decline in maximal physical work capacity
10	8-hour occupational exposure limit in Alberta, OSHA PEL; anaerobic metabolism threshold during exercise
20-50	conjunctivitis (eye irritation) and lung irritation. Possible eye damage after several days of exposure; may cause digestive upset and loss of appetite
100	eye and lung irritation; olfactory paralysis, the odour disappears
150-200	sense of smell paralyzed; severe eye and lung irritation
250-500	potentially fatal accumulation of fluid in the lungs (pulmonary edema), from the central nervous system headache, nausea, dizziness, especially if the effect is prolonged
500	Serious damage to eyes within 30 minutes; severe lung irritation; ''knockdown'' (sudden unconsciousness) and death within 4- to 8-hours; amnesia for period of exposure
1000	Breathing may stop within 1 or 2 breaths; immediate collapse

Modern ideas about the quantitative characteristics of air and water pollution in drainage networks are based on many of measurements and statistical processing of the obtained data [6-8].

According to observations, in different parts of the sewer network of Kharkiv, the concentration of hydrogen sulfide in the atmosphere of the under crownspace of pipelines varies significantly not only during the year (Fig. 1), over the previous seasons, but also during the season (quarter) – spring (Fig. 2), as well as quite dramatically during the day (Fig. 3).

Fig. 1. Dynamics of hydrogen sulfide concentration in the atmosphere of the under crown space in the collector sections of Kharkiv Tractor Plant (XTZ) [6, 7]

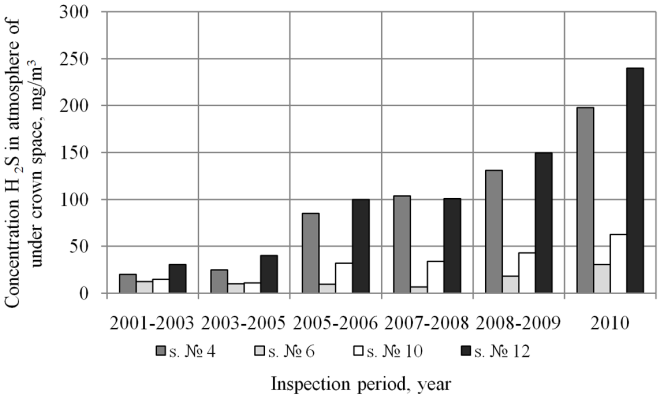


Fig. 2. Dynamics of hydrogen sulfide concentration in the atmosphere of the under crown space in the area of XTZ collector [6, 7]

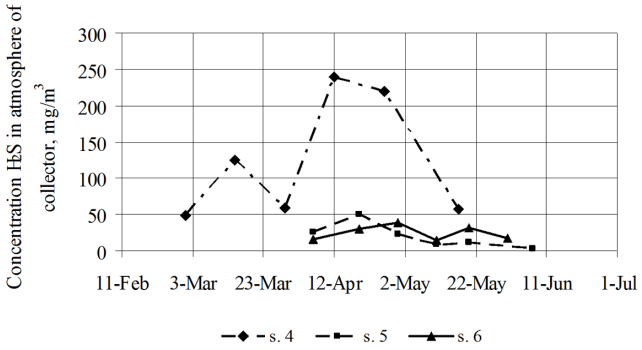
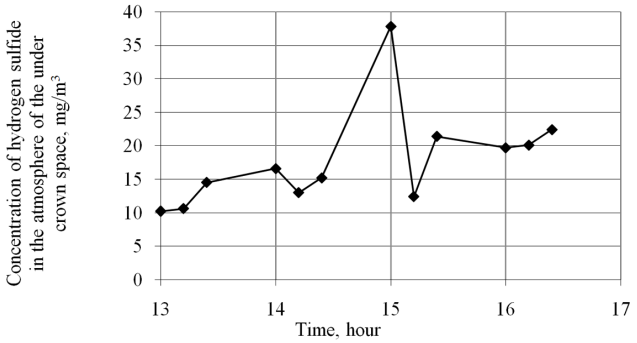


Fig. 3. Daily changes in hydrogen sulfide concentration in the atmosphere of the under crown space of Ivanivka collector (shaft № 5) [6, 7]



The dynamics of hydrogen sulfide concentration in the atmosphere of the undercrown space in the area of XTZ collector of the shaft № 4 of XTZ collector for the period from March to June varied from 47 to 240 mg/m ^{3}, i.e. by more than 400%. During the day, the hydrogen sulfide concentration in the atmosphere of the undercrown space of the shaft № 5 of Ivanivka collector varied from 7.9 to 37.8 mg/m^3, i.e. almost 400%. At all research sites, the concentration of hydrogen sulfide constantly exceeds the maximum allowable concentration of the working area, posing a threat to workers.

Every year with the onset of spring and summer in Ukraine and the world, there is a sharp increase in occupational injuries, including fatalities. Some statistics are below.

In June 2019, in the village of Skhidne of Bilozerka District of Kherson Region, due to poisoning by sewer, gases died two people who tried to eliminate the blockage in the sewer [9].

In June 2013, four employees of Communal Enterprise "Kharkivvodokanal" were poisoned by sewer gases and died during repair work on sewer facilities on Rudyka Str. (Fig. 4). The death occurred due to occupational safety and health rules violations because workers did not use seat belts and gas masks [10].

Fig. 4. Photo from the scene of the accident in Kharkiv, Rudyka s. [10]

In August 2013 in Sloviansk, at the intersection of Zhovtnevoi Revoliutsii Str. and Frunze Str., two workers died while cleaning of the sewer collector [11].

In July 2015, during the operation of the sewer pumping station in Sloviansk, Donetsk Region, the group accident occurred – three people were poisoned, one of them – deadly. On July 13, 2015, three workers died due to drowning while cleaning the sewer pumping station in Zolotonosha, Cherkasy Region [12].

In September 2015, 2 water utility employees were killed in Sevastopol, who fell into the sewer well without protective equipment for its cleaning due to suffocation by toxic fumes [13].

In June 2019, 7 people died while cleaning the sewer in the village of Fartikui in western India. The cause of death was poisoning by toxic fumes [14]. According to statistics, in 2017, every 5 days in India, 1 worker died while working in sewers, but it is believed that the real mortality rate is much higher [15].

In August 2019, in Rivne Region in Zorya Village, communal workers were poisoned by vapors from the sewer during the current works, one of them was not saved by medics [16].

In June 2015, the employee of the enterprise and two residents of the private house died in Novotroitsk housing and communal enterprise of Kherson Region while cleaning the sewer system in the cesspool of the private house [17].

In June 2019, in Pennsylvania (USA), two workers were killed during the inspection of drainage pipelines after poisoning by sewer gases [18].

Cases of poisoning with toxic gases in the sewer lead to multiple deaths since in such cases, employees instinctively try to help colleagues as quickly as possible and thus also die due to poisoning.

According to the State Labor Service of Ukraine on fatal accidents and group accidents in 2018, 6 accidents were registered at sewer and water supply companies, including 3 fatalities (4 people died). All fatalities occurred during the warm season (May and August 2018) [19]. In the cold season, there were 2 accidents – 4 people were poisoned by gases contained in sewer networks.

In June 2021, in Ternopil Region, two handymen were found in the sewer well without signs of life. The men died from gas poisoning while performing work related to flushing the septic tank sewer on the territory of the enterprise [20]. In July 2021, two employees of the communal enterprise in Cherkasy Region, during the routine examination of the sewer well, felt the deterioration in their health, fainted, and subsequently, doctors pronounced their death.

In 2019, 10 people, employees of water utilities, and 2 people were hospitalized during the elimination of emergencies or the entry of planned works on sewer pipelines. Many accidents occurred in spring and summer (May-August) [9].

Thus, about 75% of accidents occur from May to October, and the lowest number – in the winter. This is because most repair, adjustment, cleaning, and other types of work are carried out in the warm season when the ambient temperature rises sharply, and there is a more intense formation and release of toxic gases [21].

Analyzing the cases of death of water supply, and sewer workers during emergency, commissioning, construction, repair and other types of work, we can classify the main places of accidents (Fig. 5). It was found that most often, deaths at sewers occur due to gas poisoning (Fig. 6) [21].

Fig. 5. Distribution of accidents of water supply and sewer workers by location [21]

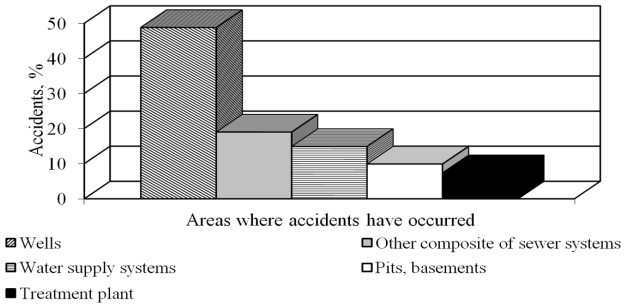
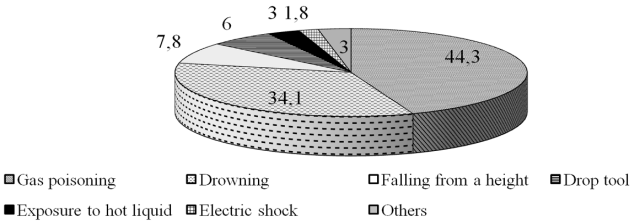


Fig. 6. Distribution of causes of accidents in sewer systems [21]



Analysis of foreign publications allows us to conclude that foreign experts also pay much attention to the problems of labour protection in sewers.

To prevent accidents, representatives of various enterprises and international labour protection organizations issue short reminder bulletins. For example, the Occupational Safety and Health Administration – OSHA, which deals with occupational safety and disease prevention, in 2016 published the bulletin "Best Practices to Guard Against Hydrogen Sulde in the Workplace", which contains the following questions [22]:

- sources of hydrogen sulfide and its derivatives;
- hydrogen sulfide concentrations and possible adverse effects;
- consequences of poisoning;
- methods and devices for determining hydrogen sulfide concentrations;
- personal protective equipment;
- first aid measures.

Other companies distribute similar products (newsletters, reviews, brochures) to raise awareness among employees and train employees [23-36].

In general, foreign experts note similar problems in labour protection during the operation of water supply and sewer [36, 37]: the danger of hydrogen sulfide and other gaseous compounds, lack of oxygen, psychological discomfort, viruses and bacteria, and so on.

Foreign experts also pay attention to the presence of toxic gases in the reservoirs, but they emit hydrogen sulfide and carbon monoxide and methane. Particular attention is paid to the distribution of these gases in the atmosphere of the collectors, as different gases accumulate at varying levels of sewers. During work, a person who has not descended deep enough may not smell hydrogen sulfide because it is heavier and lower, fatal. As means of personal protection in addition to gas masks, foreign experts recommend the use of oxygen respirators of various designs [31].

In some cases, the employee has a so-called personal alarm, which can give signals shortly after the person loses mobility (usually 20 seconds). Therefore, anyone entering the confined space should wear this particular device to ensure timely rescue [38].

The bulletin, published by the National Health and Safety Administration in Canada, proposes that gas monitors with audible alarms sensitive to low hydrogen sulfide levels should be installed [39].

Thus, analyzing all of the above, we can determine that the leading causes that affect the number of accidents in sewer networks -non-use or absence of personal protective equipment, safety and protective equipment, the unsatisfactory condition of ventilation systems in sewerage facilities; deficient organization of repair and emergency works on sewer structures, namely: admission to work of employees without appropriate training on labour protection, without registration of the order-admission, non-compliance with instructions on labour protection and work with gross violations of labour safety requirements; lack of training sessions at water supply and sewer enterprises, etc. The largest number of accidents at the enterprises of water supply and sewer facilities falls on sewer wells due to the high gas content of the latter. The leading cause of death in sewers – poisoning by so-called "sewer" gases – hydrogen sulfide, carbon monoxide, ammonia and methane.

The dynamics of gassiness of sewer structures in the city of Kharkiv was analyzed, and it was found that in almost all surveyed areas, the hydrogen sulfide content exceeds the maximum allowable concentration of the working area.

To reduce the incidence of injuries at sewer facilities, water supply and sewer workers should be provided with means of communication, such as walkie-talkies, and in some cases, "personal alarms" to signal in case of immobilization.

Work-related to the descent of workers into sewers and chambers is dangerous and requires caution and strict compliance with labour protection requirements. To prevent the death of workers and reduce injuries, comprehensive technical and organizational measures should be taken to ensure occupational safety during inspections and maintenance of the sewer system.

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CECHY BEZPIECZEŃSTWA PRACY PODCZAS EKSPLOATACJI SIECI KANALIZACYJNYCH

Streszczenie
Obsługa urządzeń odprowadzających wodę w trakcie przeprowadzania prac awaryjno-naprawczych lub eksploatacyjnych stanowi ważny element utrzymania terenów zurbanizowanych. Największe zagrożenie przy eksploatacji i naprawach systemów kanalizacyjnych stanowią toksyczne gazy powstające w kolektorach kanalizacyjnych – siarkowodór, metan, tlenek węgla itd. Pracownicy obsługujący instalacje kanalizacyjne powinni ściśle przestrzegać zasad bezpieczeństwa pracy, aby uniknąć zatrucia szkodliwymi gazami co może doprowadzić do wypadków śmiertelnych. Przy przeprowadzaniu zarówno prac planowych jak i awaryjno-naprawczych w sieciach kanalizacyjnych, co roku mają miejsce wypadki śmiertelne na całym świecie. W pracy scharakteryzowano zagrożenia dotyczące zagazowania kolektorów kanalizacyjnych pod względem stężenia siarkowodoru, w tym ryzyka emisji gazów z szybów i studni kanalizacyjnych dla środowiska miejskiego na przykładzie danych dla miasta Charkowa. Do podstawowych przyczyn wpływających na stan zagrożenia w ujęciach kanalizacyjnych można zaliczyć: niezastosowanie lub brak środków ochrony indywidualnej, brak wyposażenia w środki prewencyjne i ochronne, niezadowalający stan systemów wentylacyjnych w sieciach kanalizacyjnych, niestosowanie się do wymogów instrukcji ochrony pracy oraz wykonywanie prac z poważnymi naruszeniami wymogów bezpieczeństwa pracy; brak kursów szkoleniowo-treningowych w przedsiębiorstwach gospodarki wodociągowo-kanalizacyjnej itd. W celu zmniejszenia ilości potencjalnych zagrożeń i ich skutków w sieciach kanalizacyjnych, pracowników gospodarki wodociągowo-kanalizacyjnej należy wyposażyć w specjalistyczne środki łączności, a w szczególnych przypadkach w „osobiste sygnały alarmowe" do przekazywania sygnału w przypadku unieruchomienia. Jako środki ochrony indywidualnej zalecane jest stosowanie nie masek przeciwgazowych lecz tlenowych aparatów oddechowych

Słowa kluczowe: bezpieczeństwo pracy, sieci kanalizacyjne, urazy, gazy ściekowe, siarkowodór.

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