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ANALYSIS OF REASONS OCCURRENCE OF DANGEROUS SITUATIONS DURING THE OPERATION OF GAS STATIONS

Purpose. To identify the level of risk of dangerous events occurring at gas stations.

Materials and methods. To assess the risks of hazardous events at petrol stations, the "HAZOP" method and the "FMEA" method were chosen because they are well combined with each other and allow detailing each stage of the production process to identify hazards and the performance of the system, which is carried out by a specially selected team of five expert specialists.

Results. A risk management procedure at gas stations has been developed based on a combination of the "HAZOP" and "FMEA" methods, which allows to assume of the emergence of a possible scenario for the development of a dangerous event by keywords, as well as to assess the magnitude of priority risk, based on the possibility of detecting the occurrence of a discrepancy or threat. Four main scenarios of the occurrence of a dangerous event due to the inconsistency of the technical component of gas stations and the presence of errors and dangerous actions of operators are analysed. It has been established that the highest level of risk of a dangerous event – an explosion and fire at a gas station can occur due to leakage of connections and the accumulation of gasoline vapours in the dispensers.

Originality lies in the establishment of the relationship between different methods of risk assessment, which allows to determine the most probable scenario for the development of a dangerous event through a combination of various dangerous factors.

Practical value. Recommendations have been developed to reduce the probability of occurrence of a dangerous event of explosion and fire at a gas station due to the development of an improved risk management process based on a combination of well-known methods.

Keywords: risk, danger, threat, dangerous factor, gas station.

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АНАЛІЗ ПРИЧИН ВИНИКНЕННЯ НЕБЕЗПЕЧНИХ СИТУАЦІЙ ПІД ЧАС ЕКСПЛУАТАЦІЇ АВТОЗАПРАВНИХ СТАНЦІЙ

Мета. Встановлення рівня ризику виникнення небезпечних подій на автозаправних станціях.

Матеріали і методи. Для оцінки ризиків виникнення небезпечних подій на автозаправних станціях були обрані метод "HAZOP" та метод "FMEA", оскільки вони добре поєднуються між собою та дають можливість деталізувати кожен етап виробничого процесу для ідентифікації небезпек і працездатності системи загалом, що проводиться спеціально підібраною групою з п’яти фахівців-експертів.

Результати. Розроблено процедуру керування ризиками на автозаправних станціях на основі поєднання методів "HAZOP" та "FMEA", що дозволяє припустити формування можливого сценарію розвитку небезпечної події за ключовими словами, а також оцінити величину пріоритетного ризику, виходячи з можливості виявлення невідповідності чи загрози. Проаналізовано чотири основні сценарії настання небезпечної події через невідповідності технічної складової автозаправних станцій та наявності помилок і небезпечних дій операторів. Встановлено, що найбільший рівень ризику настання небезпечної події – вибуху та пожежі на автозаправній станції може статися через негерметичність з’єднань та накопичення парів бензину у колонках.

Наукова новизна полягає у встановленні взаємозв'язку між різними методами оцінювання ризику, що дає змогу визначити найбільш вірогідний сценарій розвитку небезпечної події через поєднання різних небезпечних чинників.

Практична цінність. Розроблені рекомендації із зменшення ймовірності настання небезпечної події – вибуху і пожежі на автозаправній станції завдяки розробці удосконаленого процесу керування ризиками на основі поєднання загальновідомих методів.

Ключові слова: ризик, небезпека, загроза, небезпечний чинник, автозаправна станція.

Introduction. The term "risk" symbolises a significant number of hazards and threats that can potentially affect the life and health of any employee [1, 2]. At the same time, each participant in the production or operational process has his own judgment regarding the level of risk from the danger of a particular phenomenon [3, 4], which forms his further behavior. In case of incorrect threat assessment, the probability of a dangerous event resulting from inappropriate risk perception increases. Unfortunately, in the qualitative assessment of risks, its perception is the result of the employee's interaction with the environment [5, 6], which is based, first of all, on the psychological assessment of the impact of dangerous factors associated with the work process [7, 8]. Hence, there is a need to form an appropriate attitude to the procedure for calculating occupational risks. This will increase the level of professional hygiene, especially at high-risk facilities, which include gas stations. Employees of gas stations are affected by a number of different physical, chemical, psychosocial, ergonomic hazards, as well as dangerous factors (human, technical, organisational, climatic). They increase the likelihood of a dangerous event and require an appropriate detailed analysis to avoid biased judgments about the level of risk and irresponsible behavior of employees, which depends on their perception. Therefore, the analysis of hazards, the justification of their impact on the safe operation of gas stations, the behaviour of employees, as well as the calculation and determination of appropriate safety factors is a topical task.

Purpose. To identify the level of risk of dangerous events occurring at gas stations.

Materials and methods. To assess the risks of hazardous events at petrol stations, the "HAZOP" method and the "FMEA" method were chosen because they are well combined with each other and allow detailing each stage of the production process to identify hazards and the performance of the system, which is carried out by a specially selected team of five expert specialists. The presented algorithm is based on the processes of assessing the severity of the consequences and the probability of occurrence of a dangerous event, which allows to determine the level of risk - acceptable or unacceptable.

Results. A risk management procedure at gas stations has been developed based on a combination of the "HAZOP" and "FMEA" methods, which allows to assume the emergence of a possible scenario for the development of a dangerous event by keywords, as well as to to assess the magnitude of priority risk, based on the possibility of detecting the occurrence of a discrepancy or threat. Four main scenarios of the occurrence of a dangerous event due to the inconsistency of the technical component of gas stations and the presence of errors and dangerous actions of operators are analysed. It has been established that the highest level of risk of a dangerous event – an explosion and fire at a gas station can occur due to leakage of connections and the accumulation of gasoline vapours in the dispensers.

Literary analysis. The analysis of scientific articles has shown considerable interest in assessing fire risks at gas stations [9, 10], since it is believed that fires and explosions have the greatest probability and severity of consequences due to large volumes of storage of motor fuel, features of technological processes associated with receiving, storing and dispensing fuel. Thus, in the paper [9], the authors proposed to use simulation modelling of time characteristics and effectiveness of preventive measures to establish the frequency characteristics of a fire and the expected size of possible consequences, but it does not take into account the possibility of injuries to gas station employees. This drawback was partially eliminated in the paper [10], where the authors considered the problem of assessing the risk of thermal damage to workers in the event of a fire. As a result, we built a mathematical model that allows us to quickly determine the dynamics of changes in the temperature field and predict the magnitude of risk based on this information. At the same time, there is no information that would allow determining the scale of the fire based on the characteristics of the gas station. The paper [11] considers scenarios for the potential consequences of severe man-made accidents at gas stations predicted as a result of universal method for studying the failure tree using, which allowed the authors to obtain a variety of combinations of events that can occur. At the same time, the authors did not operate with any statistical data that would allow them to calculate the level of risk of each scenario.

There are also works devoted to identifying the risk of occupational diseases in gas station workers. Thus, in the paper [12], calculations of non-oncological risk to public health from exposure to vapors of petroleum products are presented, which made it possible to determine the time of onset of negative changes in the people's bodies that are in the

affected area and calculate the level of risk. Also in this direction, work has been carried out [13] to study the consequences of the impact of gas stations on people's health on the assumption of the presence of a logarithmic relationship between the intake of a toxin and its reaction.

In general, the analysis shows that gas station employees are affected by

- physical hazards: noise as well as thermal radiation [14, 15]; it is noted that at gas stations the air temperature reaches up to 40.6 °C, and the noise level - 90 dBA; In addition, sources of artificial light radiation (fluorescent lamps) in the workplace can cause skin cancer [16];

- chemical hazards: studies [17, 18] have shown that such compounds as Cr, Cu, Pb, Cr and Zn, which are found in petroleum products, as well as in car exhaust gases, pose a significant risk of cancer for workers; in addition, gas station workers are often exposed to toxic petrochemicals, including volatile organic compounds such as benzene, toluene, ethylbenzene, xylenes and methyl tertiary butyl ether, leading to a number of different occupational diseases (hematological, respiratory, reproductive, immunological, dermatological pathologies) [19, 20];

- psychological hazards caused by an imbalance between the tasks and skills (opportunities) of the employee [21, 22];

- ergonomic hazards: uncomfortable working posture, a lot of manual labour increase the likelihood of developing diseases of the musculoskeletal system [2, 23].

The analysis of the conducted studies showed a significant interest in identifying various threats and dangers at gas stations. At the same time, all the analysed publications do not allow to obtain a systematic approach risk management of the identified hazards, since they use a diverse scientific base for research. In accordance with the requirements of the 1993 Convention on the Prevention of Major Industrial Accidents, which is in force on the territory of Ukraine, the owner of a filling station is faced with the task of minimising the risks of major accidents by ensuring appropriate control over them and applying preventive measures, which is carried out on the basis of identification and analysis of hazards and risk assessment, based on the requirements of the ISO 31000: 2018 Risk Management standard. Hence, the task arises to develop an effective risk management procedure at a gas station, which takes into account all the dangers and dangerous factors that may arise during its operation.

The first step is to identify the hazards and operability of the gas station. To identify an undesirable event, we use a few guiding words of the "HAZOP" method (Fig. 2) [24].

For example, with a negative deviation: the guiding word: "no" - the process of discharging oil products is absent due to a logistical failure, or with a deviation of a quantitative modification: the guiding word "more" - an increase in air temperature. Directional words are also used to investigate potential hazards. For example, we analyse the technological nodes of the process until we exhaust all the possibilities of analysis. Then, the procedure moves to the next node, where we again search for potential hazards.

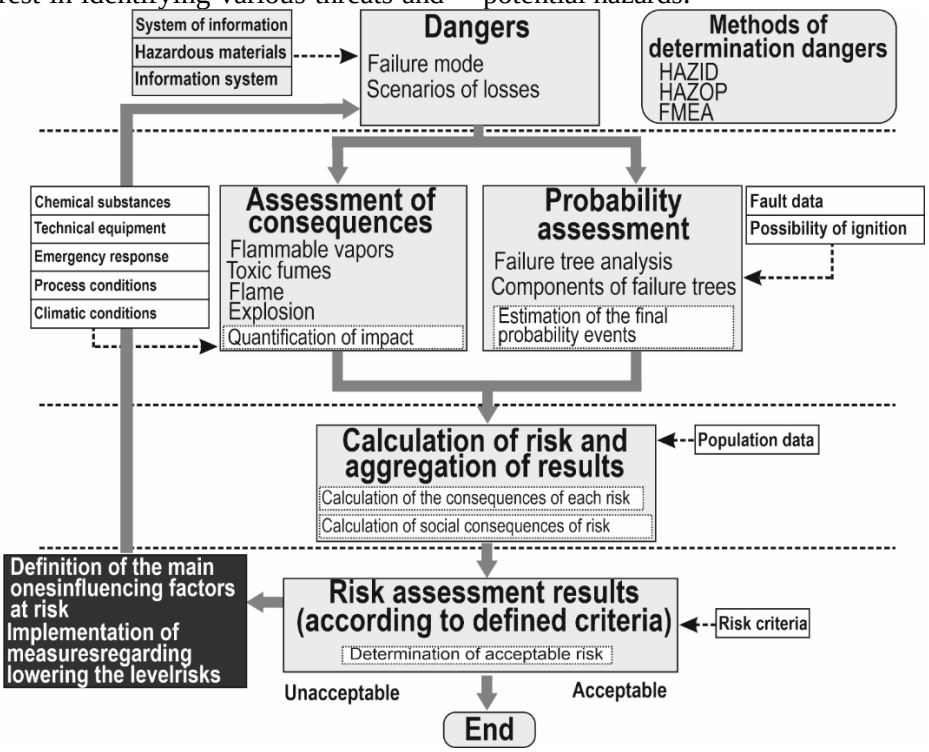

Figure 1 - Algorithm for assessing the risks of a dangerous event occurring

To do this, we study the causes of already known incidents, study reports and articles that describe the factors that lead to complete or partial disability of technological equipment in accordance with the declared results and working conditions.

The analysis of the failure rate was made on the basis of estimates of the probability of negative scenarios that were caused by dangerous situations. Moreover, the frequencies were synthesised using an evaluation scale, based on the determination of combinations of failures and circumstances that may arise during the operation of the gas station.

To determine the consequences, statistically assessed results of the target population were used in terms of the risk of deterioration in the level of safety or health, the economic component, as well as the occurrence of an emergency. Impact assessments were made in accordance with the risk assessment matrix (Table 1). The proposed protective barriers to prevent the implementation of certain consequences of the identified risks were based on the current possibilities of industrial progress.

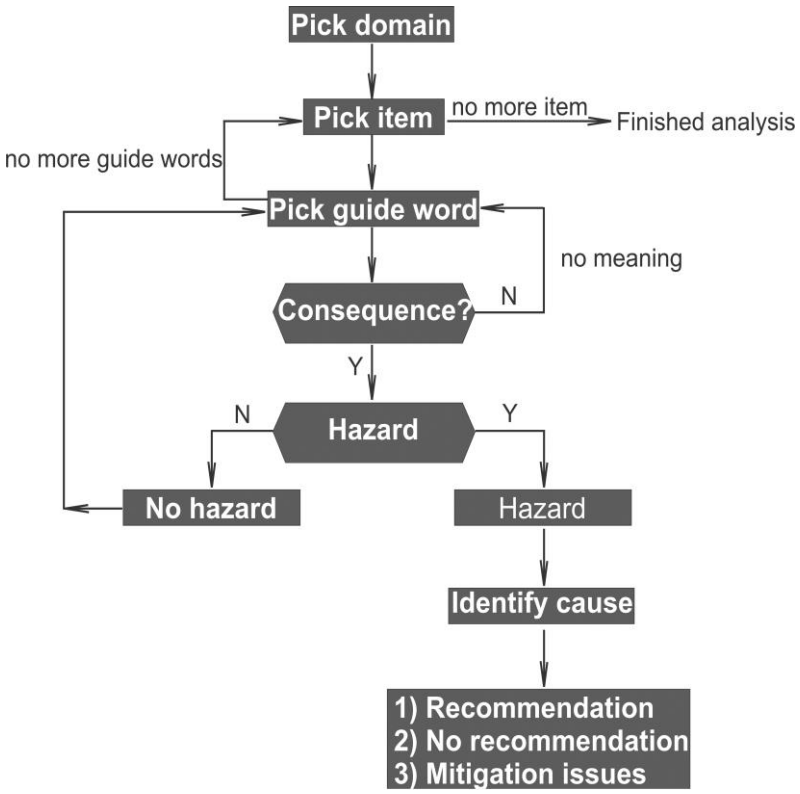

Figure 2 - Algorithm of actions during the assessment by the "HAZOP" method [24]

Table 1

Risk assessment matrix

Risk Classification		**Frequency**				
Matrix		**Unlikely**	**Remote**	**Casual**	**Likely**	**Frequent**
Severity	Catastrophic	Moderate	Moderate	Hight	Hight	Hight
	Critical	Moderate	Moderate	Moderate	Hight	Hight
	Average	Low	Moderate	Moderate	Moderate	Hight
	Moderate	Low	Low	Moderate	Moderate	Moderate
	Low	Low	Low	Low	Moderate	Moderate

The next step is devoted to the quantitative assessment of the risks that arise during the operation of gas stations. To do this, we will use the algorithm of the "FMEA" method, which allows, on the basis of the application of organisational, logical and mathematical-statistical procedures, to calculate the rank of priority of the occupational risk of disabling a dangerous situation based on three indicators of the severity of consequences (S), the probability of failure/incident occurrence (O) and the possibility of detecting a defect that is associated with or without a dangerous action (D). The last indicator is also related to determining the impact of the employee's psychosocial state on the occurrence of human

mistake - a dangerous action or no action. According to the value of the risk rank, rational decisions are selected and substantiated, which are aimed at improving safety during the operation of gas stations. The actions of experts according to the algorithm of the "FMEA" method (Fig. 3) are described in detail in the standard [25].

The expert group (Table 2) assesses the three main occupational risk factors for the treatment of possible potential hazards: severity of consequences (S), probability of failure/incident occurrence (O) and detection of defect (D). The product of these components S, O and D allows us to determine the RPN value using the formula [25]:

$$RPN = S \cdot O \cdot D, \quad (1)$$

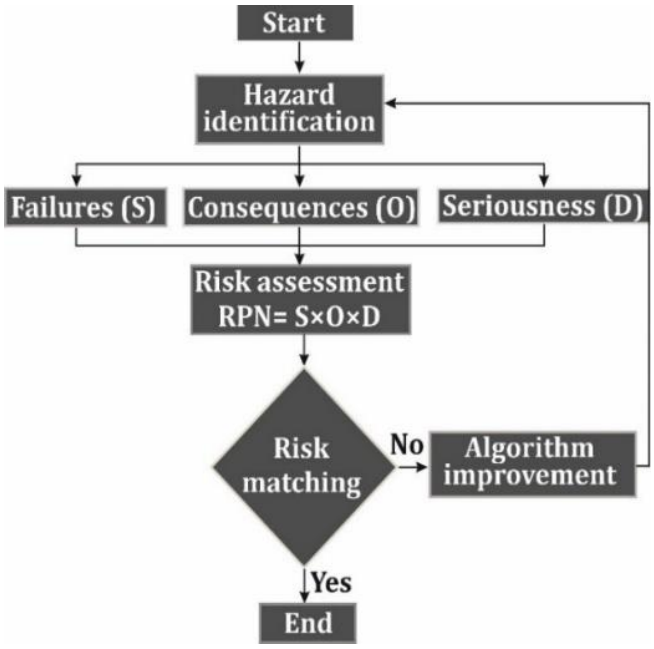

Figure 3 - Algorithm of actions for conducting risk assessment using the "FMEA" method [25]

Table 2

Data from experts who took part in the research

Information	Quantity
Number of experts	6
Work experience in transport logistics positions	from 10 to 14 years
Experts' education	higher in transport technology
Work experience	more than 10 years
Availability of an auditor's certificate for quality and safety management systems	Yes
Advanced training in risk assessment according to requirements [25]	Yes

The assessment of occupational risk, which is obtained by the algorithm of the "FMEA" method, continues until the RPN value is fully identified, which indicates the highest values of the value of occupational risk. The most influential factors are those whose RPN value exceeds 150 points [25]. A scale from 1 to 10 is used to determine the severity of consequences (S), the probability of failure/incident (O) and the possibility of detecting a dangerous psychosocial condition (D), where 1 is the smallest value of the indicator, and 10 is the largest.

To process the results obtained, which were provided by experts and verify their emission estimates, the Grubbs criterion was applied:

$$G_{\max} = \frac{X_n - \bar{X}}{s}, \quad (2)$$

where X_n are the proposed expert assessments; $\bar{X}$ - the average value of the sample; S is the standard deviation.

Where it is necessary to calculate the expected value or the average value of the results obtained:

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i, \quad (3)$$

It is also necessary to calculate the standard deviation:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2}, \quad (4)$$

Using the provided formulas, we check for outliers in the maximum and minimum results of expert assessments under the condition that the indicator exceeds the critical value.

$$\begin{cases} G_{\max} \geq G_{n,\ 1-\alpha} \\ G_{\min} \geq G_{1,\ 1-\alpha} \end{cases}, \quad (5)$$

where α is the level of significance, which is determined in accordance with the requirements [25].

If this inequality is not met, the results of the assessments will be considered outliers that must be excluded. Moreover, for the experts who gave such an assessment, an explanation is made regarding the validity of their choice of points during the examination. Critical values of statistics are chosen based on the distribution law of the random variable. These values can be found for a normal distribution according to the requirements [26]. If there is suspicion of two outliers, an assessment of the set of results is conducted for Grubbs' two-sided outlier statistics.

Research results. Consider a gas station, which consists of the following buildings: the main building, fuel storage (storage tanks), the canopy and fuel dispensers. The gas station provides all the necessary functions for refueling, storing and dispensing fuel using the appropriate equipment. Gas stations contain hazardous substances — fuel (gasoline, diesel fuel), which according to the international rules for the transportation of hazardous substances (ADR) are classified as hazard class 3 — flammable liquids, as well as liquefied gas, which is classified as extremely flammable gas [27]. The main sources of danger associated with the occurrence of a dangerousevent - fire, vapor explosion are associated with the leakage of petroleum products, the accumulation of fuel vapors in the air of the working area, their spillage, which is associated with the equipment of the gas station where the fuel is located (stored and pumped) [28, 29].

In addition, hazards at gas stations include the solitary work of the operator at night, aggressive behavior of customers, as well as the use of hazardous chemicals by operators (contact of fuel with skin, contact with eyes, inhalation of fuel [30]). A preliminary analysis of the risks that affect the life and health of gas station employees using the HAZOP method made it possible to determine that among all the identified hazards, the most dangerous is the situation with the leakage of petroleum products and the accumulation of gasoline vapors in the dispensers. This requires a more detailed analysis of the process of acceptance, transportation, storage, release and accounting of oil and petroleum products at gas stations, which is convenient to carry out using the FMEA method, which, unlike other risk assessment approaches, will allow you to determine how reliably it is possible to identify a defect that will lead to a dangerous situation.

Analysis of the above risk assessment (Tables 1 and 2) shows that the most dangerous situation, which is likely to lead to an emergency, is

- accumulation of gasoline vapors in the dispensers in the presence of oil leaks due to leakage of joints;
- lack of a protective mechanism against fuel overflow;
- lack of control over static electricity;
- use of the wrong material for the pipeline, accumulating static, heat and lack of recovery;
- fuel leaks due to malfunctions.

It is these listed factors that lead to the probability of occurrence of a dangerous event, due to the high numerical values of the factors of severity of consequences and the ability to timely identify the first signs of the occurrence of a dangerous event.

At the same time, the RPN risk priority number is 176, which exceeds 150 points. According to experts, a significant reduction in RPN can be achieved by improving safety systems at gas stations, which will ensure regular detection of the main dangerous factors that increase the likelihood of a dangerous event, and in its case will reduce the consequences due to timely notification of the created dangerous situation. These include a system for automatic control of the explosion hazard of the gas environment in columns, systems for determining the concentration of gasoline vapors; detection of the level of electrostatics, provision of fire extinguishing, evacuation of staff, creation of a regulatory ventilation system; establishing clear lines of communication for emergency preparedness; ensuring that employees are trained in relevant safety knowledge daily.

Based on the analysis of the hazards that affect the life and health of petrol station employees, as well as the consequences of such impact (Table 3), the risk priority number was calculated for work at petrol stations, the results of which are shownin Table 4.

Table 3

An example of an analysis of hazards that affect the life and health of gas station employees, and their consequences

Parameter	Keyword	Hazards	Hazardous Event	Severity of Consequences	Probability	Risk	Preventive Actions	Reference
Tanks	More	Fuel leak Spillover of petroleum products, Accumulation of fuel vapors in the air of the working area Oil spills	1. Toxic effects of hazardous fumes 2. Creating a cloud of combustible vapors **3. Explosion** **4. Fire** 5. Exceeding the permissible pressure value in the tank	Life and health of gas station employees, complete or partial disability (IV)	D	H	Use of special protective equipment – grounding of the fuel tanker before starting the discharge. Using grounding in a discharge bath – all pipes are covered with sand At each fuel discharge, fire equipment is prepared to position "ready to use" - fire extinguisher (for 50 or 100 kg of powder)	[3, 23, 24]
Dispensers	More	Leakage of petroleum products Accumulation of gasoline vapors in the dispensers	1. Toxic effects of hazardous fumes 2. Creating a cloud of combustible vapors **3. Explosion** **4. Fire** 5. The tightness of the connections in the columns is broken		D	H	Ensuring regular diagnostics of the integrity of tanks and connected pipes Equipping tanks and connected pipes with devices for monitoring the pressure in the system	[24]
	Part	Energy			D	L		[2, 25]
Forecourt attendant	More	Aggressive customers' behavior	Experiencing stress		B	L L	Providing psychological assistance to employees to get out of stress Replacement of video surveillance with better quality at all gas stations	[23, 26] [24, 25]
	Other	One-man shift at night	Physical violence		B	L	The gas station is equipped with a communication system with a security company. An employee at a gas station presses security button 1 time per hour according to the instructions.	[27]
Employee	More	Hazardous chemical substance	Vessel explosion		B	L	Engineering design of the vessel, as well as tanks in the car, which do not allow filling the vessels by more than 85%, otherwise, when heated, the gas expands and the vessel may explode	

Table 4

Calculation of risk priority Number when working at a gas station

№	Type of object	Description and function of the object	Description of possible hazard	Description of possible cause of danger	Description of possible consequences	Calculating the Risk Priority Number				Preventive Measures
						S	O	D	RPN	
1	Dispenser	Double-sided fuel dispenser type Quantium 500 TU Tokheim), each of which is equipped with a coaxial filling hose with distribution nozzles with a capacity of 40 l/min. At the same time, one passenger car can be refueled on one side of the pump.	Accumulation of fuel vapors in the air of the working area	Displacement of gasoline vapors from the fuel tanks of cars when they are refueled	Deterioration of the employee's health, environmental pollution	4	5	2	40	1. Provide employees with portable gas analyzers 2. Ensure capture, removal and recovery of fumes generated during refueling
2			Spillover of petroleum products	Overfilling of fuel cars' tanks during refueling	Ignition of dispenser, car, burns	6	4	2	48	1. Stop refueling 2. Turn off the power 3. Absorb the spilled gasoline or cover it with sand
3			Fuel leak	Leaks of petroleum products from the dispenser, hoses and connections	Ignition of dispenser, burns, severe injuries	7	4	3	84	1.Turn off the dispenser. 2. Call the maintenance service. 2. Monitor the condition of the fittings and connections on the fuel dispenser hoses in shifts
4			Accumulation of gasoline vapors in the dispensers	The tightness of the connections in the columns is broken	Explosion of the fuel-air mixture, car fire, burns, serious injuries	7	4	7	176	1. Equip the dispensers with automatic explosion control and explosion protection
5			Oil spills	Accidental spillage of petroleum products on the ground	Ignition of dispenser, burns	6	3	3	54	1. Turn off the power 2. Absorb the spilled gasoline or cover it with sand
6	Tank	The tank is divided into three sections and is designed for storage of diesel fuel, gasoline and emergency drain: with a volume of 25 m3 for	Leakage of petroleum products from the tank	Leakage of the tank due to corrosion	Contamination of groundwater and soil with petroleum products	4	4	6	96	1. Call the emergency services 2. Clear the territory of the gas station from cars 3. Inform the management of the organization
7			Oil spills	Leakage and Spillover during fuel discharge	Ignition of spilled oil products, burns	6	3	3	54	1. Stop fuel discharge 2. Turn off the power 3. Absorb the spilled gasoline or cover it with sand

8			Exceeding the permissible pressure value in the tank	Safety valve failure to operate	Violation of the integrity of the tank, leakage of petroleum products, contamination of groundwater and soil	4	3	6	72	1. Call the maintenance service. 2. Check the condition of the safety valve at least twice a month 3. Equip with indicators of automatic control of excess pressure
9			Reducing the pressure in the tank below the permissible value	Safety valve failure to operate	Body deformation, oil leakage, groundwater and soil contamination	4	3	6	72	1. Call the maintenance service. 2. Check the condition of the safety valve at least twice a month 3. Equip with automatic vacuum control
10	Employee, Forecourt attendant	provides customers with services for refueling cars, preparing fast food and hot drinks; Work with cash desk, fuel discharge	Aggressive customers' behavior	Dissatisfaction with the quality of service, inadequate psychological state	Experiencing stress	4	3	6	72	1. Providing psychological assistance to employees to get out of stress 2. Replacement of video surveillance with better quality at all gas stations
11			One-man shift at night	Lack of opportunity for help from colleagues	Physical violence & stress	6	3	3	54	1.The gas station is equipped with a communication system with a security company. 2. An employee at a gas station presses security button 1 time per hour according to the instructions.
12			Vehicle collision	Inattention of pedestrians, and inattention of drivers	Traumatic brain injury, fractures, damage to internal organs	6	3	3	54	1. Development of a road marking plan 2. Installing Adequate Lighting and Fencing 3. Safety clothes for employees must be equipped with reflective stripes

It is important to note that the prioritisation of the priority risk number can be significantly increased when describing a scenario where there is no column recuperation system [31] that reduces the risk of explosion, especially at elevated temperatures. In addition, another problem that arises at gas stations is due to the emission of gasoline vapors and their inhalation by forecourt attendants, which leads to the development of various diseases (systemic inflammation of the lungs, kidneys, cardiovascular changes and even cancer), if poisoning does not occur immediately [32].

Discussion of research results. Risk perception consists of two main characteristics, the frequency of risk occurrence and the magnitude of possible loss [33]. However, experts assess these risk characteristics subjectively. Therefore, there are often situations with a decrease in possible consequences, which lead to underestimated risk assessments, which, accordingly, leads to erroneous decisions [34]. On the other hand, overestimating risk is also not acceptable since it increases the financial costs of additional security measures [35]. At the same time, as the risk analysis has shown, as well as the analysis of various studies, regarding the occurrence of dangerous situations [36] at gas stations, the main cause of incidents is the irresponsible behavior of operators (employees) [37], who often do not realise the full threat of the situation. Understanding the risk is the primary task, the solution of which will ensure the prevention of dangerous events. Hence, several main tasks arise. The first is related to the provision of continuous training of employees in the formation of risk-oriented thinking, and the second is the creation of such security systems that will reduce the influence of the human factor on decision-making in the performance of operational tasks.

Based on the analysis and the results obtained, it was recommended that the highest probability of a dangerous event is associated with the accumulation of gasoline vapors in the dispensers, which is confirmed by several similar studies due to explosions at gas stations. At the same time, in the analyzed works, this cause is considered separately, without considering other dangerous factors that can increase the probability of its occurrence of a dangerous event [38]. Therefore, there is a need to continue research on the interaction of several dangerous factors that can collectively significantly increase the likelihood of a dangerous event. Thus, there is potential for further research by collecting data on the effectiveness of various automated protection systems to detect various threats and their combination. In addition, to find out the relationship between occupational risk management and employee health, as a result of the study, it is necessary to assess their long-term impact on the development of certain diseases. To achieve this goal, other statistical methods focused on long-term management efficiency can be used in future studies.

Sometimes judgments are incomprehensible and cannot be quantified in numbers. Therefore, in these conditions, there is a need to use other methods for risk assessment [40]. In this study, the proposed approach evaluates only direct data in which the information and output exactly match each other. Unfortunately, they cannot assess the risk where the incoming and outgoing information do not directly affect each other, but only through certain intermediate events.

Conclusions. A risk management process at gas stations has been developed based on a combination of the "HAZOP" and "FMEA" methods, which allows to assume the emergence of a possible scenario for the development of a dangerous event by keywords, as well as to estimate the number of priority risk, based on the possibility of detecting the appearance of a discrepancy or threat. Four main scenarios of the

occurrence of a dangerous event due to the inconsistency of the technical component of gas stations and the presence of errors and dangerous actions of operators are analysed. It has been established that the highest level of risk of a dangerous event – an explosion and fire at a gas station can occur due to the accumulation of gasoline vapors in the dispensers and leakage of connections. Recommendations have been developed to reduce the probability of occurrence of a dangerous event of explosion and fire at a gas station through the development of an improved risk management process based on a combination of well-known methods.

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