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TECHNOGENIC SAFETY OF GRAIN-PROCESSING ENTERPRISES

Abstrakt

The article deals with the issue of technogenic safety of grain-processing enterprises. The legislative background of this issue is considered – the laws of Ukraine, regulatory legal acts.

The grain-processing industry contains a significant number of high-risk objects, potentially hazardous objects, where high-risk works are carried out.

The most common emergencies and accidents found in the grain-processing industries are those related to the explosion and fire hazard. The factors of fire and explosion and the fire hazard of enterprises for storage and processing of grain raw materials are given. The potential sources of ignition of grain raw materials and grain products, the causes of explosions of the dust air, gas-air or hybrid mixtures are specified. The list of the most common places and reasons for the ignition sources and explosions in technological structures and buildings, and the ways of flame propagation are given. The main dangerous factors that arise in the accident and the most fire-dangerous buildings of the grain-processing industry are presented.

The grain-processing enterprises carry out high-risk works, which are covered by the special requirements, observance of which protects against accidents, but the level of occupational injuries, including those with deadly repercussions, remains high in the agro-industrial complex of Ukraine. One of the main causes of accidents resulting in death is the lack of permits for the execution of works and operation of equipment, machinery, mechanisms and high-risk objects. The works for the fulfilment of which the employer must have permission to hazardous work and the operation (use) of high-risk machines, machinery, equipment or declaration conformity of the material and technical resources to the requirements of occupational safety legislation are defined.

The analysis of the hazards of grain-processing industry enterprises helps to identify all possible emergencies and accidents. This is a compulsory procedure for the emergency response plan.

The plans for localization and liquidation of the consequences of accidents in high-risk objects are developed for adjustment and coordination of the actions of the authorities and civil defence forces of the enterprise, institution, organization, which owns or uses at least one high-risk object in case of threat or occurrence of emergencies. The plans are developed and approved by a legal entity or an individual, which owns or uses at least one high-risk object, as well as enterprise, institution or organization that plans to operate or operates at least one high-risk object.

Key words: grain-processing industry, technogenic safety, high-risk objects, potentially hazardous objects, hazardous works, emergency response plan.

One of the components of the national security of Ukraine is the prevention and liquidation of technogenic emergencies in order to preserve life and health of people and ensure the sustainable development of the state. Today, the intensive development of the man-made objects generates a number of dangerous factors that can negatively affect people and the environment. The main regulatory documents defining the legal, economic, social and organizational fundamentals of activity related to the high-risk objects, protection of life and health of people and the environment from the harmful affect of accidents on such objects and preventing their occurrence, limitation and liquidation of consequences, are the Law of Ukraine "On high-risk objects" dated 18.01.2001 No. 2245-III [1], Civil Protection Code of Ukraine [2] approved by the Supreme Soviet of Ukraine on October 2, 2012 No.5403-VI, Procedure for the development of activity plan of unified state civil protection system [3] approved by the resolution of the Cabinet of Ministers of Ukraine on August 9, 2017 No. 626.

The Civil Protection Code of Ukraine (2013) interprets the notion of technogenic safety as the absence of the risk of accidents and/or disasters in potentially hazardous objects, as well as business entities, which can create a real threat of their occurrence. Technogenic safety characterizes the state of protection of the population and territories from technogenic emergencies, and its assurance is a special (specific) function of protecting

population and territories from emergencies. The Article 52 of the Civil Protection Code explains that requirements for compliance with technogenic safety must comply with the norms of protection of population and territories from emergency situations, ensuring sanitary and epidemiological welfare, environmental protection, ecological, fire and industrial safety, labour protection, construction, as well as requirements of the national standards, and the requirements for compliance with technogenic safety shall be developed by the central executive authorities, local state administrations, business entities in accordance with their competence on the ground of this Code and other laws [2].

According to the Rules of technogenic safety (2018), the assurance of technogenic safety is a set of actions of the authorities, business entities, managers (owners) and responsible persons of objects aimed at preventing accidents, incidents and emergency situations of technogenic nature in hazardous objects and hazardous areas [4].

The sources of hazard of the occurrence of technogenic emergencies on grain-processing industry facilities include the potentially hazardous objects and high-risk objects; buildings and structures with breached operating conditions; business entities with a critical state of production assets and breached operating conditions [2].

It should be recalled that high-risk object (HRO) is an object, where one or more hazardous substances or



categories of substances are used, manufactured, processed, stored or transported in quantities equal to or exceeding the prescribed threshold masses, and as well as other objects, which according to the law constitute a real threat of technogenic or natural accidents. The potentially hazardous object (PHO) is an object, where hazardous substances, biological preparations can be used or manufactured, processed, stored or transported, or other objects which can create a real threat of an accident in certain circumstances.

A detailed list of HROs and PHOs, emergencies and accidents of grain-processing enterprises contains a joint decree of the Ministry for Emergencies and Affairs of Population Protection from the Consequences of the Chernobyl disaster and the Ministry of Agrarian Policy of Ukraine "On Approval of the Regulation on the Development of Emergency Localization and Response Plan of grain and grain product storage and processing facilities, which to date is invalidated by the Decree of the Ministry of Internal Affairs No. 1098/352 dated 10.09.2015, but remains yet information-bearing document, where one can find information about grain processing enterprise facilities, which require the technogenic safety [5].

The main HROs and PHOs of grain-processing enterprises include:

- reception and release devices for acceptance and release of plant raw materials;
- grain storage sections of elevators, silo-type warehouses, metal bunkers and warehouses for bulk storage, and conveyor galleries;
- workshops, departments, block-modular and aggregate plants for the production of flour, grouts, malt, mixed fodders and feed mixes, seeds and corn-processing plants;
- preparatory, breaking, crushing compartments for cleaning, crushing of malt, grain, peeling of oilseed;
- compartments for unpacking, weighing, flour bolting, sugar grinding;
- grain drying plants, receiving-cleaning and drying-cleaning towers, workshops of wastes, dust, cleaning and sorting of sacks.

Sometimes, other HROs and PHOs that are not related to the main production are located on the territories of grain and grain product storage and processing enterprises, namely fuel and lubricant warehouses, gas and product pipelines, etc.

At the same time, the emergencies and accidents involving fire and explosion hazard are the most widespread in such production facilities.

The explosion-fire and fire hazard of grain raw materials storage and processing enterprises is characterized by the presence of the following factors [5,6]:

- a large amount of combustible grain raw materials and their derivative products;
- the ability of the grain raw materials and their derivative products to create explosive air-dust, gas-air and hybrid (combined) mixtures and explode;
- tendency of grain raw materials to self-ignition or inflammation due to ignition source, the possibility of self-burning after its removal;
- high energy loading of industrial equipment;

- self-heating of grain raw materials as a result of vital activity of microorganisms and grain in the conditions of limited heat removal and high sorption capacity of the product. Nearly all types of plant raw materials are susceptible to self-heating, especially those under-dried;

- accumulation of explosive gas-air mixtures of carbon monoxide, methane and hydrogen during the self-heating process, preceding self-ignition of grain raw materials, the minimum ignition energy of which is much lower than for dust-air mixtures.

The fire hazardous properties of various types of grain raw materials are determined by their ability to ignite from foreign sources of ignition and to self-ignition, and to the explosion in a suspended state (in the state of gaseous suspension). The potential sources of ignition of grain raw materials and grain products, causes of explosions of dust-air, gas-air or hybrid mixtures may be:

- open flame;
- heated surfaces of structural elements, electric arc, sparks, droplets of molten metal during fire works;
- sparks from strokes or friction;
- heated surfaces of structural elements in case of a malfunction of equipment or penetration of metal objects into equipment, a spark in a faulty electrical equipment;
- static electricity discharges;
- sections of grain and grain products self-heating;
- high-temperature drying agents for grain, sections of ignition in grain dryers.

The most common places and causes of sources of ignition and explosions in technological facilities and buildings are:

- band-type bucket elevators - slipping, backward motion, buckling and deviation of a tape, disconnection and strokes of buckets on distorted pipes of band-type bucket elevators, wear of bearings of drive pulley or reduction gear shaft, penetration of foreign metal objects, static electricity discharges on tapes, violation of the Rules of safe operation of electrical plants (NPAOP 40.1-1.01-97) and the Rules for the construction of electrical plants. Electrical equipment of special plants (NPAOP 40.1-1.32-01) [7,8];
- turbo blowers (fans) - the penetration of foreign metal objects, wear of bearings, strokes and disconnection blades, violation of NPAOP 40.1-1.01-97 and NPAOP 40.1-1.32-01 [7,8];
- grain dryers - increased temperature of drying agent and plant raw material, malfunction of automatic controls; impurity of plant raw materials and equipment;
- air ducts (aspiration, gravity) and material pipelines (gravity flow, pneumatic transport) - static electricity discharges;
- silos and bunkers - storage of plant, grain raw materials and derivative products with high humidity and impurity, exceeding of storage terms, failure to take cleaning measures before loading, absence or malfunction of temperature and gas control devices, unloading of self-ignited grain and plant raw materials with violation of security measures;



- cyclones - the penetration of foreign metal objects, static electricity discharges;
- crushers - the penetration of foreign metal objects, disconnection of hammers, wear of bearings, pressing of plant raw materials, static electricity discharges, violation of NPAOP 40.1-1.01-97 and NPAOP 40.1-1.32-01 [7,8];
- roller machines - the penetration of foreign metal objects, rolls skewing, static electricity discharges, violation of NPAOP 40.1-1.01-97 and NPAOP 40.1-1.32-01 [7,8];
- mixers - static electricity discharges, the penetration of foreign metal objects, violation of NPAOP 40.1-1.01-97 and NPAOP 40.1-1.32-01 [7,8];
- filters - static electricity discharges.

Due to the presence of dust in equipment, transport communications and containers, industrial and auxiliary premises, the fire at grain-processing enterprises is distributed in the following ways:

- band-type bucket elevators, scraping transporters, gravity flows, pneumatic transport;
- shafts used for the passage of the band-type bucket elevators;
- open hatches of silos, empty silos in case of disconnection or absence of emptying funnels;
- ventilation and conducting windows between silos;
- not suppressed pipes, open holes of gravity flows, band-type bucket elevators and other equipment;
- air ducts of aspiration, air heating and ventilation, ventilation shafts and dust aspiration shafts;
- openings in ceilings, partitions, door openings, mounting holes, screw holes;
- conveyor galleries and tunnels connecting separate industrial buildings, release and reception devices.

The main dangerous factors that arise in case of an accident are:

- open flames and high-temperature explosive combustion products;
- fragments in the destruction of equipment, building structures and constructions;
- excessive pressure in the explosion zone and adjacent areas;
- explosive (shock) waves;
- environment not suitable for breathing.

By the way, the risk of technogenic emergencies is increased with the use of obsolete fire safety systems, which are still used in a number of enterprises in this industry. Installation of more advanced equipment and modern automatic fire protection systems can increase the reliability of the enterprise, but the fires occur even at such plants. Compliance with fire safety requirements on grain dryers is very relevant. The most common causes of fires according to the State Emergency Service of Ukraine are:

- personnel mistakes during the operation of grain dryers, therefore the constant supervision of the operation of equipment is required, as well as training on personnel actions in case of emergencies;
- violation of the temperature conditions of drying;

- untimely and low-quality cleaning of dryers from accumulated debris;
- untimely emptying of grain dryers (the emergence of ignition cells);
- low-quality grain cleaning;
- combustion of the material of the casing of dryers;
- low quality of the material of which the elevators are made.

In case of an emergency situation on grain dryers it is necessary to carry out actions in the following order: detection of ignition - cooling - unloading. By means of automatic devices, one can control the unauthorized increase in the temperature of the dried product. There are also emergency cooling systems that can be turned on automatically or manually. In addition, equipping of grain dryers with emergency exits will only increase their explosion and fire safety.

Besides the ones listed above, silos and bunkers are also the most explosive. Often, they are directly connected with band-type bucket elevators, crushers and other explosive equipment. In case of an explosion in a silo, the formation of a shock wave and the release of significant volumes of an explosive mixture, flame and combustion products into the production premises are possible, resulting in further explosions and the destruction of silos. The destructive force of the explosion is multiplied in the case of connection of silos between themselves by ventilation and conducting windows.

In the case of explosive combustion of a dust-air mixture, air-gas or hybrid mixture in enclosed volume in a deflagration regime, the pressure may increase from 700 to 900 kPa, which exceeds its permissible value for equipment and structures more than 10 times, and for structures of the buildings - more than 140 times. The striking effect of the shock air wave is determined predominantly by excessive pressure at the front and in the compression area, the time of affect and the velocity of the wave front motion. Industrial buildings suffer serious damage at a pressure of a shock wave front of more than 5 kPa.

The degree of injury to people is affected by the amount of excessive pressure of the wave front and the speed of movement of the compression area. The gaseous products of explosive combustion of gaseous suspensions of organic dust have a temperature of over 1000°C. Direct thermal action of explosive combustion products causes burns of various degrees. The severe injuries are caused by inhalation of high-temperature toxic gases formed in case of an explosion.

The combustion of structures of industrial buildings and structures of raw materials and finished products due to the action of flames of burning gaseous suspensions can cause the development of a fire, resulting in additional material damage and other severe consequences.

Human trauma can occur in case of destruction of industrial equipment, buildings, structures, in the dispersion of fragments and remains of equipment, building structures and constructions, in case of crash of coatings, ceilings and walls of the buildings.

Approximately a quarter of workers on grain-processing and grain-storage enterprises are involved in



execution of hazardous works covered by special requirements, compliance with which protects against the accidents [9].

The level of occupational injuries, including those with deadly repercussions, remains high in the agro-industrial complex of Ukraine. The main causes of accidents resulting in death is the unsatisfactory technical condition of production facilities and means of production, violation of traffic safety rules and safety requirements during vehicle operation, non-compliance with the requirements of labor safety regulations, lack of permits for work and operation of equipment, machinery, mechanisms and high-risk objects in accordance with the Procedure for issue of permits for the execution of works and operation (use) of machinery, mechanisms and high-risk objects high risk work and for the operation (application) of high-risk machines, mechanisms, and equipment, approved by the Cabinet of Ministers on 26.10. 2011 No. 1107 [11].

The permit is given to the employer and the manufacturer or supplier of high-risk machines, mechanisms, and equipment.

The permit is given to the employer:

- for execution of hazardous works or for operation of high-risk machines, mechanisms, and equipment - technical inspection, tests, expert examination (technical diagnostics), assembly, disassembly, configuration, repair, maintenance, reconstruction of high-risk machines, mechanisms, and equipment - systems for natural gas supply to the entities. The types of hazardous works also include gas hazardous work and works in explosion-hazardous areas and gas-flaming works;

- technological equipment of oil-fat, food, processing industries;

- equipment and protective systems intended for operation (application) in a potentially explosive environment; steam and water heating boilers with a heat output of more than 0,1 MW;

- steam and hot water pipelines with a working pressure of more than 0,05 MPa and a heating temperature of more than 110°C; containers operating at pressure above 0,05 MPa.

The manufacturer or supplier of high-risk machines, mechanisms, and equipment is provided with permit for the use of high-risk machines, mechanisms, and equipment, if another form of assessment of its conformity, which is a mandatory requirement, is not established by technical regulations.

On the basis of the declaration of conformity of the material and technical resources to the requirements of occupational safety legislation, the hazardous works are carried out, namely:

- works performed at an altitude of more than 1.3 meters;

- training on the safety of workers of other business entities;

- work in bunkers, enclosed space (tanks, furnaces, pipelines);

- earthworks performed at a depth of more than 2 meters or in the zone of underground communications or under water;

- examination, repair and cleaning of air ducts;

- works on preservation and processing of grain;

- examination of the state of occupational safety and industrial production safety of business entities performing works and / or operating high-risk equipment;

- storage of canisters, containers, cisterns and other tanks with compressed, liquefied, poisonous, explosive and inert gas;

- welding works;

- operation (application) of high-risk machines, mechanisms, and equipment (technological vehicles).

An analysis of the dangers of grain-processing industry enterprises helps to identify all possible emergency situations and accidents. This must necessarily be done for preparation of an emergency response plan, since the decree of the Cabinet of Ministers of Ukraine dated 09.08.2017 No. 626 Procedure for the development of activity plan of unified state civil protection system indicates that such plans are, firstly, designed for *adjustment and coordination of the actions of the public authorities, local self-government bodies, management bodies and civil defence forces*, business entities in case of a threat or occurrence of emergencies; and, secondly, determine the organization of emergency response management, the order of action and interaction, as well as the organization of the main types of support of management bodies and civil defence forces that will be involved into the response in case of a threat or occurrence of emergencies, the transfer of management bodies and civil defence forces in high alert regime, emergency situation regime [3].

An emergency response plan for business entity is developed by an appropriate business entity with a staff of more than 50 persons and shall be approved by the manager of such an entity.

In the business entities with a staff of 50 people and less, the civil defence officer shall develop an instruction on the actions of the entity's personnel in case of a threat or occurrence of an emergency, which should be approved by the manager of such entity. The instruction should contain information on possible (predicted) emergencies that may occur in the business entity facility, danger-warning signal, personnel actions upon receipt of such signals, routes for evacuation of personnel to safe places, and their sheltering in civil defence facilities, measures for the preservation of material valuables.

The emergency localization and response plans at high-risk objects are developed for adjustment and coordination of the actions of the authorities and civil defence forces of the enterprise, institution, organization, which owns or uses at least one high-risk object in case of threat or occurrence of emergency situations. Such plans are developed and approved by a legal entity or an individual, which owns or uses at least one high-risk object, as well as enterprise, institution or organization that plans to operate or operates at least one high-risk object.

The rules of technogenic danger (2018) [4] confirm the necessity and obligatoriness of the provision of technogenic safety in hazardous objects, which should be ensured by:

- assessment of risks of occurrence of technogenic emergencies in subordinate hazardous objects of the relevant branch;

- informing the authorities and civil defence forces about the main threats in hazardous objects in or-



der to take effective measures for protection of the population, industrial and agricultural objects from technogenic emergencies;

- informing the authorities and civil defence forces about the emergency and dangerous situations, the development of which has led or could lead to an accident and cause damage to life and health of the population and the environment;

- placement of information on safety measures and behaviour of the population in case of technogenic emergency situation on official websites, information stands and in the mass media;

- organization of measures to protect their employees from the adverse effects of technogenic emergencies;

- formation of the object units and specialized civil defence services, creation of the material and technical resources necessary for their functioning, ensuring the readiness of such units for the intended actions;

- training of workers on the technogenic safety rules;

- maintaining the readiness of the created operations control centres;

- development of plans for localization and liquidation of accidents;

- declaration of safety of high-risk objects;

- creation, operation and maintenance of automated systems for early detection of the threat of emergencies and population warning in case of their occurrence;

- creation and maintenance of communication facilities, rescue mechanisms and equipment and their intended use;

- emergency rescue servicing of hazardous objects;

- creation of an object's logistic reserve for the prevention and liquidation of the consequences of emergencies and the implementation of urgent repairs;

- taking of measures at own expense that reduce the level of risk of technogenic emergencies;

- development of measures to ensure technogenic safety, taking into account the achievements of science and technologies, positive experience on this issue;

- financing expenditures in the manner and in amounts necessary for the full and qualitative compliance with the technogenic safety requirements;

- fulfilment of other tasks and measures of technogenic safety taking into account the requirements of the current legislation of Ukraine.

Summarizing all above-mentioned information, it may be noted that currently the development of emergency localization and response plans at the grain-processing industry enterprises is a mandatory measure, which ensures the readiness of high-risk objects and potentially hazardous objects for emergency situations.

The abolition of the NPAOP 0.00-4.33-99 Regulations on the Development of Emergency Localization and Response Plan (according to the decree of the Ministry of Justice of Ukraine dated 13.11.2012 No. 1672/5) does not automatically exclude the plan for the elimination of emergency situations from other valid documents. Only the form of drafting of this document and the procedure for its approval in the relevant bodies are cancelled. Incidentally, since the new approved form of drafting a plan for the elimination of emergency situations is absent, if necessary, this document is drawn up according to the older form. And the procedure for approval in accordance with the Law of Ukraine "On high-risk objects" (Article 11) stipulates that the Emergency Localization and Response Plan shall be approved by the territorial bodies of the State Emergency Service of Ukraine only for high-risk objects [1].

In accordance with the Resolution of the Cabinet of Ministers of Ukraine No. 956 dated July 11, 2002, the HROs cannot register a Declaration of Safety of High-Risk Object without provision of notarized copies of the Emergency Localization and Response Plan [11].

If according to the identification of the HRO (Resolution of the Cabinet of Ministers of Ukraine No. 956 dated 11.07.2002 and the Resolution of the Cabinet of Ministers of Ukraine No. 990 dated 21.09.2011) the object is not classified as high-risk object, then the emergency localization and response plan of such object shall not be approved at all [11,12]. In other words, a plan for liquidation of emergency situation is prepared, an expert conclusion is obtained for this document and it is approved by the manager of the enterprise.

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ТЕХНОГЕННА БЕЗПЕКА ЗЕРНОПЕРЕРОБНИХ ПІДПРИЄМСТВ

Анотація

У статті розглядається питання техногенної безпеки зернопереробних підприємств. Розглянуто законодавче підґрунтя цього питання – закони України, нормативно-правові акти.

Зернопереробна галузь містить значну кількість об'єктів підвищеної небезпеки, потенційно небезпечних об'єктів, де проводяться роботи підвищеної небезпеки.

На зернопереробних виробництвах найбільш розповсюджені надзвичайні ситуації та аварії, які пов'язані з вибухопожежою. Наведені фактори вибухопожежної та пожежної небезпеки підприємств із зберігання й перероблення зернової сировини. Вказані потенційні джерела запалювання зернової сировини та зернопродуктів, причини вибухів пилоповітряних, газоповітряних або гібридних сумішей. Дано перелік найпоширеніших місць та причин виникнення джерел займання та вибухів у технологічних спорудах та будівлях, шляхів розповсюдження пожежі. Наведені основні небезпечні фактори, що виникають при аварії, та найбільш вибухонебезпечні споруди зернопереробної галузі.

На зернопереробних підприємствах виконуються роботи підвищеної небезпеки, на які поширюються спеціальні вимоги, дотримання яких захищає від нещасних випадків, але рівень виробничого травматизму, в тому разі із смертельними наслідками, в агропромисловому комплексі України залишається на високому рівні. Одна із основних причин нещасних випадків із смертельним наслідком є відсутність дозволів на виконання робіт і експлуатацію устаткування, машин, механізмів та об'єктів підвищеної небезпеки. Визначені роботи, для виконання яких роботодавцеві необхідно мати дозвіл на виконання робіт підвищеної небезпеки та на експлуатацію (застосування) машин, механізмів, устаткування підвищеної небезпеки або декларацію відповідності матеріально-технічної бази вимогам законодавства з питань охорони праці.

Аналіз небезпек підприємств зернопереробної промисловості допомагає визначити всі можливі аварійні ситуації і аварії. Це є обов'язковою процедурою для складання плану реагування на надзвичайні ситуації.

Плани локалізації і ліквідації наслідків аварій на об'єктах підвищеної небезпеки розробляються з метою упорядкування та координації дій органів управління та сил цивільного захисту підприємства, установи, організації, у власності або користуванні яких перебуває об'єкт підвищеної небезпеки, у разі загрози або виникнення надзвичайних ситуацій. Плани розробляються та затверджуються юридичною або фізичною особою, у власності або у користуванні якої є хоча б один об'єкт підвищеної небезпеки, а також підприємством, установою, організацією, які планують експлуатувати або експлуатують хоча б один об'єкт підвищеної небезпеки.

Ключові слова: зернопереробна промисловість, техногенна безпека, об'єкти підвищеної небезпеки, потенційно небезпечні об'єкти, робота підвищеної небезпеки, план ліквідації аварій

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