Eastern European
Association of the Greens

Analytical study

Technogenic risks in operation and construction of industrial facilities in Europe. Issues of risk minimizing and major accidents prevention.

Brussels
2018

Content

1. Introduction

Economic development has always been associated with the risk generated not only by dangerous natural phenomena and processes, but also by human economic activity. At the same time, the consequences of the so-called "man-made disasters" were limited to the economic systems of individual regions (areas) of a particular country, and in exceptional and exceedingly rare cases - to the national economy.

If we analyze the industry-induced catastrophes of the second half of the nineteenth century and the first half of the 20th century, we can easily see that almost all of them occurred in the coal mining industry (miners' deaths in mines) and in transport (shipwrecks, railroad accidents, air crashes). Even the notorious explosion in Canadian Halifax on December 6, 1917, which is the most powerful explosion in the history of mankind before the creation of nuclear weapons (according to official data, 1,963 people were killed, over 2,000 were missing, about 9,000 injured, 25,000 left homeless, 2 urban areas were wiped from the face of the earth, 1,600 were completely destroyed and 1,200 houses were badly damaged) was the result of a collision of two ships.

When speaking about purely industrial man-made disasters of that period, the tragedy of the factory for the production of aniline dyes and fertilizers, near the German town of Oppau, which took place on September 21, 1921, stands out. 12 tons of ammonium nitrate mixture and ammonium sulfate exploded with a force of 4-5 kilotons of TNT: 561 people died, more than 1.5 thousand people were injured and got burns, over 80% of buildings in Oppau were destroyed, over 7.5 thousand people left homeless, two neighboring villages were also destroyed. A few smaller (in terms of the number of human casualties and the size of the consequences) man-made disasters and accidents - and this is where the "contribution" of the vast majority of industries ends.

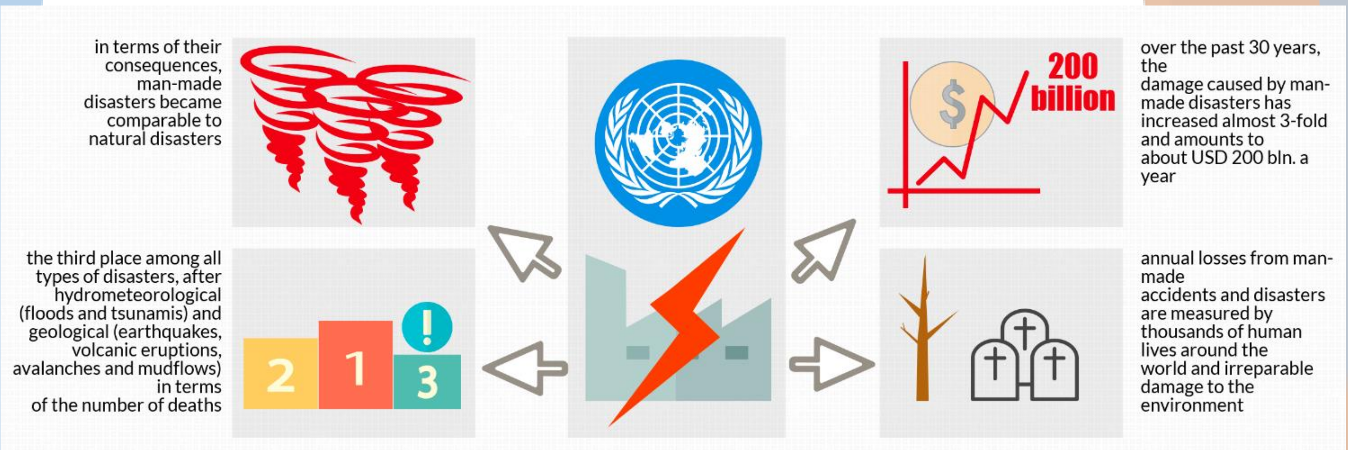
The situation radically changed in the second half of the 20th century, with the onset of another round of the scientific and technological revolution. There was a radical restructuring of the technical foundations of production based on the science transformation into a leading factor in production. The economic circulation began to involve more and more natural resources, the production base began to grow, more complex technological systems were used, and the amount of energy consumed increased.

Significant progress in the development of production at all levels of human activity has led to the emergence and operation of a huge number of production facilities using radiation, chemical, biological, fire and explosion-hazardous technologies. Accordingly, there was a potential risk of accidents and disasters at them, with much more significant scale and consequences. That was clearly demonstrated by the tragedy in Bhopal and Chernobyl disaster.

Even despite the obvious progress in the development of safety systems at industrial facilities, man-made accidents and catastrophes continue to occur. Moreover, their number is growing, as evidenced by the data of the Swiss company Swiss Re (one of the world's largest reinsurance companies founded over 150 years ago): over the period 1970-2000, the number of man-made accidents and disasters with a total economic loss of more than USD 67 million each increased more than 3 times. At the same time, they occurred 1.6-1.7 times more often than natural emergency situations with comparable destructiveness.

This fact is confirmed by the United Nations (UN) data:

- in terms of their consequences, man-made disasters became comparable to natural disasters and now have the third place among all types of disasters, after hydrometeorological (floods and tsunamis) and geological (earthquakes, volcanic eruptions, avalanches and mudflows) in terms of the number of deaths;
- over the past 30 years, the damage caused by man-made disasters has increased almost 3-fold and amounts to about USD 200 bln. a year.



In addition, the annual losses from man-made accidents and disasters are measured by thousands of human lives around the world and irreparable damage to the environment. Man-made accidents and catastrophes have a beginning, but they do not have ending, they are often unpredictable, the degree of damage caused by them does not decrease over time, as negative factors continue to operate for many more years, leading to severe environmental consequences. In addition, the increasing technogenic burden on the environment, transboundary pollution transfer and the resulting global environmental changes have led to the emergence of a new type of combined natural and man-made risks. They are increasingly beginning to prevail among the threats to sustainable development from emergencies.

In the last decades of the last century unprecedented "man-made disasters" caused mankind to seriously think about their own vulnerability and to search for ways of more secure and sustainable development. So the leading issue was the problem of man-made safety at industrial facilities in order to avoid the emergency situations during their operation.

This Study will investigate the situation in four manufacturing sectors - chemical, oil refining, coal mining and nuclear power. The choice was made based on the number and scale of man-made disasters that occurred and occur at the sites of these industries after the Second World War, as well as the amount of damage caused to human health and the environment. In addition, the Study will consider the legislative and regulatory requirements for the technogenic security of critical infrastructure facilities in several European countries, as well as practical aspects of regulation and supervision. Attention will also be paid to the key aspect, which will investigate the safety of chemical, oil refining, coal industries, nuclear power and critical infrastructure facilities- stress tests. The possibility and expediency of unifying the requirements for the safety of enterprises from the listed industries and critical infrastructure facilities will be considered.

2. Major man-made disasters in these industries

Chemical industry

Production facilities in the chemical industry is one of the most dangerous man-made sources of impact on humans and environment. A number of authoritative international experts assess the potential danger from chemical industry facilities even higher than from nuclear power facilities. Here are some confirmations.

* **July 28, 1948** - an accident at BASF concern company in Ludwigshafen (French occupation zone of Germany, now - Germany). It is with this tragedy that the history of all major man-made disasters that occurred after the Second World War begins.

On the hot (the air temperature in the shade was + 33°C) July day, a railway tanker containing 30.4 tons of dimethyl ether spent almost 10 hours in the sun between two buildings in the territory of the enterprise. According to the findings of the commission that carried out the investigation, dimethyl ether, which is a flammable liquid gas, was heated and, accordingly, expanded in the tank. Until it reached the weld, through which it began to seep out, and the mixture of dimethyl ether and air is explosive. There were to chemical explosions: the first (insignificant) occurred outside the tank, turning it over and destroying it, during the second, the main (according to different calculations it was 20-60 tons in TNT equivalent), the contents of the tank exploded.

207 employees of the enterprise were killed. 3,818 employees of BASF concern and residents of Ludwigshafen were injured, incl. 500 - seriously (including poisoning with poisonous gas resulting in complete blindness). The explosion destroyed almost a third of the enterprise: 20 buildings were completely destroyed, all buildings within a radius of 500 meters were damaged. The area of the destruction zone was about 300 thou. square meters, incl. the area of the total destruction zone of about 40 thou. square meters. In Ludwigshafen, over 4.5 thousand houses were damaged, in Mannheim (located about 3 km away) - over 2.4 thou.

* **June 1, 1974** - an accident at the caprolactam production plant (a source product for nylon production), located near Fliksboro village (Great Britain) and owned by the British-Dutch company Nypro UK.

Due to the rupture of the temporary bypass pipeline connecting the two reactors (the reactor circuit consisted of 6 reactors), the heated pairs of cyclohexane (organic matter, which is the raw material for the production of caprolactam) began to release into the environment. A huge explosive mushroom cloud containing several tens of tons of this substance began to form. A small spark was enough to ignite him. After about 40-45 minutes, the cloud reached the source of the ignition (presumably - the torch of the hydrogen plant) and a powerful explosion occurred. In its destructive power, it was equivalent to an explosion of 45 tons of TNT, blasted at a height of 45 meters, and before the fire at Hertfordshire oil storage terminal in December 2005 was considered to be the biggest explosion that ever occurred in the UK in peacetime.

Then a large fire broke out spreading over an area of about 6 ha. This was facilitated by about 1,650 tons of flammable liquids in the plant's territory, as well as caprolactam reserves, the amount of which is not known exactly. The fire fighting activities continued for 11 days, finally the fire brigades (which was a total of 50) left the site only after 20 days.

The accident took the lives of 28 people, 72 people were injured, including. 36 - seriously, 16 firefighters were injured. It should be noted that if the explosion occurred during the operation of the enterprise, and not on Friday evening, the number of victims could increase to the level of the Ludwigshafen accident discussed above.

The plant itself ceased to exist as an industrial facility. In Fliksboro village (1.2 km from the explosion site) 72 of 79 houses were destroyed. In Amcotts village (located on the other bank of the Trent River flowing near the plant) 73 of 77 houses were badly damaged. About 1,000 different buildings within a radius of 1 mile (about 1.6 km) from the blast site and about 800 buildings within a radius of 3 miles (about 4.8 km) were damaged in total.

* **December 3, 1984** - accident at the factory in Bhopal (India), owned by the American company Union Carbide Corporation.

It was directly caused by the entry of water into one of the tanks containing almost 42 tons of methyl isocyanate, a highly toxic and dangerous organic compound that served as the basis for the insecticide produced under Sevinum trademark. As a result, its chemical reaction with water began, which led to the heating of methyl isocyanate above its boiling point (up to + 39.5°C) and, correspondingly, the pressure in the tank increased. The safety valve has worked - and almost 42 tons of toxic fumes were released the atmosphere.

It should be specially noted that at the moment of the accident:

- the protection systems installed on the tank did not work;
- the tank cooling system was switched off;
- the system for monitoring and warning of the temperature increase in the tank was dismantled;
- flare device that was to oxidize (burn) methyl isocyanate to the safe gaseous substances was in an inoperative condition.

A light wind with a speed of 5 km/h carried a poisonous cloud to the nearby areas of the city's slums and the railway station. Cool weather has contributed to the fact that the deadly pairs of methyl isocyanate did not rise up, but spread along the ground. As a result, a cloud 5 meters thick covered an area of about 40 sq. m.

The exact number of dead and injured is unknown and, perhaps, will never be established. Estimated ranges are as follows: the death toll directly on December 3 - 3-5 thou. people, the number of deaths in subsequent years from the effects of methyl isocyanate vapour on the body - 10-15 thou., the total number of victims - 150-600 thou.

The reasons for such enormous losses were:

- high toxicity of methyl isocyanate affecting the eyes, stomach, liver, human skin and causing hurricane pulmonary edema;
- time of the accident (the night when the population was sleeping, so many died without even waking up);
- high population density in slums and poor quality of dwellings (primitive light structures that did not provide reliable protection);
- unpreparedness of local authorities, personnel of health care facilities and the population to such emergency situations;
- low level of qualification of health care workers, lack of medicines.

* **October 23, 1989** - an accident at the site of Battleground chemical complex (Houston Chemical Complex Battleground), located near Pasadena (USA) and owned by ConocoPhillips.

During scheduled maintenance, conducted by the contractor Fish Engineering and Construction Inc., a shut-off valve was opened at one of the polyethylene reactors, due to an employee's negligence. The control panel in the control room showed that the valve is in the "closed" position. As a result, about 40 tons of flammable gases were almost instantly released into the atmosphere. A flammable vapour cloud formed, which in 1.5-2 minutes came into contact with some source of ignition and exploded. According to experts, the explosion was about 2.5 tons in TNT equivalent, the US Geological Survey recorded a 3.5-point fluctuation of the soil on the Richter scale, the fragments scattered within a radius of 6 miles (almost 9.7 km) from the explosion epicenter.

In 10-15 minutes, there was an explosion of isobutane tank for with a capacity of 20 thou. gallons (about 75.7 thou. liters). A chain reaction followed leading to four more explosions. There was a powerful fire. Due to the fact that many fire hydrants were completely out of order, one part of the remaining ones was disconnected (the fire destroyed their power cables), and in the other part the water pressure dropped sharply, it took firemen more than 10 hours to take control of the situation and completely extinguish the flame.

23 people died, 314 were injured of varying severity. Two reactors for the polyethylene production were completely destroyed.

* **September 21, 2001** - an accident at AZF (AZote Fertilisants) chemical plant in Toulouse (France), which was a part of Total company.

There was an explosion of the hangar, in which there were about 300 tons of ammonium nitrate, a popular nitrogen fertilizer, also used as a component in the production of explosives. The explosion gave rise to a seismic wave of 3.4 points on the Richter scale, the sound from it was heard at a distance of up to 80 km, in the place of the hangar, an oval funnel about 70 meters in length, about 40 meters wide and up to 6 meters deep in the central part was formed.

31 people were killed, including 21 employees of the plant. More than 30 people were severely injured, over 3.5 thou. people got bad injuries, over 14 thousand people had minor injuries and various psychological disorders.

The plant was almost completely destroyed. All buildings and structures within a radius of 1 km from the explosion site were beyond restoration, in the buildings within a radius of 3 km windows were broken and walls were damaged, many roofs were destroyed by shock waves, almost all buildings within a radius of 8 km were left without windows. Over 27,000 apartments, about 3,000 residential and administrative buildings, social infrastructure facilities, including 79 schools, 11 lyceums, 26 colleges, 2 universities, 184 kindergartens, a psychiatric clinic and a large shopping center (both completely destroyed), the sports center, the city bus depot (150 buses burnt in its boxes). About 40,000 people were left homeless. 134 different enterprises actually ceased their activities.

According to the official version of the investigation, the fault for the disaster lies with the AZF leadership, which made safety violations in the explosive substance storage. At the same time, the cause of ammonium nitrate detonation was not established. Unofficial hypotheses vary in a wide range: from meteorite hitting a hangar (which is close to science fiction) and testing an electromagnetic bomb in this territory (in the air or underground), to a terrorist act carried out by a radical Islamist group.

Oil refining industry

The oil refining process, all the time, involves many complex technological processes at high temperatures and pressures. Raw materials and products are extremely flammable. Thus, the huge energy saturation of the industry's enterprises, combined with the possibility of harmful and explosive substance releases, creates an increased danger. Both for people (often they are located in close proximity to residential areas) and for the environment - oil refineries pollute all environment objects: air, water bodies and soil. We can say that the oil refinery is, in fact, a giant powder keg.

* **January 4, 1966** - accident at Total France-Raffinerie de Feyzin factory (Feizin, France), owned by Total S.A. The largest man-made disaster in France.

During the daily routine sampling procedure, the valve system failed at one of the liquefied petroleum gas tanks (there were 8 in total). This led to the fact that the propane (formed during the separation of associated petroleum gas during the cracking (thermal processing) of oil products) found in a spherical tank began to release extensively. A cloud of propane vapour was formed. Weather conditions (rather low temperature and lack of wind) contributed to the fact that the cloud was pressed to the ground (no more than 1 meter in height) and began to spread in all directions.

Soon it reached the highway, where by that time the traffic had already been blocked, and to the factory road on which the truck of the contract company was traveling. The driver noticed a propane cloud too late, and when he saw it, he braked sharply. It set fire to propane, the fire quickly reached the tank, and it caught fire. Before the leak there was about 700 c.m of liquid propane.

The factory firemen and their colleagues who came to help them from neighboring Lyon and Vien began to fight with fire. Since at that time the BLEVE effect (the type of explosion of a closed container with pressurized boiling liquid) was not yet known, firefighters were not trained to extinguish such fires. They simply flooded the flames and cooled nearby tanks with water. Approximately 1.5 hours after the start of the fire, a burning tank exploded, forming a fireball with a height of up to 500 m and a diameter of up to 250 m, in 45 minutes one of the neighboring tanks exploded. Fortunately, further explosions did not follow: under the influence of heat from the fire, the protective valves on the upper part of the 3 tanks opened and their contents (propane, butane) began to release into the atmosphere, 3 more tanks were not damaged at all, thanks to the wind that had started, the fire was carried away from them.

The first explosion killed 18 people (including 11 firefighters from Lyon and Vien), 84 were injured and got burns. In a radius of over 2 km from the explosion site, roofs were damaged on all buildings, in a radius of more than 8 km - windows were broken.

* **March 23, 2005** - accident at Texas City Refinery (Texas City, USA), owned by British Petroleum.

During the start-up of the hydrocarbon isomerization unit after repairs, due to a malfunction of sensors and equipment, the distillation column tower was overfilled with gas. Then it moved to the reserve block and also filled it. After that, the gas began to seep out, forming a large cloud. It began to spread across the territory of the plant, continuing to increase in size. The explosion needed a small spark, the source of which was the overheated engine of the pickup truck.

The explosion was so powerful that the windows flew out in the buildings in a radius of up to 1.2 km. The fire that started then covered the territory of about 19 thousand sq. m. It took the firemen that arrived at the scene of the accident about two hours to cope with the fire.

The explosion killed 15 people, more than 180 were injured.

* **August 25, 2012** - accident at Complejo Refinador de Amuay factory (Amuay, Venezuela), owned by the national oil company Petroleos de Venezuela S.A.

The leakage of gas vapours led to a powerful explosion. Despite the fact that the leak was noticed an hour before the explosion, the enterprise workers did not take planned works to eliminate the threat. However, in the opinion of the workers themselves, morally obsolete equipment and a catastrophic shortage of spare parts were to blame for everything.

The explosion was followed by the fire. The situation was aggravated by the fact that the fire occurred in the oil storage zone. There was an ignition of two huge oil tanks. At night of August 28, the fire started on the third reservoir. The firefighters managed to fully cope with the fire only in the second half of the same day.

As a result of the accident, 48 people died, including a 10-year-old child (a barrack in which 15 members of families of national guards guarding the plant were destroyed by a shock wave), another 151 people were injured and got burns

* **June 15, 2014** - accident at Achinsk refinery (Achinsk, Russia), owned by Rosneft.

During start-up operations at the gas fractionating plant, an explosion occurred and a fire started that covered approximately 400 sq. m of the enterprise territory. One distillation column was destroyed, several neighboring buildings were damaged. According to the investigation, the cause of the accident was the "critical thinning of the metal of the technological pipeline as a result of local corrosion and its subsequent destruction in conditions of unstable technological conditions when starting the gas fractionating plant". In other words, corrosion combined with careless actions (in the opinion of the investigation) of two employees.

As a result of the accident, 8 people were killed, 7 were hospitalized, the total number of victims was 24 people.

Coal-mining industry

There is a point of view that the negative consequences for the environment and people from the massive use of coal outweigh its economic benefits. And the use of coal for the production of electricity, from the point of view of ecology and health, is monstrously expensive. The price is extremely high.

* **January 21, 1960** - accident at Coalbrook North Mine (South African Union - the dominion of the British Commonwealth, now - South Africa), owned by Clydesdale Collieries Company.

It was caused by the so-called "cascading pillar failure" of the mine opening arch fixing: the fall of one or several racks increases the load of the arch on neighboring racks, which in turn leads to their falling, etc. In case of Coalbrook North Mine, "cascading failure" led to the collapse of nearly 900 racks in an area covering 324 hectares. Over 1,000 miners were trapped at a depth of 180 meters. And although most of them were successfully lifted to the surface (during the rescue operation which lasted 9 days), 437 people died. In addition, methane gas began to appear in the mine, a significant increase in its concentration significantly complicated the works on rescuing the miners.

* **May 9, 1960** - accident at Laobaydong mine (China).

The explosion of methane and the resulting explosion of coal dust killed 684 miners. This is the largest accident in the Chinese mines in terms of the number of casualties and the third (on April 26, 1942 - 1,549 people, on January 11, 1917 - 917 people) in the history of coal mining in China. For several decades the scale of the tragedy and the staggering figures of the dead remained unknown to the world community. Only in the 1990s the Chinese authorities allowed the publication of information on this accident.

* November 9, 1963 - accident at Mitsui Miike mine (Japan), owned by Mitsui Mining Company.

Due to the rupture of the coupling between the two trolleys which, as part of the 10 trolleys along the inclined trunk, brought coal to the surface, eight loaded trolleys, with an acceleration of 33 meters per second, went down the shaft. They flew for about 360 meters, breaking the supports and raising clouds of coal dust. After a while, there was an explosion. According to one version, the source of ignition of coal dust was a spark from the friction of the overturning trolleys to the supports and between themselves. According to another version, the trolley damaged the high voltage cable. The shock wave spread along the shaft, and 100 meters away from the first explosion there was one more. Carbon monoxide spread throughout the mine.

At this time, the second shift descended into the mine, and the first had not risen to the surface yet. Of the 1,403 miners in the mine, 20 were killed directly by the explosion, 438 died from acute carbon monoxide poisoning, 839 suffered the effects of poisoning.

The investigation revealed that the management of Mitsui Miike did not know anything about the explosion of coal dust. They believed that the explosion of coal dust could be caused only by the explosion of methane, and since the mine was a non-gas one, no dust-explosion protection measures (a set of measures to combat the accumulation and ignition of accumulated explosive dust and to prevent the spread of dust explosions through underground mine openings) were not conducted at all.

* **June 6, 1972** - accident at Wankie mine No. 2 (Rhodesia, now Zimbabwe), owned by Wankie Colliery Company.

According to the findings of the investigation commission, there was an explosion of methane gas of enormous strength, which, in turn, caused an explosion of coal dust. On the same day, 8 surviving miners and 3 dead bodies were brought to the surface. Due to significant damage, the mine rescuers could not move further than 200 meters.

On June 7, there were two new explosions, which led to even greater destruction. In addition, clouds of poisonous gas filled the underground tunnels. All this made further attempts to save the surviving miners or lift the bodies of the dead to the surface absolutely impossible. It was decided to preserve the mine in the form in which it was. 426 people were victims of the tragedy.

* **December 27, 1975** - accident at Chasnala Sudamdih mine (India), owned by IISCO (Indian Iron & Steel Company Ltd.).

Chasnala Sudamdih mine was located in the southeastern part of the Jharia coal basin, known for its underground fires, which lasted uninterruptedly since 1916. They were the cause of the fire that occurred in the early 1940-ies in one of the mines. To extinguish it over a million cubic meters of water was pumped. The mine itself was closed, and later Chasnala Sudamdih was built near it.

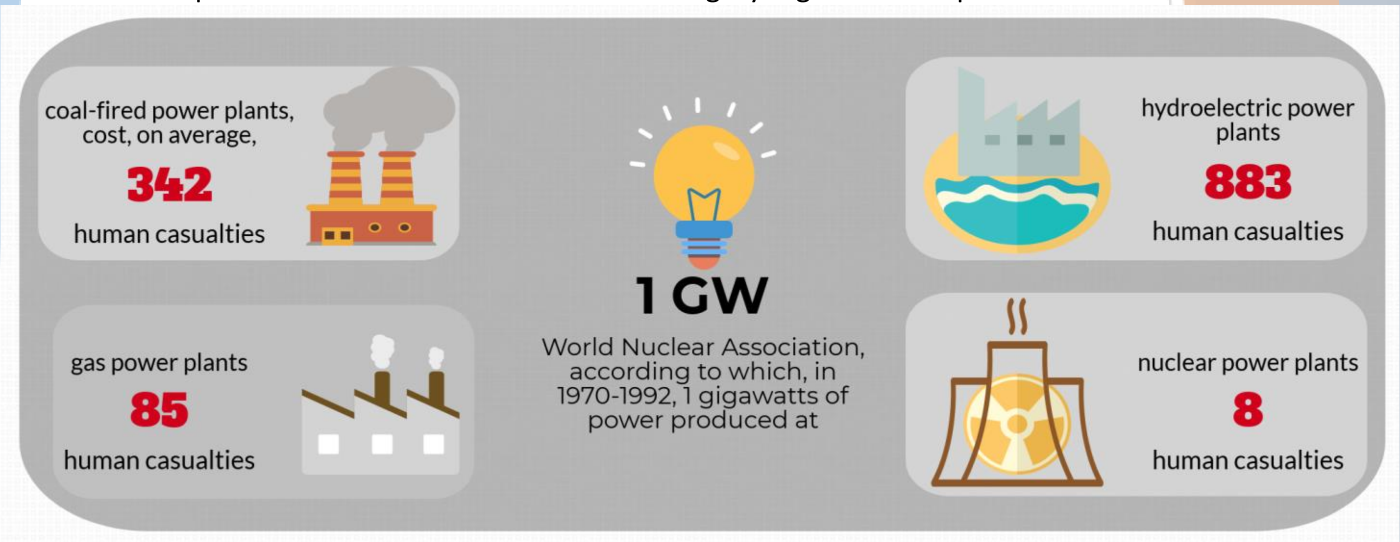
The cause of the tragedy in 1975 was explosive works (originally it was supposed to be a gas explosion), which caused a breakthrough of water from the above already explored layers, as well as also from the horizons flooded in the early 1940s. Water poured at a rate of 26 million tons per minute, quickly filled the mine and stopped about 60 meters from the surface. The official list of victims was 372 people, while the local union announced 700 miners dead (the records at the mine were poorly kept, so it was impossible to establish the exact number of victims). Rescuers continued to search for survivors for almost a month, but their efforts were futile. Most bodies were never raised to the surface.

Nevertheless, coal continues to be a fuel of industrialization and global economic growth. It is the second important source of energy in the world after oil, ferrous metallurgy and the steel industry cannot do without it. Therefore, the demand for coal continues to grow steadily. Along with this, the number of victims is also growing already at the end of the 20th century - the beginning of the 21st century,:

- March 3, 1992: accident at the mine near Zonguldak (Turkey), 263 dead;
- February 14, 2005: accident at the Sunjiawan Coal Mine (China), 214 dead (note that in the first decade of the 21st century, there were 13 major accidents in Chinese mines that killed nearly 1,960 miners);
- March 19, 2007: accident at Ulyanovskaya mine (Russia), 110 dead;
- November 18, 2007: accident at Mine named after Zasyadko (Ukraine), 101 dead;
- May 13, 2014: accident at the mine near Soma (Turkey), 301 dead.

Nuclear power industry

Since its inception to this day, this industry remains the subject of heated debate. Supporters and opponents of nuclear energy are diametrically opposed in assessing its reliability, safety, and economic efficiency. The first speak about the high profitability of the production of nuclear kilowatts, much less thermal pollution of the atmosphere than in thermal power plants, cite the data of the World Nuclear Association, according to which, in 1970-1992, 1 gigawatts of power produced at coal-fired power plants, cost, on average, 342 human casualties, gas power plants - 85, hydroelectric power plants - 883, nuclear power plants - 8. Those who are wary of the issue of safety at nuclear power facilities also have their own weighty arguments. In particular:



* On **December 12, 1952,** during the tests at the NRX experimental reactor in the Chok River Laboratory (Canada) of Atomic Energy of Canada Ltd. there was the world's first serious accident at the nuclear power plant. According to the International Nuclear Event Scale (INES), it is rated as Level 5 - "accident with wide consequences". In addition, it was the first example of a gross staff error, which today looks incredible.

On the day of the accident, two physicists worked at the top of the reactor, and the technician controlled the operation of an electric pump that supplied "heavy water" from a special tank. For safety reasons, the pump was controlled by a timer that turned it off every 10 seconds. To re-enable the pump it was required to press the button again, which was what the technician was doing. He had to stop this operation when the water reached a predetermined level. One of the physicists asked the technician to give them to the top of the reactor tools and help with the performance of the work. The technician fulfilled the request, after pressing the control button with a wooden chip, so that the timer did not stop the pump.

The level of "heavy water" continued to rise and significantly exceeded the control level. The power of the reactor increased to 90 MW, instead of the design 40 MW, after which, as required by the design, the emergency shutdown system of the reactor was activated. Its active zone overheated and partially melted. Thousands of curies of fission products have got into the external environment, and approximately 3.8 thousand cubic meters of contaminated water containing about 10 thousand curies of fission fragments were disarched into ordinary earth trenches about 1.6 km from the Ottawa River. Both physicists and technicians received radiation doses that exceeded the maximum allowable dose for the quarter.

* **September 29, 1957** - an accident at a chemical plant No. 817, which was in the closed city of Chelyabinsk-40 (USSR). Now - Production Association "Mayak" in Ozersk. Because of the nearby Kyshtym town it is known as the "Kyshtym accident". On the INES scale it is rated at level 6 - "serious accident". Until July 1989, even the very fact of the accident was placed on secret list.

The highly radioactive waste from the plant No. 817 was stored in a special complex, which was a concrete structure with cans for 20 welded stainless steel tanks, 6 meters high, 8 meters in diameter and 300 cubic meters deep, buried in the ground for 10-12 m each. The space between the canyon and the reservoir was filled with constantly circulating cooling water. From above the canyon was covered with a reinforced concrete slab-lid.

Imperfect control and safety systems in combination with the negligence of the storage personnel led to the explosion of one of the tanks, in which there were 256 cubic meters of waste in the form of a solution. Its chemical composition was explosive in a dry state. Meanwhile, the organization of the tank cooling was incorrect, and the personnel did not notice the temperature increase (up to + 330°C) inside the tank caused by dehumidification and, as a result, heating up the waste. After evaporation of the solution and heating of the precipitate, a thermochemical explosion occurred. Its strength, according to modern estimates, was 120-170 tons in TNT equivalent. Moreover, the fact that the reinforced concrete slab-cover 80 cm thick and weighing 160 tons flew to a distance of about 25 meters, and at the place of explosion, there was a funnel of 9-10 meters deep and of up to 20 meters in diameter.

About 20 million curies of radioactive substances were released into the atmosphere, some of which the explosion raised to a height of 1-2 km, where a cloud of liquid and solid aerosols formed from them. Blowing at the time of the accident for the next 10-11 hours, the wind carried this cloud in a northeasterly direction from the explosion site. Radioactive substances fell over 300-350 km, forming the so-called "East Urals radioactive trail". The area of about 23 thou. sq m with a population of about 270 thou. people in 217 settlements in three regions (Chelyabinsk, Sverdlovsk, Tyumen) was in the zone of radiation contamination was.

About 10-12 thousand people were evacuated (without notification of the reasons) from the most contaminated areas. In the 23 villages that were emptied after the eviction of people, special units carried out the liquidation and burial of houses, buildings, property of residents, food and fodder, livestock and poultry, and fields were plowed. That is, the villages were actually wiped off from the face of the earth.

Since the bulk of the official documents on the "Kyshtym accident" are still classified, it is not known either the exact number of people who received high doses of radiation or the number of deaths, if any. A number of sources say about 9-10 thousand who received dangerous doses, and about 200 people who died from radiation sickness.

* **March 28, 1979** - accident at Three Mile Island Accident nuclear power plant, located near Harrisburg (USA) and owned by Metropolitan Edison Company. On the INES scale it is rated as level 5 - "accident with wide consequences". It is even often called the "failed Chernobyl".

The main feed pumps of the second reactor cooling loop failed (for unknown reasons) at the power unit No. 2 of the nuclear power plant, while the emergency pumps did not start. Later it was found out that the technicians who had carried out repairs earlier did not open special latches, but the operators could not see this, as the status indicators of the pumps on the control panel were closed with repair plates.

As a result, the water circulation stopped and the reactor began to overheat. The further development of events was due to the simultaneous combination of a number of factors:

- failure of the equipment (the safety valve, which released steam and water from the reactor, did not close when the normal pressure was reached);

- failure of devices (although the reactor was practically empty, the instruments showed that there was too much water in it);

- a large number of technical problems;

- structural problems of the nuclear installation that have manifested itself in an unusual situation.

- the "human mistake factor" (the plant operators had neither adequate preparation for situations of this kind, nor an understanding of what was happening, so at first they were simply lost, and then all their actions were improvisational in nature).

As a result, the temperature in the reactor rose to +2,200°C and its active zone, without cooling, began to melt in the literal sense of the word. Nearly half of all components melted, which in absolute figures is almost 62 tons. After a while, emergency pumps could be started. This, it would seem, prevented the catastrophe, since the special borated water pumped into the active zone stopped its heating and further destruction. But it turned out that an explosive hydrogen "bubble" formed in the upper part of the reactor shell (volume about 30 cubic meters). A mixture of hydrogen and oxygen at any time could explode and lead to the destruction of the reactor vessel. Until April 2, nuclear power plant operators worked on removing the "bubble". When this operation was crowned with success, the danger of uncontrolled development of the accident was completely eliminated.

Three Mile Island Accident did not have any serious consequences for human health and the environment. About 2 million people received the average dose of radiation as a result of emissions into the atmosphere, which was no more than 1% of the annual dose received as a result of background radiation and medical care. About 185 cu. m of low-radioactive water was discharged in Susquehanna river. Approximately 195 thousand people for 2-3 weeks voluntarily left the 32-kilometer zone around the nuclear power plant.

*** Chernobyl disaster.** On the night of April 25 to April 26, 1986, one of the most well-known nuclear accident in history occurred at the 4th unit of the Chernobyl nuclear power plant (Pripyat, USSR). The INES scale is rated as level 7 - "major accident".

During the planned stoppage of the 4th power unit of the plant for the next scheduled maintenance, an experiment was carried out – testing of the so-called "turbine rotor run-out" mode (how long and how much power will be generated for the pumps supplying water for cooling the reactor). This situation is emergency, therefore, if it occurs, the corresponding safety systems automatically shut down the reactor. To ensure that the safety systems "did not interfere" with the experiment, they were turned off. Moreover, the emergency cooling system of the reactor was shut down.

During the experiment, the reactor power began to decrease from the programmed 700 MW: first up to 500 MW, then to 200 MW. In an effort to carry out the experiment "at any cost," NPP personnel decided to increase capacity. For this purpose, mobile absorbing rods began to be extracted from the reactor core, leaving only 7, with the minimum required 16. As a result of such actions, the reactor fell into an uncontrolled state. In an effort to remedy the situation, the operator included the highest degree of protection and immediately all the rods simultaneously began to fall into the active zone. However, due to a number of factors, the reactor was not drowned, but, on the contrary, it began to accelerate. An uncontrolled chain reaction began, which led to an explosion with a partial destruction of the reactor core and the release of fission fragments outside the zone.

According to official data, 31 people died: 2 NPP workers directly at the time of the explosion, 1 worker died from burns in the hospital in a few hours, 28 workers and firefighters, first arrived at the plant - within the next few weeks from acute radiation injury or burns. 134 patients had acute radiation sickness of various degrees of severity. All other data of different sources vary considerably. Even the official report of the UN, published in 2005, did not clarify. It says that about 4,000 people have already died and can die of the consequences of the Chernobyl disaster, whereas the World Health Organization's Office for Cancer Research suggests that there are about 9,000 such people. The so-called "direct risk group", which includes liquidators of the accident and evacuated from the 30-kilometer zone, is approximately hundreds of thousands of people.

* **March 11, 2011** - an accident at the nuclear power plant Fukushima Daiichi (Okuma, Japan), owned by Tokyo Electric Power Company Inc. The INES scale is rated as level 7 - "major accident".

It all started with an earthquake measuring 9.0-9.1 on the Richter scale. It caused a strong tsunami, whose wave height in the nuclear power plant exceeded 15 meters. Immediately at the time of the earthquake, three power units were stopped by the emergency protection system, which worked in the normal mode. An hour later the power supply was completely cut off. The tsunami was flooded by reserve diesel generators (according to the official version), and the nuclear power plant remained without electricity, which is necessary for the operation of the reactor cooling system.

Without sufficient cooling in all three power units operating before the emergency stop, the level of the heat carrier began to decrease and the pressure created by the resulting vapour began to increase. To prevent damage to the reactor, the steam was discharged into the thermo-shell. Then, to prevent the destruction of the thermo-shell, the steams were thrown into the atmosphere. The situation with the pressure was normalized, but a large amount of hydrogen penetrated into the leaky part of the reactor compartment - the result of vapour oxidation of the zirconium shell of the exposed fuel elements.

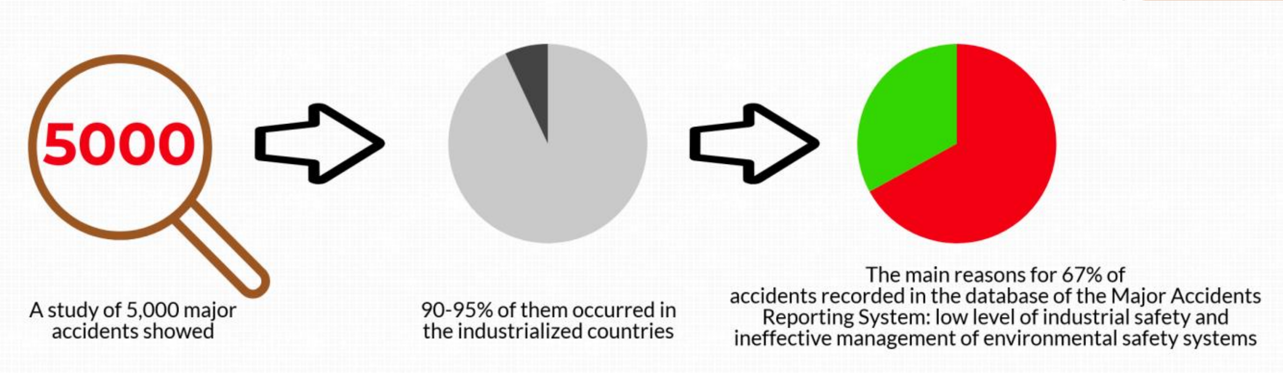
On March 12, an explosion of hydrogen occurred at the power unit No. 1 of the nuclear power plant, which led to the collapse of some concrete structures. On March 14, hydrogen exploded on the power unit No. 3, on March 15 - at the power unit No. 2. In addition, the threatening situation in the spent fuel storage pools began to form: the water that cooled it did not circulate, its level fell. Only in the middle of December, ie, 9 months after the accident, the reactors of the 1st, 2nd and 3rd power units were completely disengaged and put into a condition of cold shutdown.

As a result of the accident, radioactive elements iodine-131 and cesium-137 got into the atmosphere and the ocean, the volume of emissions of which amounted to approximately 20% of the emissions after the Chernobyl accident. The most affected was the ocean, where the water pumped into the reactors in the first week after the accident: by March 31, the radioactivity of ocean water at a distance of 330 meters from the plant exceeded the permissible norm by 4,385 times. The area of contaminated land subject to decontamination is 3% of the territory of Japan.

Thanks to the timely and mass evacuation of the population from the hazardous zone around the pant (as of March 15, about 200 thousand people were evacuated), there was no special impact on human health, since the main pollution of the area occurred after the evacuation. Even residents of the 2-kilometer zone received minimal doses of radiation that are not dangerous. Nevertheless, experts of the World Health Organization believe that the actual degree of damage to human health will become clear only in the next 15 years.

3. Regulatory framework of the European Union on man-made accidents and disasters

Since the second half of the twentieth century, mankind has faced an increase in the number of man-made accidents and disasters. The number of casualties and victims increased, the environmental situation deteriorated significantly. A study of 5,000 major accidents showed that 90-95% of them occurred in the industrialized countries of the world. The main reasons for 67% of accidents recorded in the database of the Major Accidents Reporting System, functioning under the auspices of the European Commission at the Joint Research Center in Ispra (Italy), were the low level of industrial safety and ineffective management of environmental safety systems.



Looking more closely at the causes of the major global accidents, using the example of manufacturing industries (according to the UN), we will see that half of them (44%) fall on mechanical malfunctions of equipment and instrumentation. Then follow the errors of the staff (the notorious "human factor"), the violation of the technological process, the errors of designers and designers. All this happens in the conditions of continuous scientific development, constant improvement of technology and technology.

Thus, we can draw several conclusions:

- in the foreseeable future, industry can not guarantee the full prevention of accidents and disasters.
- territories adjacent to industrial sites, their ecology and people living on them have a high degree of vulnerability to possible man-made accidents and catastrophes. Moreover, "adjacent territories" can often be located at a distance of tens and hundreds of kilometers.
- disasters caused by man-made accidents and disasters do not know the boundaries.

All three of these theses were most fully illustrated by the Chernobyl disaster, when the consequences of the actions of the "peaceful atom" were felt by almost all of Europe, up to Ireland, where radioactive fallouts also fell out. It was the last argument for the humanity in support of the need for joint efforts of states to confront man-made accidents and disasters.

As a result, on March 17, 1992, in Helsinki, under the auspices of the United Nations Economic Commission for Europe, Convention on the Transboundary Effects of Industrial Accidents was adopted (entered into force on April 19, 2000), aimed at preventing serious accidents, preparedness for and response to them . The main purpose of this document is to protect people and the environment from industrial accidents by:

- prevention of such accidents, as far as possible;
- reducing the frequency of accidents and their severity;
- mitigation of the impact of accidents on the environment and people.

The Convention provides for the adoption of measures for the prevention of accidents, preparedness for and response to them, including remedial actions. Particular importance is attached to cooperation between all stakeholders: local, national and regional authorities, industry, public and non-governmental organizations, as well as international organizations.

At present, 41 parties participate in the Convention, including the EU as a regional union. Here it should be noted that the European Union was ahead for 10 years in this issue. This is the Council Directive 82/501/EEC of the Council of Europe on the Major Accidents of Certain Industrial Activities, adopted on June 24, 1982. Also it is called Seveso I - because of the catastrophe that occurred on July 10, 1976 at the ICMESA chemical plant located in the small Italian town of Meade (about 20 km north of Milan) and owned by the Swiss concern F.Hoffmann-La Roche S.A.

On that day, dioxin, a co-product in the production of trichlorophenol, which is used to make soap and deodorants, was released into the air at the enterprise. And also one of the most potent toxins known to mankind. It is able to easily suppress human immunity, intensively influence the processes of cell division in the body and change the chemical composition of chromosomes, provoking the development of cancer. The magnitude of the lethal dose for it is several orders of magnitude lower than for a number of warfare agents (sarin, zoman, herd, etc.). If you dilute in water only about 90 milligrams of dioxin, this will be enough to kill 8 million people. Dioxin "from ICMESA" was able to destroy 100 million (for comparison: during the explosion of the atomic bomb over Hiroshima, approximately 70-70 thousand people were killed simultaneously, the total number of victims was 140-200 thousand).

The resulting poisonous cloud began to spread by the wind to the southeast of the plant and stretched for a distance of about 9-10 km. First it hung over this territory, and then the poison began to fall to the ground in the form of fog and settle on houses, trees, earth in the form of white crystals resembling wet salt. Under the influence of dioxin were the territory of the municipalities (areas) of Meda, Seveso, Cesano Maderno, Desio, Bovisio, but most affected the town of Seveso, located in close proximity to the plant.

Only 3-4 days later, when the sick people overflowed the local outpatient clinics, and the death of birds, livestock and animals took on a mass character, the owners of the enterprise admitted that the dioxin had been emitted. Before that, it was said about the release of trichlorophenol into the atmosphere. And only on July 18 the chemical plant was closed, and, according to the order of the mayor of Seveso, and not the owners.

The total contamination zone was about 1.5 thousand hectares. From the territory of the greatest infection (the so-called "zone A"), the population was evacuated. In it, the entire crop of vegetables and fruits, several thousand tons of grain and plants, absolutely all animals, including small rodents, were completely removed, a 20-centimeter layer of land (over 200,000 cubic meters) was completely removed and disposed of. For 16 months, Seveso abandoned by people turned into a ghost town. Later, his residents were allowed to return, except for 256 people, who were forbidden by doctors due to their health condition.

Fortunately, the accident did not lead to direct human casualties. Nevertheless, about 240 people, including children, suffered from chloracne (acne-like skin damage) and dermatosis (a group of skin diseases) caused by the impact of chlorine and its derivatives on the human skin. Each second of the "zone A" was soon diagnosed with "cancer."

Three factors - the scale of the tragedy, the potential consequences, the behavior of the owners of ICMESA and the concern F. Hoffmann-La Roche S.A. - prompted the European Union to start developing the Seveso I Directive. It became the foundation of modern legislation in the field of safety in industry and transport in the countries of the European Union, and for a long time was the basic international document that determined the policy of safe activity in industry and transport.

Key postulates of the Seveso I Directive:

- protection of the population and the environment, as well as safety and health in the workplace, requires special attention to certain production activities that can cause major accidents.
- for every industrial activity that is associated with hazardous substances that, in the event of a major accident, can have serious consequences for man and the environment, the manufacturer must take all necessary measures to prevent such an accident and limit its consequences.
- training and informing employees of industrial enterprises play a particularly important role in preventing major accidents and maintaining the situation under control, in the event of such accidents.
- if a major accident has occurred, the manufacturer must immediately notify the relevant competent authority and report all the information necessary to assess the impact of this accident.

The Seveso I Directive envisaged the creation of an interstate system of cooperation and interaction of national legislative and executive authorities in the field of industrial safety. The goal is to identify and take into account the risk of major accidents at the enterprises at the earliest possible stages: in the design of production facilities and technological processes, in the development of appropriate means and methods of protection against accidents, in planning events in the event of an emergency. The basic requirements of the Seveso I Directive include:

- identification of hazardous industrial activities;

- declaration of safety;
- planning actions in the event of an accident;
- informing the public about a possible emergency situation.

Soon the adoption of the Seveso I Directive began to yield positive results. So, in 1989, in comparison with 1983, the number of accidents in the European Union countries decreased by 5.7 times (from 400 to 70), including large - in 3.6 times (from 75 to 71- th).

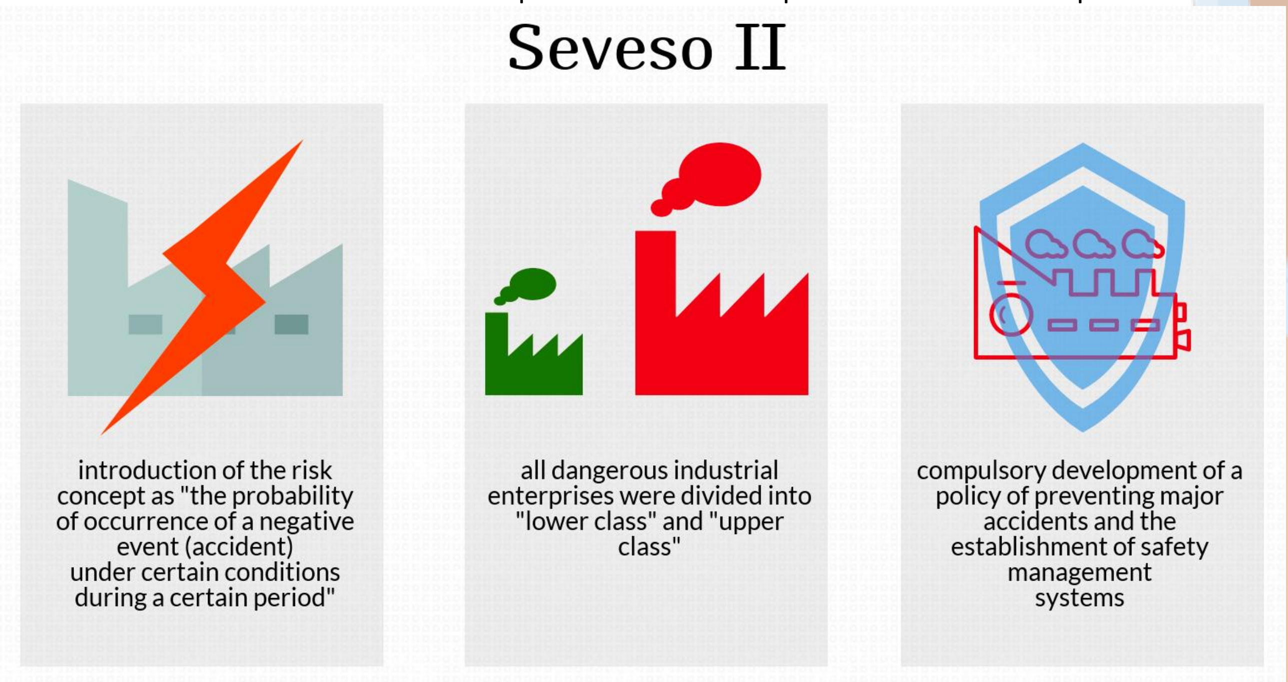
Lessons that have taught mankind the accidents and catastrophes that have occurred since the adoption of the Seveso I Directive, as well as the emergence of new requirements for the protection of the population and the environment have contributed to the emergence of the (COUNCIL DIRECTIVE on the control of major-accident hazards involving dangerous substances, adopted on 9 December 1996. It, accordingly, was entitled Seveso II.

This document was prepared with the understanding that:

- hazardous substances are used throughout the world, mainly in industrial plants;
- dangerous substances are transported by road, by waterways, by rail;
- Accidents (including fires, explosions and leaks) lead to the release of hazardous substances that can have harmful effects on human health and the environment.

The Seveso II Directive objectives were to prevent large-scale accidents, to limit their consequences for humans and the environment, and to ensure high levels of protection for the population.

The main feature of this Directive was the introduction of the risk concept as "the probability of occurrence of a negative event (accident) under certain conditions during a certain period". By the degree of risk (hazard), all hazardous industrial enterprises were divided into "lower class" facilities and "upper class" facilities (the latter contain large volumes of hazardous substances). Accordingly, they were set to two different levels of requirements. In addition, the development of a policy for the prevention of major accidents and the establishment of safety management systems, which were entrusted with the implementation of this policy, became mandatory for the enterprise in order to ensure the minimum possible risk of accidents. The provisions of the Seveso II Directive have become mandatory for both industrial facilities (more than 10 thousand) and for the authorities of the EU member states responsible for their implementation and compliance.



Although the Seveso II Directive signified a significant step forward in the field of industrial safety, many aspects were not settled or not at all subject to this document. The main emphasis of the Directive was made only on the availability of hazardous substances directly at industrial facilities, while the transportation of hazardous substances (including pipelines) and their storage outside the facilities were not considered. As well as threats arising from the activities of mining enterprises (exploration and production of minerals in mines and quarries), including the management of hazardous wastes in the process of operation of tailing dumps, protective dams, reservoir reservoirs, etc. The definition of the level of control at industrial facilities that fell under the Directive was based on quantitative threshold values. The organization of safety management systems for certain activities was not high enough.

Unfortunately, the cost for the miscalculations was too high. It is necessary to pay attention to three major catastrophes that occurred in the 21st century at chemical industry enterprises.

* At night of January 31, 2000, near the Romanian city of Baia Mare, there was a breakthrough of a reservoir-sedimentation dam belonging to the gold mining company Aurul S.A. Soman. Almost 100 thousand cu m of suspended mass contaminated with cyanide and heavy metals poured into Somes river, from where they got to Tisza (the largest tributary of the Danube) and the Danube - the second longest river in Europe. Flora and fauna on the part of the Somesh River and in the Hungarian section of Tisza, where the maximum permissible level of cyanide was exceeded 700-800 times, was destroyed by 80-90%. About 650 tons of dead fish were extracted from the water. In the north of Romania and in the east of Hungary, the supply of drinking water to the population was partially paralyzed.

* "Bloody fireworks", which happened on May 13, 2000 in the Dutch town of Enshed, in a warehouse of pyrotechnic products belonging to the company Fireworks S.E. The resultant ignition (presumably due to a short circuit in the wiring) led to several powerful explosions (from 700-800 kg - to 4-5 tons in TNT equivalent) of almost 180 tons of pyrotechnic products and subsequent fire. 23 people were killed, about 600 were injured of varying severity. Since the warehouse complex was located in the middle of the urban area of Roombeyek, the scale of the destruction was enormous: within a radius of 250 meters all the buildings were completely destroyed by explosions, within a radius of 750 meters - they were significantly destroyed, 15 streets with about 500 houses, thousands of buildings were damaged.

* Explosion of about 300 tons of ammonium nitrate at the French chemical plant AZF (AZote Fertilisants) in Toulouse, which occurred on September 21, 2001 (details of it were written above).

These three accidents, as well as the results of studies on carcinogens (environmental factors, impact on the human or animal body increases the likelihood of malignant tumors) and substances hazardous to the environment, led to the emergence of Directive 2003/105 / EC, adopted on December 16, 2003 of the year. It extended the Seveso II Directive, expanded its scope of application (processing and storage activities in the mining industry, risks from pyrotechnic and explosives, risks from storage of ammonium nitrate and fertilizers based on ammonium nitrate), introduced a number of significant amendments and additions, among which it is necessary to emphasize the following two:

- Member States must ensure that their land-use policies and relevant implementation procedures take into account the need for long-term support between industrial sites covered by the Seveso II Directive and residential areas, buildings and public places, major transport routes, recreational areas etc. corresponding distances, which do not increase the risks for people from the activities of these facilities. In the case of an already existing dangerous neighborhood, the necessary additional technical measures should be taken to reduce the potential risks.
- Member States must ensure that information on safety measures and behavior in the event of an accident is provided to all public institutions (schools, hospitals, etc.), which may be affected by

an accident at an industrial site covered by the Seveso II Directive . Moreover, this information should be provided regularly, in the most appropriate form and without the need to request it.

In 2010, the European Commission decided to revise the Seveso II Directive. On the one hand, it was necessary to make technical changes related to the adoption on 16 December 2008 of Regulation (EC) No 1272/2008 on the classification, labeling and packaging of substances and mixtures (REGULATION (EC) on classification, labeling and packaging of substances and mixtures) based on the Globally Harmonized System of Classification and Labeling of Chemicals adopted in 2003, which amended, partially amended and abolished Directive No. 67/548 / EEC, Directive No. 1999/45 / EC, Regulation (EC) No. 1907/2006 "REACH". On the other hand, there was a need to further enhance the existing level of protection (including the prevention of major accidents), by increasing the effectiveness and effectiveness of the measures developed, and in reducing unnecessary administrative barriers, provided that this does not adversely affect safety and protection of life and health of people.

As a result, on July 4, 2012, Directive 96/82/EC (Seveso II) was replaced by the Directive 2012/18/EC with the same official name as the previous one. She received the unofficial name Seveso III. Its key elements are:

- increased responsibility for compliance with the requirements of the legislation (in the Seveso II Directive there were no requirements to the EU member states on the obligation to establish penalties in national laws for violating the requirements for preventing major accidents).

- the concepts of "low-risk enterprise" and "high-risk enterprise" were added. At first, inspections are carried out at least once every 3 years, at the other - at least once a year. It is also possible to conduct unscheduled inspections. If serious non-conformities to the requirements of the Seveso III Directive are identified during the inspection, an additional inspection is necessary within the next 6 months.

- to reduce the risk of a "domino effect" (when the enterprises are located in such a way or so close to each other that the probability of occurrence of large accidents increases or their consequences become more complicated), actors are obliged to cooperate in the sphere of mutual exchange of relevant information (informing neighboring enterprises that may suffer due to an accident) and in the field of public information. In this case, this applies to businesses regardless of whether they fall under the Seveso III Directive or not.

- it is clearly defined that all enterprises should have MAPP - major-accident prevention policy, proportional to threats. MAPP should be available in writing, sent to competent authorities and updated at least every 5 years.

- the following classes of dangerous substances are established:

* Health hazards (acute substances of 3 types);

* physical hazards (explosives, flammable liquids, gases, aerosols, self-reactive substances, etc.);

* environmental hazards (substances that include acute exposure in the water environment and chronic effects);

* other hazards.

In addition, the list of hazardous substances and their mixtures has been expanded (significant amounts of carcinogenic substances, various types of petroleum products, etc.) have been added.

- Requirements for assessing the dangers of large accidents for a particular hazardous substance have been added. For this purpose, every enterprise that falls under the Seveso III Directive is provided with information about the substances to be used by the EU Commission.

- In relation to the public, there are:

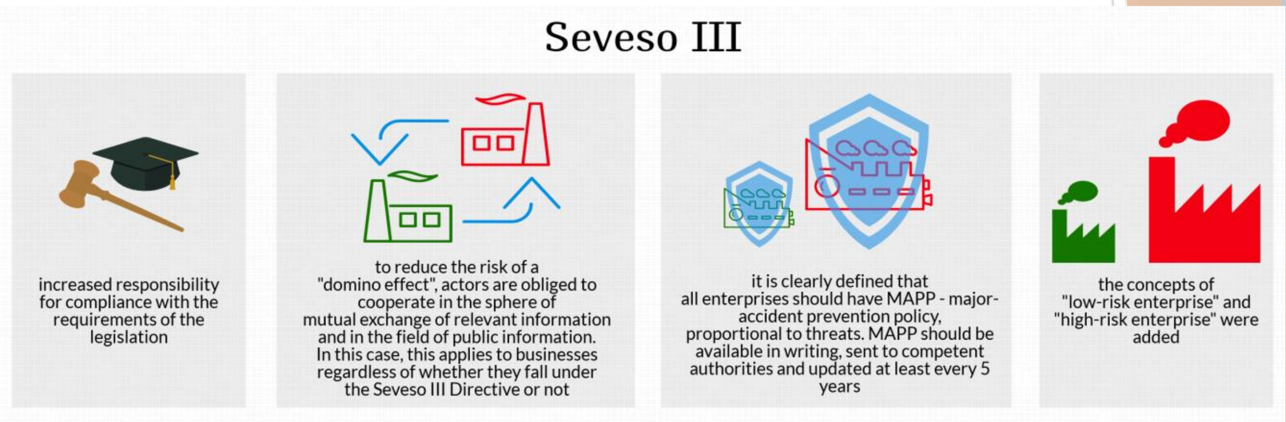
* more open and constant access to information about the risks caused by local companies, and how to behave in the event of an accident. The volume of this information is expanded, in electronic

form it should be regularly updated.

* more effective rules for participation in land use planning projects for enterprises that fall under the Seveso III Directive.

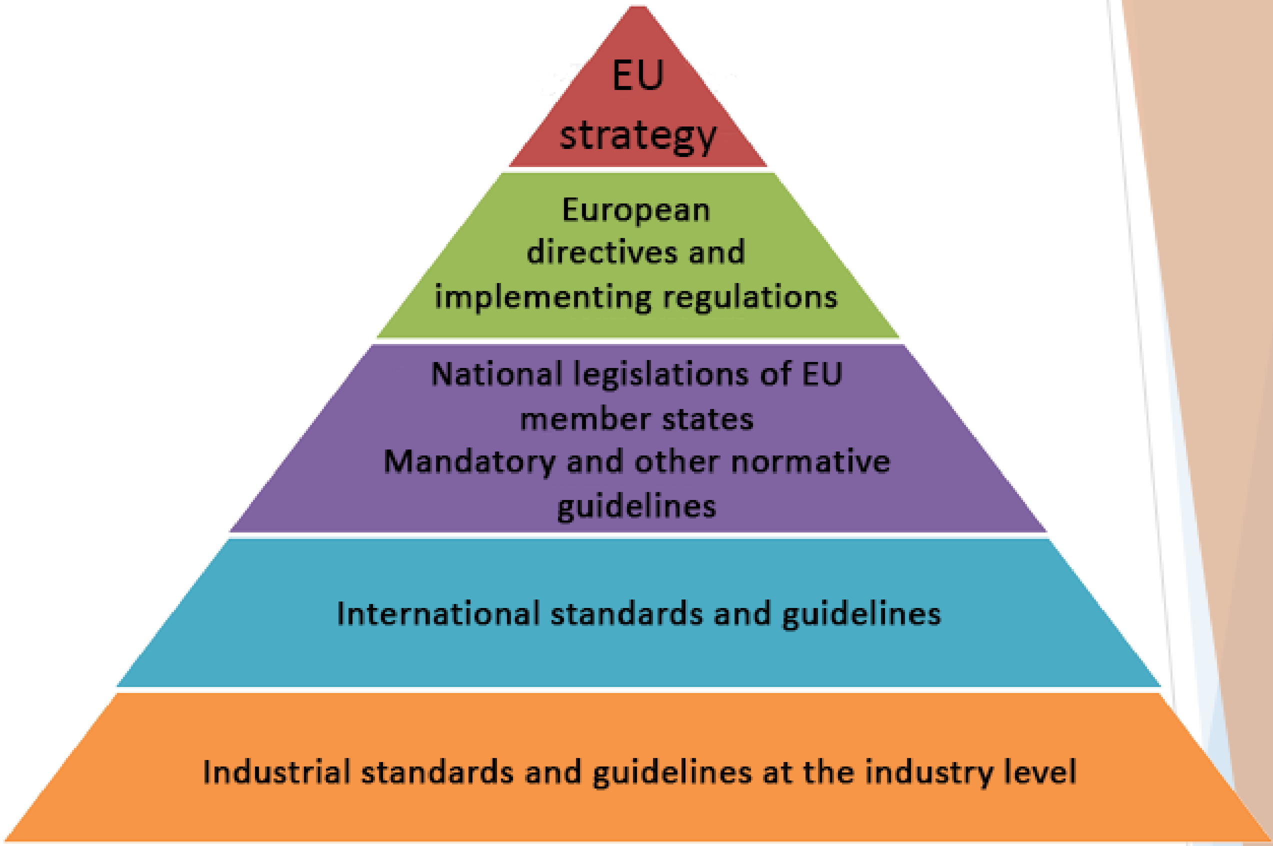
* access to the court for those who do not have appropriate access to information or participate in land use planning projects.

The Seveso III Directive terminated the Seveso II Directive and is fully applicable from June 1, 2015.



4. Supranational and national requirements to the technogenic safety of enterprises in Europe. Supervisory authorities. Practical examples of the safety surveillance

In general, the European legislative and regulatory framework, dealing with man-made accidents and disasters, can be represented in the form of a kind of pyramid.



At its top there is the EU's common strategy, which includes a public approach to preventing natural and man-made disasters, the Thematic Strategy On Air Pollution and the Air Quality Framework Directive, measures to protect water resources and comprehensive integrated water resources management (in particular, the DIRECTIVE establishing a framework for Community action in the field of water policy), and also a few Directives, Resolutions and Regulations of the EU, which are of secondary importance.

Based on the key (strategic) area of the EU strategy, a common European regulatory framework is being developed in the area of man-made accidents and disasters. Its cornerstone is the Seveso Directive (to date, Seveso III). In turn, each EU member state prepares and adopts its own national legislation, taking into account the rules and requirements established for the entire EU. The basis of the "pyramid" is the national standards and guidelines for each specific industry, developed on the basis of international standards and guidelines (both mandatory and recommended).

The modern person lives surrounded by risks, which are created by technological (man-made risks) and social (social risks) systems. Starting from the second half of the twentieth century, the subject branch of technogenic risks has significantly expanded. Man-made risks are any objects of human economic activity, but especially this applies to nuclear power, chemical, mining, oil refining industries, as well as to metallurgy, all types of transport, engineering facilities (bridges, dams, oil and gas storages). These risks are at the center of attention, since a significant number of personnel are concentrated in such facilities, often they are located near or directly in densely populated areas, the harm to people and the environment from potential accidents can be enormous, as demonstrated by more than a dozen examples.

Moreover, a comparative analysis of major man-made and natural disasters that occurred in the world over the past 20-30 years shows that at present economic losses from man-made disasters already exceed economic losses from natural disasters. Accordingly, technogenic risks prevail over the risks of natural disasters.

As Peter Bernstein (known American consultant in the field of finance and economics, the author of several best-sellers awarded prestigious prizes) noted in the preface to his book "Against the Gods: The remarkable story of risk: "The most characteristic feature of our time, distinguishing it from the millenium of the distant past, are persistent efforts to establish control over risk factors and uncertainty". This aspect is pivotal in the modern ideology of man-made safety.

In the risk and uncertainty management, the state plays three different roles:

* Regulatory role is to create a legal basis for regulating situations in which the activities of enterprises or individuals can create risks for others. Accordingly, in cases where risk can lead to direct or indirect consequences for others, the state intervenes and by regulation or otherwise restricts or takes control of such activities.

* Supervisory role in protecting people, business and the environment from external risks (natural disasters, technogenic, environmental, social, economic, political, military and other risks).

* Managerial role in the organization of their own activities, including the organization of public services and the implementation of regulatory and supervisory functions (in some cases, the state does not provide services itself, but concludes a contract with another contractor, while continuing to be responsible for the result of the service).

As to interaction with the national industry to reduce the risks of man-made accidents and disasters, each country of Europe has its own peculiarities. This is due to the state structure (federation and unitarism), national peculiarities and traditions in the field of law and in the issue of regulation at the level of "state-business", the level of development of the national economy, selected priorities in the development of various industries (say, France operates 19 nuclear power plants, whereas Greece and Denmark do not have them at all) and many other factors. Of no less importance is the number of potentially dangerous industrial facilities located in the country (correspondingly, subject to the unified Seveso Directive), as well as their share in the national economy.

Parameter	EU Member State										
	Belgium	United Kingdom	Germany	Greece	Denmark	Spain	Italy	Netherlands	Finland	France	Sweden
Number of facilities that are subject to safety declaration (pcs)	137	364	815	108	23	216	474	176	80	626	133
Share among all industrial facilities of the country (%)	4	11	26	3	1	7	14	5	2	19	4

For example, in the UK, the requirements of the Seveso III Directive are implemented through the Control of Major Accident Hazards (COMAH), which regulate the operation of ground facilities that store dangerous substances in their territory that exceed thresholds. According to the norms of this document, enterprises must reduce possible risks to a minimum level, using all necessary measures. In accordance with Rule 4 of COMAH, the operator is responsible for monitoring the enterprise and taking all measures to prevent emergencies on it. In turn, the regulator ("competent authority", which is a supervisory body that performs its duties under the Seveso III Directive and COMAH) has the right to stop the operation of the enterprise if security measures are deemed insufficient. For risk assessment, there is a wide range of methods - analysis of protection levels (LOPA), security matrix analysis, risk grading, quantitative risk analysis (QRA). Also, the "competent authority" has a number of responsibilities for managing the system for preventing major accidents, assessing the operation of facilities from the point of view of ensuring security, providing information to the EU in the event of an emergency, etc. The COMAH document guarantees that enterprises will take all necessary measures to prevent major accidents involving hazardous substances and also limit the consequences for people and the environment in the event of any major accidents.

The requirements of the Seveso III Directive provide for the availability in the EU Member State of a land-use planning system that takes into account the location of the industrial site. In the UK, this issue is resolved through the Urban Planning Act in cities and rural areas. According to it, owners of hazardous production facilities must request permission to place and store hazardous substances on the territory of their enterprise from local authorities who request information about the construction of the Health and Safety Executive (HSE). If permission is issued, an "approval zone" is created around the object. At the same time, each time when building the territories, local authorities will have to contact the HSE for recommendations on whether it can be carried out taking into account the socio-economic benefits that can be obtained. If the views of the builder and the HSE do not coincide, the issue is resolved in court.

In each of the states of Europe, there is a certain law (or set of rules) that determines the requirements for ensuring safety during the installation, maintenance, operation of hazardous industrial equipment, inspections, etc.

For example, in Germany, this role is played by the industrial safety decree and the labor protection law. These regulatory documents, in particular, set out the requirements for ensuring safety by the employer (note that German legislation uses the term "employer" - that is, the party responsible for creating and providing safe working conditions for the employees of the enterprise, as well as and for the society, as well as the environment in which the enterprise operates). The employer, in particular, is obliged to conduct periodic inspections of hazardous production equipment, the results of which are provided, if necessary, to external supervisory authorities.

Another type of compulsory inspection is a periodic inspection carried out by an external conformity assessment body. According to the requirements of the European Union, in virtually all cases, such an authority is an expert market participant organization that has been accredited and is a member of one or more professional associations.

<u>For reference</u>

The market liberalization and the actual elimination of state regulation of expert activity in the 1980s led to the emergence of a significant number of expert organizations working in the field of conformity assessment, whose supervision was often not carried out at all. Accordingly, the overall quality of the services provided in this area has started to drop noticeably (some of the expert organizations approached their functions formally). The way out of this situation was the actual introduction of a mechanism for market self-regulation, which consisted of two directions:

1. Creation of expert organizations (associations, unions, etc.) in the territory of the EU (both *within the framework of one country and cross-border) of various professional communities. At the same time, such communities were formed on the principle of introducing unified rules of activity and establishing minimum criteria for membership. They unite organizations that carry out various activities in the field of conformity assessment.*

2. Establishment of uniform requirements for conformity assessment organizations set out in ISO 17000 standards, which in turn are the basis for accreditation of these organizations. Despite the fact that the compulsory accreditation is not defined at the legislative level, at the present time, without the availability of such accreditation, the conformity assessment body can not only become a member of a professional association, but in general be eligible to perform an order. According to EU Regulation No. 765/2008, accreditation in each of the EU member states is possible only by a single national accreditation body.

In general, the implementation of industrial safety oversight for compliance with the requirements of legislation by economic operators, as well as compliance with the specified requirements used in the process of production of buildings, facilities, technical devices, equipment, materials and technologies in the EU countries are subject to state private partnership, in which the private component predominates.

The issues of industrial safety are formally assigned to the jurisdiction of the European Commission. Since, on the one hand, all its decisions are recommendatory in nature, and all arising disputable issues are settled at the level of national governments, and, on the other hand, there are objective requirements for regulating the daily life of the single economic space in the EU, practical aspects of industrial safety in the EU are the prerogative of an international non-profit organization (Association internationale sans but lucratif - Aisbl) - the European Conference of Supervisory Authorities (Colloque Européen d'Organisms de Contrôl e International - CEOC International), which unites 29 independent control and certification bodies from 22 countries.

These control and certification organizations are accredited by the state authorities of the EU member states to carry out certification and control activities in relation to hazardous production equipment (lifting equipment, pressure equipment, electrical and heat supply systems, nuclear power facilities), and buildings and structures, vehicles, conventional production equipment, etc.

The CEOC International Technical Committees are endowed with the authority of the technical expertise bodies with respect to all European regulations regulating industrial safety and standardization.

The activity of authorized control and certification organizations of the European Conference is reduced to the implementation of two main functions - regulatory (on a mandatory basis) and certification (on a voluntary basis). The first of them has the state-imperious nature and is connected, first of all, with the protection of human life and health, as well as environmental protection through minimizing anthropogenic risks and adjusting the existing socio-economic model. The second is oriented to servicing the needs of the economy and is aimed at satisfying the image and technical and economic interests of market participants.

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In the activities of the European Conference of Control and Supervisory Bodies, the commercial component associated with the second (certification) function is very strong. The annual volume of services in the world market of independent examination, certification and control tests (Testing, Inspection & Certification, TIC) is estimated at EUR 100 bln. Market participants are about 2 thousand control and certification organizations with a total staff of about 600 thousand people. The vacant share of the world market (addressable market) is estimated at more than 70 billion euros. The remaining EUR 30 bln. fall to the share of 15 largest transnational control and certification organizations, of which 11 have European roots (SGS-Group, Bureau Veritas, DNV-GL Group, DEKRA, etc.).

In addition to addressing current issues, the European Conference of Supervisory Authorities plays a significant role in determining the main directions of the EU's science, technology and innovation policies for the short and medium term. Since 2015, the European Conference of Supervisory Authorities has been an official partner of the European Technology Platform on Industrial Safety (ETPIS), an intergovernmental self-regulatory network of leading scientific organizations, industry leaders, and authoritative non-profit organizations on the platform profile . The platform is attended by 750 organizations from all EU countries. The platform is one of the elements of the VIII Framework Program of the European Union in the field of research and development for the period 2014-2020, entitled Horizon 2020 and designed to determine the priorities of scientific and technical and innovation policies that can respond to modernity challenges.

Regarding issues related to critical infrastructure. The European Union countries were among the first to start studying the problem of identification and protection of critical infrastructure. Thus, in 1999, the National Infrastructure Security Coordination Center was opened in the UK. Its task was to develop and coordinate activities to protect and defend the critical national infrastructure. Systems that played the most important role in ensuring the functioning of the state were identified. Their violation or failures could lead to harm to the standard of living of the population, to serious negative economic and social consequences. These systems included the supply of energy, water, food, feed, transportation, all public services, including health care, communications, banking, etc. In the future, other EU countries joined this initiative.

In 2002, the North Atlantic Alliance, within the framework of the Euro-Atlantic Partnership Council, determined that "critical infrastructure includes physical and cybernetic systems for ensuring important and necessary economic and public administration activities". These include, first of all, telecommunications, energy, banking, financial, water management systems and emergency services (both public and private).

In 2004, the first concept of a holistic critical infrastructure and its protection and defense appeared - "Protecting critical infrastructure in the fight against terrorism". It proposed projects to improve the prevention, training and ability to respond at the European level to terrorist acts aimed at critical infrastructure. The purpose of this document was to create an optimal level of preparedness and prevention. In it, critical infrastructure is defined as "equipment, services and information systems vital to the state, the destruction or rejection of which will lead to a weakening of the national society, national economy, public health, security and effective operation of the state system."

On November 17, 2005, the European Commission adopted the Green Paper on the European Critical Infrastructure Protection Program (EPCIP). This strategic document is based on the fact that effective protection of critical infrastructure requires communication, coordination and cooperation at both national and pan-European levels, between all stakeholders - infrastructure owners and users, regulators, professional organizations and industry associations. This should also happen at all levels of state and public administration.

On 8 December 2008, the EU Directive No. 2008/144/EC was adopted on the definition and labeling of the European critical infrastructure and on the assessment of the need to strengthen its protection. It defines the primary and final responsibility for protecting the critical infrastructure of the European scale. According to this document, all EU Member States had to introduce the problem of protecting critical infrastructure in their national legislation.

In addition, the Directive contained a list of prospective areas in which the European and national critical infrastructure is located

– Power industry:
* production of oil and natural gas, fuel production, distribution and storage (including in pipeline networks);
* power generation;
* transmission of electricity, gas and oil;
* distribution

– Communication and information systems:
* information systems and protection of networks;
* process and control elements of systems;
* Internet;
* process elements of fixed electronic communications networks;
* process elements of mobile electronic communications networks;
* process elements of radio and TV broadcasting and navigation networks;
* process elements of satellite communication;
* broadcasting;

– Water systems:
* protection of drinking water sources;
* water quality control;
* water treatment and verification of the amount produced;

– Food (production of food products, their safety and protection).

– Health care:
* medical and hospital services;
* medicines, serums, vaccines and medicines;
* biolaboratories and biological agents;

– Financial market:
* payment services and payment structures;
* public finance management;

– Social security, law and safety:
* ensuring social security, law and safety;
* administration, justice and detention facilities;

– Public administration:
* public administration;
* armed forces;
* self governance;
* postal and transportation services;

– transport:
* motor transport;

* railway transport;
* aviation transport;
* river navigation;
* maritime and coastal shipping;

– Chemical and nuclear industry:
    * production, storage and processing of chemicals and nuclear materials;
    * product pipelines of hazardous substances (chemicals);

– Space and science.

Despite the existence of a single EU directive on the definition and designation of the European critical infrastructure, EU member states have not lost the opportunity to deal with this issue independently. On the contrary, the greater the desire to unify the European critical infrastructure, the more specific is the support of each state for its legislative and practical regulation. Let's consider some examples.

Germany

Critical infrastructure sectors:
- transport (aviation, sea, railway, local, local, inland navigation, postal);
- energy (electrical, nuclear, gas, oil);
- dangerous substances (chemical and biological substances, transportation of dangerous goods, military industry);
- information technology and telecommunications;
- finance (banks, insurance companies, financial services, stock exchanges);
- supply (health care, emergency and rescue services, civil protection, food, water, waste treatment);
- institutions, administrations and legal proceedings (government, state administration, self-government, security forces, army);
- other infrastructure important for the society.

The main coordinator for the protection of critical infrastructure is the Federal Ministry of the Interior. An important role is also played by the Federal Ministry of Economy and Labour (more than 90% of the critical infrastructure is owned by private entities), the Federal Ministry for Economics and Technology, the Federal Ministry of Defense and others. To coordinate their actions (strategic development, implementation of decisions taken, etc.) in 2002, a special Inter-ministerial Working Group on Critical Infrastructure was established.

United Kingdom

Based on the US model, it primarily focuses on terrorism and cyber-space violations in defending its critical infrastructure. The state policy is presented in the legislative documents Counter Terrorism Strategy, Critical Infrastructure Resilience Program and Cyber Security Strategy.

Critical Infrastructure Sector:
- Rapid response services (police, fire brigade, ambulance, coastal police);
- government (public administration, self-government, legal proceedings, national security forces, army);
- communications, telecommunications, mail, broadcasting;

- health care (medical services);
- water (water supply network, sewerage);
- energy (oil, natural gas, electricity);
- financial services finance (asset management, financial institutions, investment banking, markets, banking for small consumers);
- food products (production, import, processing, distribution, sale);
- transport (road, rail, water, aviation).

Since 2007, the responsibility for the national critical infrastructure is borne by the Center for the Protection of National Infrastructure, which provides comprehensive information on the security of the national critical infrastructure.

France

The country's approach is based on risk management, prevention, response plans and support for information exchange. The foundations of the critical infrastructure system were established in 1997. From the legal point of view, the main document is Law No. 6600 / SGDSN/PSE/PSN on the protection of the main economic sectors (Secteurs d'Activites d'Importance Vitale).

Critical are all sectors that serve to provide basic social and economic processes. These include:
- public administration;
- judicial proceedings;
- armed forces;
- agriculture;
- electronic communication systems, audio and video information technologies;
- power engineering;
- space and scientific research;
- financial sector;
- water;
- industry;
- health care;
- transport.

The country’s Prime Minister is responsible for coordination in the sphere of critical infrastructure. Heads of individual ministries are responsible for implementing decisions. In terms of the organizational component, the responsibility for coordinating activities is borne by the Secretary General for Defense and National Security, who directly reports to the Prime Minister and assists the Office of the Prime Minister in coordinating, preparing, implementing and processing government resolutions related to security and defense.

Hungary

The country joined the European Programme for European Critical Infrastructure Protection in 2005. The critical infrastructure here is defined as "an interconnected, interactive and dependent system of elements, enterprises, services and systems important for the operation of the national economy and for the provision of public services in order to obtain an acceptable level of protection for the people, individuals and property." The main document in the field of critical infrastructure is the Government Resolution 2080/2008, which defines the National Program for Critical Infrastructure Protection of (Kritikus infrastruktura vedelem nemzeti programjarol).

Sectors of critical infrastructure protection:
- energy (oil, natural gas, electricity);

- information and communication technologies (infrastructure elements, radio and satellite network, navigation network, postal services);
- transport (motor transport, railway transport, aviation, logistics centers);
- water (supply, quality control of surface and groundwater, wastewater treatment, protection of water sources, flood protection);
- food products (production, quality control);
- health care (hospital services, medical supplies and blood bank, biological laboratories, medical insurance);
- finance (banks, securities);
- industry (production, processing, storage and transportation of chemicals, handling and storage of hazardous waste, production, storage and processing of nuclear material, research nuclear institutes, military industry, vaccines and pharmaceutical production);
- legislative activities and ensuring public order (government, public administration, self-government, justice);
- public safety (protection, defense equipment, devices, networks, security services).

Poland

Here, the critical infrastructure refers to "systems and associated functional objects, construction sites, equipment, installations, basic services for the security of the state and citizens, serving to ensure the work of government bodies, institutions and entrepreneurs". The main regulation dedicated to the protection of critical infrastructure, is the "National Program for Critical Infrastructure Protection" (Narodowy Program Ochrony Infrastruktury Krytycznej).

Critical infrastructure systems are specified within individual industries:
- energy and fuel supply systems, energy and fuel sources;
- communication;
- information networks;
- banks and financial sector;
- water supply;
- food supply;
- protection of health;
- transport;
- rescue services;
- systems for ensuring the operation of public administration;
- production, storage, preservation and use of chemical and radioactive substances, including product producers with these substances.

The Government's security center (Rzadowe Centrum Bezpieczenstwa) is engaged in protecting critical infrastructure in the country. The tasks in the field of identification and protection are also ministries, heads of government and directors of organizations designated as "critical".

The EU Directive No. 2008/114 / EC mentioned above provides for the division of the critical infrastructure into national and European ones. The national critical infrastructure includes "funds, systems and their parts located in the EU member state that are fundamental to the preservation of the most important social functions, health, safety, economic or social conditions for the population, the violation or destruction of which would have for the member- member of the EU serious consequences as a result of non-fulfillment of such functions". Since a number of infrastructure elements are important not only at the national level, but also at the international level, the European critical infrastructure is also defined. It consists of "critical infrastructures located in the member states, the violation or destruction of which would have serious consequences in at least two EU member states. The severity of the consequences is considered in accordance with cross-cutting criteria. This also applies to the consequences caused by inter-industry dependence on other types of infrastructure".

Sectoral criteria for critical infrastructure facilities are defined in each of the European countries separately. There are only recommendations of the European Commission regarding threshold parameters. Thus, each EU state has the opportunity to independently determine the list of industries in which critical infrastructure facilities will be located. In most cases, such sectors include energy, water, agriculture, food production, health, transport, communications and information systems, financial markets, emergency services, public administration.

At the same time, the countries of Eastern Europe that are the EU members also have their own standards for the construction and operation of objects of varying complexity, as well as their classification, close to international ISO standards. And although the countries of Eastern Europe are gradually coming to international standards and requirements, there is still a difference between the requirements for critical infrastructure facilities in the EU and in the post-Soviet countries. The difference between the norms in the construction of critical infrastructure in the states of the post-Soviet space from the more modern and up-to-date EU norms and requirements is that the former are much stricter. This is mainly due to different working conditions, primarily due to the fact that in countries such as Russia, Ukraine, Belarus, security equipment for the construction and maintenance of infrastructure facilities is not so much modernized as in the more developed EU countries.

Thus, for example, in Ukraine, the National Standards of Ukraine "Classification of the consequences (responsibility) and category of complexity of the facilities of prCTU-N B.1.2-XX: 201X" give the classification of infrastructure according to the consequences (responsibility) of buildings, structures, transport infrastructure

Class of consequences (responsibility)	Characteristics of possible consequences of failure of buildings, structures, linear facilities of engineering and transport infrastructure					
	Possible danger, number of people			Volume of possible economic damage, minimum wages	Loss of objects of cultural heritage, category of objects	Termination of the operation of engineering and transport infrastructure, level
	For the health and life of people who are constantly on the site	For the health and life of people who are periodically staying on the site	For the life of people who are outside the site			
CC3 major consequences	over 400	over 1000	over 50000	over 150000	of national importance	of state importance
CC2 medium consequences	from 50 to 400	from 100 to 1,000	from 100 to 50,000	from 2,000 to 150,000	of local importance	regional, local
CC1 minor consequences	up to 50	up to 100	up to 100	up to 2,000	-	-

The law establishes an exhaustive list of construction objects that, according to the class of consequences (liability), relate to objects with significant (CC3) consequences, including objects of increased danger with a level of possible danger for people more than 400 people who are constantly located at the facility, where and which enterprises belong coal, oil, chemical and nuclear industry.

In addition to the usual design situations that should be envisaged during design, the possibility of occurrence and consequences of emergencies that may arise due to projected effects or errors of personnel (designers, builders, maintenance personnel, etc.) should be analyzed.

It is recommended to consider, for example, the following events:

- failure and destruction of a separate supporting structure due to its overloading over combinations of loads and impacts;
- occurrence of large drafts of soil bases during their emergency soaking;
- influence of possible karst failure, landslides, etc.;
- Impact of impact on the impact of vehicles;
- the possibility of failure of structures in the event of a fire;
- damage to building structures by emergency explosions (e.g. domestic gas);
- the possibility of violating the technological regulations or damage to the equipment (pipeline breaks, cargo falling, other non-design impacts).

The Law of Ukraine "On Hazardous Facilities", as amended and supplemented by the Law of Ukraine of May 15, 2003, No. 762-IV, regulates the issues of operation of hazardous facilities, namely: state supervision and control in the sphere of activity related to hazardous facilities, identification of hazardous facilities, plans of localization and elimination of accidents at hazardous facilities, investigation of accidents at hazardous facilities and other.

Most of the critical infrastructures in Eastern Europe were built over 30 years ago, and the urgent issue of the safety of their work is the extension of service life. So, for example, it comes from the nuclear power plant. Managing aging to prolong the life of the NPP creates the basis for maintaining existing power levels and subsequent growth in power generation at NPPs. The operating organization is able, along with the preservation of generating capacities, to form an additional fund for the withdrawal of nuclear power plants from operation due to the additional generation of electricity at moderate costs for the maintenance of the working units of power units. For example, the prospect of prolonging the operation of the nuclear power plant in comparison with the thermal power plant by the average relative indicator of capital, fuel and operating costs is: for nuclear power plants - 70, 20, 10% respectively; for thermal power plants - 20, 70, 10% respectively. According to the best international experience, two basic concepts of extending the service life of NPPs have been formally developed. The first concept (called "American" in some sources) is based on the substantiation of the adequacy of the implemented measures, which compensate for the effects of aging, degradation, wear and tear of equipment/systems of nuclear power plants, which take into account the actual technical condition of the elements. The prolongation of the license for prolonging the operation of the nuclear power plant does not require the bringing of more "old" nuclear power plants to the level of requirements imposed on modern projects. Thus, in the United States, a final version of the rules governing the continued operation of nuclear power plants has been developed, allowing the nuclear power plant to be operated for the next 20 years on the same basis as when issuing a license for the designation of a service life.

Another concept lies the premise that the "old" NPPs should be brought to the level of safety and reliability of the NPPs of new generations, which is achieved through the development and implementation of organizational and technical measures, modernization, reconstruction, strategy of repairs and inspections, maintenance, and prevention, replacement equipment that worked out the resource during the operation of the nuclear power plant. With such an approach, there are no restrictions on the period of operation of the nuclear power plant in the form of a design (project) period, but periodically (in Japan, for example, every year in France every 10 years), a deep inspection and assessment of the safety of nuclear power plants and the development of activities for the closest and strategic perspective. According to the IAEA recommendations, any nuclear power plant constructed according to "old" standards has an acceptable level of safety in accordance with the requirements of the later normative documents if: all problems of the high and medium importance categories for safety are compensated for the low category of safety impact through the realization of all reasonable and practically acceptable compensatory measures; identify and resolve all issues by implementing measures of a low importance category for security.

According to the best international experience, management of aging and compensation of degradation processes of NPP elements is recognized as a basic conceptual approach to the strategic perspective and priority direction of practical activity in the field of using nuclear power engineering, based on the principles: provision of safety standards; safe operation of the technical condition of the elements of the nuclear power plant; social and economic requirements.

Problems related to the safety of man-made facilities and critical infrastructure sometimes get a specific turn. An example of this is the construction of a nuclear power plant in Belarus, which has opponents, who make claims on safety issues. These include the Public Organization "Eco", the international group "Eco-Protection!" and the Lithuanian authorities, who not only actively oppose the implementation of this project, but also urge the EU countries to boycott it. For many years, they have stated that the plant design allegedly does not comply with the requirements of the "Convention on Environmental Impact Assessment in a Transboundary Context" (the so-called "Espoo Convention", signed at the initiative of the United Nations Economic Commission for Europe in 1991 and came into force in 1997 year) and the established safety criteria, posing a potential threat to the environment and public health. Moreover, in June 2017, the Lithuanian Parliament (Saeima) unanimously adopted a law according to which the Belarusian NPP being erected "poses a threat to the national security of the Republic of Lithuania", and in January 2018, in the framework of the World Economic Forum in Davos, the President of Lithuania, Dalia Grybauskaitė stated that "nuclear power plant in Belarus can be used both and a nuclear threat and an unconventional weapon".

This position contrasts with the statement of the Director General of the IAEA Yukiya Amano: "Belarus is developing its own nuclear power industry, following the most stringent international security standards in this area, and the construction of the first NPP in Belarus can be considered one of the most successful such projects among the" newcomers "in the peaceful an atom We are very pleased to note Belarus's commitment to the most stringent safety measures in the nuclear energy sector. " The compliance with the high safety requirements is confirmed by the international experts on safety of the NPP - the Belarus-based plant has successfully passed several inspections by the IAEA, including so-called SEED-mission (https://www.iaea.org/sites/default/files/documents/review-missions/seed_mission_report_belarus_2017.pdf). The same is confirmed by the National Report on Stress Tests, which on October 31, 2017, the Belarusian side submitted to the European Commission and the European Nuclear Safety Regulators Group (ENSREG).

The obligatory conduct of stress tests has become a reaction of the European community to an accident at the Japanese nuclear power plant Fukushima Daiichi. "The safety of all nuclear power plants in the EU needs to be reviewed on the basis of a comprehensive and transparent risk assessment", the European Council said. Stress tests helped to make this decision that would determine the stability of nuclear power plants in conditions of exceeding the limits of their normal operation, to identify the vulnerabilities of plants to external extreme natural influences and their analysis, to determine additional measures to ensure the survival of nuclear power plants in the conditions of multiple failures.

Based on the proposals of the Western European Nuclear Regulatory Authority (WENRA), the ENSREG and the European Commission have developed the appropriate framework and mechanisms reflected in the document entitled Declaration of ENSREG or EU Stress Tests Specification. The concept of "stress test" is defined as "an objective reassessment of the safety limits of nuclear power plants in the light of the events that took place in Fukushima: extreme natural phenomena that have challenged the plant's safety functions and resulted in a serious accident."

This reassessment is to assess the reaction of the nuclear power plant facing a set of emergencies, as well as to check the preventive and mitigating effects of measures. By their nature, stress tests focus on measures that can be taken after the alleged loss of security systems installed to provide protection against accidents. The technical scope of the stress tests was determined taking into account the problems that were identified during events occurring at the Fukushima Daiichi nuclear power plant, including a combination of triggered events and failures.

Main areas of inspections:

1. External extreme effects (earthquakes, floods, extreme weather conditions).
2. Consequences of loss of safety functions from any event possible at a nuclear power plant:
   - loss of power supply, including full blackout;
   - loss of main heat sink;
   - combination of both factors.
3. Major Accident Management Issues:
   - means of protection against the loss of the reactor core cooling function and control of plant in the event of such situation;
   - means of protection against the loss of the cooling function in the pool for the storage of spent nuclear fuel and the control of the plant in the event of such situation;
   - means of protection against loss of integrity of the protective shell of a nuclear reactor and control of the plant in case of such a situation.

During the stress tests, the conditions in which the nuclear power plant is located should be the most adverse operating conditions that are permitted in accordance with the technical conditions. It is also necessary to consider all operating conditions of the plant. Must be given attention:

- automation operations;
- operations of the plant operators indicated in the emergency operational procedures;
- any other planned measures to prevent, recover and mitigate the accident consequences.

In 2011-2012, the stress tests and subsequent partner inspections of stress tests were conducted in the EU, Switzerland and Ukraine. In June 2011, Belarus officially declared its willingness to conduct such assessments on a voluntary basis, taking into account the common approaches developed by the EU and ENSREG. However, it could not do it at the same time, for the following reason: the license for placing the 1st and 2nd power units of the plant was issued by the relevant regulatory body of Belarus on May 31, 2012, the general contract for the nuclear power plant construction was signed on July 18, 2012, construction work on Unit number 1 began in November 2013, at the unit number 2 - in April 2014. As a result, the 160-page "National Stress Test Report" was ready at the end of October 2017.

The State Inspectorate for Nuclear Safety of Lithuania (VATESI) made a statement that it had more than 100 comments to this document. The Public Organization Eco, the Green Party, Greenpeace, Central and Eastern Europe also framed a lot of questions. Let's put aside philosophical and technical aspects, such as "deterministic approach to freelance situations", "account of the effect of cliff-edge," the work of condensers, the system of passive heat removal through a steam generator, provided that the sprinklers of the tower evaporators are switched off, "the requirements for the system of heat recovery from the container with projected crashes ", etc. Especially since the Belarusian side prepared in a timely and detailed way answers to 465 questions raised by European experts and sent them together with additional materials. This openness and transparency in interaction was noted by the representative of the Office for Nuclear Regulation of the United Kingdom, Mark Foy, who headed the delegation of 17 authorized European experts from 15 countries, which, in the framework of a partner inspection of stress tests, March 12-16, 2018 worked in Belarus.

We shall dwell on the key and comprehensible claims of the Lithuanian side and environmental organizations, considering them objectively and not biased.

1. The National Stress Test Report does not address issues related to the selection of the site for the construction of the Belarusian NPP.

It is true but it is because the Declaration of ENSREG does not require this. The norms set therein are the same for all nuclear power plants in the EU member states and in the states that voluntarily joined the stress testing. Similarly, there is no mention of the choice of a construction site at the Mochovce NPP in Slovakia, where the 3rd and 4th power units are currently being built (only a description of the characteristics of the plant’s site, as in the case of the Belarusian NPP). There are no claims to the placement of new power units of the Hungarian Paksi NPP, which is located only 100 km from the capital of Budapest. Yes, and in the Lithuanian report on stress tests conducted at the Ignalina NPP, this aspect is completely absent. As for the plant in Belarus, officials of the country repeatedly informed the public about the reasons for choosing exactly this location. Also, there are a lot of official documents on this issue, such as, "Conclusion No. 98 of the State Environmental Review of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus under the design documentation "Belarusian NPP" dated 23.10.2013.

Initially, 74 locations for a possible plant placement were considered. 20 of them were subsequently excluded, as they fell under the influence of prohibitive factors, determined by the main criteria and requirements for the selection of sites for the placement of nuclear power plants. The specially created expert commission thoroughly analyzed the remaining and selected 3 sites - Krasnopolyanskaya (Chau district of Mogilev region), Kukshinovskaya (Goretsky district of Mogilev region), Ostrovets (Ostrovets district of Mogilev region). After conducting studies and exploratory work, the choice was made in favour of Ostrovets platform. On the other two:

a) there was a high potential for activation of underground geological processes (soil movements);

b) there were complicated engineering-geological conditions (lack of regularity in the laying of soils of various composition and properties);

c) there were underground pressure water, the level of which was close enough (up to 1.5 m) from the surface of the earth.

However, the NPP site may not be constructed in areas of karst where, for the erection of buildings and structures, soils require additional substantial and costly activities in areas with a constant inflow of pressurized groundwater. These circumstances combined with the IAEA recommendations made it impossible to use Krasnopolyanskaya and Kukshinovskaya sites for the NPP construction.

In addition, the Ostrovets site most met two important requirements:

- proximity of the river (any nuclear power plant is a large water user for feeding the cooling system);
- presence of a number of railways and high-quality roads (for the transport of building materials and equipment).

On the one hand, the concern of the Lithuanian side can be understood, given that the construction site of the Belarusian nuclear power plant is located 53 km from the Lithuanian capital - Vilnius (from the 4th power unit of the Chernobyl NPP, which exploded in 1986 as a result of the accident, to Kiev (the capital of Ukraine) it is approximately 108 km). On the other hand, in several European countries, nuclear power plants are even closer to the settlements: Muehleberg NPP (Switzerland) - 13 km from Bern, Cattenom NPP (France) - 15 km from the Luxembourg border, Doel NPP (Belgium) - 16 km from Antwerp, Krsko NPP (Slovenia) - 39 km from Zagreb (the capital of Croatia). Near Zurich, there are two plants - Beznau (30 km) and Gosgen (43 km).

In this regard, the situation with the Ignalina NPP in Lithuania located a few kilometers from the border with Belarus cannot be ignored. Although the plant itself has not been operating for more than 8 years (Unit 1 reactor of was stopped at the end of December 2004, the Unit 2 reactor is December 31, 2009) and is being decommissioned, an intermediate storage of spent nuclear fuel was constructed on its territory, designed for 190 special metal-concrete containers. Over the next at least 50 years, they will have about 16,000 spent fuel assemblies (rods) from both plant reactors - the world's most powerful reactors at the time of their operation.

Although Ignalina NPP also carried out stress tests (according to their results, additional safety measures had to be introduced - sensors to monitor the water level in the pools, diesel generators, etc.), this did not protect the plant from emergency situations that often occurred. The last was on April 1, 2018: during the processing of spent nuclear fuel in the hot chamber of the power unit 2, part of one assembly was disengaged from the used lifting mechanism and remained at the bottom of the hot chamber. In addition to the fact that the storage facility itself is a much more hazardous object than a nuclear power plant, not one of the countries of the world has previously been involved in the planned decommissioning of a plant with RBMK reactors installed at the Ignalina nuclear power plant. Lack of experience in this matter raises well-founded concerns.

In addition to purely technical problems, there are also financial problems: the European Union and the European Commission do not guarantee the financing of the completion of the dismantling at Ignalina NPP in the amount of about EUR 1.2 bln. Thus, beginning in 2021, Lithuania will have to independently seek funds for the completion of work at the plant. This has already led to the fact that the deadline for the completion of the dismantling was postponed from the planned year 2029 to 2038.

2. Doubtful analysis of the Belarusian NPP stability in the event of an extreme earthquake.

Even before VATESI's remarks, the Ministry of Foreign Affairs of Lithuania, in its special statement on the Belarusian NPP, reported that since 1616 earthquakes of magnitude 5 on the Richter scale have been recorded 40 times in the region where the plant is being built. It should be noted that the American seismologist Charles Richter proposed the scale he developed for classifying earthquakes according to their energy in 1935. Therefore it is not clear how it is possible to specify with such accuracy the magnitude of earthquakes that occurred in the 17th-early 20th centuries. Not to mention the fact that the first network of seismic stations was organized in England, in the mid-XIX century, and the registration of earthquakes by seismographs began in Japan in 1888.

The construction site of the Belarusian NPP is located in the territory of the western part of the East European platform (any platform is a fairly stable and stationary place), in the Belarus-Baltic seismotectonic region. This area is characterized by relatively weak seismic activity: from 1887 until now, only 4 historical ones were recorded, not supported by instrumental observations (in 1887, 1893, 1896, 1908), and 4 instrumentally recorded in 1940, in 1977, in 1986, in the 1990s) of the earthquake. The latter were an echo of earthquakes in Romania (Vrancea mountains in the southern part of the Eastern Carpathians), had magnitudes of 3-5 points on the Richter scale, did not lead to destruction and did not cause any damage.

In assessing the safety of nuclear power plants, Belarusian geophysicists in their calculations were guided by the majority principle, taking the value of the maximum estimated earthquake at the level of 7 points on the MSK-64 scale (the 12-point scale of the intensity of the Medvedev-Sponkheyer-Karnika earthquakes, developed in 1964, in the countries of Europe (before 1996) and the USSR, continues to be used in the CIS countries). This indicator means "very strong earthquake" (cracks and damages in the walls of stone houses) and is characteristic for seismically active regions of the states located in the Carpathian Mountains. That is, significantly exceeds the maximum possible values for Belarus. Furthermore, SEED-mission report there is no question to the seismic issue.

3. The consequences of possible forest fires and possible floods due to the presence of three reservoirs on the river Viliya are not considered.

Separate small arrays of coniferous forest are located in all directions from the nuclear power plant (woodiness is about 10%), but at a distance of 3 km or more. Thus, if it is theoretically possible to allow simultaneous ignition of all forest areas in conditions of total absence of the fight against fire, the maximum harm can only be caused by smoke, which is not able to affect the performance of machinery and units of the plant.

As for the floods, on the river Viliya there are really 3 reservoirs: Olkhovskoe on the Stracha River (tributary of the Viliya River) - an area of 0.7 sq. km, the average water volume is 2.1 million cu.m; Rachunskoye (Snigyanskoye) on the Oshmyanka River (tributary of the Viliya River) - an area of 1.5 sq. km, the average water volume is 2.3 mln. cu m; Vileyskoe on the Viliya River - an area of 64.6 sq. km, the average water volume is 238 million cu m. The first two have a small water reserve, so even if they are destroyed, they will not have a significant effect on the maximum water levels in the river Viliya.

Vileyskoe Water Reservoir is the largest artificial reservoir in Belarus. But even in the event of a breakthrough of its dam, neither the formed wave nor the leaked water will damage the plant. Favourable factors are the considerable remoteness (about 150 km) from the dam section and the presence of various structures (bridges, roads, etc.) throughout the area from the nuclear power plant to the reservoir, which will become natural obstacles and will accumulate significant amounts of water. According to scientists, the possibility that, with simultaneous confluence of all the most unlikely circumstances, the Belarusian NPP will still be flooded, is 1 time in 10 thousand years.

4. No substantiation of Belarusian NPP stability in case of a heavy commercial aircraft falling onto it.

The best answer to this claim can be a quotation from the Declaration of ENSREG: "Risks associated with security threats are not part of the ENSREG mandate, preventing and responding to incidents caused by malicious or terrorist acts (including aircraft crash) is associated with various competent authorities". Therefore, it is suggested that, in order to solve these problems, the Council of Europe established an ad hoc working group consisting of representatives of the European Commission and EU member states. Consequently, as in the case of substantiation of the choice of a construction site, stress testing does not require an assessment of the consequences of aircraft falling onto a nuclear power plant, since it is not considered within stress tests.

Nevertheless, while designing the Belarusian NPP, such possibility was still envisaged. This was done in accordance with IAEA requirements for air crashes: in the event of a light aircraft with a weight of up to 6 tons falling onto a nuclear power plant, there should not be an accident on it.

The lightweight aircraft weighing 5.7 tons (the maximum take-off weight for the so-called "small aircraft" aircraft, according to the international classification) was taken as a basis, flying in the airspace above the plant at a speed of 100 m/s (maximum flight speed). The protective shell of the reactor at the Belarusian NPP is capable of withstanding a pressure of up to 7 kg/sq.cm, whereas in the case of an explosion of 1 ton of TNT at a distance of 60 meters, the overpressure is less than 0.3 kg/cm^2 (i.e. 23 times less).

Nevertheless, VATESI and environmental organizations insist that the Belarusian plant must withstand the direct fall of a Boeing passenger aircraft onto it. The question arises as to why Boeing, and not, for example, a two-deck giant Airbus A380, which is the largest passenger aircraft in the world. In any case, the probability of such occurrence is negligible, and that's why. First, as world practice shows, most air crashes occur during take-off or during the landing of a passenger aircraft. There are no airports near the Belarusian NPP. There may, of course, be a malfunction during the flight, but the probability of an exact falling of the aircraft onto the plant from a height of several thousand meters is analogous to the probability of an earthquake of magnitude 10-12 points in this region. Secondly, starting from the moment when nuclear fuel is delivered to the Belarusian NPP, the zone above the plant will be completely closed for flights. It will be guarded by air defense forces, which, when an airplane of any type approaching the forbidden zone will intercept it or, in an exceptional case, shoot it down.

As far as the safety of the nuclear power plant is concerned, it is worth noting several of its main principles, which are the basis of the constructed Belarusian nuclear power plant.

1. Defense-in-depth (five levels provide for the procedure for the operation of the plant personnel in all modes - from normal operation to the management of accidents with severe consequences and localization of radioactive releases) and the planning of protective measures (a set of measures excluding radioactive contamination of the terrain and exposure of people).

2. Self-protection of the reactor facility (provided by the selection of neutron-physical characteristics of the reactor, providing for self-termination of the fission reaction in any contingency situation, regardless of the operator's actions).

3. Presence of safety barriers (at least 4 independent safety barriers prevent the spread of radiation outside the plant site).

4. Multiple duplication of safety channels (each of the 4 safety channels has its own diesel generator, the design and location of which provide for operation in flood conditions, in the event of failure of all safety systems, the reactor is equipped with a system for managing beyond design basis accidents).

5. Use of passive safety systems (they do not require power sources and do not contain rotating elements, with a complete loss of external power supply, stop the reactor and remove residual heat due to laws of nature).

6. Presence of means for managing the consequences of beyond design basis accidents (ensure localization of radioactive substances within the hermetic shell of the reactor).

7. Availability at the plant of its own civil defense and emergency situation unit (a staff structure equipped with all necessary technical means and in constant combat readiness), shelters for the staff and means of their protection.

A practically similar situation is occurring around the Armenian NPP, which is also called the Metsamor NPP (located not far from the city of Metsamor, which is straight in a 22-23 km distance from Yerevan - the capital of Armenia). The only nuclear power plant in the Southern Caucasus consists of 2 power units: the first one was commissioned in December 1976, while the second one - in January 1980. In March 1989 the power plant was stopped completely, but in November 1995 the 2nd power unit was launched again. The Metsamor NPP produces up to 40% of the electricity, consumed in Armenia, and its price is almost 3-4 times as cheap as the price of the electricity, generated by thermal power plants of the country.

In 2015, a complex program was launched that concerns prolongation of the service life of the operating power until 2026. This decision had no alternative for Armenia, and this is why it was the case. The state did not have 5 to 6 billion US dollars for building a new power unit, and there were no investors found ready to finance the construction. Refusing from nuclear energy and switching to renewable energy sources: firstly, will require significant expenses for removing from service, stopping completely and dismantling the Metsamor NPP equipment, for which there are no funds available (at present these works at Ignalina NPP in Lithuania are mostly financed by the European Union); secondly, will last for many years, if not decades; thirdly, require considerable expenses as well, while there is a lack of those willing to invest money in alternative energy in Armenia.

Since 1995 (resumption of the power plant operation), the governments of Azerbaijan and Turkey have been demanding full closure of the Metsamor NPP. These demands have become even more insistent after the Armenian government has made the decision to prolong the service life of the power plant for another 10 years. The main argument is as follows: The NPP is in the seismic region (as the representatives of the governments of Azerbaijan and Turkey put it, "it is likely that a strong earthquake should happen in this territory in the nearest future"), and there is old equipment installed in it, therefore it constitutes a threat for 4 frontier countries at the same time (it is located in about a 16 km distance from the Turkish border, about a 60 km distance from the Iranian border, and from Azerbaijan and Georgia it is separated by about a 120 km distance).

Thus, there is no point in arguing about the location. Let us consider two other aspects.

1. The seismic resistance. The Metsamor NPP is able to withstand earthquake shocks of the 9.5 magnitude according to Richter scale. For the past 100 years, just a few such earthquakes have happened around the world. The reliability of the power plant was confirmed by the Spitak earthquake, which occurred in Armenia on December 7th, 1988. It had the 6.8-7.2 magnitude according to Richter scale, while the seismic intensity in the epicentre reached 9-10 points according to MSK-64 scale. Almost the entire northern part of the former Armenian SSR was destroyed (the city of Spitak and 58 villages were razed to the ground, while 3 ones and over 300 settlements were destroyed partially), and about 40% of the industrial potential of the republic were disabled. However, the nuclear power plant was not damaged at all and remained absolutely functional, having withstood the 6.2-6.3-magnitude earthquake shock according to Richter scale without any problems. Thus, the decision of the USSR government to close the Metsamor NPP was not guided by any doubts concerning its reliability, but only for social and psychological reasons - the gigantic number of casualties and enormous destructions caused by the earthquake, combined with the Chernobyl disaster that had occurred two years earlier.

The seismic resistance of the NPP is ensured by special hydraulic shock-absorbers installed in it, which were manufactured by one of Japanese companies. In case of an earthquake, they firmly bind the foundation (base concrete) of the power plant and its equipment (including the nuclear reactor), preventing it from moving under the impact of shakes and inertia. This safety technology was applied and tested at the Metsamor NPP for the first time in the world history.

2. The obsolete equipment. Indeed, the power unit, which is operating today, was put into operation a little more than 38 years ago, 7 years of which were a downtime period. However, there are lots of examples of successful operation of similar equipment, which is even older than the one installed in the nuclear power plant in Armenia.

* Belgian Doel NPP: The 1st power unit was launched in 1974, and the second power unit – in 1975;

* British Hunterston B NPP: The 1st power unit – in 1976, and the second power unit – in 1977;

* The only operating in Holland Borssele NPP: The only power unit – in 1973;

* Finnish Loviisan NPP: The 1st power unit – in 1977;

* French Bugey NPP: 4 operating power units – in 1978-1979;

* Swiss Beznau NPP: The 1st power unit – in 1969, and the second power unit – in 1971;

* The largest Swedish Ringhals NPP: 2 first power units – in 1974.

(It should be noted that: a) these are just a few examples; b) only European NPPs have been considered here; c) it goes about the power units that were launched before 1980).

IAEA members emphasise the fact that since the moment of the Metsamor NPP being re-launched there have been almost 1400 different improvements made in it: reactor building reinforcement, modernization of the earthquake-proof storage batteries, electric cabinets and cooling towers, installation of new American equipment in the earthquake-proof reactor cooling system, modernization of the fire safety system etc. Moreover, preventive maintenance is performed on a yearly basis. The IAEA official persons estimate that at present the 2nd power unit of the power plant is much safer than at the time of its being launched in January 1980.

In 2015, at the Metsamor NPP a series of stress tests was carried out according to the requirements of ENSREG and the European Commission (the National Report was presented in July of the same year). The emergency that had led to the accident at the Japanese Fukushima Daiichi NPP was fully simulated at the power plant in May 2011, including a massive tsunami which is a priori impossible in the Ararat Plain, where the Armenian NPP is located. There was no risk for its operation discovered.

The permanent and close cooperation with IAEA, ENSREG and different international organizations in the area of nuclear energy concerning safe operation of the Metsamor NPP (the Armenian government’s decision to prolong the life cycle of the power plant was also made only after consultations with IAEA and other foreign partners) along with the independent, objective and de-politicized position, acquired by these structures, have led to the Azerbaijan and Turkish parties’ juggling with facts and events (including the ones of the Soviet period), deliberate misrepresentation of information and outright fabrications. In order to apply pressure on the world community, they have started a real campaign under the slogan “The Metsamor NPP is too dangerous to exist!”, which is not even based on any convincing evidence. For example, the Turkish mass media quite often publish information on a threat, which is supposedly constituted by the power plant to health of the inhabitants of Iğdır city, which is located close to the Turkish-Armenian border. They are telling their people about an alleged increase in the number o people with oncological diseases and a significantly increased number of newborn infants with health anomalies. However, if we think logically, the negative consequences caused by the NPP must affect the inhabitants of Armenian settlements near the power plant in the first place. Yet no increase in the number of people with cancer and infants with anomalies has been detected by either Armenian healthcare authorities or corresponding international organizations.

In its turn, Turkey itself has got down to building a four-unit Akkuyu NPP right on the shore of the Mediterranean Sea, not far from the well-known Antalya resort. Neither reasonable and justified objections of international experts nor protests of Turkish and international environmental organizations along with the local inhabitants exert any influence on the government of the country as the opinions of the experts are ignored and the protests are meanly suppressed. Moreover, even the national law, prohibiting construction of technological facilities closer than 3 km to olive groves (in Turkey even 3 olive trees are considered a grove), has been breached.

It is worth mentioning the following important points:

– In Turkey, there is a lack of legal basis, regulating the activity of nuclear energy industry.

– Experts believe that the assessment of the potential seismic threat has been performed incorrectly, although the region is situated just on the joint of tectonic plates and exposed to frequent earthquakes with the possible 8-point magnitude according to Richter scale. (On April 5th, 2018, the government of Cyprus expressed its formal protest to Turkey against the beginning of the

Akkuyu NPP construction. The Cypriot party stated that the region of construction is exposed to earthquakes, and any emergency at the NPP will threaten all the neighboring countries).

– The assessment of the power plant's impact on the environment does not take into account the lessons, learned during the emergency at the Japanese Fukushima Daiichi NPP.

– The power plant is going to discharge about 1 million cubic meters of water per hour into the sea. This will lead to increase in temperature of the sea water in the adjacent territory, causing the living marine fauna to be unable to live and propagate.

– The issues of safety, related to radioactive waste and spent fuel, are not taken into consideration (they are planned to be transported through the Turkish capital and the strait of Bosporus).

It is obvious that the claims of Azerbaijan and Turkey against Armenia concerning the Metsamor NPP are exclusively of a political nature. They are the echo of Armenia-Azerbaijan Nagorno-Karabakh conflict (descending to the beginning of the 20th century), in which Turkey is fully on the side of Azerbaijan, and have no direct connection with the safety problems in the nuclear energy area.

The regulation system in the European nuclear energy area. The regulating authorities.

In this Research, such close attention is drawn to the nuclear energy facilities, because, despite the lowest death rate among the four areas under consideration in the Research, in case of accidents and emergencies at nuclear facilities potential hazards can have irretrievable consequences.

Concerning the issues of industrial facilities safe operation, the nuclear energy is an entirely separate area to such an extent that it falls neither under the aforementioned Convention on the Transboundary Effects of Industrial Accidents, nor under the Prevention of Major Industrial Accidents Convention, adopted by the International Labour Organization, nor under a row of other documents of a global character, which may be in a similar manner applied both to a chemical factory and to an oil refinery, for instance.

The issues of safety in the nuclear energy area are the subject of IAEA – the International Atomic Energy Agency. This independent intergovernmental organization within the UN system was created in 1957. Since 1968, after the Treaty on the Non-Proliferation of Nuclear Weapons was concluded, the work of the Agency has become especially important as the Treaty made it obligatory for each participant country to conclude a guarantee agreement with IAEA. At present, the Treaty has not been signed by Israel, India, Pakistan, South Sudan, and DPRK has quit it.

According to Article III of its Charter, IAEA has the power to establish and adopt safety regulations for protecting human health, minimizing hazards to life and property, and ensuring application of all such regulations. With this purpose, the logical system of objectives and principles of nuclear facility safety has been developed:

* Safety Fundamentals – set forth the general principles of human and environmental protection.

* Safety Requirements – establish, what has to be done to apply the principles.

* Safety Guides – provide the recommended methods to be applied in order to ensure meeting the requirements.

IAEA established regulations (standards), issued in the special IAEA Safety Standards series. They are divided into 3 groups:

1. Safety Fundamentals, SF-1 series.
2. General Safety Requirements, GSR series Part I-VII.
3. General Safety Guides, GSG series.

The general requirements include:

– state, legal and regulation basis for ensuring safety;

– guidance and management for ensuring safety;

– radiation protection and safety of radiation sources;
– assessment of plants and activity safety;
– radioactive waste management prior to burial;
– decommissioning and cessation of facilities' activity;
– anti-emergency readiness and response to emergencies.

Precise Safety Requirements include:
– assessment of nuclear installation sites;
– safety of nuclear power plants (including designing, building, licensing, commissioning and operation);
– safety of research reactors;
– safety of nuclear fuel cycle facilities;
– safety of subjects to disposal (burial) of radioactive waste;
– safety of radioactive materials transportation.

The IAEA standards, being the key element of the global safety regime, have been developed based on the international consensus concerning the basis of high-level safety for human and environmental protection. The responsibility for safety regulation activity is imposed directly on the countries, and a lot of countries have made the decision to apply the IAEA safety standards in their national regulatory acts. As a whole, the situation is seen as follows:

* using the IAEA standards as reference documents during development of national legislation and national standards – by all the countries;

* direct use of IAEA standards for a national nuclear energy regulation authority – by Germany, Czech Republic, Canada, South Korea, Russia etc.

* official adoption of IAEA standards – by China, Holland etc.

Moreover, for the parties of various international safety agreements, the IAEA standards is a concerted and reliable means of ensuring efficient fulfillment of obligations, arising from these agreements.

In the European Union, nuclear energy is one of the areas, which are regulated in the most detailed way. It even has a separate institutional organization – the European Atomic Energy Community (EURATOM), created in 1957, at the same time as the European Economic Community (the so-called "Common Market"). In 1965, the treaty (the so-called "Merger Treaty") was signed in Brussels, which united the authorities of three structures – the European Economic Community, EURATOM and the European Coal and Steel Community, herewith the united European Council and united European Commission were established. On February 7th, 1992, the so-called Maastricht Treaty was signed that initiated creation of the European Union, which absorbed all the existing European structures within the framework of the united European community. However, EURATOM has retained its clear legal personality, being a separate independent legal entity. Switzerland (as an associated state) has been participating in its programs since 2014; agreements of cooperation in various areas of nuclear energy have been concluded with the USA, Canada, Japan, Australia, Ukraine, Kazakhstan, RSA and Uzbekistan.

Despite its independence, EURATOM is governed by the European Commission, which considers nuclear activity from three points of view. Firstly, the nuclear safety is safe operation of nuclear installations, supplemented with radiation protection and radioactive waste management. Secondly, the nuclear guarantees are the means of ensuring the nuclear materials being only used for the purposes, declared by their users. Thirdly, the nuclear safety is connected with physical protection of the nuclear material and installations against purposeful malicious acts.

The European Union, where the nuclear energy occupies only 30% of the general amount of power generation, maintains the highest safety standards for all types of civil nuclear activity, including electric power generation, scientific research and medical use. The main document related to ensuring safety is the Council Directive No. 2009/71/EURATOM, adopted on June 25th, 2009 and establishing a European Union framework for the nuclear safety of nuclear installations. The accident at the Japanese Fukushima Daiichi NPP has led the European Union to the necessity of strengthening the existing legal and regulatory basis for safety of nuclear installations. With this purpose, the Directive No. 2014/87/EURATOM under the same name, abolishing the previous directive, was adopted on July 8th, 2014. Therein we should note the following points:

* The national structure of each EU member country in the nuclear installations safety area shall provide:

– allocation of responsibilities and coordination among corresponding state authorities;

– requirements of the national nuclear safety, covering all stages of nuclear installations life cycle;

– the licensing system and prohibition of unlicensed nuclear installations operation;

– the nuclear safety regulatory control system, implemented by a competent regulatory authority;

– efficient and adequate coercive actions, if necessary – corrective actions or suspension of activity along with alteration or revocation of license.

* The national regulatory authority shall:

– be functionally separated from any other authority/organization, dealing with promotion or use of nuclear energy; neither request nor receive directions from any other such authority/organization, while performing its routine duties;

– make regulatory decisions, based on reliable and transparent requirements related to nuclear safety;

– establish procedures of prevention and solution of any conflicts of interests;

– provide information on nuclear safety without permission of any other authority/organization, provided it does not jeopardize other main interests (for example, safety), recognized in the corresponding legislation or international documents.

* The framework of the national legislation shall provide the national regulatory authority with powers:

– to suggest, determine or participate in determination of national nuclear safety requirements;

– to demand from the license holder to fulfill and demonstrate fulfillment of the national nuclear safety requirements and conditions of the corresponding license;

– to check fulfillment of the requirements by means of regulatory assessment and audits;

– to suggest or perform efficient and adequate coercive actions.

* The precise obligations of a EU member country for ensuring nuclear safety along with the measures of fulfilling this objective have been determined.

Thus, the national regulators in the area of nuclear energy safety, creation of which was one of the main requirements of Directive No. 2009/71/EURATOM, have received more rights for performing their activity, but at the same time they are imposed with more responsibilities.

In 2007, the European Nuclear Safety Regulators Group (ENSREG) was founded by the resolution of the European Commission. It is an independent expert consulting group, including high-ranking officers from national authorities for nuclear safety, radioactive waste safety or radiation protection, as well as senior public officers, competent in these areas, from all EU member countries plus representatives of the European Commission.

The role of ENSREG lies in helping to create conditions for continuous improvement and reaching common understanding of the issues of nuclear safety, safe spent fuel management, safe radioactive waste management etc. Its activity as an independent authoritative expert body is directed to improvement of cooperation and openness among the EU member countries concerning the aforementioned issues and increase of their common transparency. One more direction of ENSREG activity is consulting the European Commission.

The currently valid Directive No. 2014/87/EURATOM provides that the decisions concerning the way of how the national nuclear safety requirements are adopted and what the instruments of fulfilling them are - should remain within the competence of the EU member countries. Each of them has its own bodies, authorized to regulate the nuclear energy area. Thus, in Germany the regulatory authority consists of the federal government and authorities, whereas the controlling bodies at the federal level are the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Office for Radiation Protection. France has its Nuclear Safety Authority (Autorite de surete nucleaire) - an independent administrative authority, invested with powers to regulate all issues of nuclear safety and radiation protection on behalf of the state: to participate in development of regulatory documents, to consult the government, to check fulfillment of standards and regulations by carrying out audits, to pronounce punishments, to in form the public etc. In the United Kingdom, similar functions are performed by the Office for Nuclear Regulation. Since April 1st, 2014 it has been functioning as an independent authority (”statutory corporation”), being responsible for nuclear safety regulation, health and safety at nuclear facilities, nuclear safety, nuclear guarantees, transportation of radioactive materials etc.

In 1999, the regulatory nuclear safety authorities of the EU member countries and Switzerland decided to start cooperation within the framework of the Western European Nuclear Regulators Association (WENRA). There were two reasons for that: firstly, nuclear safety was included into the criteria for expanding the European Union; secondly, although national approaches to nuclear safety had been developed based on the IAEA standards, this had been done independently in each of the countries. Thus, the need arose for developing a common approach to nuclear safety and providing an independent potential for studying this aspect. Nowadays, the WENRA members are 16 EU member countries besides Switzerland and Ukraine. Among the 13 observer countries, there is Canada, Japan, Russia, Belarus, Armenia, Poland etc.

5. The modern scientific approaches to stress testing of critical infrastructure facilities and prerequisites for unification of safety requirements

The critical infrastructure facilities are the basis of modern society and provide opportunities of getting and consuming numerous staple goods and services. They are highly integrated and interconnected. These growing interdependences are making our complex developing society more vulnerable to various accidents and disasters.

The recent events, such as the accident at the Japanese Fukushima Daiichi NPP, have shown that the cascade failures of critical infrastructure facilities are potentially able to cause failures of many other infrastructure facilities and vast socio-economic consequences. The shift to a safer and more stable society requires:

* improvement and standardization of tools for estimating hazards and risks of unlikely events with severe consequences (so-called extreme phenomena);

* systematic application of these new tools to entire classes of critical infrastructure facilities.

Among the most important tools of ensuring this, there are stress tests, designed for testing their vulnerability. After the stress tests, conducted for European nuclear power plants, it is necessary to carry out the corresponding stress testing for all other classes of critical infrastructure facilities. It order to do it, it is necessary to develop a new structure of stress tests for non-nuclear facilities based on innovative models for estimating hazard, risk and extreme phenomena resistance. Such an approach will make it possible to implement the common policy of the European Union concerning systematic conduction of stress tests.

The European Critical Infrastructure Protection Policy applies the approach, based on all hazards, in order to improve their general protection. The planned actions include systematization of advanced practice, tools and methodologies of estimating risks, studying interdependences, as well as detecting and reducing vulnerability. Moreover, increasing Europe's resistance to natural and anthropogenic disasters is among the long-range goals of the EU Internal Security Strategy, which is directed to development of guiding principles of struggling with natural disasters, related to all hazardous phenomena, and establishment of a risk management policy.

In this aspect, the Directive on the identification and designation of European critical infrastructures is directed to improvement of such facilities for better safety protection and satisfying the people's needs. A safety policy must be established and reviewed regularly for each of the facilities of the European critical infrastructure. Every other 2 years, the EU member countries must report on the risks, hazards and vulnerabilities, faced by different European sectors of critical infrastructure.

On the other hand, Seveso Directive establishes the rules of preventing accidents, while working with hazardous substances, and limiting their consequences for human health and environment safety. The operators are suggested that they should make and regularly update safety reports, which shall in particular include risk detection and analysis along with measures of major accident consequence restriction.

The modern strategies of decreasing vulnerability and increasing resistance, adaptation potential and efficiency of critical infrastructure facilities, as well as providing corresponding analytical tools, must follow the integrated approach. However, these facilities are frequently developed and operated in an isolated way; there is lack of attention both to interdependence among them and to their interaction with their social and economical environments. Therefore, it is not enough to know how to model and increase their resistance – it is necessary to obtain a profound systemic understanding of interconnected infrastructures and principles of their operation. It is necessary to estimate hazards and risks of unlikely events with severe consequences (so-called extreme phenomena) and their systematic application to all classes of critical infrastructure facilities, focused on integration of risk mitigation strategy.

To this end, research has been carried out in Europe, known as the STREST Project. They made it possible to obtain fundamental knowledge beyond the current level of assessing the dangers, vulnerability, risk and stability of non-nuclear critical infrastructure facilities and the systems that form them. STREST Project had the following key goals:

1. Establish a common and consistent taxonomy of critical infrastructure facilities, their risk profiles and their interdependencies in relation to resistance to natural hazards.

2. Develop a rigorous general methodology and consistent approach to modeling to assess the hazard, vulnerability, risk and resistance to unlikely events with severe consequences used to determine stress tests.

3. Develop a methodology and structure of stress tests, including an assessment system, and apply them to assess the vulnerability and sustainability of individual facilities, and to eliminate the first level of interdependencies of critical infrastructures from local and regional perspectives.

4. To work with key European critical infrastructure facilities to apply and test developed frameworks and models of stress tests chosen for typing critical infrastructure facilities.

5. Develop standardized protocols and operational guidelines for stress tests.

The main achievements of the research within the framework of the STREST Project are: :

- a probabilistic basis for assessing many hazards/risks, including cascading effect scenarios;
- coordinated consideration of uncertainties and the mechanics of hazard assessment;
- creation of probabilistic models of the fragility of critical infrastructure facilities, vulnerability and impact assessment;
- a comprehensive assessment of the risks of geographically dispersed such facilities, taking into account interdependence and cascading effects;
- probabilistic structural and system performance models for determining losses;
- methodology of multi-level stress test, based on engineering risks, with the scheme of technological process and tools.

The STREST Project allowed to obtain fundamental knowledge that goes beyond the current level of assessment of the danger, vulnerability, risk and stability of non-nuclear critical infrastructure facilities.

The technological process of conducting stress testing is as follows.

The first stage is a preliminary assessment. The available data on the critical infrastructure facility and the dangers that may arise from it are collected. Then, the measures and objectives of the risk, the time frame, the total cost of the stress test and the most appropriate level of the stress test are determined.

The second stage is evaluation. The initial levels of demand for design for each component are compared with the best available information on their capacity, and then a systemic probability analysis of the risk of the entire facility is carried out.

The third stage is decision making. The results of the evaluation stage are compared with the objectives of the risk study identified in the preliminary assessment stage. That comparison leads to a classification that provides information about the magnitude of the risk created by the a facility. If the risk is high, it is determined how necessary to improve the security of the critical infrastructure object until the next periodic inspection. Strategies and recommendations for risk reduction are being prepared.

The forth stage is reporting. The experts present the results of the stress test to government bodies and regulators. The presentation includes the results of a stress test in terms of assessing the onset of critical events, recommendations for reducing the risk and accuracy of the methods used in the stress test.

The conducted studies provide advanced methods and reliable methodologies for stress tests. In particular, they allow to systematically identify the main hazards and potential extreme events, vulnerabilities and interdependencies of critical infrastructure facilities and also select a process flow chart for the stress test based on risk factors.

A unified methodology for stress testing for critical infrastructure facilities developed within the framework of the STREST Project, was tested at 6 different representative sites:

- Petrochemical plant in Milazzo (Italy);
- hydroelectric dam in the region of Valais (Switzerland);
- pipelines for transportation of hydrocarbons in Turkey;
- national gas storage and distribution network in the Netherlands;
- The infrastructure of the Greek port of Thessaloniki;
- industrial area in Tuscany (Italy).

They were divided into three categories:

A - individual objects with one center with high risk and potential for high local impact and regional or global consequences;

B - distributed and/or geographically dispersed facilities with potentially high economic and environmental impacts;

C - distributed, objects with several centers with low individual impact, but greater collective impact or dependencies.

Although, there's no need in such classification for the proposed methodology of stress tests, but that was done for greater visualization and clarity.

The results demonstrated that the stress testing methodology and structure of the stress test developed within the framework of the STREST Project can be used as a prototype for a stress test aimed at the stability of critical infrastructure facilities. Once the sustainability of facilities and social sustainability are determined in an agreed manner, acceptable levels of sustainability are agreed upon, methods for a transparent and consistent assessment of the sustainability of critical infrastructure facilities are developed and adopted in practice. Thus, the basis for the possibility of transition to a unified approach to stress testing in all industries is laid. We believe that it is possible to begin with nuclear energy, given the presence of a number of extremely important points.

First, no other sector of the security requirements set by national regulators, differ so much. If the IAEA Standards were officially adopted by all the states of the world without exception, there would be no problems. Unfortunately, that is not so. Moreover, several important countries (Israel, India, Pakistan, the DPRK) have not even signed the Treaty on the Non-Proliferation of Nuclear Weapons and, accordingly, have not concluded an agreement with IAEA on guarantees.

The two cases with the French nuclear reactor EPR-1600, developed by Areva Inc., illustrate the diversity of the approaches.

In November 2009, the regulators of the United Kingdom, France, and Finland issued a joint statement regarding the automated process control system (ACS) of the reactor, requiring additional explanations from the developers concerning the interrelations between the two subsystems of the process control system. Having received appropriate technical documentation from Areva, the British and French regulators quickly withdrew all their claims. The disagreements with the Finnish regulator existed until 2014.

One more example. In the UK, the licensing of the reactor lasted 6 years and was successfully completed at the end of 2012. Licensing in the US began in 2007 and went up until 2015 and Areva did not ask American Nuclear Regulatory Commission to freeze the process.

Secondly, the countries of the European Union, as well as Switzerland, Ukraine, Belarus, Armenia successfully conducted stress testing of nuclear power plants, based on the methods and mechanisms developed by the European Commission and ENSREG. If it was possible to evaluate the reactions of a nuclear power plant in a collision with a set of emergency situations, then this can be done for all processes in nuclear power.

Thirdly, work on the harmonization of various regulations, codes and safety standards is already underway. For example, Multinational Design Evaluation Programme – MDEP which is implemented under the auspices of the Nuclear Energy Agency, an intergovernmental body under the Organisation for Economic Co-operation and Development. It is an initiative to develop innovative approaches to the use of resources and knowledge of national regulatory bodies, which will be entrusted with the consideration of new projects of nuclear power reactors. In fact, MDEP is a platform where national regulators from 16 countries share technical data, exchange standards, and standard practices to avoid duplication of work.

Or, for example, the working group Cooperation in Reactor Design Evaluation and Licensing - CORDEL). It operates within the framework of the World Nuclear Association, an international organization dedicated to promoting nuclear energy, and is sponsored by industrial manufacturers. The aim of the CORDEL group is to stimulate dialogue between the industry and national regulators to bring security standards around the world closer together (in particular, the benefits of creating internationally recognized standards for III and III + reactors) are analyzed. And the global challenge is to create a regulatory environment around the world in which the world-renowned standardized reactor designs could be widely implemented without significant changes, with the exception of the facilities dictated by the specifics of the site.

The benefit for national regulators is that convergence, harmonization, and unification of national standards that will facilitate their international cooperation. Regulators will be able to share methods and data obtained during the examination of projects, and that will allow them to improve its effectiveness. The transfer of data on all regulatory issues, including practices, will contribute to the development of civilian nuclear power in developing countries, a regulatory regime in which has not yet been established. Also, regulation can improve: regulators will understand why their foreign partners have chosen a solution, and together they will be able to choose the most reasonable and effective solutions. That, in turn, will have a positive impact on public confidence in regulatory decisions in the nuclear energy sector.

Returning to the consideration of the current state of security in the four sectors discussed above, we summarize the main potential problems in the field of industrial and industrial safety.

Chemical industry

Since the appearance of the world's first chemical plants (1736 and 1766 - sulfuric acid plants (Great Britain and France), 1793 and 1823 - soda plants (France and Britain), in 1842 and 1867 - artificial fertilizers plants (United Kingdom and Germany)) and to this day the enterprises of the industry have made a revolutionary leap. Not only in terms of applied technologies, used equipment, manufactured products, but also in terms of impact on people and the environment. Figuratively speaking, the way was passed from the September 21, 1921 explosion at the plant of aniline dyes and fertilizers of the BASF concern, located near the German town of Oppau, which killed 561 people - to the Bhopal tragedy, which killed approximately 3-5 thousand people (plus about 10-15 thousand people died in the following years from the effects of poisoning).

Of course, examples are given of the biggest accidents in the industry, which will forever remain in world history. But let's look at the usual statistics: for the period of 1998-2015, only once (in 2002) there were no human victims in chemical and petrochemical enterprises; the number of deaths in 2005-2015 was 690 people. Here is the latest example of the tragedy: on March 22, 2018, in the Czech city of Kralupy nad Vltavou (located near the capital of the Czech Republic, Prague), an explosion occurred in a chemical plant belonging to the group of companies Unipetrol Synthos, which killed 6 people.

Nowadays, chemical industry enterprises are also one of the largest sources of impact on the natural sphere. This was caused by a number of factors. First, there is a huge number of not only existing ones in the world but also a certain number of objects under construction and projecting. Secondly, all chemical enterprises function on the principle of an "open system", that is, they have a direct connection with the surrounding environment. Thirdly, the danger of chemicals and products manifests itself in both accidents and in the ordinary (standard) mode of operation of enterprises. Fourth, all the technological components of chemical production are to a varying degree toxic, their entry into the environment is dangerous. Fifth, the danger of toxic substances entering the environment appears even at a great distance from the sources of chemical pollution, and everything is susceptible to chemical toxicity.

In the process of operation of most enterprises in the industry, hazardous substances enter the environment. In normal operation of the equipment, such emissions are not large-tonnage, but they can cause significant harm. The situation is aggravated by the fact that most of the emissions are made up of chemical mixtures (carbon dioxide, nitrogen oxides, and sulfur, phenols, alcohols, ethers, fluorides, ammonia, petroleum gases, etc.), so their qualitative purification is very difficult.

The technology of chemical production requires increased consumption of water, which is used for a variety of needs. Then, not sufficiently purified, it flows back into rivers and water bodies in the form of sewage.

It should be noted and the problem of production waste. There is a huge amount of hazardous and harmful substances in storage facilities, on landfill sites and landfills. Those places are subject to constant dusting and erosion, resulting in waste entering the atmosphere, soil and water.

Coal industry

There is a view that the negative consequences for nature and people from the massive use of coal outweigh its economic benefits. And the use of coal for the production of electricity, in general, is monstrously expensive from the point of view of ecology and public health. Nevertheless, it continues to remain the world's second most important source of energy; without it, ferrous metallurgy, coke and chemical industry and steel industry cannot do without, coal is used in the chemical industry, agriculture, at home, etc.

The demand for coal continues to grow, with it the number of accidents, accidents, and catastrophes in mines, as well as the number of dead miners. According to these indicators, China is the undisputed leader: in 2005-2015, 28854 people were killed in the Chinese coal mines (according to official data). During the same period, the number of victims in the US coal mining industry amounted to 288 people, i.e. in 100 something times less.

The essence of the key environmental problems of this industry is the following:

- subsidence of the earth's surface in underground mining and disturbance of the soil cover, leading to the development of soil erosion, landslides of unstable slopes.
- emissions into the atmosphere of methane, accompanying coal, as well as coal dust.
- the adverse effect on the air, water, and soil of various toxic substances released as a result of various physical and chemical processes occurring in dumps.
- risk of spontaneous combustion of coal.

- discharges of highly mineralized mine wastewater into surface water bodies or catchments (lead to significant environmental damage associated with water quality degradation and salinization of soils).

- Rejection of land for storage of solid waste, in huge quantities formed during coal mining (heaps, flat rock dumps, sludge collectors).

- adverse effect on the air and water (underground and surface waters) of the environment of toxic substances released as a result of physical and chemical processes occurring in the storage of solid waste.

- the appearance of land plots allocated for the storage of solid dumps, which in the future can not be used or reclaimed, due to their contamination and degradation.

- Radioactivity of brown coal containing uranium, thorium, and potassium-40 (for example, about 100 million tons of brown coal and about 460 tons of overburden with 380-390 tons of uranium are extracted annually in the Rhineland region of Germany).

Pollution of the environment and changes in environmental parameters have a slow and accumulative effect of adverse effects on human health, manifested in several decades. In places where active coal mining has been going on for a long time, already today the negative impact on the local population. That is reflected in:

- the decrease in life expectancy;
- high level of congenital anomalies;
- increase in the number of oncological diseases, diseases of the circulatory and nervous systems, occupational diseases;
- the high specific gravity of groups of the population, vulnerable to the influence of the environment.

Nuclear energy

Nuclear power is one of the biggest achievements of scientific and technological progress, providing people with cheap electricity. In addition, during normal operation, NPPs are at least 5-10 times cleaner ecologically than thermal power plants (TPPs) operating on coal, since they do not release harmful substances into the atmosphere (sulfur and nitrogen oxides, carbon monoxide and carbon dioxide, ash, etc.). However, powerful heat sources in the form of cooling towers are sources of thermal pollution of the environment. Thermal pollution has an impact on the climate of the region where the nuclear power plant is located. The humidity of the air increases, especially in the autumn-winter period, which adversely affects the health of people, as well as the condition of crops, forests, buildings, and structures (including switchgears and power lines). Also, the reservoirs that drain warm water from cooling systems suffer. First, a decrease in the concentration of oxygen dissolved in water lead to fish stocks reduction. Secondly, in the warm water, there is a rapid development of blue-green algae, leading to a "flowering" of water, which makes it impossible to use such a reservoir for drinking water supply.

But the main danger is radioactive radiation. Applicable to the plant itself, this problem can be solved if the station is operating in the normal mode. However, there is also the fact that it is connected with the operation of the nuclear power plant: the place where the radioactive waste is buried, the equipment that has worked its end, the clothes of the maintenance staff, etc. Therefore, conditions of their storage have to be 100% safe.

Indicative is the fact that despite a certain number of incidents and accidents at nuclear power facilities, in the 21st century they all did without victims, directly caused by incidents or accidents. This is a consequence, among other things, of the fact that the system of supranational and national regulation of nuclear power is the most effective - in comparison with the chemical, coal and petrochemical industries.

Oil refining industry

The industrial process of oil processing proceeds at high temperatures and pressure, raw materials and products are extremely flammable substances. The process itself is not wasteless, a significant amount of substances enters the environment. Thus, a dangerous symbiosis of the huge energy saturation of the enterprise and its ability to throw out harmful and explosive substances is obtained, which creates an increased danger from the objects of the industry. In case of accidents or catastrophes, it significantly increases.

Environmental problems in the processing of oil at enterprises extend to the entire environment.

- Atmospheric air. Air pollution occurs at all stages of processing of oil and its components, but the greatest amount of harmful substances enters the atmosphere during catalytic cracking. About 100 items are included in the emissions, including heavy metals, methane, sulfur dioxide and carbon monoxide, hydrogen sulphide, various dioxins, benzene, phenol, hydrofluoric acid, mazut ash, etc. Most of the gases emitted by oil refineries to the atmosphere are harmful to the living body and can cause a person to have various pathologies of the respiratory system (asthma, bronchitis, asphyxia). Also, gaseous emissions contain a significant amount of fine solid particles, which, depositing on the mucous membranes of the respiratory tract, interfere with normal breathing processes.

- Soil cover. Its pollution occurs during the spill of crude oil during its transportation to oil refineries, or directly at enterprises At the same place, during a serious accident, pollution occurs with products of oil refining. All this causes disturbances in the dynamic equilibrium in the ecosystem, due to a change in the structure of the soil cover, the geochemical properties of soils, and also the toxic effects on living organisms. The danger of this pollution is determined by the high sensitivity of higher plants, which occupy a key position in virtually all terrestrial ecosystems and determine the existence and composition of the remaining biological components of biogeocenoses. Getting to the soil, crude oil and its processing products (due to the slow rate of destruction of heavy oil fractions) have a long negative impact on plants: from 10 to 20 years and more, if the contamination is severe. The conducted soil studies in the areas where oil refineries were located showed that, on average, it is polluted within a radius of 3 km from the facility and to a depth of 60-80 cm.

- Water system. The negative impact on it is due to the use at the enterprises of the industry of a large amount of water in technological processes. Wastewater from oil refineries is diverted through two sewerage systems. The waters of the first system are used repeatedly, the waters of the second fall into natural water bodies. No matter how perfect the cleaning system is (in the current period), a large number of pollutants still fall into the sewage: salts, sulfur compounds, benzenes, phenols, alkanes, etc. They have a carcinogenic, mutagenic and teratogenic (embryonic developmental disorder) effect on water inhabitants, and also reduce the concentration of oxygen in the water, which leads to their death. In addition, the dead organic matter serves as an excellent substrate for decay bacteria, which in cases of mass death of living matter in a matter of months can turn a pond into a lifeless settler.

The effect of waste from the oil refining industry on the environment can have a cumulative effect. Direct entry of a large number of oil products into the environment leads to a complete decay of ecosystems at the site of the spill, the migration of harmful substances from the spill site to significant distances and disruption of the life of macroecosystems. Pollution leads not only to environmental degradation but also has a negative impact on the deterioration of public health. For example, the dependence of exacerbation of chronic bronchitis and bronchial asthma on the level of air pollution with sulfur dioxide has been repeatedly confirmed: the incidence of diseases among children aged 0 to 15 increased significantly on days when the concentration of sulfur dioxide in the atmosphere exceeded 0.13 mg / m3.

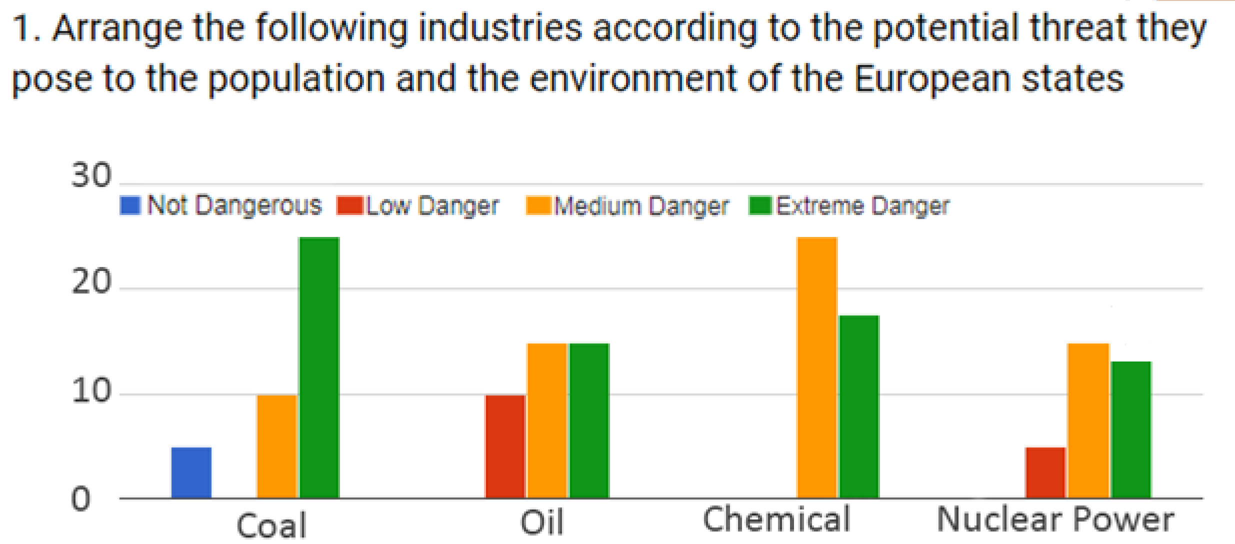
Oil refineries, like all industrial facilities, carry a potential threat to the health and life of personnel working for them. In this case, overheating of crude oil, inhalation of toxic fumes, chemical burns, etc. can be added to the completely traditional causes of accidents and death (defects and malfunctions of the equipment, improper maintenance, violation of the technological process, non-observance of safety measures). According to statistics, for the period from September 7, 1995, to January 12, 2015, US oil refineries killed 137 people, that is, an average of 20 people per year. Of course, the figure is not that big, especially compared to the victims in the coal industry. However, let's not forget that we are talking about the US, with its advanced technologies and strict control.

6. Opinion poll

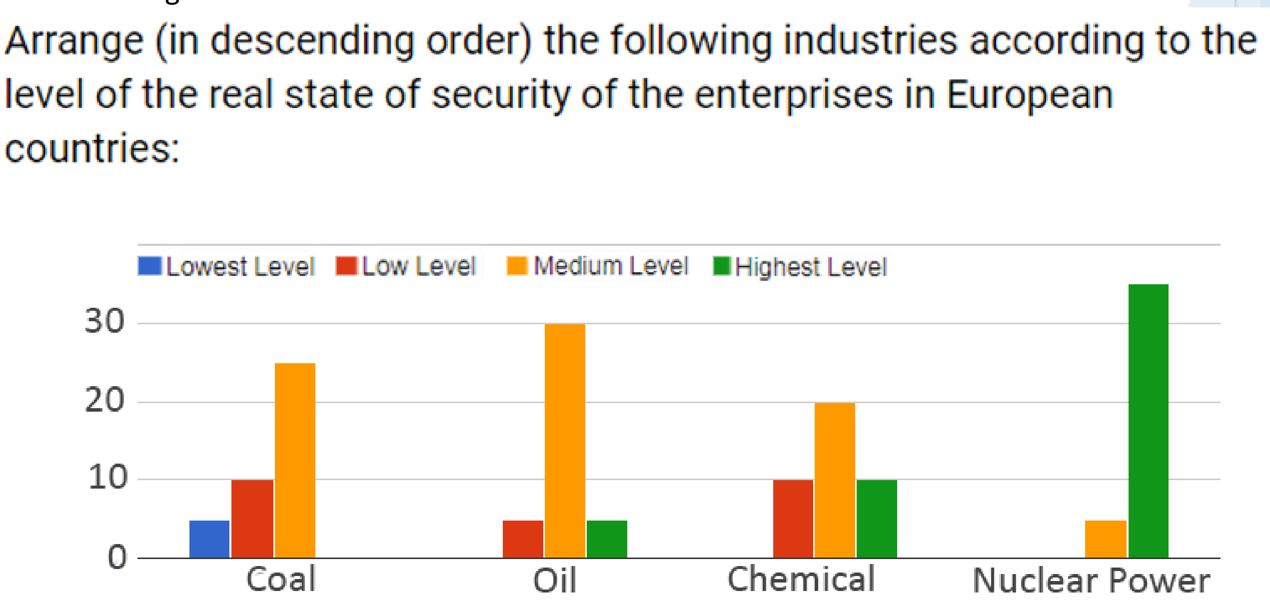
During the preparation of the Study, a survey was conducted among experts from the coal, nuclear, chemical and oil industries, as well as environmental experts from several European countries (Hungary, Norway, Ukraine, Czech Republic, Slovakia, Belgium and others) on "Safety Criteria and Risks in Construction and the work of chemical, oil, nuclear and coal industries: stress tests and other safety criteria. "

Evaluating the results of the expert survey, it is first of all necessary to pay attention to the results of the ranking of the safety levels obtained as a result of expert consensus assessment.

1. The ranking according to the degree of potential danger of enterprises for the population and the environment of European states is as follows (in descending order):
- coal and oil refining industry (at the same level)
- chemical industry.
- nuclear power.

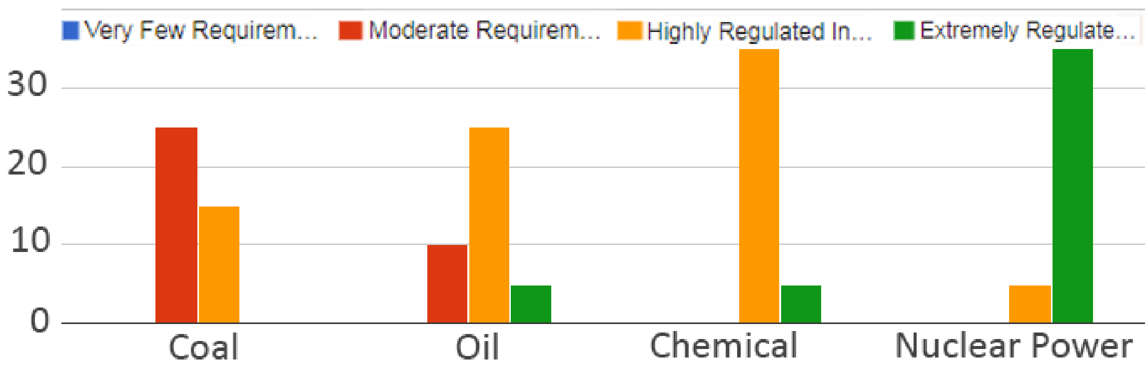


2. Rating of the real state of security of enterprises in European countries (in descending order):
- nuclear power.
- the chemical industry and coal industry (at the same level)
- oil refining



3. Rating of the degree of rigidity of regulatory requirements for the safety of enterprises in European countries (in descending order):
- nuclear power.
- chemical and oil refining industry (at the same level)
-coil industry.

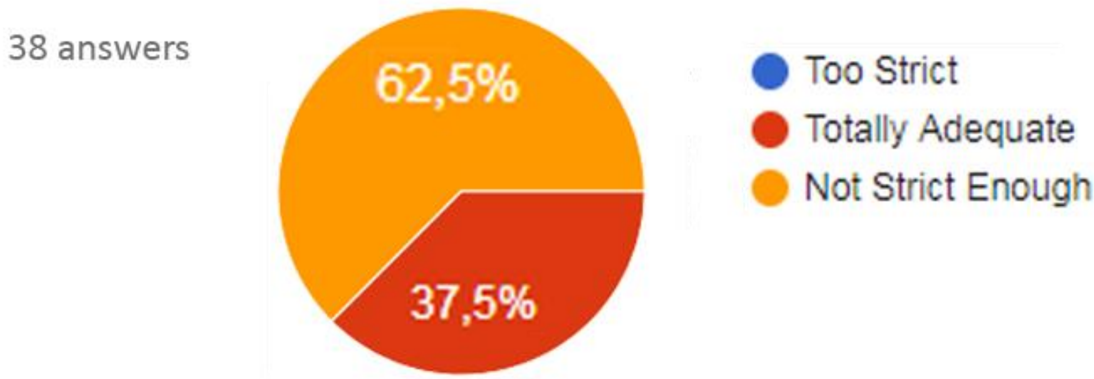
3. Arrange the following industries in terms of the severity of the requirements for the safety of the enterprises in the European countries



The consensus assessment of experts indicates that, despite medium level of potential risk of nuclear energy enterprises in comparison to other industries, the real state of industrial safety at nuclear enterprises, as well as the level of regulation and control thereof, is at the highest. It is seems to be logical - proceeding from potentially possible technogenic risks of the industry.
The worst estimate is for the coal industry, which, in the opinion of the majority, is the most dangerous in terms of the number of victims and man-made disasters.

It should also be noted that 2/3 of the total number of experts interviewed consider it possible and appropriate to unify the requirements for man-made and industrial safety to European enterprises in the oil, coal, chemical industries, and nuclear energy.

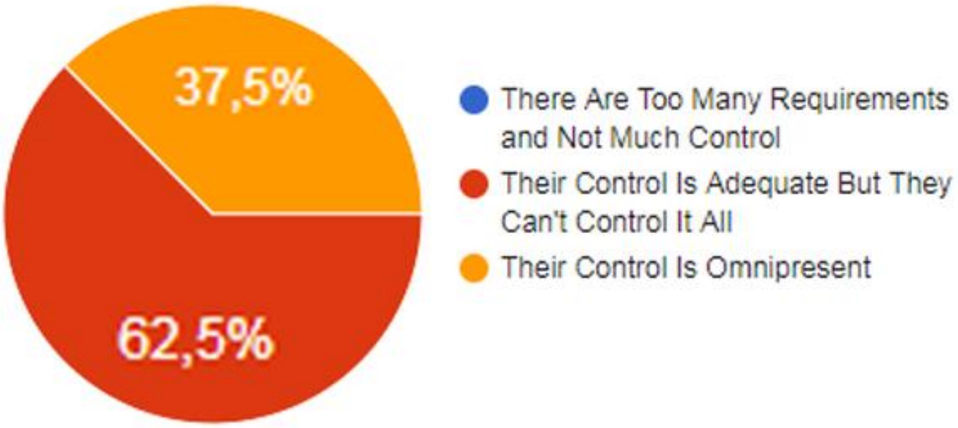
4. The European safety requirements for the energy enterprises (in the industries listed above) are



Indeed, as we see in the diagram, most experts consider that relevant regulatory and controling bodies have proper regulations and legislation, but can’t control it all.

5. Are the relevant national regulatory bodies of the European countries observing adequately the compliance with the existing requirements for the safety of enterprises in oil, coal, chemical industries and nuclear energy?

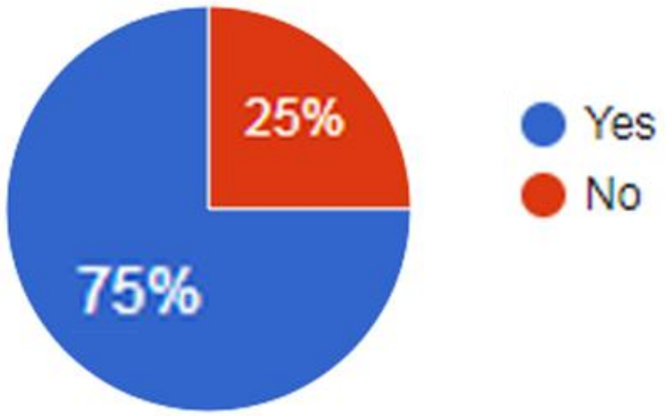
38 answers



On the question whether the requirements for the safety of chemical, oil, coal and nuclear industries should be unified, the majority of the respondents gave a positive

7. Should all the European requirements for the safety of enterprises in oil, coal, chemical industries and nuclear energy be unified?

38 answers



The consensus answers of experts can be reduced to the following theses:

- Unification of the requirements for the safety of enterprises in the oil, coal, chemical industries, and nuclear energy can be a serious measure aimed at raising the level of industrial and industrial safety;
- Nuclear power is a complex industry and it will not be easy to implement common norms for all countries taking into account the specifics, mentality, approaches to licensing. First of all, one should develop common documents and reference levels, as well as get out of the selective approach and politicization.
- Currently, the general guidelines are developed, there are European stress tests that are mandatory for European countries. But, opponents of that approach will be countries with poorly developed industry, inefficient and energy-intensive production, which do not comply with environmental norms to reduce emissions of harmful substances into the atmosphere.

7. Summary and conclusions.

The development of industry in the modern world invariably leads to an increase in the dangers associated with the emergence of man-made accidents and catastrophes. They sometimes entail the death of people and cause significant damage to the environment.

Humanity, both at the level of governments of different states, and at the level of company managers, has come to understand that the problem of security in various industries needs to be solved jointly. Regularly, under the auspices of the United Nations and other international organizations, forums, conferences, and consultations are held, various international documents are adopted, of a regulatory nature. There is an exchange of experience on the prevention of all kinds of man-caused disasters and the elimination of their consequences, the causes of the emerged emergencies are analyzed, measures are being developed to prevent them in the future.

At the same time, there are obvious differences in approaches to the safety of industrial facilities. Often this happens even within the framework of one industry. The requirements for a conventional chemical factory, nuclear power plant, oil refinery in one country in the world, sometimes differ substantially from requirements in another country. This can happen even within the framework of one continental union of states (for example, the European Union), not to mention the differences on the continents or in the regions of the world.

That is why there is the advisability of a gradual transition to unified safety requirements for industrial enterprises. The possibility of such a step is confirmed not only by scientific research and development in this field but also by the concrete, successful practice of their application - there are stress tests conducted at nuclear power plants of the EU member states and some other European countries.

Successful solution of problems of technological security will not be possible without close cooperation between all stakeholders: authorities at the national and regional levels, industry, the public, non-governmental and international organizations. But the stress testing of European nuclear power plants has shown that the extremely important safety issues are excessively politicized, the uniform standards worked out at the highest (European Commission) and authoritative (IAEA, ENSREG, WENRA) levels are supplemented by personal requirements that are purely opportunistic in nature That practice is vicious and unacceptable since it is about people's health and the state of the environment, which should not be accompanied by speculation. It should be replaced by a balanced and constructive dialogue that will facilitate the adoption of decisions that are beneficial to all stakeholders.

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