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ECOLOGY ACCIDENTS PROTECTION AS EFFECTIVE FIRE-FIGHTING AND EXPLOSIVE PREVENTION OF PORT'S CONTAINER'S TERMINALS IN ACCORDANCE OF ANALYZE OF FIRE-EXPLOSIVE-TOXICALLY CATASTROPHE AT SEA-PORT AT TIANJIN-TOWN

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The analysis of the causes, the development process of the catastrophic fire, including a series of subsequent explosions, is given. The reason of the failure of the extinguishing operation is open – low efficiency in localizing and extinguishing the fire, despite the dedicated work of more than 1,000 firefighters (21 fire brigades) with 150 power fire trucks. It is shown that the main reason for the rapid and large-scale development of the catastrophe was the low range and scale of the delivery of extinguishing agents; inflexible, slow change of modes of submission of agents; lack of technique for supply the gas-sprayed sand, inert dust, which became necessary to extinguish burning chemical-active materials, in compatible with water, foam in agents and powder are ineffective. A new modernization of impulse fire-equipment and automatic fire-extinguishing systems is proposed to localize and extinguish fires in terminals of containers, coal, oil, gas warehouses, cargo-berths. The modernization consists in additionally equip in the existing automatic fire-extinguishing systems in the ports at the launching sites with multi-barrels modules (MM) of volley spray in creating a parallel executive system of several MM place around the fire and explosion hazard site at distances from 50 to 200 m. This will make it possible to improve the efficiency of fire-extinguishing and to provide effective light and thermal protection and prolong the life of expensive start-up designs. The validity of the proposed project is confirmed by the results of the last successful demonstration tests of the MM system, placed in a semi-circle around the target and focused their volleys on one local, powerful fire. *Key words:* catastrophic fire, explosion, container's terminal, fire-extinguishing equipment, impulse delivery, fire-extinguishing gas-liquid flurry, fire-extinguishing gas-vortex, automatic extinguishing system, executive modules, multi-barrels modules, containers with fire-extinguishing compounds, cartridges with spray gun-powder charges.

Ефективний захист контейнерних терміналів порту від екологічних аварій, спричинених вибухонебезпечними засобами, на основі аналізу катастрофи в морському порту міста Тяньцзінь. Захматов В.Д., Бондар О.І. Проаналізовані причини та процес розвитку катастрофічної пожежі, а також вибухи, до яких вона призвела. Зазначено, що мета вогнегасних операцій не досягнута через низьку ефективність дій із локалізації та гасіння пожежі, незважаючи на самовіддану роботу понад 1 000 пожежних (21 пожежна бригада) та використання 150 пожежних машин. Показано, що основною причиною швидкого та масштабного розвитку катастрофи є вузький діапазон вогнегасних речовин; негнучкі, повільні зміни режимів подачі агентів; відсутність техніки для подачі пісків із газоподібним покриттям, інертного пилу, необхідного для гасіння спалювальних хімічно активних матеріалів. Модернізація імпульсної пожежної техніки й автоматичних систем пожежогасіння пропонується для локалізації та гасіння пожеж у контейнерних терміналах вантажних причалів із вугіллям, нафтою, газом. Модернізація полягає в додатковому обладнанні наявних автоматичних систем пожежогасіння мультимодулями для залпового реагування на виникнення пожежі і вибуху на відстані від 50 до 200 метрів. Це дозволить підвищити ефективність пожежогасіння та забезпечити ефективний світловий і тепловий захист, подовжити термін експлуатації дорогих пускових конструкцій. Актуальність запропонованого проекту підтверджена результатами останніх успішних демонстраційних випробувань системи мультимодулів зі спрямованою дією на джерело потужного вогню, розташованих навколо цілі. *Ключові слова:* катастрофічний пожежа, вибух, контейнерний термінал, устаткування пожежогасіння, імпульсна доставка, гасіння вогнегасною газовою рідиною, вогнегасниковий газовий вихор, автоматична система пожежогасіння, виконавчі модулі, багатошарові модулі, контейнери з вогнегасною системою з'єднання, патрони з наповненням пульверизатора.

Эффективная защита контейнерных терминалов порта от экологических аварий, вызванных взрывоопасными средствами, на основе анализа катастрофы в морском порту города Тяньцзинь. Захматов В.Д., Бондарь О.И. Проанализированы причины и процесс развития катастрофического пожара, а также взрывы, к которым он привел. Отмечено, что цель спасательных операций не достигнута из-за низкой эффективности действий по локализации и тушению пожара, несмотря на самоотверженную работу более 1 000 пожарных (21 пожарная бригада) и использование 150 пожарных машин. Отмечено, что основной причиной быстрого и масштабного развития катастрофы является узкий диапазон средств для тушения пожаров; негибкие, медленные изменения режимов подачи агентов; отсутствие техники для подачи песков с газообразным покрытием, инертной пыли, необходимой для борьбы с последствиями возгорания химически активных материалов. Модернизация импульсной пожарной техники и автоматических систем пожаротушения предлагается для локализации и тушения пожаров в контейнерных терминалах грузовых причалов с углем, нефтью, газом. Модернизация заключается в

дополнительном оборудовании имеющихся автоматических систем пожаротушения мультимодулями для залпового реагирования на возникновение пожара и взрыва на расстоянии от 50 до 200 метров. Это позволит повысить эффективность пожаротушения и обеспечить эффективную световую и тепловую защиту, продлить срок эксплуатации дорогих пусковых конструкций. Актуальность предложенного проекта подтверждена результатами последних успешных демонстрационных испытаний системы мультимодулей с направленным действием на источник мощного огня, расположенных вокруг цели. *Ключевые слова:* катастрофический пожар, взрыв, контейнерный терминал, оборудование пожаротушения, импульсная доставка, тушение огнетушащей газовой жидкостью, огнетушащий газовый вихрь, автоматическая система пожаротушения, исполнительные модули, многослойные модули, контейнеры с огнетушащей системой соединения, патроны с наполнением пульверизатора.

The world entered a period of regular industrial catastrophes to prevent which is almost impossible. The saturation of large industrial facilities in hundreds and thousands of tons of fire-explosive and toxic substances has exceeded the critical limits controlled by traditional fire-fighting technique. The various execiting devices for automatic systems, extinguishers, Fire-machines are ineffective for the protection of modern chemical and oil and gas enterprises, tank farms, port terminals, does not guarantee the prevention of the development of fires, arson in a catastrophe. The main reasons are: low intensivity, scale, area of extinguishing jet's front when spray extinguishing agents. There are need for a qualitatively new technique of rapid localization and elimination of the consequences of accidents – first fires of the most destructive consequences of almost any large sea-ports, energy and industry objects [1].

On the night of 12 August, 2015 year in the container terminal at one of the largest seaports in China (Tianjin), containers with explosive-able, chemical substances (EaCS) caught fire and two powerful explosions with TNT equivalent of 3 tons and 21 tons occurred (Fig. 1a). The metro station and a number of buildings in the radius of 1–1. 5 km were destroyed, within a radius of 2–3 km all windows were completely knocked out, 2 400 cars were parked outside the shock wave's destroyed zone, but the cars were burned by strong radiation from great Fire-Ball, created by second Explosion; 112 people were killed, more than 1 100 people were injured, 720 were hospitalized, 66 of them were seriously injured, 95 were missing, over 50 fireman's died. Losses amounted to several billion dollars – hundreds of burned containers, thousands damaged by explosions (Fig. 1b), a simple port – the disruption of many contracts, the evacuation of tens of thousands of residents [2].

The development of the consequences of the first two explosions could not be quickly localized and eliminated, despite the fact that the maximum possible forces for the city of Tianjin were 21 fire brigades with 150 vehicles. Due to the presence of explosive and active chemicals in containers, it was impossible to extinguish traditionally by supplying large masses of water and foam with compact and sprayed jets. The possibilities for effective quenching were limited only by remote and intensive feeding of sand, inert dusts, in combination with high-precision supply of finely-dispersed water and gels to high-temperature areas – the most powerful sources of re-ignition. Fire trucks for intensive water supply and foam were idle. Firefighters were forced to throw sand in a highly toxic environment, as there are no fire trucks that supply sand and inert dust to extinguish fires of active chemicals that explode on contact with water or burning materials with unknown chemical composition. Strong toxicity up to 8–10 times higher than the norm did not give an opportunity to work as a fireman. Then 214 military chemical specialists worked with biochemical and nuclear substances from the chemical industries of the People's Republic of China, but they did not have the experience and technology to extinguish complex, explosive fires. Repeated ignitions began on August 15 and local fires in the epicenter of the disaster burned until the active materials were completely burned out of containers [2, 3].

Analysis of operations to extinguish fires and prevent explosions in chemical and oil and gas facilities over the past decades has shown the low efficiency of modern samples of powerful water supply systems with an intensity of up to 330–500 liters per second for knocking out the flame fires of gas jets and oil bottles to preserve expensive technological equipment, tanks and , the main thing is to prevent their explosions, which is most conducive to spreading the fire and turning it into a catastrophic fire. Even when the system of powerful fire barrels, the rate of supply of 100 liters / sec and more (water cannons) literally spew water falls – still does not provide timely and effective quenching. Firefighters "water cannons" are inertial – it takes several minutes from switching on before starting the water supply and reaching the maximum feed rate [4, 5].

Currently, political tensions and local military actions in Ukraine remain a high probability of terrorist acts and sabotage at enterprises of Ukraine and Russia, primarily in the storage and use of fire-explosive-dangerous, toxic, radioactive products and materials, including storage terminals and loading docks in sea and river ports, technological installations, lines and warehouses at chemical and gas-oil objects, etc. For example, as a result of artillery shelling and subsequent fire of industrial enterprises of the Donetsk – Lugansk region, toxic, radioactive emissions and smoke can almost freely spread to the territory of most of this region and the border regions of Russia by airflows [6, 7].

The low efficiency of traditional firefighting equipment and TSA executive systems was revealed in the 1980s. Therefore, the fuel and energy complex, the chemical industry, including terminals and warehouses in ports and railway stations, was financed during the period 1982–1991. Right up to the collapse of the USSR research into the creation of new fire engines and executive

subsystems of the TSA with high parameters for range and squaring area. The latter is mainly determined by the area of the front of the extinguishing jet and the ability of the operator to control the spray of the extinguishing agent (EA) [8, 9].

The author offers new OS delivery systems and executive systems consisting of pulsed-spray devices and multi-module pulsed, fine-dispersed, universal, flexibly controlled spraying of various fire-extinguishing agents: liquids, gels, powders, gases, and, for the first time, natural materials: sand, dust, capable of providing quenching of chemically active materials. In addition, the new technology can spray sea salt water and cloudy water, unfiltered from any sources, quickly disabling pumps of traditional fire trucks and ships [10].

The current state of the problem. The experience of liquidation of industrial accidents in peacetime has shown the low efficiency of modern, fire equipment, even its best American and European models. In the modern period of technical development, the most effective system for protecting automated ports, for example, in Qingdao, China, new sections of the port in St. Petersburg, industrial enterprises are automatic fire extinguishing systems (TSA). However, modern executive modules for TSA are very expensive, complex, require long-term installation, commissioning; highly qualified personnel for service. Therefore, even the most expensive and perfect TSA and fire engines produced in Germany, Austria, the US are not able to effectively eliminate the consequences of sabotage, explosions – to prevent their transition to secondary explosions and catastrophic fires. Electronic blocks of TSA are quite perfect and unified in different countries. The speed and efficiency of the systems is determined by the executive part, consisting of pipelines, large, heavy, metal-intensive high-pressure tanks, powerful pumps.

Industrial accidents suddenly arise, due to the direct hit of a rocket, projectile, subversive or terrorist explosion. Another cause of the catastrophe is hidden damage, apparatus, pipelines and machinery, due to the destructive impact of the shock wave, the debris is a delayed accident that can occur suddenly in months and years for no apparent reason, for example during repair or disposal.

Necessary and urgent measures to ensure the safety of fire-explosive-toxic-hazardous facilities in Russia from potential diversions that cause man – made accidents, which cannot be eliminated in time with the help of traditional technology. Therefore, the only possible way to quickly equip potentially dangerous objects of TSA with a cheap, simple, easily and quickly mounted executive part consisting of multi-barrel modules of volley spraying of extinguishing, explosion-preventing, heat-lightning, and localizing agents is proposed.

Previous application. Since the early 80s of the last century, a number of multi-barreled MM modules on biaxial carriages and runners have been developed proactively and then within the framework of state military and economic programs. These MM were created, manufactured in large quantities and have been sufficiently tested at landfills and in a number of operations to eliminate the various consequences of accidents and disasters. The first 4-barrel module (MM-4) was manufactured at the Moscow Higher Engineering Technical School of the Ministry of Internal Affairs of the USSR and successfully tested at a training ground near Moscow, under the author's scientific guidance in April 1981. In September 1982. MM-8 on runners (Fig. 2b), made according to sketches and under the guidance of the author during the day in the repair shop of Kiev regiment of Civil Defense. As the barrels used oxygen 200 liters cylinders with an cuted bottom. The hemispherical head of cylinders with a vent hole was used as a loading chamber into which a spray cartridge with a charge of gunpowder was laid. Within the framework of the demonstration part of the All-Union Collections Civil Defense, MM-8 successfully extinguished a pile of wood from a distance of 50 m at the Civil Defense training ground in Koncha-Zaspa in 2 seconds. In Fig.1 shows a full volley of 8-barrel pulse-pulverize 120 kg of extinguishing powder (EP) in the form of a gas-powder vortex with a range up to 60m, with a shock front expanding from 1m to 8m in width and in height from 0,5 m to 3 m. The front of the vortex has covered an area of up to 350 m^2 in the form of an elongated longitudinal section of the drop along its trajectory [7].

The only competitor at that time and still single-barreled, pneumatic-pulse-pulverizing installation on the skid (Fig. 1a), designed by Prof. Abduragimov I., associate professor Makarov V. pulse-pulverizing of 200 kg of fire extinguishing powder (EP), with a small muzzle velocity and not more than 15–20 m. Therefore, it is able to extinguish only low-pressure gas fountains from a distance of up to 10 m in a hard-to-reach zone along heat fluxes and flame tongues. It's export to the position of hard-labor and dangerous. The level of the pullback force is greater than the rollback at a salvo ejection of the same mass from several barrels by 20–35% [8].

In May – July 1986, up to thirty MM-9 and two MM-16 were manufactured at the pilot plants of the Research Institute of the Academy of Sciences and the Arsenal-2 military repair plant. MM from this batch was effectively used in the Chernobyl zone as the executive modules of the TSA, quickly put on the position and put into standby waiting mode. They protected transformer stations near the destructed building of the reactor's 4-unit and sections of the 3–4th blocks [6].

In May – June 1989. MM-8, MM-9, MM-25 were successfully used for multiple extinguishing attacks from a distance of 50–100 m along a burning "bush" of 14 Oil wells at area of Oil Rocks in the Caspian Sea. MM on the two-axle carriage carried on the wide, aft deck of the emergency ship, and then on one side of the high deck of the Finnish crane in a row in the adjacent compartments. The directory sights of the barrel packs had a certain convergence angle so that the vortices formed by neighboring MMs converged at a distance to 80–100 m, which made it possible to achieve the maximum quenching efficiency

when a powerful, turbulent total fountain of fire was shot from a distance relatively safe by thermal radiation from a burning fire bush. A volley of 40 barrels created a powerful squall with a range of up to 140 m, a front width of up to 20 m, a height of up to 5 m. The ship with deck MM quickly and reliably knocked down the flames, ensuring the landing of workers on the deck of the platform to block wells and insuring people against re-ignition. The PMMM worked synchronously with the ship's, water trunks of the firefighters of the Kaipiisko-Volzhskaya flotilla, considerably exceeding their total effect on the range and scale of the fire-extinguishing flurry [9, 10].

In the period up to several days of preparation of the next fire-extinguishing attack (the MM itself was recharged per hour), MM were effectively used to localize oil spills from the emergency platform by large-scale spraying of sorbents – peat chips on the filling film. MM on the decks (Fig. 2c). Rescue and fire ships stationed only in large ports will ensure rapid localization and neutralization of large oil bottles with the most efficient use of bio-sorbent with a specified specific consumption of 10–100 g/m^2. For example, a volley from 5 barrels per 1sec evenly sprayed 7,5 kg of bio-sorbent pellets over an area of 450 m^2 (Fig. 2c). When bottling oil products on rivers, as was the case with an accident at the Ufa Refinery – bottling along the Belaya River, these bottles can be liquidated by spraying the sorbent from mobile MM from the river sides (banks) [8, 13].

A powerful and long-range 9-barrel module on a biaxial carriage (Fig. 3a) sprays a volley from all the trunks up to 180 kg of EP for a range of up to 90 m with an extinguishing area of up to 500 m^2. We developed even more powerful non-range spraying systems, and in the number of 8–10 barrels, for example, a 25-barrel MM, spraying volleys of 8–9 barrels of 120–135 kg EP for a range of up to 60–70 m and extinguishing up to 350–400 m^2 for volley, in the sum up to 1 200 m^2 at volleys with large intervals and up to 2 500 m^2 at volley with intervals of up to 3–5 sec. A more simple 30-barrel recoilless MM with (removable) barrels of 152 mm cartridges was created and successfully tested. It was sprayed with volleys from 5–6 barrels at 75–90 kg OP for a range up to 40–45 m and extinguished to 150–200 m^2 for a volley [6, 7].

Within the framework of the project, with China, the new design of the fixed, stationary, designed for mounting on a baffle with a biaxial or ship deck, a vessel, a tanker was developed, taking into account the identified shortcomings in testing the above-described structures. For the first time, sealed containers have been developed for fast reloading of the barrels (Fig. 4a) for water, liquid, gels. Containers are strong enough for transportation, overloading and loading, long stored, quickly and conveniently loaded into the barrel bore. Containers are easily destroyed by a propulsive wave of propellant gases into small, light fragments that do not have a damaging effect and fly beyond the trunk not further than 10 m. Spray charges are manufactured in the most convenient and safe for charging option – metal cartridges with an electro-capsule, based on the cartridges manufactured industrially in China. The last stage of the tests showed that 2 times higher values were achieved than on the above-described structures. For example, 60 liters of water were volley-shot-sprayed from the 3barrels, creating a flurry that flew to a range of L = 70 m (Fig. 4b) and created a trace along the spray trajectory with respect to the uniformly sputtered water (determined by the appearance of the track and the time it dried). The width of the track is from 2 to 8 m, the total area is S = 300 – 350 m^2, which, with a certain approximation of + –10–20% [13] (based on the analysis of previous experiments) can be equated to the quenching area.

A full-scale experiment on the volley-spraying of 200 kg of powder with a volley of 9–10 barrels created a gas-powder vortex flying at a range up to L = 240 m and along the flight path, creating a band of increasing width from 1,5 m to 20 m with a relatively uniform coverage of the area to S = 1200–1500 m^2, potentially an area of effective extinguishing. This is confirmed by the fact that the large 10 x 3 x 2 m model fire of class A has been extinguished from a distance of 150 m in 1,5 sec., while a powerful gas-powder vortex literally penetrated the source and traveled to a distance of L1 = 230 m. Subsequent with an interval of 10 sec., two volleys of 10barrels from other modules MM-20 and MM-30 have already passed through the extinguished focus, with the range of spraying L2 = 220 m and L3 = 240 m.

Sufficiently convincing demonstration tests were carried out in December 2014 to demonstrate the possibilities of the total operation of the three MM subsystem to create multiple protection of the dangerous area with a series of three volleys with intervals of 5 sec.: MM – 20-first volley from the distance L1 = 150 m; MM-30 – second volley with distance L2 = 140 m; MM-9 – the third volley from the distance L3 = 125 m (Fig. 5). The focal point of the model from the distance L1 = 150 m was again extinguished by the first volley, the subsequent two volleys demonstrated a technically not complicated and not expensive real possibility of multiple, reliable, trouble-free; programmable and flexibly controlled protection of a given hazardous area. Protection can be a combined series of three volleys: 1 – extinguishing powder, most long-range blow flame & smoke, inhibiting fumes of fuel + 2 – spraying water or wet sand destroying and cooling the char, high temperature burning surface + 3 – gel, spraying an adhesive film – insulating from access to heat flow and oxygen – programmable spraying of various ES by serial of volleys at predetermined intervals.

Special containers for spraying liquids are designed and manufactured only in China. In this case, the difficulty in creating the container consisted in the real possibility only of an experimental selection of the thickness of the polyethylene container wall, in order to determine the approximate optimal combination of uniform destruction of the container under the influence of a "soft-impact" wave of powder gases in the barrel channel and sufficient strength of the container for long-term storage, transportation,

reloading. On the basis of a standard cartridges with an electro-capsule sleeve, a production of a spray charge is created, more powerful, stable and reliable, in comparison with the previous charge, on the basis of a nonstandard cardboard sleeve and pyro-igniter. In China, you can order containers and spray cartridges, high quality and long-term storage.

These containers are suitable for the first time for highly effective, spraying a wide range of extinguishing agents: liquids, gels powders and natural environmentally friendly materials – sand, ground, dust, water, dirty. This allows for the combined, effective extinguishing of all classes of fires and multi-faceted protection: localization and deactivation of toxic emissions and spills of oil and petroleum products, for example, by spraying microbiological preparations in the form of sorbents or living cultures of various types of action for the biological destruction of oil and oil contamination, for 3–10 years, biological remediation, restoration, reclamation of disturbed ecosystems.

In 1986, in the Chernobyl Zone, the technology of localization of radioactive dust on various surfaces, first of all on hard-to-reach ones, has been worked out. The real possibility of precipitation of radioactive and toxic clouds in the first period after their release from emergency technological devices, reactors, tanks, pipelines is shown. This is the first time that allows creating an effective technology to prevent the release of active, hazardous emissions outside the industrial site of the plant and nuclear power plants. A real reliable automated system for preventing accidents of the 7-category with the help of an executive subsystem of MM, placed around a potentially dangerous object and capable of providing a multi-localized localizing effect by a series of gas-water squalls – precipitation and then gas-gel sticky squalls to fix radioactive dust on a local site, which greatly facilitates its subsequent disposal – loading into containers and removal to cemeteries.

MM stationary or MM on the carriage (trailer) for mounting on the industrial site of chemical and gas-oil refineries, reservoir parks around the most fire-explosive-dangerous technological installations, buildings, structures. MM-trailers executive part extinguishing automatic system of suppression of fires and fires, prevention of explosion of leakage of vapors, gases; installation of light and heat shielding curtains to ensure the evacuation of the facility's personnel. Experimental installations – 7, 8, 9, 10, 25 bar were made on the basis of 2-axle trays, mine carriages, trailers, sleds and effectively tested in the Chernobyl zone, in mines, a burning aircraft on the runway, etc. The simplest in production and mounting on the protected object, but the high-performance monolithic design of the MM (Fig. 2a) is safe, since it successfully extinguishes the powerful return of the volley of the shafts by a small pullback of the installation for 1–3 m at least.

MM-trailer does not require servicing except for monitoring by the standard device with a low-current impulse of the integrity of the initiating circuit. Once a year for the control can shoot back 1–2 barrels, if the spraying is normal, it is allowed to recharge only these barrels. The qualitative assembly of containers with ES and spray cartridges with proper loading can guarantee trouble-free operation of the MM for up to 5–10 years of standby. Ammunition traditional keep suitability up to 15–20 years. Fire extinguishing containers, equipped with viscous, frost-resistant gels or powders, spray powder charges can be eventually brought to the same level of reliability. The big advantage of the MM– trailer is that, in case of an emergency, the modules can be quickly placed around a hazardous area.

The MM volleys create vortices with a wide, shock front that rapidly and scale destroy and cool the combustion zone, preventing destructive explosions. The whirly & Squalls extinguish from distances up to 200 m, in areas of 1 000 m^2 and more in 1–2 sec. volley and 30–60 sec. with a series of sprays – a shot or volleys. MM can be used in automatic fire extinguishing systems as executive elements on trailers and carriage carriers in order to create or reinforce extinguishing systems around different stacks of containers in a timely manner as the situation in the warehouse changes.

Algorithms of programs for the order of the triggering of lines and groups of MM are compiled during the study of the patterns of combustion on the protected objects, the dynamics of possible fire development options depending on a number of factors – technological lines and their operation modes; variants of disconnection of the main raw-material and energy lines, separate apparatuses, ventilation, etc. Study of the ways of occurrence and development of fires differentially in different protected areas will allow to determine the optimal extinguishing tactics – the order (algorithms) of the triggering of groups and individual MMs. The effectiveness of management of the executive subsystem MM is determined by the ease of reconfiguration of the quenching algorithm and correction of control programs, depending on the change in the current parameters of the protected objects. This is especially true when extinguishing arsons affecting the main, technological lines, changes in the operating modes of which, associated with fire and extinguishing, must be quickly associated with the state of the object as a whole.

The use of MM for the first time in the practice of automatic quenching systems makes it possible to obtain the correspondence of the time scales of the set of successive processes: fixing the stage of development of a fire (arson), processing information, making decisions and effectively implementing them. This means the possibility of timely extinguishing during various arson attacks. The correspondence of the times of decision-making, their implementation, control and correction of subsequent impacts is the main condition for the effective use of automatically, extinguishing systems. MM stand on the same quality level with sensors, analog and command blocks of modern automatically, extinguishing systems, and therefore for the first time can extinguish arson and rapidly developing fires. Versatility of automatically,

extinguishing systems designs is provided due to different layout of typical, interchangeable MM, for example MM-9 – the best module for today, and typical electronic units interacting in a single functional scheme.

The reliability, speed of the system, reduction in the probability of false triggering is achieved by the following ways: increasing the resistance of sensors to interference due to the optimal structure of the sensor network, their duplication or the introduction of a subsystem that distinguishes interference from fires; the use of sensors operating according to logical schemes that confirm the reliability of the occurrence of a fire; use of centralized collection of information on changes in the parameters of the state of the object and its environment. The speed and quality of MM volley extinguishing, volume explosive prevention, localization and eliminate the Oil-spreads at water and seaside compensates for the loss of time for the reliability analysis of the sensor network.

Economically of automatically system modernization is achieved by the universality and cheapness of MM, their inclusion into an existing automatically system or object management system, the use of standard nodes and devices, simple maintenance, the implementation of trial launches without processing the protected object with a fire extinguishing agent; ensuring the safe evacuation of the facility's personnel from the emergency rooms and the safety of materials and equipment with the minimum necessary vortex quenching, volume explosive prevention, localization and eliminate the Oil-spreads at water and seaside. The proposed modernization of the TSA in quality is superior to other possible options, therefore it is the MM that is promising for rapid, enhanced protection of ports, chemical, gas-oil, nuclear power plants, oil and gas, military enterprises and facilities.

As a result of these studies in the USSR, Russia, Ukraine, China, the results obtained are extremely topical for carrying out operations to eliminate the emergency-dangerous consequences of rocket and artillery shelling of chemical and radiation facilities in the territory of the Donetsk – Lugansk region. It way of ensuring the safety of industrial and energy facilities in China are actually possible and real realize the quickest and cheapest way – produce MM and special fire-extinguishing ammunition for them in China and equipping them with existing safety extinguishing system at potentially hazardous facilities or creating on their basis new inexpensive systems for eliminating the consequences of sabotage. Unfortunately the creation of MM production and fire extinguishing ammunition for them in Ukraine requires significant, organizational efforts to allocate large financing and organization of production in the defense industry plants – now it's real, despite of it's only single way for protect ammunition depots, energy, chemical, Oli-Gas objects and river-sea-ports at Ukraine now. Protection of the most dangerous region of the Ukraine requires a detailed survey of all potentially hazardous facilities for the development of a specific rehabilitation program with the prevention and rapid elimination of the consequences of possible environmental disasters.

The offered essentially new executive subsystem for automatically systems on the basis of MM is highly effective, safe, universal, qualitatively superior to the best in the world fire-saving automatically systems and machines:

– the cost of fire extinguishing compounds is 10–100 times lower, which makes it possible to extinguish autonomously – only the ES reserve in MM barrels;

– flexible and simple adjustment of the type, power and scale of the impact;

– increasing in proportion to the number of volley-firing trunks, modules without reducing reliability and effectiveness of the impact;

– low cost of production and service;

– environmentally friendly quenching and provision of evacuation;

– the small size of high pressure vessels, the life time of high pressure of 0,05 sec., the 10-fold safety margin of public parts of the trunks – summary practically excludes their rupture, ensuring safety of work;

– simple design – no gas cylinders, compressors, pumps, reservoirs and pipelines, hazardous containers with long high pressure, supply hoses ES – provides high process ability and low cost of mass production, simple repairs and maintenance;

– maintenance of a stationary MM requires only the control of an initiation trigger;

– reliable and stable spraying in a wide range of temperatures – 50°C + 50°C, climatic conditions, wind, humidity, dust;

– prevention of explosions of gas-steam-dust-air environments indoors and outdoors;

– localization of oil spills on rivers, lakes, the sea, the ocean;

– stopping terrorist attacks and guaranteed not deadly, non-toxic, safe, but effective, fast and large-scale control of riots;

– range up to 10 times – work with almost safe distances, in light protective overalls;

– for the first time there are no restrictions on the aggregate state, density, viscosity of the ES and natural materials, effectively spraying turbid fresh and sea water, soil, dust, sand, dirt, providing the required duration, combined quenching without the supply of OS reserves.

As a fire fighting vehicle for extinguishing explosive fires, it is most effective and provides a high degree of safety for the crews of the technique, which the author created in the USSR on the instructions of the Main Missile and Artillery Directorate for firefighting at arsenals, bases, ammunition depots, production facilities and explosive stores. These are armored fire trucks with systems to protect them from toxic and radioactive gases, dusts, aerosols, dispersing and dispersing any fire extinguishing compounds autonomously solving large-scale tasks of extinguishing, localization and decontamination Oil spreads at sea and seaside, evacuation. "Impulse-3M" with 50-barrels module on the chassis of the T-62 tank (Fig. 5a), with sparks and volleys, sprays liquids, gels, foam, sand, dust, dirt. "Impulse-3M" repeatedly increases

the scale and power of the impact, reducing its time to fractions of a second. The coefficient of useful use of the fire-fighting system is 40–70% for multi-barrel modules of spraying with shots and volleys (MM); 3–5% for traditional fire-fighting machines with a compact jet, 10% for a sprayed jet.

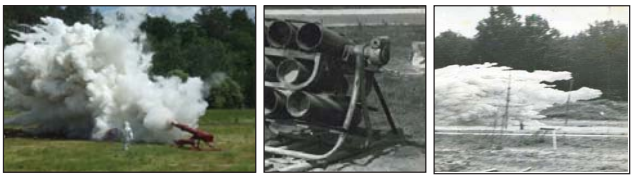
In 1991 year the 30 vehicles were developed and manufactured by the experimental-industrial party – the fire, caterpillar, armored machine "Impulse-3M" MM-50 on the T-62 chassis is operated in the quantity of 7 machines in Ukraine, 12 in Russia since 1992. "Impulse-3M" is simple, reliable, all-weather at temperatures of – 500C – + 500C. The range of extinguishing one volley from 10 barrels, spraying 250 kg of fire extinguishing powder at a range of up to 110 m (Fig. 6), the extinguishing area with a series of 5 volley of 10 barrels up to 5 000 m^2, without recharging. Impulse-3M has no analogues in the world in terms of efficiency, speed, safety of work in explosive industries and warehouses, in toxic and radioactive areas, where speed, accuracy, reducing costs of special and protective compounds, the use of environmentally friendly, natural materials – dirt, sand, dust.

"Impulse-3M" is the first fire engine capable of providing a multifunctional, effective effect: extinguishing class A, B, C, D fires, setting light and heat shielding curtains to create evacuation corridors (Fig. 6), deposition and neutralization of toxic clouds, deposition and localization of radioactive clouds, localization and liquidation of oil spills, control of riots, stopping terrorist attacks and disarming them. For the first time, with the use of a tank chassis for installing a fire installation for the supply of ES, the thick armor and crew protection systems from fragments, collapses, toxic and radioactive vapors, gases, dust have been preserved. "Impulse-3M" is the most protected fire engine in the world. The versatility of spraying for the first time provides combined extinguishing, flexibly controlled by the form, scale and intensity of the ES flow from a single fire installation – multi-module pulse impulse. Fine dispersion in the form of a vortex with a large area front, resistant to aerodynamic resistance, provides a fast, uniform coverage of the burning area and, as a direct consequence, minimum ES costs. This ensures the safety of equipment, materials, buildings, safety for personnel who have fallen under fire extinguishing effect, as well as the possibility of stopping and disarming terrorists on the perimeter and inside the facility. Even the first samples of MM stationary and on the carriage showed high efficiency and allowed to obtain a number of unique practical results. For example, pilot-industrial 50-barrels tower, modules on the T-62 chassis since the 1990s and still successfully work in the object, fire departments of Russia and Ukraine, guarding the Chernobyl nuclear power plant, chemical and gas-oil objects [11].

After the collapse of the USSR, despite numerous appeals by the author, work on further improvement of MM and other samples of pulse-spraying fire equipment was not funded in Ukraine and Russia. Currently, the work continues under the scientific guidance of the author in China, Estonia and Finland. The greatest funding and pace of work in China, which allowed to achieve in the last two years the unique results analyzed in this article. In

a b

Fig. 1. Explosion and subsequent fire in the port of Tianjin



a b

Fig. 2. A-pneumatic-pulse single-barrel module is used to arm Gazprom's emergency squads to extinguish gas wells. b-first 8-barrel module on skids, spraying with shots and volleys, in-volley of 8 barrels, spraying 120 kg of powder at a range of up to 60m with a quenching area of up to 350 m^2

a b

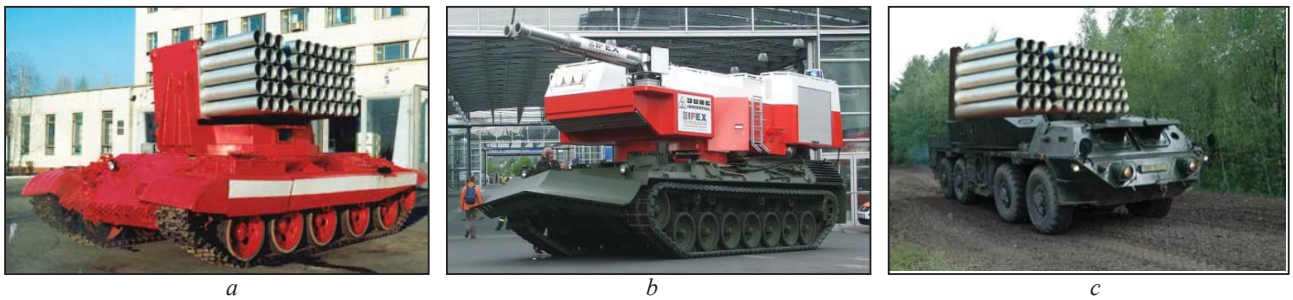
Fig. 3. A-recoil spraying 9-barrel module on a biaxial gun carriage, spraying up to 180 kg of OP for a range of up to 90 m with an extinguishing area of up to 600 m^2, a 10-barrel deck module, spraying 12,5 kg of biosorbent with a volley from the barbs, a range of 53– 55 m, area of 450 sq. m

a b

Fig. 4. A – a one-time container with a capacity of 20 liters in the barrel channel of the multi-barrel module, b – spraying 60 liters of water at a range of up to 70 m with a volley from the canals

recent years, there has been a progressive increase in the scale and quantity of man-made disasters in industrialized countries, the local focus of the civil war in Ukraine and non-state armed groups throughout its territory, and the growing danger of terrorist attacks in Russia. As in the USSR, after the successful participation of prototypes of pulsed-spraying equipment in the liquidation of the consequences of the Chernobyl disaster, Russia and Ukraine are again awakening interest in this direction of fire engineering. For example, a series of catastrophic fires in

Fig. 5. Indicative tests in China, December 2014 on the protection of a particularly dangerous area by the concentrated action of three modules 9, 20 and 30 barrels



a *b* *c*

Fig. 6. A – caterpillar, armored, fire engine "Impulse-3M" with a 50-barrel tower module on the chassis of the Soviet tank "T-62", $ 120.000; b – two-barrel "gun" IFEX-30x on the chassis of the German tank "Leopard-1", 1.400.000 $; multi-barrel module on the chassis of the Czech wheeled tank "Dana", 950.000 $

Fig. 7. Field-range experiments to provide light and thermal protection and create an evacuation corridor for a group of people caught in the ring of fire-extinguishing, gas-powder vortex, created by the machine "Impulse-3M", spraying 200 kg of fire extinguishing powder with a volley of 10 barrels

Ukraine's arsenals made the leadership of the relevant department of the armed forces of Ukraine consider the issue of restoring the release of "Impulse-3M" – a 50-bar module on the T-62 chassis at the Kiev or Lviv tank repair facilities. The reason is that there are no real alternatives to pulsed-spray equipment in extreme situations, especially in the absence of sufficiently powerful water pipes and reservoirs in the vicinity of the fire. Also, the urgency of equipping emergency rescue vessels of seaports with effective localization systems and liquidation of oil spills that occur in large, intensively operating ports almost daily, while large bottles are relatively rare, although they account for up to 60% of losses [11, 12] .

The nearest competitor, "Impulse-3M", is a double-barreled, air-impulse, water cannon on the armored chassis of the Leopard-1 tank (Fig. 5b), spraying two 20-liter barrels at a range of up to 40 m at a range of 20–30 liters, with an effective quenching range of up to 20–25 m. This fire engine is inferior to "Impulse-3M" in terms of protection of the crew; range, scale, quenching efficiency, light-thermal protection, deposition of toxic clouds; can not contain radioactive dust, control riots and counter terrorists. At present, there are 6 machines on duty in firefighters, object units: the plant "Azot" in Cherkassy, the fire department in the city of Chernobyl (2 machines), the Poltava part for the liquidation of oil and gas fountains (2 machines), the Gnedinsky refinery, the Chernigov region. In Russia 4 machines are located in Bashkortostan, 3 in Norilsk, one at Syzran Refinery, one at Balakovo NPP. The machines have well-trained crews.

However, until now, money has not been allocated to eliminate one of the main drawbacks – the development and manufacturing of special containers of the original design and spray cartridges in standard sleeves with an electrocob sleeve. It should be noted that the design of the trunks, require a simple and inexpensive revision of public parts of the trunks. The above is how this problem is solved in China.

Variant MM on the chassis of the wheeled tank "Dana" (Fig. 5c) with armored protection of the crew, engine compartment from large fragments and protection systems against radioactive and toxic dusts, gases, vapors, aerosols. The Dana-Suzanne chassis, carrying a 155 mm long-range, long-barreled cannon with a powerful recoil, is potentially capable of carrying MM from 70 (5 rounds per 14 barrels) – 90 (6 x 15) barrels with volleys of 12–15 barrels can provide advantages in comparison with "Impulse-3M":

1. To increase the range of the gas-powder vortex in 2 times from 120 m to 240 m, the gas-water squall in 3,2 to 30 m to 70 m, to increase the area of impact 2–3,5 times.

2. Increase the speed of movement from 60 m to 120 m, freely move along highways and other roads where heavy tracked vehicles do not start up.

3. The scale, range of extinguishing and small intervals between volleys can effectively protect objects from the effects of incendiary and thermobaric ammunition.

4. The parameters of paragraphs 2 to 3 allow timely arrival at the accident site of tankers with toxic or explosive products and precipitate smoke, toxic or explosive clouds, localize and eliminate bottling of oil and oil products, localize radioactive dust in the air and on various surfaces.

5. Non-toxic, guaranteed non-fatal control of riots and stopping terrorist attacks on the perimeter of the facility.

Taking into account a number of topical tasks of protecting container warehouses, nuclear power plants, chemical, gas and oil, government, military facilities, railway accidents, tunnels, and quality lines, MM will undoubtedly ensure their success in the fire market in Europe, Asia, America and Australia. Such a project to ensure a broad market is most expedient to implement it in cooperation with one of the European countries (Czech Republic, Slovakia, Serbia, Estonia) at a sale price no higher than traditional airfield fire trucks 1,5–2 million dollars. The new machine surpasses them by fire-fighting range up to 3 times, in scale (quenching speed) up to 10–50 times, according to the feed rate to 100 times and reduces the extinguishing agent costs by 10–100 times, ensuring environmentally friendly quenching in the shortest possible time and from safe distances. This machine for the first time will solve a number of topical above-mentioned tasks not available for modern fire-fighting equipment, for example, quenching of port terminals, warehouses and productions with toxic and explosive materials, localization and liquidation of Oil-spreads at port-harbor, sea-area and seaside.

Conclusions

1. The new equipment will allow to solve for the first time a number of actual above-mentioned tasks not available for modern firefighting equipment, for example, quenching of port terminals, warehouses and productions with toxic and explosive materials.

2. The new technique is the only one known to be able to remotely extinguish sand extensively and, as shown in the port of Tianjin, was the only extinguishing compound able to extinguish the fire of chemically active materials. In addition, this technique can also be extinguished for the first time remotely and extensively by dust, soil, inaccurate water, sea water.

3. The implementation of this project in China's ports, chemical and gas-oil facilities will significantly improve the safety of not only industrial facilities, the population and the environment of the surrounding areas, but also the security of the Chinese state as a whole.

4. This technique is high perspective for protection sea ports, chemical, Oil-Gas, power objects in China and other countries, therefore China financing this Project may & can get Profit in China and abroad in numerous countries, including industry countries primary.

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