# SCIENTIFIC INVESTIGATION OF IMPROVING THE EFFICIENCY OF FIRE EXTINGUISHMENT SYSTEMS

**SH. Khusanov**
Major, Head of the Emergency Situations Department,
Uzun District, Surkhandarya Region
**Anvarjonov I.**
Master at Tashkent University of Architecture and
Civil Engineering

**Abstract:** This article provides a scientific justification for the supply of fire-extinguishing agents, with a focus on the required intensity values of fire suppression systems used in the calculation of forces and resources. It presents scientifically grounded views on relevant reference data regarding these values. In the context of preventing natural and man-made disasters that may occur at energy facilities, the analysis highlights the importance of improving indicators such as the delivery rate of water or foam-generating agents, the consumption coefficient, and the foam expansion ratio. Furthermore, it emphasizes the need for research aimed at ensuring the rapid elimination of fires and accidents that have occurred.

**Keywords**: foam, volume, empirical method, parameter, intensity, expansion ratio, pressure, spraying

**Introduction.**

Today, in many countries around the world, the rapid and effective extinguishing of fires depends largely on the correct selection of fire-extinguishing agents and on the accurate identification of the composition of the burning material. The effectiveness of any fire-extinguishing agent, as well as its delivery through various flows, is ensured by means of fire-extinguishing equipment. Currently, in our republic, it is also required to gradually and fully localize fire-extinguishing equipment and methods, to increase their efficiency, and to ensure the widespread introduction of new types of fire-extinguishing technologies for combating future fires.

Another important direction in organizing fire suppression at energy facilities is to achieve the efficiency of fire-extinguishing agent supply. The uninterrupted delivery system of fire-extinguishing agents consists of fire-protection water supply systems, stationary and mobile fire-fighting equipment, which ensure the specified flow rate during fire suppression.

Statistics show that between 2011 and 2018, 75% of fires at energy facilities were extinguished with water, 15% with foam, and in other cases with powder (3.3%), gas and gas-aerosol compositions (0.35%), and other extinguishing agents (6.35%).

In accordance with fire safety requirements, energy facilities—particularly large-scale ones—are provided with fire-protection water supply systems capable of ensuring the required delivery of fire-extinguishing agents within the specified time frame. The indicators that allow for assessing the adequacy of fire suppression—both at the maximum one-time concentration of extinguishing forces and during the entire suppression period—have shown that the actual and standard specific consumption of fire-extinguishing agents has been exceeded.

The intensity of fire-extinguishing agent supply (J) is defined as the amount of agent delivered per unit of the calculated fire parameter (area, perimeter, front, or volume) per unit of time. Where: linear intensity – JlJ_lJl (L/(s·m), kg/(s·m)); surface intensity – JsJ_sJs (L/(s·m²), kg/(s·m²)); volumetric intensity – JvJ_vJv (L/(s·m³), kg/(s·m³)) represent the flow rates. Numerically, the required intensity of fire-extinguishing agent supply is determined on the basis of the analysis of statistical data on fire suppression and experimental studies. In other words, the required intensity is an empirical value, which is established through empirical methods. Thus, the intensity of fire-extinguishing agent supply can be expressed as follows:

$$J = \frac{Q_и}{П_{ёў} \cdot \tau'} \qquad (1)$$

Here, $Q_и$ – the consumption rate of the fire-extinguishing agent during an experiment or during fire suppression; $П_{ёў}$ – the value of the calculated fire parameter; τ\tauτ – the duration of the experiment or the fire extinguishing time.

In calculations, the most commonly used surface supply rate (on the fire area) is determined. The required intensity values of fire-extinguishing agent supply used in the calculation of forces and means are provided in the relevant reference materials. The consumption of the fire-extinguishing agent for the calculated fire parameter during the fire suppression time is referred to as the specific consumption, and it is determined by the following formula:

$$Q_{ик} = \frac{Q_r}{П_Т} \qquad (2)$$

Here, $Q_r$ – the indicator of fire-extinguishing agent consumption during the fire suppression time; – the specific consumption indicator

The specific consumption of the fire-extinguishing agent is one of the main parameters of fire suppression. It depends on the fire load (P) and the fire-extinguishing agents (W), their physico-chemical properties, the surface coefficient of the fire load ($K_{ёюк}$), the specific consumption ($Q_{ист}$), and the specific losses of the fire-extinguishing agent. This consumption occurs during the delivery to the burning area and at the area itself.:

$$Q_{ик} = f(\Pi, W, K_{ёюк}, Q_{ист}) \qquad (3)$$

The actual specific consumption of the fire-extinguishing agent, to a certain extent, allows the fire suppression leader to evaluate the performance of fire brigades and units in relation to similar types and classes of fires. Reducing the specific consumption is one of the indicators of successful fire suppression. The actual ($q_{х}$) and required ($\tau_{ўч}$) unit expenditures are determined by the following formulas:

$$Q_{ҳ} = q_{ҳ}\tau_{ўч} \qquad (4)$$

Here, $q_{ҳ}$ is the actual expenditure of the fire-extinguishing agent per unit of time; $\tau_{ўч}$ is the time required to deliver the fire-extinguishing agent to the fire area..

$$Q_{ҳ} = q_{тал}\tau_{в} \qquad (5)$$

Here, $q_{тал}$ is the required actual amount of fire-extinguishing agent delivered per unit of time (necessary flow rate)

$\tau_{в}$- тахмин қилинган вақти.

According to calculations, the actual specific consumption in reality is the sum of the required comparative consumption of the fire-extinguishing agent and its losses ($Q_{ист}$):

$$Q_{ҳ} = Q_{т} + Q_{тал} \qquad (6)$$

This formula (1.6) applies to all principles of fire suppression. Under the condition of complete consumption for extinguishing the fire, the required amount of fire-extinguishing agent needed to stop combustion for the given fire measurement parameter is called the required specific flow rate ($Q_{х}$). The specific consumption is influenced not only by the fire development stage and the characteristics of the extinguishing agent but also by the degree of contact with the burning surface.To determine the actual consumption of the fire-extinguishing agent more accurately, a burning surface coefficient ($K_{ёюк}$) is introduced when the fire area is accepted as a design parameter

$$Q_{ҳ} = K_{ёюк}(Q_{ҳ} + Q_{тал}) \qquad (7)$$

he surface coefficient of solid combustible materials decreases proportionally with the direct increase of the fire load, which in turn increases the specific consumption of the fire-extinguishing agent. Furthermore, under real conditions, the process of stopping combustion involves relatively large losses due to the depletion of the fire-extinguishing agent and other factors.

The ratio of the actual amount of fire-extinguishing agent consumed to the required amount is called the damage coefficient ($К_{тал}$).

$$К_{тал} = \frac{Q_х}{Q_х} \qquad (8)$$

The loss of the fire-extinguishing agent can be caused by several factors, including: smoke obscuring the burning area and high temperatures preventing the operator from bringing the fire-extinguishing agent close enough to the burning surface for effective action; deflection of the fire-extinguishing agent streams by gas flows or wind; the presence and distribution of combustible material surfaces within the burning area affected by the fire-extinguishing agent; and other related factors affecting the efficiency of fire suppression.

Analysis of fire suppression shows that, in practice, the specific water consumption for extinguishing fires in civil and industrial buildings ranges between 400–600 l/m². If we approach the determination of the required specific consumption from the perspective of internal fire heat balance and assume that up to 50% of the fire load burns during free fire development, then the water required to cool the remaining fire load, building structural elements, and heated gases can be calculated. Under these conditions, the specific water consumption reaches approximately 80–160 l/m²:

$$Q_х \geq Q_х; \qquad (9)$$

$$I_х \geq I_{тал}, \qquad (10)$$

Here, $I_х$ denotes the actual intensity of fire-extinguishing agent supply, provided per unit of the fire’s geometric parameter per unit of time.;

$I_{тал}$ – the required intensity of fire extinguishing agent supply, delivered per unit time for a unit of the geometric parameter to stop the fire.

The actual specific consumption of a fire extinguishing agent is not directly used for calculating forces and resources, but it is required to determine the actual intensity of fire extinguishing agent supply when studying fires and in other related cases

In fire extinguishing operations, it is appropriate to use such intensities of fire extinguishing agent supply that ensure effective fire suppression with minimal consumption of the agent over a specified (optimal) period using the available technical support means. To assess the adequacy of fire extinguishing agents at energy facilities in the event of a fire, the actual consumption rates and real intensity values of agents used in extinguishing fires from 2011 to 2018 were studied. The calculation of specific consumption was carried out taking into account the amount of agent used for extinguishing, the fire extinguishing duration (from the initial supply to the complete suppression of open flames), and the area of the fire.

$$Q_{уд} = \frac{q_{ёўч} \cdot T_{оё}}{S_{в}} \quad (11)$$

Here: $q_{ёўч}$ – the consumption of fire extinguishing agent per unit of time during fire suppression; $\mathrm{T}_{оё}$ – the duration of open burning; $S_{в}$ – the fire area..

The increase in normative intensity (ΔI) is calculated as the ratio of the actual supply intensity $I_{х}$ to the established normative intensity $I_{\mathrm{H}}$ for a given type of facility or combustible material:

$$\Delta I = \frac{I_{х}}{I_{\mathrm{H}}} \quad (12)$$

If the required intensity and the necessary flow rate are related to the fire area, the amount of fire extinguishing agent supplied to the fire site can be estimated using the exceedance of the actual intensity over the normative value. The results of processing statistical data distributed according to functional classes of fire hazard are as follows: F1 – buildings intended for residential purposes; F2 – entertainment and cultural-educational facilities; F3 – government service buildings; F4 – buildings of educational institutions, scientific and design organizations, and administrative bodies; F5 – industrial apparatus buildings or storage warehouses..

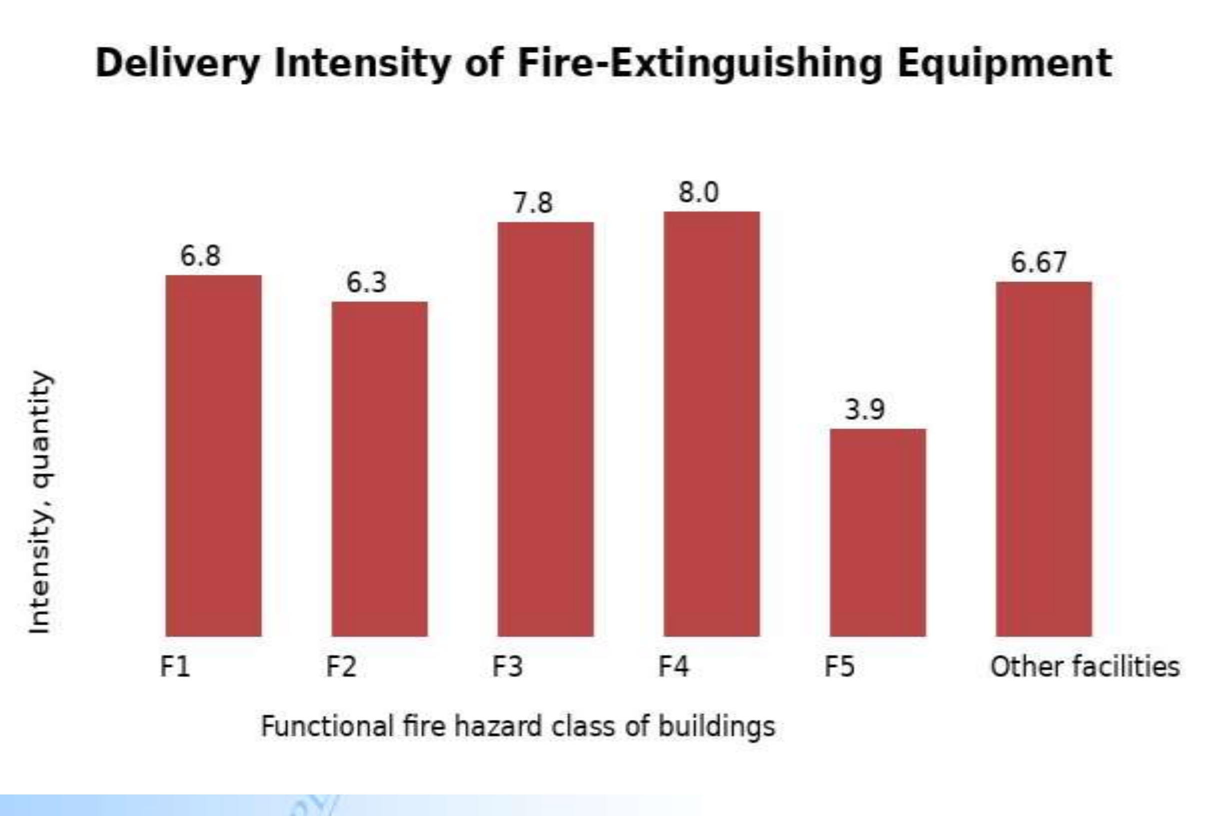



**Figure 1.** Fire extinguishing agent delivery intensity during fire suppression from 2011 to 2018 – illustrating cases where the delivery intensity of fire suppression agents exceeded the required intensity

ISSN: 2053-3578 I.F. 12.34

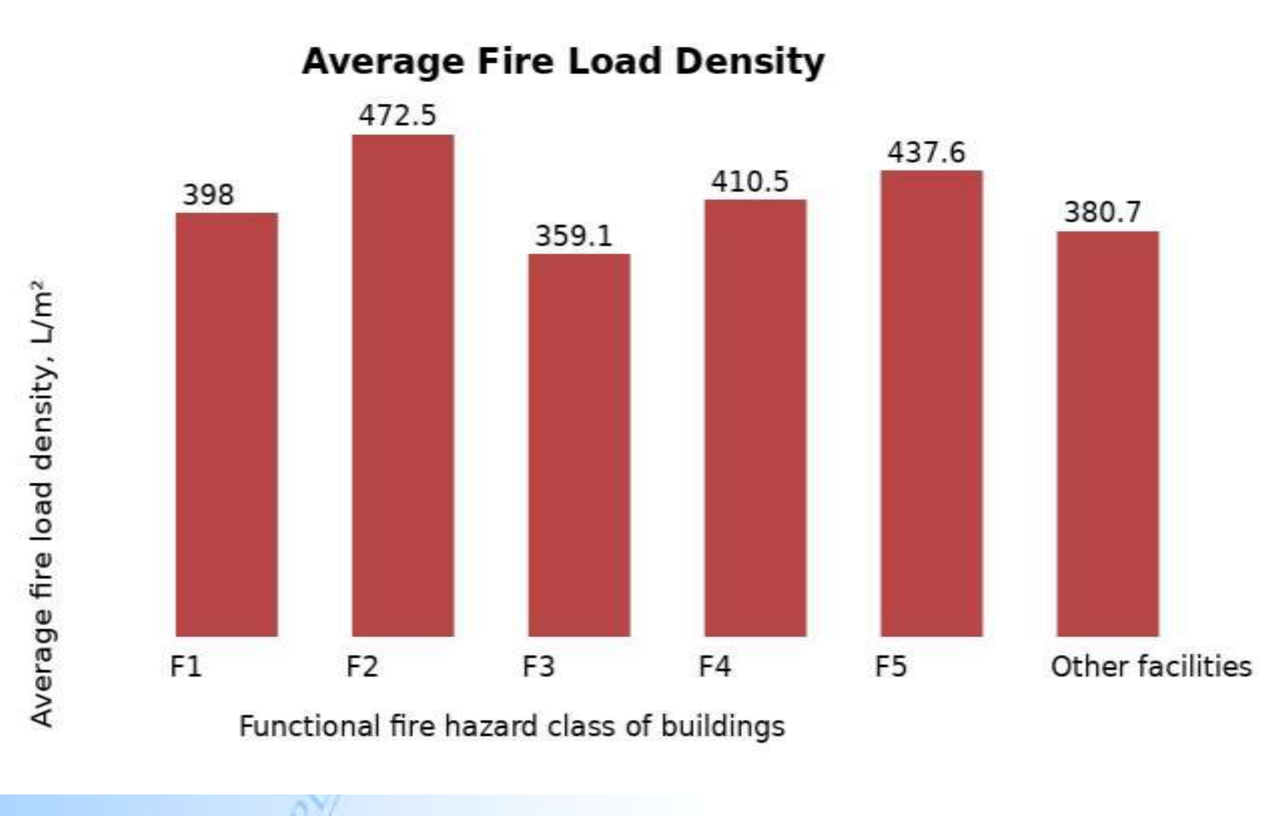
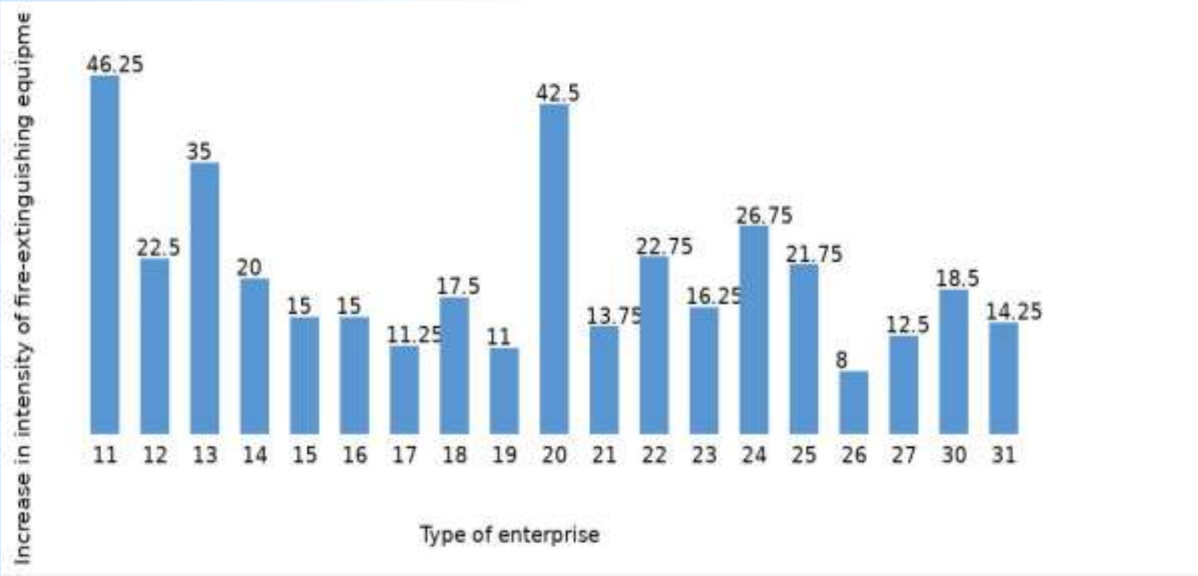



**Figure 2.** Specific consumption of fire extinguishing agents for fire suppression from 2011 to 2018 – showing the total consumption of fire extinguishing agents in l/m²

For buildings in fire hazard class F5, the difference in the increase of intensity compared to other functional fire hazard classes is associated with the adapted fire suppression management method for this type of facility during the initial stage (immediately after the arrival of the first fire-rescue units). These facilities have a dedicated Fire-Rescue Service personnel and, additionally, Fire Technical Commissions are always established. In such facilities, due to the complexity of fire suppression, one of the highest consumption rates of fire extinguishing agents has been confirmed.

INTERNATIONAL JOURNAL OF EUROPEAN RESEARCH OUTPUT
ISSN: 2053-3578 I.F. 12.34



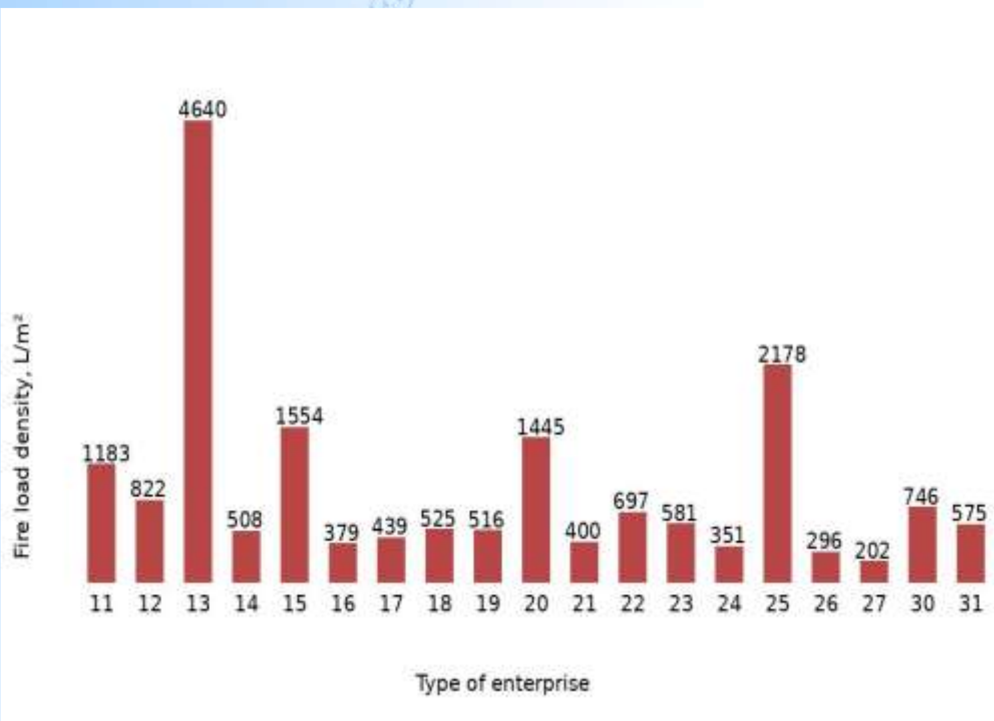




**Figure 3.** Specific consumption of fire extinguishing agents exceeding the comparative expenditure during fire suppression from 2011 to 2018

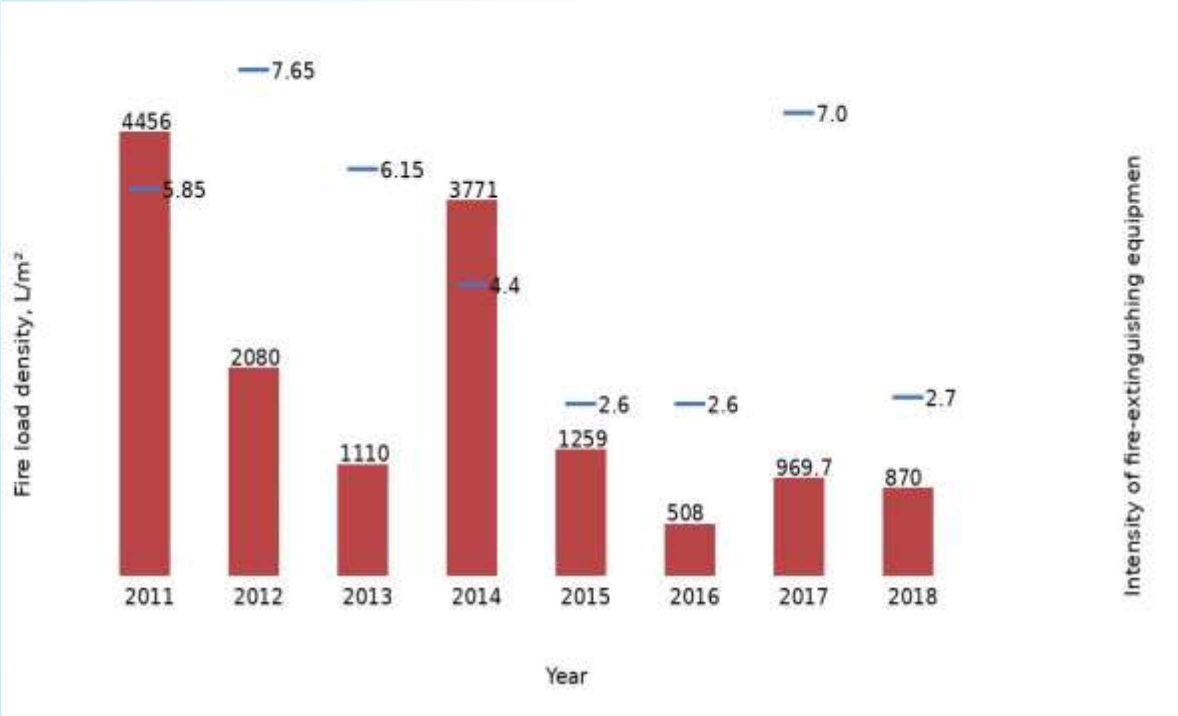



**Figure 4.** Comparative consumption and excess of fire extinguishing agent supply intensity for 2011–2018 in the fire suppression of buildings at thermal or hydroelectric power plants: - Average specific consumption of the fire extinguishing agent, l/m²; - Increase in the intensity of fire extinguishing agent supply..

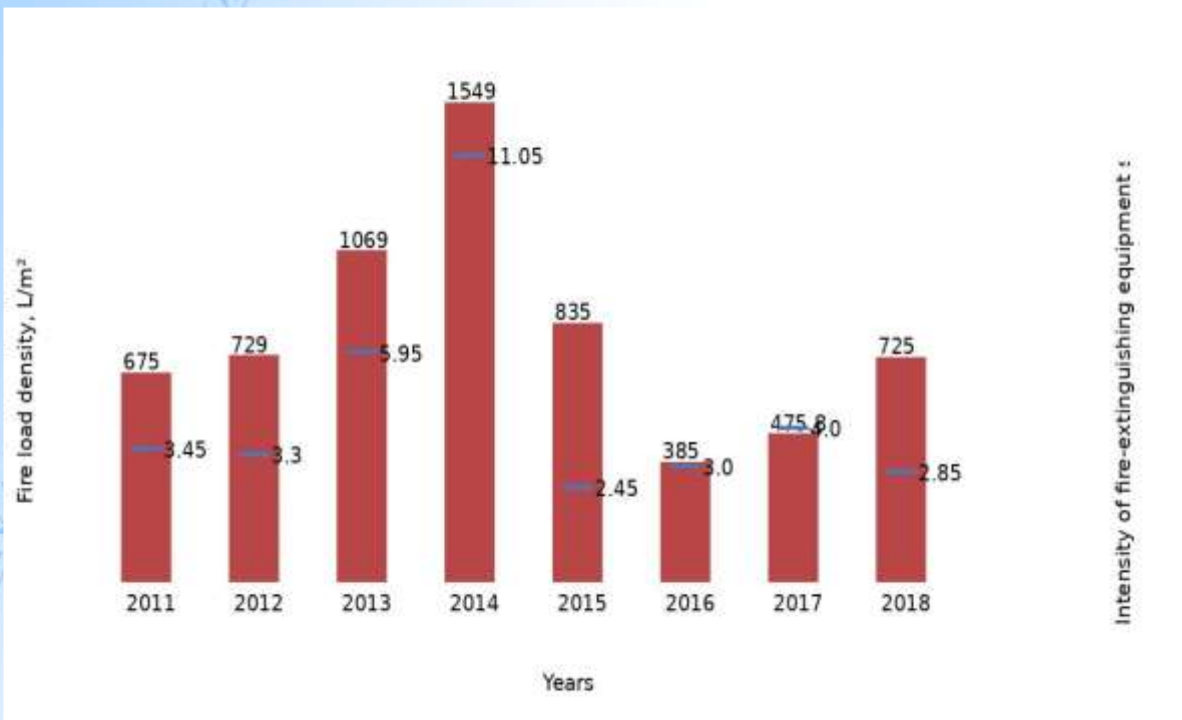


**Figure 5.** Specific consumption of fire extinguishing agent supply intensity for 2011–2018 in the fire suppression of diesel power plant buildings: Average consumption of the fire extinguishing agent; - Excess over the required supply intensity of the fire suppression agent.

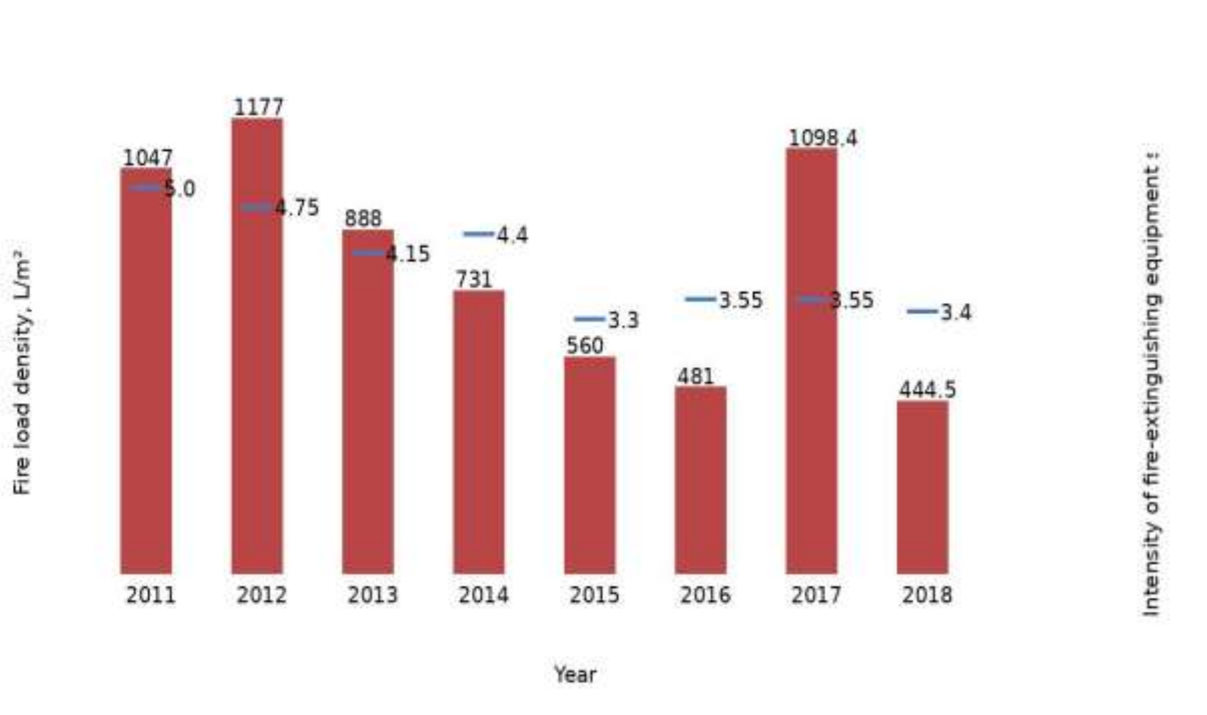



**Figure 6.** Specific consumption of fire extinguishing agent supply intensity in 2011–2018 for fire suppression in boiler house buildings:

Average comparative consumption of the fire extinguishing agent

Exceeding the supply intensity of the fire suppression agent

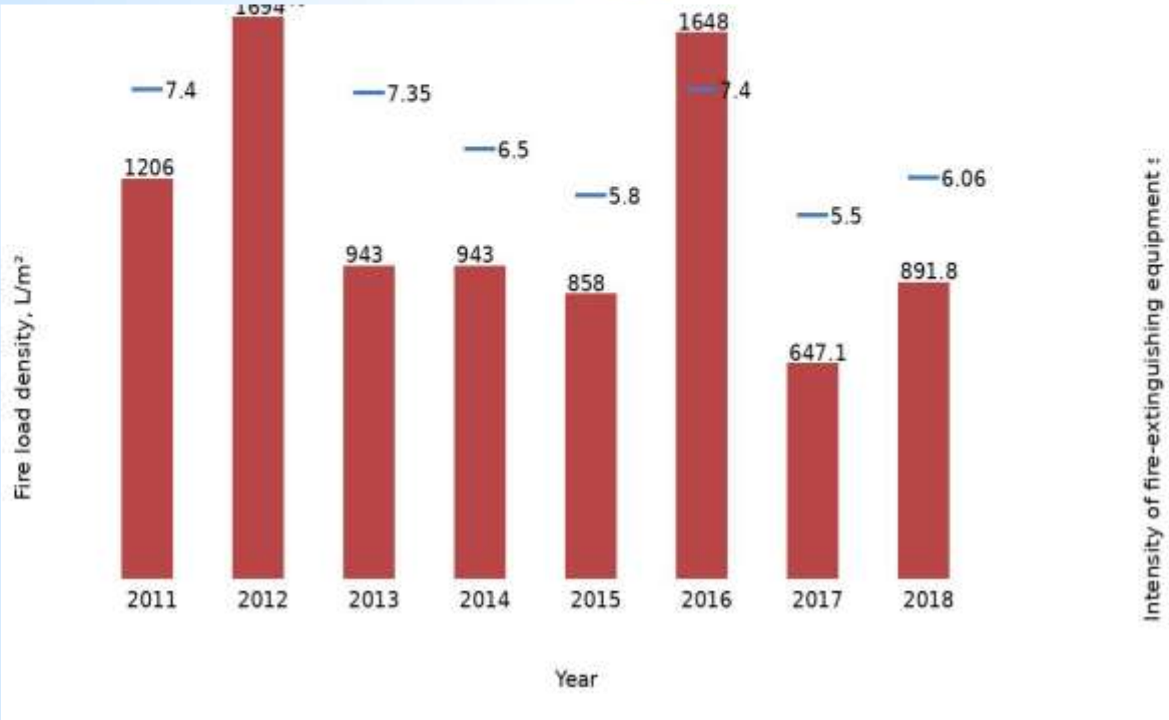
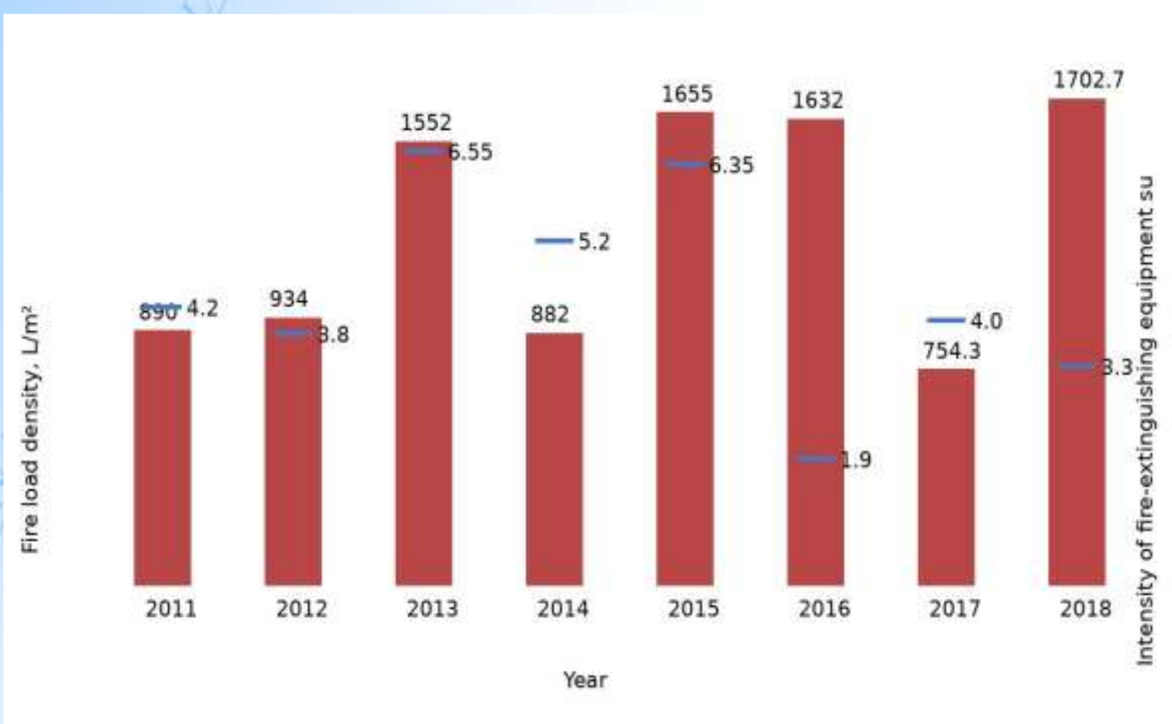



**Figure 7.** Specific consumption of fire extinguishing agent supply intensity in 2011–2018 for fire suppression in electrical transformer substations, transformers, and diesel electrical equipment:

Average consumption of the fire extinguishing agent

Exceeding the supply intensity of the fire suppression agent;



INTERNATIONAL JOURNAL OF EUROPEAN RESEARCH OUTPUT
ISSN: 2053-3578 I.F. 12.34

**Figure 8.** Increase in the specific consumption and delivery intensity of fire extinguishing agents during the extinguishing of cable tunnels and galleries in 2011–2018:

Average consumption of fire extinguishing agents;

Exceeding of the delivery intensity of fire-fighting agents.

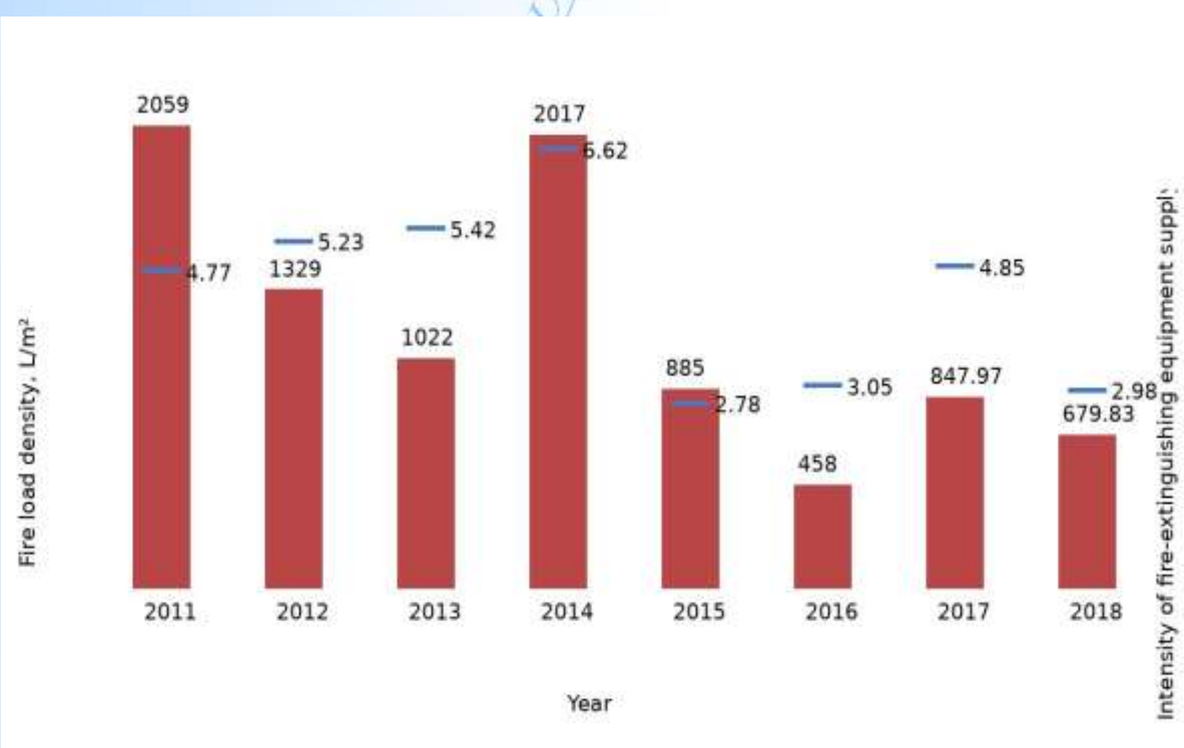



**Figure 9.** Specific consumption of fire-fighting agents delivery intensity during the extinguishing of electric power generation facilities in 2011–2018:

- Average consumption of fire extinguishing agents;
- Exceeding of the delivery intensity of fire-fighting agents.

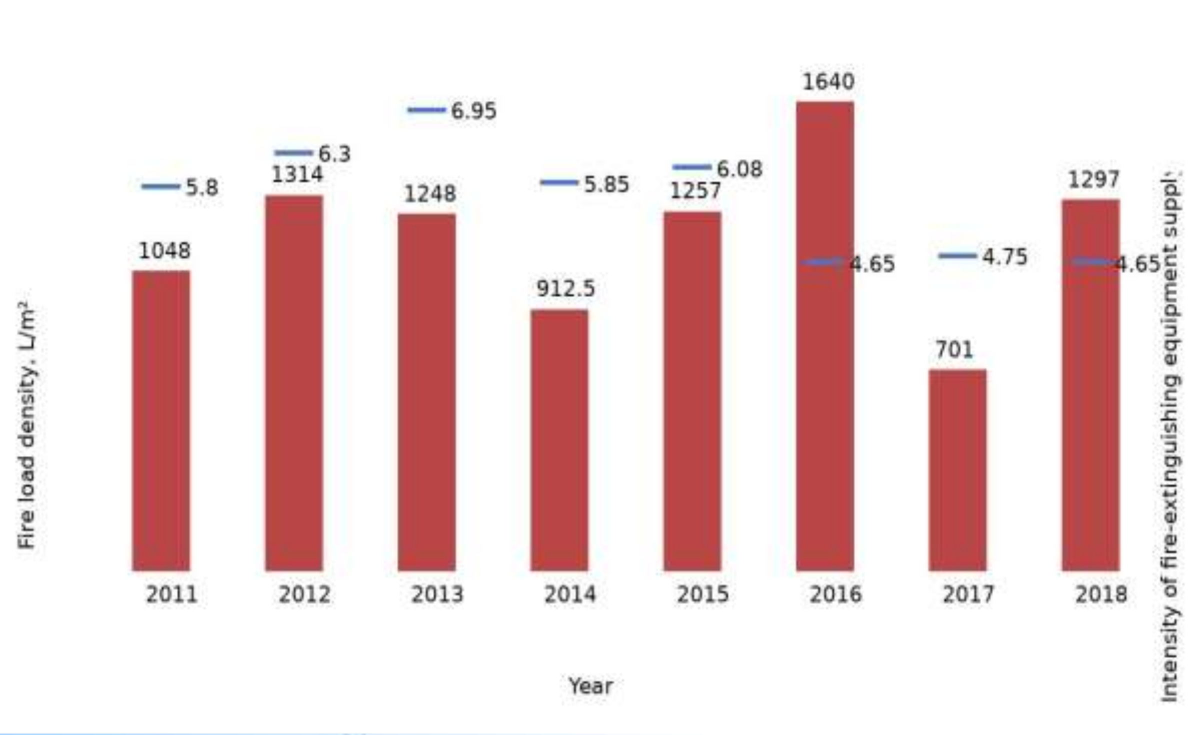



**Figure 10.** Specific consumption of fire extinguishing agents during the extinguishing of energy-producing facilities in 2011–2018:

Average consumption of fire extinguishing agents;

Exceeding of the delivery intensity of fire-fighting agents.

The increase in the required flow rate and the high values of the specific consumption of the fire extinguishing agent indicate that energy facilities are sufficiently supplied with fire extinguishing agents and the means for their delivery. At the same time, the excessive nature of these indicators reflects the difficulty of directly delivering the fire extinguishing agent to the burning area against the background of adequate agent supply. Overconsumption of the fire extinguishing agent is mainly associated with the concealment of the burning area by smoke, which obstructs the firefighters' access.

**Conclusion.**

Research has identified that there are still significant challenges worldwide in preventing natural and man-made disasters at energy facilities and in improving the firefighting of occurring fires. In preventing such disasters at energy facilities, it has been analyzed that conducting studies to optimize parameters such as the delivery rate of water or foam-forming agents, consumption coefficients, and foam formation efficiency, as well as ensuring rapid elimination of fires, is one of the crucial aspects.

**References:**

1. Law of the Republic of Uzbekistan dated September 30, 2009 “On Fire Safety” No. URQ-223 // (Collection of Legislation of the Republic of Uzbekistan, 2009, No. 40, Article 430).

2. Taslimov A.D., Rismukhamedov D.A., Rakhmonov I.U. Methodical Guide for Laboratory Work on Energy Control and Accounting in Electrical Supply Systems. Tashkent: Tashkent State Technical University, 2014.

3. Taud R. Prospects for the Development of Thermal Power Plants Using Organic Fuel. Teploenergetika, 2000, No. 2, pp. 68–72.

4. **Twidell J., Weir A.** *Renewable Energy Sources*. **Moscow:Energoatomizdat, 1990.**

5. Karimov H.G., Rasulov A.N., Taslimov A.D. Electrical Networks and Systems: Textbook. Tashkent: Tafakkur Kanoti, 2015.

6. Karimov R.Ch., Rafikova G.R. Fundamentals of Electrical Safety: Textbook. Tashkent: Spectrum Media, 2015.

Karpekin V.V., Didenko N.S., Kuleshova T.Y. Assessment of Regenerative Respirators by the Comprehensive Indicator of Energy Ergonomics [Text] // In: Methods and Means of Conducting Mine Rescue Operations and Preventing Accidents in Mines. Donetsk, 1979, Issue 16, pp. 25–29.