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Some methodical aspects of critical infrastructure protection

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ABSTRACT

The priority ranking that relates to critical infrastructure facilities protection against acts of terrorism (as exemplified by the fuel and energy complex facilities) has been discussed. The ranking algorithm as applied to similar facilities, which is based on their systemic significance for the fuel and energy complex, has been suggested. Besides, the algorithm for forming the ranked list of different-type facilities of the fuel and energy complex has been suggested, too.

1. Introduction

The current and prospective structures of the global fuel and energy complex considerably complicate the matters related to ensuring its steady functioning and reliable supply to consumers. The fact that the above issues are of an intersectoral nature calls for developing such solutions which will be coordinated and aimed at ensuring reliability, safety and security of separate specialized subsystems within the fuel and energy complex. Also their interrelations, including the projected development of the energy systems for 15 years to 20 years and up to operating management of the systems during their operation need to be considered, too. Generally, stable functioning of the fuel and energy complex has the intersectoral nature and as such it is determined by interrelations between power industry and other sectors of the national economy, as well as by the social and economic development plans of countries and regions.

An intersectoral approach to ensuring security and stable functioning of the fuel and energy complex needs a comprehensive methodical approach to investigations into reliability, security, and stability of the fuel and energy complex components represented by various energy systems be developed. Such approach should account for the existence of certain specific features of various energy systems, that are generally widespread, which could ensure solving, both theoretically and methodically, the above issue from the generally shared standpoint. The above features of the fuel and energy complex include: interrelation with other national economy systems (industries); territorial distribution and complexity; continuity and persistence of development, etc. Inconsistent (adaptive) behavior principles under the conditions of potential risks and uncertainties inherently rest on the idea of management of the fuel and energy complex subsystems. Where such risks arising from heterogeneous circumstances exist this may block or cause changes in this or that way in development thus forcing the system to existence "under another scenario" that obviously differs from multiple previously generated plans.

The everlasting conditions of the changes in the scope and intensity of threats to stable development of the industry till pose a true problem that hinders search for the ways of ensuring security of the fuel and energy complex facilities (Gheorghe et al., 2006; Biringer et al., 2013; Flammini, 2012; Lewis, 2006).

The safety and security requirements established for the higher- and medium-grade hazard facilities are robust and considerably increase expenses borne by the facilities' owners. It is practically impossible to improve protection and security to the level required by the federal legislation at a single step. This brings up the issue of ranking the facilities within the preset grades for their prioritizing with respect to determining the order of priority for provision of the facilities required protection means. To do this, it is necessary to identify the criterion, relative to which the importance (and, accordingly, the serial number) of this or that facility in the ranked list will be determined.

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Nomenclature

r_i	systemic significance (integral criterion)
α_i	weighting factor (showing the importance of filling the unit of work)
β_i	weighting factor (reflects comparison of various types of the facilities by their attractiveness for attacker)
w_i	second-level basic criterion (criticality)
q_i	second-level basic criterion (unconditional vulnerability)
θ_{ii}, γ_{ij}	weights of indicators ($i = 1, 2, \ldots, \mu; j = 1, 2, \ldots, \rho$)
w_{ij}	criticality indicators (resource criterion)
q_{ij}	unconditional vulnerability indicators (resource criterion)
X	damage
$i = 0, 1, \ldots, I^{[k]}$	the protection level for the k-th facility
j	attacker preparedness level
$X^{[k]}(i,j)$	damage from attacker attack with preparedness level j is launched against the above k-th facility with the protection level i
$Q^{[k]}(i,j)$	probability varying
$Y^{[k]}(i^{[k]})$	expenses from creation and maintenance of protection of facility k at the ith level
Y	the total of all expenses required to protect the facilities provided protection system variant $i^{[k]}$ is selected for each facility k
$\lambda^{[k]}(j)$	probability of the attack against each kth facility by the attacker with the jth preparedness level
$R[k, i^{[k]}]$	median value of the risk from the attack against the kth facility by the attacker with the jth preparedness level, assuming the $i^{[k]}$ facility protection system
$\theta\lfloor k, i^{*[k]}\rfloor$	value of the prevented risk per unit of investments into protection
$\mu^{[k]}$	adjusting factor
O_i	object (or facilities)
$x_1, x_2, \ldots, x_N$	several describing variables (resource criteria)

2. Statement of the task

It is proposed to consider a possible approach to the security issue facilities using the example of the Unified Gas Supply System of Russia (hereinafter, "UGSS"), which is operated by JSC Gazprom. UGSS is characterized by a geographical mode of distribution in space, greater divergence and interaction between different facilities, the heterogeneous structure of the process chains, and unique conditions for different risks that threaten the subsystems' facilities and, generally, the system as a whole.

The current configuration of UGSS established by the mid-80s of the previous century features substantial reserves of various types and purposes. If need be, the networking of cross-country gas pipelines, gas distribution and gathering nets makes it possible to execute large-scale maneuvers of flows among the transport corridors or maneuvers within a local pipeline net, which increases reliability of supplies to the consumers. As to UGSS the structural redundancy methods include creation of standby pipelines (supply to essential consumers from various directions) and bridging gas pipelines. Redundancy on the site facilities is possible through selecting the process layout of the piping, i.e., the main and standby equipment connection layout. Pipeline divisions are segmented by way of constructing links between the parallel lines, laying the loop lines, and duplication of the pipelines at the high-risk areas, which are the typical methods of redundancy of the cross-country gas pipelines' infrastructure. Underground gas storage facilities are the most effective redundancy methods in UGSS. In case of major disasters and during the peak demand periods the gas reserves in the underground gas storage facilities make it possible to operate for certain time without disruption of supplies to the consumers. Irregularities of gas supply are partly compensated by means of the accumulating capacity of the end gas pipeline divisions, as well as by temporary well yield level variation.

Assuming that stable UGSS functioning is fulfillment of its development plan with permissible deviations of both the scope and deadlines of the tasks, then this system safety management minimizes extraordinary losses where an emergency situation occurs or measures to prevent its effect are undertook.

It should be noted here that JSC Gazprom, acting within the frameworks of preventing any anthropogenic threats on the regular basis, developed and introduced its corporate standards to ensure uniformity of the approaches toward organization of protection for certain facilities; besides those standards set forth the principles and rules for classification of protection sites broken down by potential aftereffects (risks) of terrorist acts. The above standards are instrumental to identify key vital facilities and the facilities first and foremost subject to be equipped with technical protection equipment sets, formulation of the requirements to anti-terrorism security of the protection sites, and determine where time-sensitive and long-term solutions for their protection prove to be adequate. While solving the problem of classification on the whole, these approaches do not result in an unambiguous rating of the facilities with allowance for their significance for the whole system of the fuel and energy complex. The differences in the tasks classification (rating) and ranking are shown in Figs. 1–3.

The economic aspects of security issues are always of close interest. The idea that there exist both complex protection of everybody from the threats of hazard actualization on the level of reasonable adequacy (first-type tasks) and the individual security needs, whose level is determined depending on the circumstances of place and time for the protected facilities (second-type tasks), has but a long history.

If the collective security mechanisms are ensured by the systems of the "armed forces", "common law-enforcement authorities", and "emergency action services" types, specific individual security of high-security facilities is provided by specialized bodies in compliance with the normative standards exceeding the normative standards for protection of average facilities.

The increased level of protection of the fuel and energy complex facilities is a sort of response to the growth of the terrorist threat and belongs to the second-type tasks. Where we have to deal with common criminal activities (thefts, vandalism, etc.), it is sufficient to satisfy the "average industry standards for all facilities"; meanwhile protection against terrorism implies that the acts of terrorism should be understood as single and rare events.

The requirements, which are adequate in case of collective population protective mechanisms, in their pure form turn to be ineffective and inappropriate and therefore cannot ensure improved functioning of the facilities as redundant equipment of the facilities which practically face no threats at all turns into a dramatic shortage of protection equipment for the facilities which are "attractive" for terrorists.