ANALYSIS OF THREATS TO THE PHYSICAL PROTECTION OF NUCLEAR FACILITIES AND SITES

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Introduction

Given the dynamic security environment and the constantly changing threats in the world, it is essential that countries focus their efforts on the never-ending implementation of new tools for physical protection which should include policies, rules, technology for neutralizing negative effects such as malicious acts, anthropogenic mistakes, natural risks, etc., against nuclear sites and facilities as objects of critical infrastructure.

The research problem pertains to the fact that no tools based on methods and models for assessing the social, economic and ecological influences which result from the occurrence of random or non-random events involving the physical protection of nuclear sites and facilities have been implemented to the physical protection system.

Based on these arguments, *the purpose* of the study is to offer tools for improving the physical protection of nuclear sites and facilities through the use of quantitative and qualitative methods and models from various scientific approaches, which are also based on the international and national legal framework in the field of nuclear security and safety.

The expected results involve the detection of oversights in the physical protection of nuclear sites and facilities on the basis of emergency situations (both random and non-random) that have occurred by accounting for breaches in the protection system. These instances will be used as the basis for the development of scenarios for eventual threats for physical protection system.

Characterization of Threats to Plan Physical Protection of Nuclear Facilities and Facilities

General threats can be divided into the following: threats of human and technological errors; of nature (earthquake, flood, tsunami); deliberate – terrorist acts, sabotage, unauthorized removal of nuclear or other radioactive material; and the combinations of the first three threats.

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In order to determine the physical protection parameters of nuclear facilities and sites, first of all, the potential threats to them have to be identified, the degree of susceptibility of the systems under consideration should be determined and, finally, the mechanisms to improve protection should be provided. The threats to the safety of nuclear facilities and sites in fact involve potential acts of intruders, impacts of elementary forces, failures in the operation of the resources under the physical protection system, the negative effects of the personnel of the facility, insufficient level of qualification.

Threats are divided into external and internal based on their manifestations in terms of boundaries of the site. These factors determine the vulnerabilities. In order to compile a list of threats, the source data should be determined, information about possible threats collected and normalized so that this information be usable. All this is important for identifying the full range of potential threats.

The assessment of external threats comprises a description of the range of threats, such as natural, criminal, terrorist, and occasional threats, to the critical infrastructure. An important point in this assessment is to determine the possible occurrence of one or another threat, on the basis of which the security elements are to be defined. For natural threats, historical data on the incidence of natural disasters such as tsunamis, tornadoes, hurricanes, floods, fire or earthquakes can be used to determine the likelihood of a threat occurring – the Fukushima accident is a case in point. Natural disasters can have a significant impact on infrastructure in a relatively short period of time.

Threats of terrorism are associated with so-called a "dirty bomb" that is a radiological dispersal device and combines conventional explosives, such as dynamite, with radioactive material. Depending on the situation, a "dirty bomb" explosion can create fear and panic. Providing timely and accurate information to the public can prevent the panic demanded by terrorists (Michael, B., Jenkins and John Lauder, 2016).

The dirty bomb is in no way similar to a nuclear weapon or a nuclear bomb. A nuclear bomb creates an explosion that is a million times more powerful than a dirty bomb. Clouds of nuclear bomb radiation can spread from tens to hundreds of square miles, while radiation from a dirty bomb can be scattered within a few blocks or miles from the explosion. This may be the target of terrorists, as all other terrorist scenarios for attacking nuclear sites and facilities are not excluded here (Nuclear Regulatory Commission (NRC)).

Identifying potential internal threats is the most complex part of the physical protection of nuclear sites and facilities and their design. Measures to counteract internal threats are also described in the recommendations of the Physical Protection of Nuclear Material (INFCIRC/225).

Individuals may have different motivations and therefore they are defined as active or passive. The term "motivation" is used to describe the driving forces that have prompted the offender to perform or attempt to commit a malicious act. Motivation may include ideological, personal, financial and psychological factors and other forces such as coercion. Internal persons may act independently or in collusion with others. One can be forced to become an internal threat by forcing himself or forcing members of his family. Passive insiders limit their involvement in providing information that can help offenders perform or attempt to commit a malicious act (IAEA Nuclear Security Series No. 10).

Active insiders are willing to provide information to perform actions and can be violent or non-violent. Active insiders are willing to open up the site to provide assistance in neutralizing the staff or reaction forces.

When considering internal threats, account must be taken of the following: Domestic persons may take up a position in an organization (for example, to undertake laboratory research, to participate in site design or physical protection, security, security officer, operational and support worker or senior manager). Other threats are related to persons who are not directly employed by the operator but who also have access (such as sellers, emergency personnel, including firefighters and contractors, subcontractors and inspectors from regulatory organizations).

Internal persons may have access to some or all parts of the facility, systems, equipment or tools. Therefore, insiders may be able to commit a malicious act under normal operating conditions of a facility, maintenance, transport of nuclear material or emergency situations, and may choose the most favorable time to commit a malicious act.

Sabotage is also a threat to the physical protection system and constitutes any deliberate action against a nuclear facility or nuclear material in use, storage or transport that could directly or indirectly endanger the health and safety of personnel, the public, or the environment by exposure to the impact of radiation or release of radioactive substances (IAEA, Division of Nuclear Security, NSS ver. 1.3, 2015).

Physical protection against sabotage requires a combination of hardware (security devices), procedures (including organization of security and execution of duties) and equipment design. Physical protection measures are designed to take into account the characteristics of the nuclear facility, the nuclear material and the potential radiological consequences. The most important area is a "protected area" containing equipment, systems or devices or nuclear material which, as a result of sabotage, may directly or indirectly result in unacceptable radiological consequences. By assessing the consequences of malicious actions, safety experts, in close cooperation with security experts, identify potential sabotages within nuclear facilities that require protection to prevent unacceptable radiological consequences in the event of an attack (IAEA, Nuclear Security Series No. 4).

The identification of sabotage targets in a facility starts with a safety analysis, including probability analysis of external event safety, if any, and other sources that could help in identifying the potential consequences of accidents that could have significant radiological consequences for workers, the public and the environment.

Criminal threats are determined by crime in the region and the types of criminal activity that can threaten a community. In addition, the type of assets and activities in the region can also increase the attractiveness of the aggressor‘s target. The type of assets and activities in a community will also directly address the likelihood of different types of accidents. For example, a community with a high concentration of industrial facilities will be exposed to a higher risk of industrial accidents such as chemical spills or explosions than one with a concentration of small retail businesses.

A threat to the physical protection of nuclear facilities and sites is the unauthorized removal of nuclear and other radioactive materials, which can have significant consequences for the health of the population and the environment. Unauthorized removal of such materials typically occurs through theft from the objects themselves or during the transport of such materials (IAEA Nuclear Security Series No. 13).

The International Atomic Energy Agency, in response to a resolution adopted by the General Conference of September 2002, adopted an integrated approach known as Design Basis Threat (DBT) to protect against nuclear terrorism. This approach coordinates the activities of the IAEA related to the physical protection of nuclear materials and nuclear installations, the detection and response of trafficking in nuclear and other radioactive materials, the security of radioactive sources, the security of transport of nuclear and other radioactive material, emergency response, and preparedness to act in emergency situations in the Member States and the IAEA.

DBT contains this set of characteristics of malicious individuals against whom operators and government organizations are responsible for protection and accountability. The division of these responsibilities may vary from country to operator. The responsibilities assigned to the operator to protect against DBT must be defined in accordance with the mission, capabilities, resources and powers of the operator (IAEA, DBT, NSS 10).

Case studies of internal and external threats to the physical protection of nuclear facilities and facilities

An accident at Fukushima NPP

The accident at the Fukushima nuclear power plant occurred as a result of two disasters – the earthquake in the Tohoku area on 11 March 2011 and the 40-minute tsunami that followed, causing a malfunction in the reactors. Immediately after the quake, all operating reactors in the power plant automatically stopped working. However, the wave caused by the earthquake damaged the auxiliary generators that provide the energy needed to cool the reactors. Insufficient cooling power leads to the melting of three out of the six nuclear reactors. This led to the leakage of highly radioactive in both the water and the air material.

In the report of the General Director of the International Atomic Energy Agency, Yuki Amano points out that this is the worst accident in a nuclear power plant after the Chernobyl disaster in 1986. The company, the owner of the Fukushima-Daiichi Tokyo Electric Power Plant, safety requirements, such as risk assessment, preliminary preparation for possible secondary damage, and evacuation plans. The report examines human, organizational and technical factors, resulting in such a catastrophe. According to the report, more than 100,000 people were evacuated due to the release of radionuclides into the environment (Yuki Amano Report).

Although they did not die directly after the Fukushima accident, experts believe that high levels of radiation in the area take between 130 and 640 people a year. It is estimated that for the first year the victims were about 1,600 people. As a result of the accident and the previous tsunami, more than 160,000 people lost their homes.

Studies have shown that radiation levels in Fukushima are far lower than those in Chernobyl, but they can cause cancer. In addition, doctors believe the accident and the tsunami may have caused mental trauma to the residents, as they have all changed their way of life after them. Since March 2011, the level of registered suicide in the region has continued to increase.

During the Fukushima Daiichi disaster, some weaknesses appeared in the Japanese regulatory framework. The responsibilities were shared among a number of authorities, and it was not always the role of the different institutions. Weaknesses were also found in the design of the nuclear facility, in its physical protection, as the vulnerability of the site, emergency preparedness and response as well as the planning of the management of a major accident were not identified and evaluated. Japan is the most prepared country in terms of earthquake protection, but planned protection in the country's regulatory framework has not provided a tsunami scenario with such a scale of damage.

After the incident, Japan reformed its regulatory system to better meet international standards.

Economic impacts

By 2016, Japan's Ministry of Economy, Trade and Industry estimated the direct cost of the accident to be $188 billion, including plant decommissioning, cleaning costs, interim storage facilities for contaminated soil, the removal of nuclear fuel fragments from affected reactors, and all expenditure on population evacuation and first aid. Along with the direct costs resulting from the accident, there were also indirect costs that cannot be quantified, but according to the agency, the price for replacement of electricity by the Japanese fleet from idle reactors was the highest. Energy substitution includes energy efficiency negatives, increased use of renewable energy sources and increased use of fossil fuels (Green. J.).

According to the US Society of Mechanical Engineers (ASME), a mid-2012 report states that the main consequences of severe accidents in nuclear power plants are socio-political and economic interruptions that put huge costs on society. In other words, even when there are no visible radiological consequences for public health from a nuclear accident, the observed and potential destruction of the socio-economic structure of society by a large release of radioactivity is not an acceptable result.

Macroeconomic effects are associated with rising electricity prices by an average of 20% due to higher fuel costs.

The 2014 Ministry of Economy, Trade and Industry report also noted that rising electricity prices due to various factors put pressure on the profits of energy-intensive industries and small and medium-sized enterprises and began to cause adverse effects, including cuts in staff and transfer of production abroad due to the deterioration of the profitability of the business in the country. This is a significant barrier to increasing local investment from abroad. Furthermore, this also increases the burden on the household economy.

Social impacts

According to the World Health Organization, as a result of the accident, public health implications related to disaster response actions such as evacuation and relocation of people from the affected area have occurred. These measures were taken on the basis of considerations of radiation safety and large damage to infrastructure and facilities after the earthquake and the tsunami. These measures have resulted in a wide range of social, economic and societal consequences. There has been a sharp rise in the mortality rate among older people living in temporary premises, as well as an increased risk of non-communicable diseases such as diabetes and mental health problems. Lack of access to health care has further contributed to the deterioration of health (WHO).

Some 40-50 people were physically injured or burned by radiation at the nuclear facility, the number of direct deaths from the incident was quoted as zero. However, radiation exposure mortality is not the only threat to human health: according to estimates, about 1600 people died as a result of stress relocation. This data ranges between 1,000-1,600 deaths from evacuation. Deaths caused by stress affect mostly elderly people; more than 90% of deaths occurred in people over 66 years of age (Our World Data).

Theft of a radioactive source during transport

On 2 December 2013, a truck near Mexico City, carrying a "dangerous radioactive source" (cobalt-60), was stolen. The load was a telethropic device used to treat cancer. It was stolen near the disposal site to which it was transported, after a journey of almost 1800 miles from the northern border town of Tijuana. The vehicle did not have any tracking or security equipment as required (Database of Radiological Incidents and Related Events). On 4 December, near Heyospasla, Mexico, 40 kilometers from where the truck was stolen, the medical device was found in a maize field, but the drain capsule was removed from the shielding. There was no contamination because the capsule had not opened on its own. A local person discovered that the device was abandoned and had it taken to his home, hoping to sell it as scrap. The person began to suffer from nausea, vomiting and burns on his back, causing him to seek medical attention a few days later, and thus the authorities found the source. The source was secured by a police robot (Moore, George M.).

The IAEA tracking report has shown that the strength of cobalt 60 is 3,000 boxes (radiation unit), making it a category 1 source – the most dangerous of the five IAEA radioactivity classes. At a distance of 30 centimeters from an unshielded source with the same activity of the material means that anyone who is exposed to it for 30 seconds will die. This is a serious incident with potential consequences for participating thieves (IAEA‘s IEC).

Economic consequences

There is no evidence of material damage, but it can be said that ensuring the safety and security of people can be measured by the costs incurred for them. But if we look at DBT, we can investigate what would be the motivation of malicious people to steal the device. A scenario for a "dirty bomb" can be developed that can cause significant material damage and result in a significant number of casualties. In addition to peaceful medical and industrial applications, experts say cobalt-60 can also be used in a dirty bomb where conventional explosives spray radiation from a radioactive source. If the Mexican source had been used in a spraying device, the economic consequences could have been extremely significant.

Social consequences

Based on the IAEA report, it can be argued that thefts of this kind can lead to damage to people's health and lives.

The theft of radioactive material in Brazil

On 13 September 1987 in Guyana, Brazil, when the radiotherapy institute moved, many old hospital machines and supplies that would be redundant in the new building were abandoned. Marauders stole from an abandoned hospital part of the radiotherapy installation containing the radioactive isozype cesium 137 in the form of cesium chloride and then disposed of it. But after a while, it was found in the dump by two workers who decided to carry the source of radiation in their homes, impressed by the blue light of the dust. They shared parts of it with friends and thus spread radioactive contamination. Cesium 137 spreads around Guyana, people start getting sick and many of them suffer from acute poisoning with radiation. Some 112,000 people were tested for radioactive contamination, and 249 of these were found to have significant levels of radioactive material in or on their bodies (Guyana Nuclear Accident, Brazil 1987).

From the Guyana accident survey on the potential occurrence of such accidents, one major observation is that nothing can reduce the responsibility of the person identified as being responsible for the security of a radioactive source. Radioactive sources that are removed from the site where it is identified, registered and licensed may pose a serious danger. Therefore, such breaches should be avoided, ensured by those responsible and should include screening procedures and appropriate security measures. Although the regulatory system is a verification of the effectiveness of the professional and management system, it should be stressed that regulatory and legal control cannot and should not detract from the responsibility of the management.

Regulatory requirements must be observed, they are easy and applicable. Society should be informed of the potential hazards of radiation sources, which is in fact an important factor in reducing the likelihood of radiation accidents. Consideration should be given to a system of radiation hazard markings that could be recognized by the general public. The physical and chemical properties of radioactive sources are very important in relation to radiation accidents.

They must be taken into account when licensing the production of such sources, in view of the potential impact of these sites on the consequences of accidents and misuse of sources. Emergency response preparedness in the event of a radiological emergency should cover not only nuclear accidents but also the whole range of possible accidents resulting in exposure to radiation.

Ecological consequences – there was polluted water, soils on the territory of the city, covering an area of about 67 sq. km. There were outbreaks of pollution in the warehouses where the capsule's integrity was broken – covering an area of about 1 sq. km. during the accident. So the environment was heavily polluted. Actions taken to clean up the pollution can be divided into two phases. The first phase was in line with the urgent action needed to bring all potential sources of pollution under control. The second phase, which can be considered as the corrective phase to restore normal living conditions, continued until March 1988.

On the issue of tackling environmental pollution due to an accident, it is important to note the question of the decisions on the intervention levels. It is quite often the case that very restrictive criteria for corrective actions, usually driven by political and social considerations, are imposed. However, such criteria create a significant economic and social burden in addition to what is caused by the incident itself, and this is not always justified.

Conclusion

The objective of any system of physical protection of nuclear facilities and sites is to prevent unauthorized access to equipment, installations, materials as well as the prevention of espionage, sabotage, damage and theft and protection of personnel. Physical protection systems for sheltered facilities are usually intended to deter potential offenders by using different protective devices and means. Such systems are related to limited access to the designated objects of the different types of personnel working on the site (access cards), physical inspection of the persons working on the site, determination of the route by which the personnel can be moved depending on the job description of the person the activities it performs. At these sites, strict rules are established for the construction of physical protections – barriers, warning signs, marking, surveillance systems.

All this involves significant investments in identifying, developing, testing, deploying, using, managing, monitoring and maintaining access control, as well as wider issues related to human rights, health and safety, public norms or conventions.

When considering the specificity of such objects, the following questions should be answered: what nuclear facility or site are different from other critical infrastructure objects; how these objects are protected; when they have to defend themselves; what is the price of the protected facility and how much money should be spent on this physical protection.

Bibliography:

Database of Radiological Incidents and Related Events, http://www.johnstonsarchive.net/nuclear/radevents/index.html#2010

Development, Use and Maintenance of the Design Basis Threat, IAEA Nuclear Security Series No. 10, http://www-ns.iaea.org/security/dbt.asp?s=4

Development, Use and Maintenance of the Design Basis Threat, IAEA Nuclear Security Series No. 10, http://www-ns.iaea.org/security/dbt.asp?s=4

Development, Use and Maintenance of the Design Basis Threat, IAEA Nuclear Security Series No. 10, http://www-ns.iaea.org/security/dbt.asp?s=4

Engineering Safety Aspects of The Protection of Nuclear Power Plants Against Sabotage, IAEA Nuclear Security Series No. 4, https://www-pub.iaea.org/books/IAEABooks/7574/Engineering-Safety-Aspects-of-the-Protection-of-Nuclear-Power-Plants-against-Sabotage

Goiania Nuclear Accident, Brazil 1987, http://large.stanford.edu/courses/2018/ph241/gerli1/

Green. J., The economic impacts of the Fukushima disaster, https://www.wiseinternational.org/nuclear-monitor/836/economic-impacts-fukushima-disaster

IAEA, https://www.iaea.org/newscenter/news/mexico-prepares-recover-dangerous-radioactive-source-field

IAEA, The Fukushima Daiichi Accident, Report By The Director General, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1710-ReportByTheDG-Web.pdf

Japan nearly doubles Fukushima disaster-related cost to $188 billion, https://www.reuters.com/article/us-tepco-fukushima-costs/japan-nearly-doubles-fukushima-disaster-related-cost-to-188-billion-idUSKBN13Y047

Michael, B., Jenkins and John Lauder (2016), The Nuclear Terrorism Threat: How Real Is It?;

Moore, George M.,Bulletin of the Atomic Scientists, Home > Analysis > Lessons from a Mexican theft, https://thebulletin.org/2013/12/lessons-from-a-mexican-theft/

Nuclear Regulatory Commission (NRC), Home, NRC Library, Document Collections, Fact Sheets, Backgrounder on Dirty Bombs, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-dirty-bombs.html

Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5), Recommendations, IAEA Nuclear Security Series No. 13, IAEA, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1481_web.pdf, 22.08.2018

Nuclear Security Series Glossary, Version 1. 3 (November 2015), International Atomic Energy Agency, Division of Nuclear Security, https://www-ns.iaea.org/downloads/security/nuclear-security-series-glossary-v1-3.pdf
Our World Data, https://ourworldindata.org/what-was-the-death-toll-from-chernobyl-and-fukushima
WHO, https://www.who.int/ionizing_radiation/a_e/fukushima/faqs-fukushima/en/

ANALYSIS OF THREATS TO THE PHYSICAL PROTECTION OF NUCLEAR FACILITIES AND SITES

Abstract

The modern trends in threats to international security, such as the nuclear arms race, terrorist threats through improvised explosive devices with radioactive materials, cyber-threats against hi-tech production and operating security systems, the 2011 earthquake with a 9.0 magnitude on the Richter scale which caused a tsunami, which in turn led to the Fukushima nuclear disaster, have drawn attention to the various dimensions and degrees of the physical vulnerability of nuclear sites and facilities.

Key words: nuclear insider threat analysis, physical protection, nuclear disaster

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