Ukrainian Efforts in Implementation of Fundamental Principles of Physical Protection

Ihor Kuzmyak, Valery Kravtsov

State Scientific and Technical Centre for Nuclear and Radiation Safety

35/37 V.Stusa St., 03142, Box 124, Kyiv, Ukraine

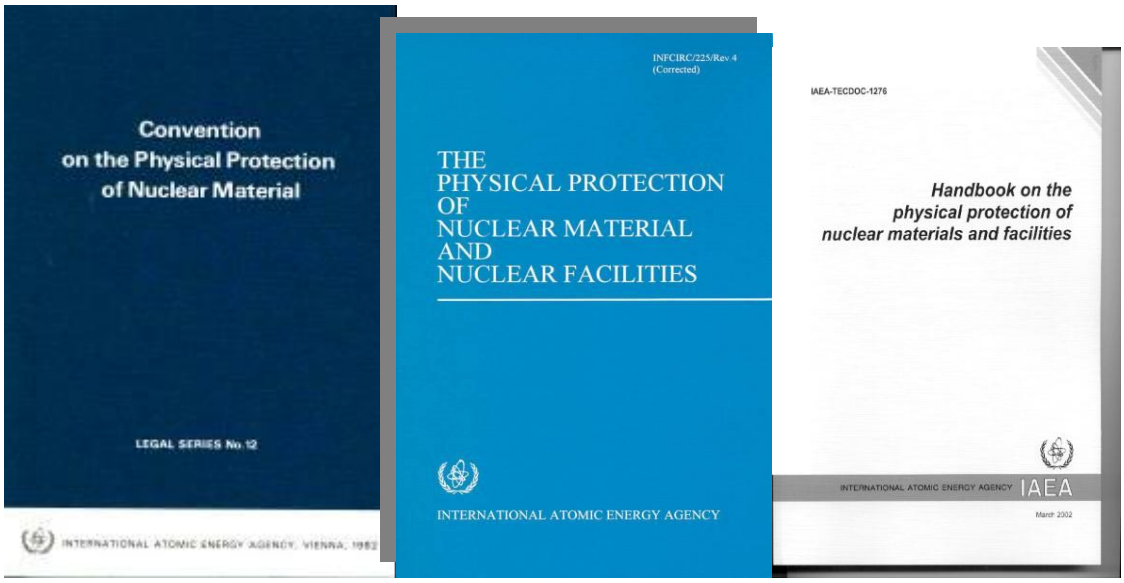
Abstract:
Ukraine having a well-developed nuclear energy infrastructure attends greatly to its nuclear security. Especially physical protection of nuclear facilities, nuclear and other materials is always the matter of great concern. Ukraine was among the initiators of development and acceptance of the Amendment to Convention on the Physical Protection of Nuclear Material and ratified it in 2008. Taking into consideration that fundamental principles of physical protection of nuclear material and nuclear facilities, worded in the Amendment, are the quintessence of physical protection standards, all the efforts of last years are intended for their implementation at the operators' level as well as at the State's one. The main steps included implementation of the above principles in physical protection legislation and establishment of a state physical protection system as well as modernization of physical protection systems of facilities. This work is devoted to examination of implementation measures for each of the twelve principles and a brief overview of the nuclear security status in Ukraine.

1 INTRODUCTION

Intensive utilization of nuclear energy started in the middle of the 20th century – nuclear power plants appeared in several countries right simultaneously. Radiation sources came in use in industry, scientific research, medicine.
Dynamic introduction of nuclear facilities into operation provided considerable changes in the structure of world energy complex. Nuclear energy input to the world production of electrical energy came to more than 17%. Nuclear power engineering became a ponderable branch of the world energy economy important for its development. During the last decades, the so-called "nuclear renaissance" is to be observed as traditional power sources, especially carbohydrates, decrease implacably and utilization of recoverable sources is not always possible or advantageous. A lot of countries aspire to develop and expand their nuclear power engineering. Ukraine extends the operation life of two power reactors and has planned to build 15 new ones. Russia scheduled to build 30 new units till 2030. In Vietnam the first unit is under construction and 5 more are planned. Also Turkey, Poland, Belarus, Lithuania, Czech Republic, Armenia are planning to build new facilities.
Nevertheless, nuclear energy is the most potentially hazardous man-caused source of energy. This hazard is in its nature – in release of great amount of destroying energy of nuclear fission.
The menace hidden in nuclear energy was demonstrated at the same time with the first steps in utilization of peaceful atom. Nuclear bombing of Hiroshima and Nagasaki illustrated that a comparatively small amount of fissile material could not only annihilate the whole cities together with population but cause the radioactive contamination of territory and have an effect on health of several generations.
Comprehension of this deterrent forced the mankind to combat the proliferation and use of nuclear weapons as well as the unmanageable dissemination of nuclear material and technology.

2 NUCLEAR AND RADIATION SAFETY AND PHYSICAL PROTECTION. BRIEF EXCURSUS INTO MUTUALITY

Probably the might of nuclear power forced scientists and politics of the world to reflect on the hazard of careless and uncontrolled development of technologies, especially those for military and dual purposes. Thus in 1957 under the aegis of UN and with motto “Atoms For Peace” the International Atomic Energy Agency was established.
The objectives of this organization including now 153 members was to support the development and contribution of nuclear energy for peace, welfare and prosperity in the world. And one of the most important tasks was ensuring the safeguards that fissile material would not be used for military purposes.
In the 1950-1960s, the practice of application of this principle showed that integrity and non-proliferation of nuclear materials would not be efficient without accountancy, control and appropriate guarding.
Thus the concept of physical protection emerged just as the instrument for safeguards and at the beginning was inseparable of it. Only in 1972 the earliest IAEA document specific for physical protection appeared – Recommendations on the Physical Protection of Nuclear Material, published in 1975 as INFCIRC/225. In 1980 the Member States of IAEA undersigned The Convention on the Physical Protection of Nuclear Material [1]. For years only nuclear material was the object of principal concern of physical protection.
Just in 1998 basing upon the long-term experience of operators and regulators and especially on the lessons learned of the Chornobyl accident the protection requirements were formulated for primary equipment of nuclear facilities as well as for nuclear material. A new revision of INFCIRC/225 was named Recommendations on the Physical Protection of Nuclear Material and Nuclear Facilities [2] and a new chapter on requirements for measures against sabotage of nuclear facilities was included.



a) b) c)

Fig. 1. Primary IAEA publications of different levels on physical protection: a) Convention on the Physical Protection of Nuclear Material [1]; b) The physical protection of nuclear materials and nuclear facilities (INFCIRC/225) [2]; c) Handbook on the physical protection of nuclear materials and facilities (TECDOC-1276) [3].

At the beginning of 2001, the IAEA Board of Governors approved document GOV/2001/41 [4], which pioneered the introduction of the Physical Protection Objectives and Fundamental Principles. The same year the General Conference approved document GC(45)/INF/14 “Measures to improve the security of nuclear materials and other radioactive materials” [5].

This document endorsed the “Physical Protection Objectives and Fundamental Principles” as a Security Fundamentals document, as a step towards strengthening the physical protection regime. Important was also extension of fundamentals for all the radioactive materials. The 4 objectives and 12 principles became the basis for development of the Amendment to the Convention on the Physical Protection of Nuclear Material [6] undersigned by Member States in 2005.

The establishment and development of physical protection in nuclear energy of Ukraine started practically at once after constitution of the independent State in 1991. Decree of Supreme Council No. 3182-XII dated 5 May 1993 [7] adopted the Convention on the Physical Protection of Nuclear Material as binding for Ukraine and declared the necessity of state regulation of relationships in the area of physical protection. Decree of the President of Ukraine No. 608/93 “On measures of the physical protection of nuclear materials and nuclear facilities“ (replaced now) was published in December of the same year and was the primary legal document constituting the physical protection requirements.

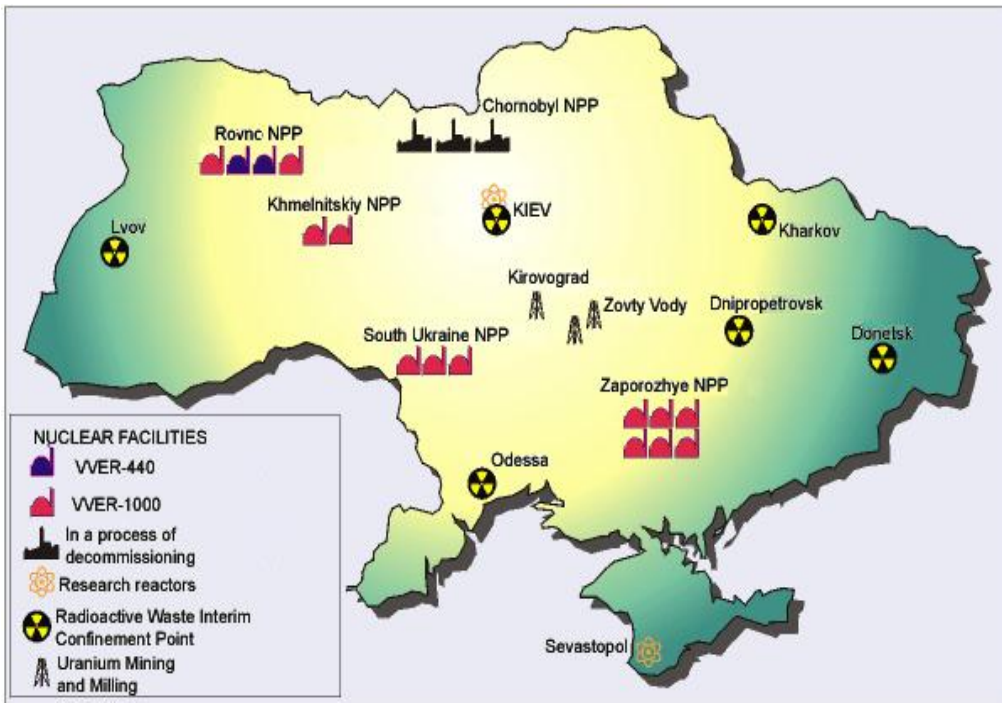


Fig. 2. Map of Ukraine with indicated nuclear facilities and radioactive waste storages.

Ukraine being the country with intensive utilization of nuclear energy, as seen in Fig. 2, permanently places high emphasis on physical protection of nuclear and other radioactive materials and associated facilities. Our country was among the initiators of amending the CPPNM [1] and undersigned the Amendment to the Convention on the Physical Protection of Nuclear Material [6] in 2005. Ratification of the above Amendment by the dedicated law [10] of Ukraine in 2008 was the most important step in physical protection improvement. This law and associated specially amended law “On physical protection of nuclear facilities, nuclear materials, radioactive wastes and other radioactive sources” [9] implemented not only 12 fundamental principles of physical protection but also identified concepts new for Ukraine such as nuclear security, physical protection regime, design basis threat etc.

3 RISKS AND THREATS

Nuclear energy by itself now and then reminds the mankind about the jeopardy hidden in nuclear materials and facilities. Beginning in the 1950s, a considerable list of accidents at nuclear facilities was shaped. The first severe accidents (INES level 5) were conflagration at the military reactor in Windscale (UK) in 1957 and core fusion at the Three Mile Island NPP (USA) in 1979. The Three Mile Island accident demonstrated what could human errors cause in combination with insignificant and improbable failures of technological equipment.
The accident at the Chornobyl NPP in 1986 showed what could be caused by the violation of nuclear safety during tests of a physically deficient reactor. The main cause of the Chornobyl disaster was the lack of safety culture as such. This concept exceeds far beyond the operation of particular facilities and objects and covers all the activities in nuclear energy sphere including the legislative and industrial ones.
One of the main causes of all the above accidents was the human factor. The accident at the Fukushima NPP (Japan) in March 2011 showed how disregard of geographical location features when technological equipment failed because of a tsunami resulted in explosion of the reactor.

a) b)

Fig. 3. Accidents at nuclear facilities with overall consequences: a) Chornobyl NPP, April 1986; b) Fukushima NPP, March 2011.

As world practice displays, the main causes of accidents at nuclear facilities are:
- failures of technological equipment and construction deficiencies;
- human errors and violation of nuclear safety.

The above accidents were caused mostly by inadvertent errors and violation of safety by personnel of nuclear facilities. More numerous radiation incidents but with less radiological consequences are emerging at facilities using radioactive sources for different purposes: in industry, medicine, scientific research etc. The causes are mostly the same – personnel errors, fortuitous, unintentional or involuntary violations of radiation safety rules.
Nevertheless, the same or even worse consequences may result from deliberate or malicious acts aimed at nuclear facilities, facilities for management of radioactive waste or other radioactive sources. Threats of criminal or unlawful acts involving nuclear or other radioactive materials increased noticeably at the beginning of the 1990s. It is well known that some terrorist groups got the idea to assume such materials in a nonviolent or forcible way.

a) b)

c) d)

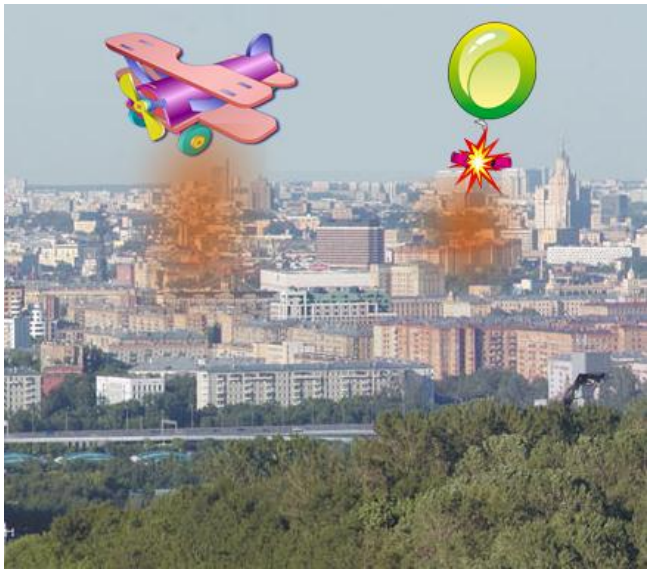
Fig. 4. Application of high-level sources in Ukraine: a) in industry; b) in medicine; c) for scientific research purposes; d) for needs of metrology.

Concerning the nuclear materials, we have to take into consideration the next three main types of risks:
- risk of unlawful acquisition of nuclear material for production of a nuclear explosive device – atomic bomb;
- risk of unlawful acquisition of nuclear material resulting in dispersion and dissemination of material;
- risk of sabotage at a nuclear facility.

Concerning the radioactive wastes and radiation sources, the main risks are:
- theft or other unlawful acquisition for subsequent sale when the offender does not intend to apply materials by himself;
- theft or other unlawful acquisition for production of a radiological dispersal device – so-called dirty bomb;
- risk of sabotage at facilities directly.

The most notorious case of applying a radiation source for malicious purposes is poisoning Alexander Litvinenko, the former employee of the Federal Security Service of Russia, by radioactive isotope Po-210. This case which happened on 23 November 2006 and resulted in Litvinenko's death was called the act of nuclear terrorism in the middle of London.

a)



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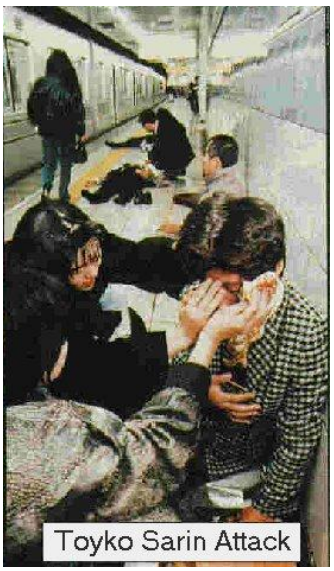


c)

Fig. 5. Deployment of radioactive materials for malicious purposes: a) A.Litvinenko before and after radioactive poisoning; examples of possible application of dirty bomb: b) airborne dissemination over the large populated area and c) dispersion in the closed space of crowd (e.g. metro).

According to the indicated risks, the threats of commitment of such acts exist. As the experience shows, the major and real threats are terrorist groups. Such groups undertake acts of different scale but always with the same purpose – to cause social response, panic and instability. It is known that the threat of a terrorist act is real not only in large countries where the attacks are often and where large groups and organizations act “traditionally”, as, for instance, the USA, Great Britain, Russia or Spain. Ukraine is reputed as a more latent country in respect of terrorism, especially nuclear one. As was announced at the Seoul Nuclear Security Summit in April 2012, the terrorist threat in Ukraine vanished after removing the high-enriched nuclear material from the country. Series of explosions in Dnipropetrovsk in May 2012 with application of small amounts of conventional explosives demonstrated that, nevertheless, the threat exists and is quite real.

Therefore, in preparation for the Euro-2012 football championship scheduled in Ukraine for June 2012, the matters of security were of great concern. Great attention was also paid to nuclear security and countering illicit trafficking. The measures taken for these purposes seem to be effective as no case had happened during the championship. Some of these measures will be reviewed below.

a) b)

Fig. 6. Terrorist attacks may differ by objectives, targets and scale: a) airborne attack in New York, 11 September 2001; b) series of explosions on tram and bus stops in Dnipropetrovsk, 25 May 2012.

Another type of threat specific for Ukraine is infringement relative to nuclear and other radioactive materials for profiteering purposes – thefts, other unlawful acquisitions aiming at subsequent sale. These events were most widespread in the 1990s. Nevertheless, there are also attempts now to steal radioactive sources, radioactively contaminated metal scrap, especially from the Chornobyl zone and Sub-Dnieper industrial site. Offenders act solely for profiteering and mainly secretly, non-violently, alone or in small groups. Very often such offences are perpetrated by insiders – regular employees or, predominantly, temporary staff. Sometimes such thefts are fulfilled on demand of or in agreement with criminals.

a) b) c)

Fig. 7. Primary targets of unlawful acquisition in Ukraine: a) radioactive contaminated metal scrap, especially nonferrous; b) industrial radioactive sources; c) small amounts of nuclear material mainly for research purposes.

Radioactive sources pose the considerable material and commercial value, not speaking about the nuclear material, although it is not easy to push it off. So there have been no attempts of theft of enriched nuclear material (e.g. fuel) in Ukraine since 1996. The last case of discovering the nuclear material in illicit trafficking was a small amount of uranyl nitrite for medical research purposes, seized in attempt of sale in 2008 (see Fig. 7c).
The growing world demand on radioactive materials and especially the concernment of well-subsidized terrorist organizations stimulate the appearance of new offences – illegal market of radioactive materials and even the “nuclear fraud” when there are attempts to sell radioactive imitation or even nonradioactive substance under the guise of nuclear material .

a) b)

Fig. 8. Case of “nuclear fraud”: attempt to sell, under the guise of 3,7 kg of plutonium, a lead container (a) with a radioactive source for smoke detector, of 500 μg mixed isotopes of plutonium inside (b). Zalischyky, Chernivtsi region, Ukraine, 2009.

The third large group of threats is formed by persons and organizations protesting against the nuclear energy utilization for ideological motives. This group includes not only comparatively pacific demonstrators and activists (for example, Green Party, FEMEN) but also aggressive extremists (right or left radicals, religious fanatics).
Movement of anti-nuclear remonstrants has intensified the last years, especially after the disaster at the Fukushima NPP, and became apparent not only as street marches and mass-meetings but active operations as well. For example, in May 2012, a Greenpeace activist flying by motor paraglider threw a smoke bomb to the vault reactor block and landed inside the Bugey NPP, France (see Fig. 9d), where he was detained. The similar movement against construction of new reactors and radioactive waste storages exists also in Ukraine and showed its worth repeatedly.
In addition to the above threats, there is a risk of leakage of sensitive nuclear information suitable for malicious use. The risk of unlawful acquisition, destruction or distortion of such vital information using computer networks has significantly increased in recent years. Moreover, the computer offenders, hackers could act with any motivation – on demand of terrorists or ideological views or even to test and prove their capabilities.

a) b)

c)

d)

e)

f)

Fig. 9. Credible threats for nuclear security: a) well-subsidized and capable terrorist organizations; b) criminals acting alone or in groups; c) mass demonstrators; d) extreme activists; e) extremist organizations often involving young people; f) hackers are also involved.

To withstand all these threats, the physical protection of nuclear facilities, nuclear materials, radioactive wastes and other radioactive sources is assured, managed and regulated in Ukraine. The aforementioned 12 fundamental principles serve as the basis for all these activities.

4 IMPLEMENTATION OF FUNDAMENTAL PRINCIPLES OF PHYSICAL PROTECTION IN UKRAINE

4.1 Fundamental Principle A: *Responsibility of the State*

The responsibility for the establishment, implementation and maintenance of a physical protection regime within a State rests entirely with that State.
In new Article 2A introduced to CPPNM [1] by Amendment [2], “Each State Party shall establish, implement and maintain an appropriate physical protection regime applicable to nuclear material and nuclear facilities under its jurisdiction”. For implementing this regime, the State should provide:
- legislative and regulatory framework of physical protection;
- competent authorities responsible for the implementation of this framework;
- physical protection systems, including these for transportation of nuclear material.

In Ukraine, the concept of physical protection regime is established by the Law [9]. For this purpose, the State determines a procedure for ensuring physical protection and establishes a State Physical Protection System [11].
The objectives of the State Physical Protection System (SPPS) are:
- legal regulation of physical protection matters;
- ensuring the nuclear security taking into consideration the Design Basis Threat;
- establishment and maintaining of a united system of protected communication for state and other entities responsible for accountancy and control of materials, physical protection and counteraction to attacks on materials and associated facilities and transport;
- state supervision and control of physical protection;
- management and security of information exchange for physical protection matters.

The subjects of SPPS are:
- specially empowered central authority for state regulation of physical protection;
- central authorities for government of physical protection and National Academy of Science;
- Security Service of Ukraine;
- Internal Troops of Ministry of Interior;
- other enforcement authorities.

Licensees acting in nuclear energy and physical protection spheres are also included in SPPS.
The SPPS activities are coordinated by the competent authority – State Nuclear Regulatory Inspectorate of Ukraine.
SPPS objects are as follows:
- nuclear facilities;
- radioactive waste management facilities;
- nuclear materials;
- radioactive wastes;
- other radioactive sources;
- radioactive materials discovered in illicit trafficking.

In performing an important and primary task of physical protection such as training of specialists, SPPS relies upon the State system of training, retraining and advanced training of specialists on physical protection, accountancy and control of nuclear material established in Ukraine [12].
In the case of a terrorist attack menace, SPPS cooperates with the State Antiterrorist System [9,13]. A good deal of subjects are common for these two systems.
Consequently, the responsibility of the State for physical protection in Ukraine is exercised mostly through the State Physical Protection System.

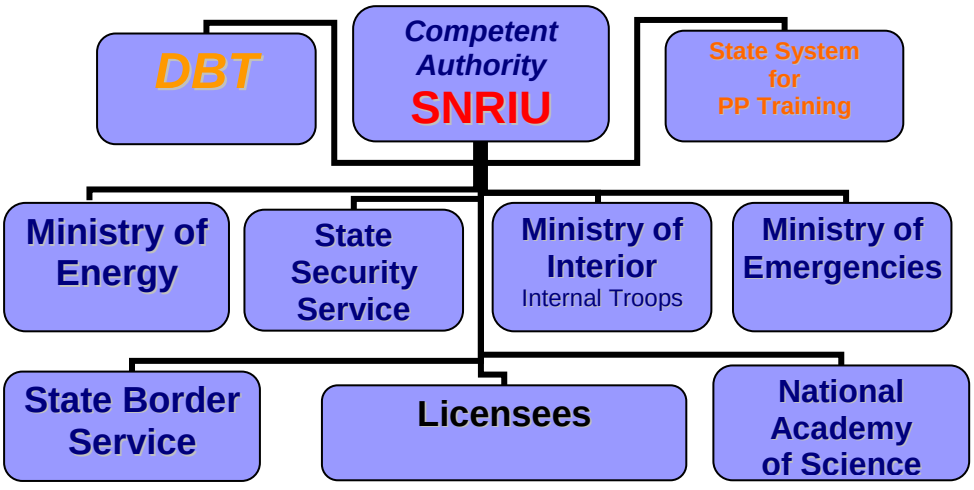


Fig. 10. Interaction scheme of State Physical Protection System of Ukraine.

4.2 Fundamental Principle B: *Responsibilities During International Transport*

The responsibility of a State for ensuring that nuclear material is adequately protected extends to the international transport thereof, until that responsibility is properly transferred to another State, as appropriate.

Ukraine has not a closed fuel production cycle. Therefore, it is forced to import fresh nuclear fuel and remove the spent one. These transportations are performed with Russia by land and, as experiment, by sea with some other countries. According to international agreements of Ukraine and the Working Plan of Washington Nuclear Security Summit of 2010, highly enriched fuel and other highly enriched nuclear materials were removed from Ukraine to Russia. The removal was performed by air.

Moreover, transit transportation of fresh and spent fuel for Bulgaria, Hungary and Slovakia by land and waterway via Ukraine is performed. Shipment of radioactive sources, fresh or spent, transit and terminal, takes place as well.

a)

b)

c)

d)

Fig. 11. Transportation of nuclear and other radioactive materials: a) by railway; b) by sea shipping; c) by aircraft; d) by trucks.

In such a way, the transport of nuclear and other radioactive materials through the Ukrainian borders is intensive. All these transportations are carried out according to bilateral or trilateral international agreements and in compliance with international conventions in which Ukraine participates, including the CPPNM [1].

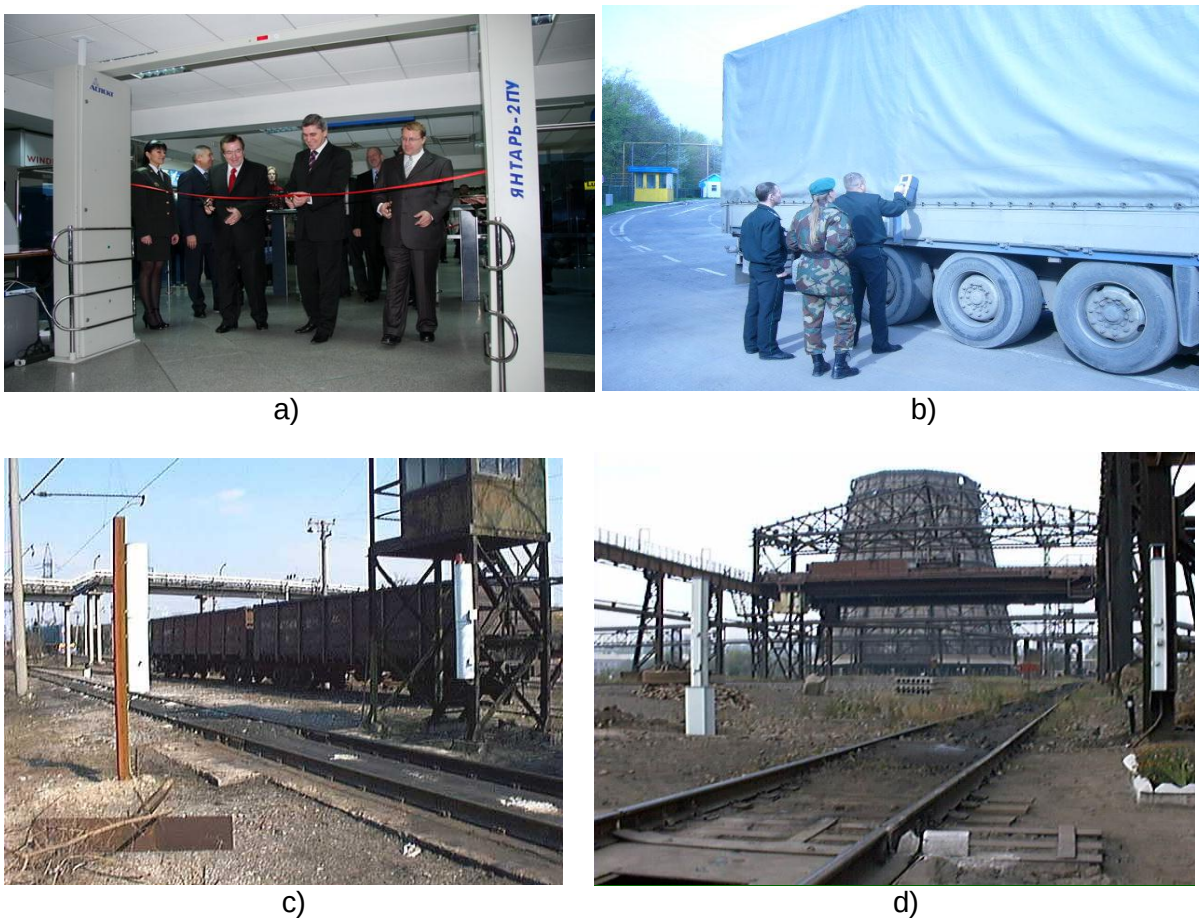
In doing so, Ukraine adheres to the following principles:

- the export of nuclear material is not permitted to a country which does not provide assurance that such material will be protected during the international nuclear transport at the proper level;

- the receipt/conveyance of nuclear material is not permitted from a country which does not provide assurance that such material will be protected during the international nuclear transport at the proper level;
- the transit transportation of nuclear material is not permitted if other member states do not provide assurance that such material will be protected during the international nuclear transport at the proper level;
- in crossing the state borders, points and procedure for assignment of responsibility for physical protection are established;
- detailed information on transportation is confidential and should be protected;
- for every transportation, physical protection system is established;
- transportation of nuclear materials all along the territory of Ukraine is guarded by Interior Troops of the Ministry of Internal Affairs [14].

Nevertheless, besides secure and legal transportations of nuclear and radioactive materials, the threat of illicit trafficking through the state border (nuclear smuggling) still exists. Thus for counteraction to malicious acts as well as for detection of cases of indeliberate transportation of radioactive objects, the border crossing points are equipped with radiation detectors.

The same equipment is applied at airports, on railroad, international distributing post offices and metallurgical enterprises. In such a way the radiation surveillance on transfer of materials is assured and radioactive materials out of regulatory control are seized of illicit trafficking. All these activities are regulated by special governmental decree [15].



a) b) c) d)

Fig. 12. Means of surveillance over transport of radioactive materials on borders and within Ukraine: a) inauguration of a passenger detecting portal on border crossing at Boryspil International Airport; b) customs inspection using a portable radiometer; c) railway portals on border crossing (c) and spur-track of Donetsk metallurgical plant.

4.3 Fundamental Principle C: *Legislative and Regulatory Framework*

The State is responsible for establishing and maintaining a legislative and regulatory framework to govern physical protection. This framework should provide for the establishment of applicable physical protection requirements and include a system of evaluation and licensing or other procedures to grant authorization. This framework should include a system of inspection of nuclear facilities and transport to verify compliance with applicable requirements and conditions of the license or other authorizing document, and to establish a means to enforce applicable requirements and conditions, including effective sanctions.

Ukraine has established an advanced multilevel legislative framework for physical protection. The laws of Ukraine constitute the highest level: the basic law for nuclear energy [8] and dedicated law for physical protection [9] and also the law [10] ratifying the Amendment [6] and establishing the Fundamental Principles of Physical Protection in Ukraine. Furthermore, several matters of Physical Protection – information security, counter-terrorist activities, guarding by internal troops etc. – are established by other laws [13,14,16]. International conventions and agreements in which Ukraine participates and which have priority on the laws of Ukraine are positioned at this level as well.

The lower level constitutes Decrees of President and of Cabinet of Ministers of Ukraine. They determine procedures in particular areas of physical protection: defining of protection level [17], access granting [18], state inspections on physical protection systems [19] etc. Presidential decrees are applied mostly to nuclear security measures: implementation of the Washington Summit Working Plan, DBT approval, nuclear terrorism counteraction.

The bottom level represents regulatory acts approved by the regulatory authority or other involved ministries and registered by the Ministry of Justice. Such acts are generally binding in Ukraine and contain rules of physical protection [20], requirements for particular elements [22] and regulatory procedures [24].

To provide an instrument to systemize the legislative framework for physical protection, discover the gaps or duplications and outdated acts, a Hierarchy Pyramid of legislative acts of physical protection was developed in 2009. It represents a diagram indicating the titles of acts and regulatory matters, shows the position of acts by levels and their interrelations.

The Hierarchy Pyramid does not show international documents such as IAEA recommendations or acquis communautaire. According to Ukrainian legislation, such documents are implemented in Ukraine by means of transformation, i.e. issuing of a harmonized national act based on the international document after its considerable working-up. The Hierarchy Pyramid is not illustrated here for its sizeable volume. It is an item for separate discussion.

4.4 Fundamental Principle D: *Competent Authority*

The State should establish or designate a competent authority which is responsible for the implementation of the legislative and regulatory framework, and is provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities. The State should take steps to ensure an effective independence between the functions of the State's competent authority and those of any other body in charge of the promotion or utilization of nuclear energy.

It means that in the State should designate an authority independent in its activities from other state authorities in the area of nuclear energy and responsible for establishment and development of regulatory framework as well as for supervision of compliance with obligations and requirements.

As mentioned above, the competent authority of the State physical protection system of Ukraine is the State Nuclear Regulatory Inspectorate. Article 62 of Law [8] and Article 25 of Law [9] determine the status and responsibilities of the regulatory authority for physical protection. In 1996, following Article 5 of the CPPNM [1], it was appointed by governmental decree [26] as a central authority for physical protection matters. In the Presidential Decree

of 2011 establishing the Statute of the State Nuclear Regulatory Inspectorate of Ukraine [27], it is appointed a competent authority for physical protection matters.
Hence, Ukraine has established a competent authority for physical protection, with appropriate responsibilities and competency and basically sufficient financial and human resources for providing physical protection activities.

The above fundamental principles relate to functions of the State in assuring physical protection, including the interaction and cooperation for these matters with other states. The next principles have more particular features and constitute the requirements for institutions, organizations and enterprises in their activities.

4.5 Fundamental Principle E: *Responsibility of the License Holders*

The responsibilities for implementing the various elements of physical protection within a State should be clearly identified. The State should ensure that the prime responsibility for the implementation of physical protection of nuclear material or of nuclear facilities rests with the holders of the relevant licenses or of other authorizing documents (e.g., operators or shippers).
Licensees, i.e. entities that received an appropriate authorization according to the law [28] to act in the sphere of nuclear energy, are subjects of the State Physical Protection System as well. Functioning in different areas of nuclear energy and being responsible for nuclear and radiation safety under their licenses, the licensees are also responsible for physical protection.
The basic law [8] determines responsibility of operators in Article 33 and of other licensees in Article 32 for fulfilment the immediate and principal requirements of physical protection. These requirements are stated in articles 18-21 of the physical protection law [9] and in the rules of physical protection [20].
Fulfilment of requirements of physical protection is obligatory for granting a license or another authorization and for further economic and other activities in nuclear energy.

4.6 Fundamental Principle F: *Security Culture*

All organizations involved in implementing physical protection should give due priority to the security culture, to its development and maintenance necessary to ensure its effective implementation in the entire organization.
Security culture has many common features with safety culture. Its lack could also result in serious consequences as it was mentioned at the beginning of part 3.
Having in mind the lessons learned in the Chornobyl disaster in Ukraine, one highly recognizes the importance of both safety and security culture. The priority of nuclear security culture as one of the essential elements of state's policy in physical protection is recognized in the physical protection law [9]. The requirements on implementation and improvement of security culture are prescribed in the rules of physical protection [20].
The definition of security culture is cited in the above law [9] and differs a little from that given in the IAEA Recommendations [28], but more in letter then in spirit:
Security culture is the characteristic of activities of institutions and of behaviour of individuals testifying that for security of nuclear facilities, nuclear materials, radioactive wastes and other radioactive sources attention is paid, giving proper significance of security to nuclear and radiation safety.
To adhere to Principle F, a Working Group for building, improvement and support of security culture in entities ensuring physical protection was established in Ukraine in 2010 under the regulatory authority. The members of this group are decision-makers responsible for physical protection of authorities, operators and other prominent licensees.

4.7 Fundamental Principle G: *Threat*

The State's physical protection should be based on the State's current evaluation of the threat.

It was shown in part 3 that threats for nuclear energy are real and probable. To take into account not only possibility but features of threat, it is necessary to assess, describe and implement it into physical protection systems of appropriate level. The end-line instrument for these purposes is the Design Basis Threat introduced by the IAEA Recommendations [30].

In Ukraine, the concept of DBT is defined by the physical protection law [9]. Development of DBT is coordinated by the appointed authority in participation with law enforcement and intelligence services.

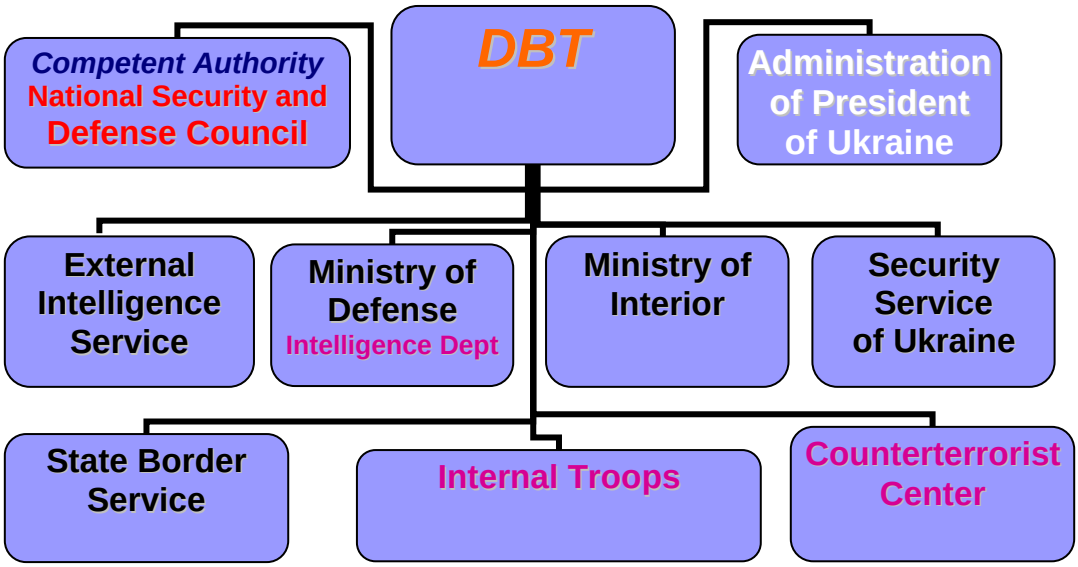


Fig. 13. Scheme of interaction between authorities involved in development and maintaining the DBT in Ukraine.

The work on information collection, treat assessment and build-up of DBT in Ukraine started in 2009 under the leadership of the National Security and Defence Council. It is a deliberative body attached to the President of Ukraine. For this purpose, a working group was established, consisting of representatives of the Security Service of Ukraine and attached Counterterrorist Centre, Ministry of Interior and Command of Internal Troops, State Border Service and external and military intelligence bodies. DBT was approved by a Decree of President of Ukraine on May 2011. This document is not for publication and contains, in addition to DBT, also the procedure for development and maintaining the DBT. DBT should be reviewed every two years or less often if necessary.

Functioning of SPPS is based on DBT, and it is SPPS that is responsible for compliance of physical protection systems of facilities with DBT. Evaluation of physical protection systems is also based on DBT.

4.8 Fundamental Principle H: *Graded Approach*

Physical protection requirements should be based on a graded approach, taking into account the current evaluation of the threat, the relative attractiveness, the nature of the material and potential consequences associated with the unauthorized removal of nuclear material and with the sabotage against nuclear material or nuclear facilities.

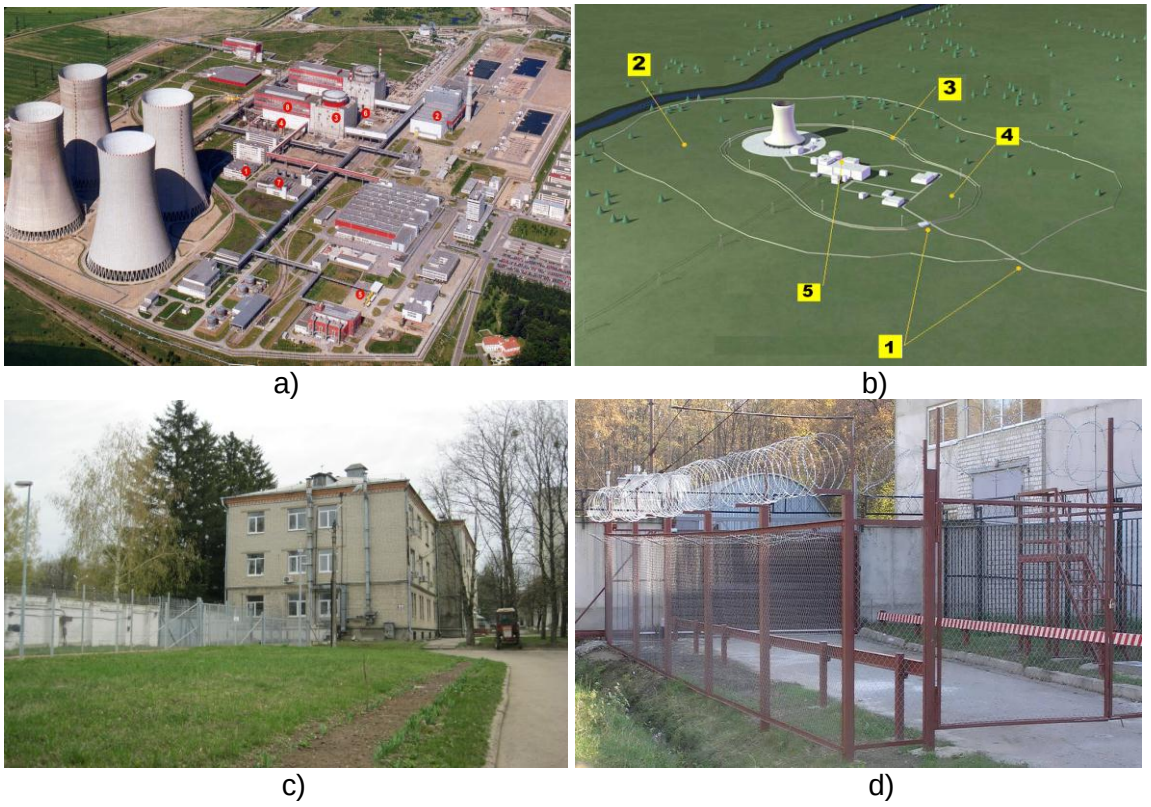
If Principle G takes into account characteristics of offenders capable of performing malicious acts involving materials or associated facilities, the graded approach pays attention to risks posed by these materials or facilities in the case of sabotage, theft or other malicious act.
For these purposes, categorisation of materials and facilities is established in Ukraine. The category is the determining factor for level of physical protection of materials and facilities and depends upon their potential danger. The categories were elaborated especially for needs of physical protection according to IAEA recommendations and do not coincide with those of nuclear and radiation safety.
The category and physical protection level of a particular material and facility is determined in compliance with the procedure approved by the governmental decree [17]. All four levels are approved in compliance with the highest standards of physical protection starting from the first one and with proven practice requirements till the fourth.

a) b) c)

Fig. 14. Examples of objects for physical protection: a) Zaporizhzhya NPP – category I nuclear facility; b) near-surface storage – category II radioactive waste management facility; c) State Enterprise “Izotope” – facility for management of category I radioactive sources.

4.9 Fundamental Principle I: *Defence in Depth*

The State's requirements for physical protection should reflect a concept of several layers and methods of protection (structural or other technical, personnel and organizational) that have to be overcome or circumvented by an adversary in order to achieve his objectives.
This concept is also similar to that of safety. Nevertheless, while in nuclear and radiation safety it is a set of physical barriers to the spread of radioactive substances and radiation [31], in physical protection the offender has to overcome several physical barriers as well as other technical or organizational obstacles [20].
For this purposes, nuclear facilities and radiation objects in Ukraine are surrounded along the perimeter by one or more restricted areas specially equipped by detectors and surveillance systems included in the physical protection system.
The detailed requirements on this areas are described in the dedicated document [32]. Besides critical linear parameters of areas, it contains requirements for management of the territory including that outside the perimeter and access points. For needs of physical protection of low-category nuclear materials, wastes and radioactive sources, in addition to the areas recommended by IAEA, one more area is established in Ukraine – a controlled access area. Requirements on this area are less strict then on the protected area. It is important for fulfilment of physical protection requirements, for instance, for hospitals or scientific institutes using sources or small quantities of nuclear material.



a) b)

c) d)

Fig. 15. Defence in Depth: a) air photo of NPP; b) restricted areas of NPP; c) protected area of research nuclear assembly; d) entrance to controlled access area of waste storage.

4.10 Fundamental Principle J: *Quality Assurance*

A quality assurance policy and quality assurance programmes should be established and implemented with a view to providing confidence that specified requirements for all activities important to physical protection are satisfied.

According to physical protection legislation of Ukraine [9], establishment and maintaining of quality assurance system of physical protection are among the primary requirements for granting a license. Operators develop and implement measures for quality assurance of physical protection at the stages of determining, development, and operation of physical protection systems and provide information on its status in annual reports for the regulatory authority. This requirement is also imposed on other licensees that manage radioactive materials or perform design or construction of physical protection systems.

a) b)

Fig. 17. Quality assurance of physical protection: a) diagram of quality improvement process; b) examples of quality certificates of service providers.

4.11 Fundamental Principle K: *Contingency Plans*

Contingency (emergency) plans to respond to unauthorized removal of nuclear material or sabotage of nuclear facilities or nuclear material, or attempts thereof, should be prepared and appropriately exercised by all license holders and authorities concerned.

Physical protection rules in Ukraine foresee that operators should develop plans of actions in extreme situations, including sabotage or other malevolent acts. The regulatory act containing detailed requirements on these plans prevails in Ukraine [23].

The objectives of the contingency plan are to:

- ensure effective counteraction to attempts of offenders described in DBT to perform sabotage, theft or other malicious act;
- prevent mass meetings, demonstrations or other public events on the territory of a facility;
- prevent the above events outside the territory if they can violate the systems of a facility.

The plan foresees scenarios of movements of offenders and scenarios of response to them. Forces and means necessary for detection, interruption, seizure and neutralization of adversaries and mitigation of radiological consequences are determined. If the forces of facility are inadequate, a scenario for involvement of off-site forces should be worked out.

The procedure of interaction for mitigation of radiological consequences establishes order of access to contaminated territory, entrance of emergency groups, rescue, control and detection of possible explosives and weapons of adversaries, control of individuals and transport leaving the restricted area.

The contingency plan foresees the cases when a crises becomes an emergency. For these matters, the contingency plan is linked with the emergency plan.

a)

b)

c)

d)

Fig. 18. Scenario examples: a) adversary movements; b) off-site force involvement; c) sufficient counteraction to adversaries; d) mitigation of radiological consequences.

4.12 Fundamental Principle L: *Confidentiality*

The State should establish requirements for protecting the confidentiality of information, the unauthorized disclosure of which could compromise the physical protection of nuclear material and nuclear facilities.

As the saying goes, who possess information, possess everything. Information protection is crucial for physical protection. We could develop perfect plans, create the most advanced physical protection system, and train highly professional stuff, but if an adversary obtains information on the tactics of response forces, situation of vital equipment or date of transportation, he may reduce all our efforts to nothing.

In Ukraine access to confidential and secret information is regulated by the Law "On Information" [16]. Physical protection legislation provides limited access to nuclear security information for the matters of national security. Basing on this, the Rules for securing the information on physical protection were approved in 1998. This act constitutes a procedure for classifying information as confidential or secret, rules of using and securing such information.

Of course, these rules do not take into account the need of securing the electronic information. Protection of information in computer networks is a separate item which is only starting to be examined and regulated in Ukraine.

5 CONCLUSIONS

1. The presence of a substantial number of nuclear facilities, radioactive waste storages and other radioactive sources in Ukraine poses threats of malicious acts – sabotage, theft and dissemination of radioactive materials, which could result in inadmissible radiological consequences.
2. The threats are real and taken into account at the State level as threats to national security.
3. The principal instrument of counteraction to these threats is physical protection.
4. Twelve fundamental principles of physical protection are the reliable and comprehensive basis for creating the up-to-date physical protection systems at the state and facility levels and for assessment, control and regulation of physical protection and are fully implemented in Ukraine.

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