

MODERN CONDITIONS OF RADIATION SAFETY IN THE CONTEXT OF DEVELOPMENT PLANS OF NUCLEAR ENERGY IN POLAND

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Review article

Abstract: In the era of globalization, the issue of energy security is very important. Nuclear energy is an important component in the context of energy security. Despite the disasters and accidents of nuclear power plants this domain is booming and plays an important role in national energy systems. Hence planning a nuclear power plant in Poland is an extremely important issue. This project is part of the diversification of energy sources in Poland. Radiation safety is an important element of construction of a nuclear power plant. This is the whole system which consists of the legal, organizational and technical parts. The system comprises radiation environment protection and physical security along with measures protecting nuclear materials.

Keywords: Radiation safety, nuclear power, nuclear power plant, radiation protection.

Introduction

Nuclear energy is an essential element not only in terms of energy security but is also a potential threat because of its presence. Development of nuclear energy causes increase in threats such as: threats caused by nuclear power plants' functioning (breakdown, leak), transport of radioactive materials, transport of waste radioactive materials, storage of waste radioactive materials (nuclear fuel). Radioactive waste can also fall into the wrong hands, which is why there is a necessity of their securing.

It is connected with the whole energy process aimed at providing energy. The whole energy process is based on exploiting the products from the process of the fission or synthesis of radioactive elements in conditions controlled by people.

The process in nuclear power plant consists of energy sources, techniques of processing energy carriers, storage and utilizing converted radioactive material (Łucki, 2010). Because of the above an essential element is an activity aimed at possessing and maintaining infrastructure securing converted radioactive materials with a view of protecting against its radiation environment.

As a result of technological revolution as well as human activity there are new dilemmas, which initially seemed to be only challenges and by now

have become threats. They are of subjective nature. The issue of approaching radiation safety in spite of uniformed standards is varied. As examples one could use the following incidents:

- Goiânia (Brazil) - abandoned equipment with radioactive material fell into the wrong hands,
- Tammik (Estonia) - radioactive elements got stolen from the warehouse.

Such incidents show that radiation protection is not only a well protected infrastructure but also a number of legal, technological and organizational undertakings, which are aimed at exclusion of radiation incidents, and in the case of their taking place limiting its range and duration of radiological event.

Materials and Methods

Nuclear power in the world between 2011 ÷ 2014

In favour of nuclear power development out of many sources of gaining electric energy one can mention low emission of greenhouse gases, comparable with best solutions found in power plants based on renewable energy sources such as wind energy and water energy (IAEA, 2012; IAEA,

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2014). Low emission of greenhouse gases and high efficiency of nuclear energy make it possible to be considered to be an alternative in energy policy in many countries as opposed to energy plants based on non-renewable energy sources or so-called renewable energy source. In comparison to nuclear power plant or traditional power plants wind, solar or water power plants need a lot of space, which leads to changes in the environment, including the building of huge water dams, solar or wind farms. Another factor that makes it harder to use renewable energy is the location of wind and solar farms as well as water dams (Łucki, 2010). The factor that is of vital importance when it comes to coming back to nuclear energy is still increasing demand for electricity from 17.571,3 TWh in 2004 to 23.127,0 TWh in 2013 (BP, 2014).

In 2011 in the world there were 435 reactors in 30 countries, whereas 62 reactors were being built. The reactors generated 12,3 % of world electricity and 5,1 % of world GGS. Within West Europe 25,7 % in 2011 was generated by built nuclear power plants, 18,8 % in North America, 18,7 % in Eastern Europe, 6,9 % in Far East, 2,2 % in Latin America, 2 % in Africa whereas in the area of Southern Asia and Middle Asia 1,8 %. Out of all those active reactors working at that time 82 % were light water reactors, 11 % heavy water reactors, 3 % cooled by gas, another 3 % water-graphite as well as two fast reactors situated in China (IAEA, 2012).

In 2011 after an accident in a Japanese energy plant in Fukushima I in blocks 1, 2, and 3 there was a change in perception of nuclear energy. For many societies, including the western ones this way of generating energy became dangerous, that is why for example German government made a decision to abandon nuclear energy, whereas by 2013 all Japanese nuclear reactors had been closed (Ruhl, 2014).

By the end of 2014 nuclear energy provided 374 GW(e) [exactly 374 899 MW(e)], of which its biggest contribution is within Europe. The leading country in Europe when it comes to nuclear energy consumption in order to meet the energy needs of its population is France (World, 2013). After 2011 the number of reactors working in the world increased to 327 by the end of 2014 (IAEA).

In Argentina, Belarus and the United Arab Emirates they had started building the construction of nuclear power plants by the end of 2014. In China and Argentina new structures were joined to electric systems (Exactly 4 new structures - 3 in China, 1 in Argentina) (IAEA).

Division of nuclear power plants

Development of modern technologies remarkably influences constant development of nuclear reactors technology. In between 50 years there were 4 generations of energetic reactors starting with the first activated nuclear power plant in Obninsk in 1954.

The first generation of nuclear power plants includes power plants in Shippingport, Dresden, Fermi 1 and Magnox. The second and the third generation ones include modern reactors, the fourth one - the most modern one is at the project stage.

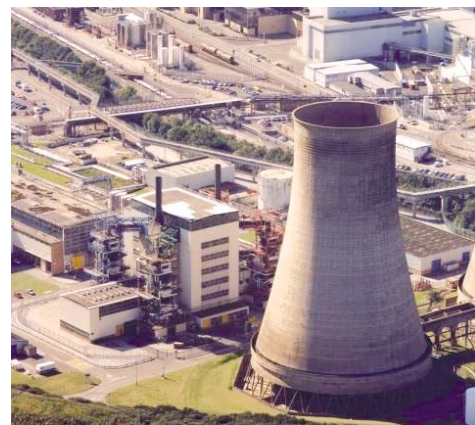


Fig. 1 First generation nuclear power plant of Magnox type from 1956. Power plant Calder Hall In the UK, view of reactor number 4 (Wikipedia, online)



Fig. 2 Nuclear power plant Bruce, second generation type Candu from 1977 (Wikipedia, online)

The process of converting energy in nuclear power plants can be divided into 3 stages. It applies to each generation of nuclear power plant. These stages are: converting the energy of splitting of the atom nuclei into thermal energy, converting the energy into mechanical energy and the last stage is converting mechanical energy into electricity (Ackerman, 1987).



Fig. 3 Nuclear power plant Flammanville, Power plant EPR third generation from 1986
Source: <http://energetykon.pl/jadrowy-suppliers-day-w-gdansk,24251.html>, [08.01.2015]

The purpose of exploitation of nuclear power plant can be an indicator of division into certain types of applied reactors. There are research, thermal, special purposes, energetic, training, high-temperature and generation reactors. Each of the above reactors has its defined purpose and task. The most widely used are the research reactors aimed at research work, special purposes reactors such as production of isotopes, desalination of sea water etc. as well as energy reactors (Celiński, 1984).

The latter ones generate electricity from chemical reaction of radioactive elements. Energy reactors are not only „mature structures” aimed at commercial purposes but also structures which as a result of technological evolution and research work are made in order to research new technological solutions (by „mature structure” the authors mean Z. Celiński and A. Strupczewski’s structure, which is fully technically and technologically controlled and operates systematically as a power plant (professionally)). Additionally among energetic reactors there are reactors used to demonstrate new technologies, and their power is bigger than of pilot structures.

Another type of nuclear power plants are prototype structures of predictable power. Pilot and demonstrative reactors can work for many years until a final decision is made concerning their technical and technological level, work economy or safety level. Prototype structures are such structures whose building and exploitation was stopped because of many reasons.

An important factor to distinguish the type of power plant is the way of using neutrons and sorts of fuel. As a result there is a division into fast and thermal reactors, and the difference in terms of used energy remarkably influences the „structure, process technology, regulations and the way the two types of reactors work” (Celiński, 1984). In the same way one distinguishes nuclear power plants in terms of

the usage of fuel. The extent of enriching chemical elements influences the type of core structure and its materials.

The classification of nuclear power plants can also depend on structure solutions of reactors. Because of those reasons one can distinguish between tank and duct reactors (in case of fast reactors cooled by sodium structure solutions refer to loop and pool reactors) (Jeziński, 2005).

Existing power plants serving consumption functions, i.e. to generate and sell electricity can be situated in for example special barges, ships or even lorries. Such power plants could be called „mobile nuclear power plants”, and defined as Small Modular Reactor - SMR. Their location depends on current population needs and meteorology conditions, which may not facilitate the building on the land surface. It must be mentioned here that Russian Federation tries to introduce this type of power plant to a wider scale in the country, especially in hard to access areas such as Kamchatka or some regions of Far East, however it is not Russia which is the pioneer here. Americans worked on that solution in the late 60-s and 70s. Module/Mobile Reactors can be an important element of meeting people’s needs not only in terms of electricity but also heat or drinking water (Berowski). The question that is raised here refers to infrastructure safety and its protection during the process of its moving and fuel replacement in hard to access regions, which can be the result of a human factor.

The Americans were the first ones to try to introduce such a solution, however the break down in a nuclear power plant in 1979 as well as high costs and objections of the inhabitants led to abandoning the project. The first such power plant was established for US Army needs in the 60s in the XXth century. In Russia there was a competition for the project of such a power plant between 1991÷1994, which might be an indicator of the country’s serious attitude to such solutions. The reactors would have the power of 50 MW, structure type of the reactor is KLT-40S. The reactors can be found on nuclear icebreakers of The Russian Federation and nuclear boats in the country. Significantly, Russia is the only country with its own fleet of nuclear icebreakers (Karlik, 2010; Berowski; Nowacki; Jeziński, 2005).

The most common criterion of the mentioned classification is its division according to structure solutions in terms of using refrigerant, moderator and fuel used. The usage of certain refrigerant, moderator and fuel leads to a following division of reactors: heavy water, light water, gas-graphite, light-heavy water, fast, water-graphite reactors.

Moderator In a nutshell is a neutron moderator serving to stabilize and control operation of the reactor. Moderators can be water, heavy water and graphite. So far the only technical breakdown took place in Chernobyl in 1986. The reactor in Chernobyl is defined as RBMK so Duct Water Reactor(Reaktor Bolszoj Moszcznosti Kanalnyj) (Jeziński, 2005; Celiński, 1992; IAEA, 2012).

Power plant where there was the biggest breakdown and pollution in the last decade was the power plant in Chernobyl. In this power plant the structure of the reactor was based on water-graphite solutions. The reactors turned out to be dangerous because of the structure of cooling system and application of moderator in nuclear reaction. What is important, after the breakdown in Chernobyl there are still working commercial power plants of this type, which raises the issue of radiant protection and still makes it still current.

Radiation and radiation protection

Radiation is a phenomenon present all the time in people's surrounding that was discovered and researched at the end of the XIX-th century. Research and scientific discoveries of radiation phenomenon did not play a significant role until outbreak of WWII. Splitting of atom nuclei along with freeing energy in 1938 by O.Hahn and F. Strassmann intensified work on a new type of weapon by scientists all over the world. Political decision and exploitation of earlier discoveries resulted in creating a new weapon - atomic bomb, which was built and used in 1945 (Hiroshima and Nagasaki). So far it has been the only case in history of using nuclear warheads during war actions against another country.

The possibility of human influence on changes in atom nucleus leads to distinguishing between two types of radiation sources: independent sources or sources depending on human activity (Pellowski, 2013).

Because of physical characteristics radiation can be divided into many ways, e.g.,:

- because of influence on atom nucleus through making it ionization:
 - ionizing radiation,
 - non-ionizing radiation,
- because of the way radiation is created:
 - corpuscular (otherwise partial),
 - wave (otherwise electromagnetic),
- because of the way it spreads we can divide radiation into:

- primary,
- scattered,
- secondary,
- because of the source of radiation:
 - natural - cosmic radiation, cosmogenic isotopes, natural isotopes, radionuclides, radon,
 - artificial.

Radiation and its influence on human life caused the creation of the whole system aimed at human protection not only in terms of exploitation and work with radioactive measures, but also in case of incidents taking place as a result of human mistake, natural forces or intentional actions aimed at freeing the environment from radioactive agents or derivatives thereof. In Poland the system is regulated by legal acts. One of them is an act Atomic Law of 29th November 2000.: nuclear safety and radiation protection.

The act defines such notions as for example:

- nuclear security - „reaching appropriate exploitation conditions, preventing breakdowns and mitigation of the consequences, which results in protecting employees and population against threats caused by ionizing radiation from nuclear installations”;
- nuclear installation „nuclear installation - nuclear power plant, research reactor, isotopic enrichment plant, nuclear fuel fabrication plant, plant for the reprocessing of spent nuclear fuel, spent fuel storage installation, as well as indirectly connected with any of such installations and situated in the area a facility for the storage of radioactive waste”;
- radiation safety - „preventing from exposing people and contaminating the environment, and in case of failing to prevent such situation - reducing their consequences to the level as low as it is reasonable, attainable when taking into consideration economic, social and health factors” (Atomic, 2000).

In order to assess radiation on human body and its protection against its harmful influence they the notion of dose has been introduced. The dose used to be defined as a notion defining exposure to ionizing radiation. The notion of dosage is broad and most often we can mention: exposure, absorbed, equivalent and effective dose (Gorączko, 2011).

To minimize the effects of radiation incidents protective measures have been introduced in order to provide radiant protection while exploiting the equipment and measures ensuring the protection against releasing the substance in result of a breakdown. Such measures make it impossible to influence radiation with the matter as well as maintain

the level of border values of doses at the lowest level possible in case of exposure of radioactive agents (Ackermann, 1987). The activities that make it possible to undertake the measures described above are: eliminating sources, making barriers stopping from radiation penetration and evacuation of people from the area, in which there was exposure.

Exploitation of nuclear power plant enforces the creation:

- radiation shielding for the working staff so as not to cross the acceptable limits of radioactive exposure,
- barriers' system (Celiński, 1992; Celiński, 1984; Jezierski, 2005).

In order to control the surrounding of nuclear facilities and control exposure of the staff exploiting nuclear facilities what is really important is dosimetry control.

The control refers to:

- technological systems through various kinds of covered detectors (such systems are e.g., primary, secondary, ventilation, sewage system etc.),
- space (monitoring contamination in space is to e.g., point the possibilities of employees' access and informing about leaks in nuclear installations),
- surrounding of nuclear power plants (it is treated the presence of radionuclides in the air, water, precipitation, soil etc.). The control defines conditions of spread of the factors discharged into the environment from nuclear power plant (e.g., air, water). Within that control one also checks the exposure of the surrounding while transshipment of fuel during fuel cycle (Celiński, 1984; Ackermann, 1987).

Dosimetry control is not limited to defining the factors in the surrounding but also to limiting the exposure of population, including radiant exposure of the employees being on the move in the area of the facility. Such control includes the measurement of radioactive doses from outside sources for the people temporarily or permanently staying in the area of a nuclear facility by means of individual ionizing or photometric dosimeters.

Because of the presence of radioactive measures there is a risk of penetrating to human body. A limitation of radioactive elements penetration into human body is applying individual protection measures e.g., protective breathing masks. In this case the constant control includes testing of mucus samples.

Summing up dosimetry control one can divide internal and external exposure. In the first case we deal with external source of radiation, and in the

second case with penetrating to the body radioactive elements through breathing, absorption and intake (Regulation, 2008).

Additional element of radiant protection is physical protection. In this case it is understood as:

- measures and equipment ensuring functioning and interaction of security services,
- procedures in case of:
 - breakdown,
 - attempts of entering by unauthorized people.

Physical protection according to Council of Ministers Regulation of 4th November 2008 in case of physical protection of nuclear materials and nuclear facilities is defining unavailable areas i.e.

- strict protection (includes nuclear materials of I category),
- internal area (includes nuclear materials of II category),
- protected area (includes nuclear materials of III category) (Regulation, 2011).

The Regulation provides that where there are radioactive agents in two different categories one should apply precautions for the sake of higher security (Regulation, 2008).

Areas are protected by elements such as: special fencing, walls, ceiling, door, gates, security window and roof protection, ventilation shafts, special locks and padlocks, safes or steel blades. Additional elements of physical protection are electronic pieces of equipment and alarm systems.

The regulation defines different types of IDs with „A” - unlimited access to the facility to ID „C” - one-time access to the zone with the knowledge and consent of the issuing person as well as accompanied by the person entitled to access a given area (Regulation, 2008).

Physical protection also refers to radioactive measures during transport. Transport of radioactive substances across the area of the Republic of Poland is possible due to regulation issued in 2011.

Discussing safety of the work of nuclear facilities one must take into consideration the location of such a facility. Locating the building is an important element of safety. It can be influenced by e.g., distance of the recipients from electricity delivery, connection to the grid, way of water supply, natural environment safety near the potential location, communication and transport conditions as well as seismic and geological conditions. Another element of safety apart from the discussed location is quality and execution as well as exploitation of nuclear reactor. One can mention here inspections and

controls while building and training the employees both before and during exploitation of the power plant.

Another element of ensuring safety against breakdowns are different sorts of systems. According to Z. Celiński one can mention here measurements lines, signalization and automatic activities in order to provide protection against breakdown. The last element according to the author in case of the breakdown is to yield to it. In such a case one must analyze and create scenarios as well as creating the system of security based on analysis of specific scenarios connected with breakdowns (Celiński, 1992).

The building of nuclear power plants is connected with a great circulation of forces and means. Forces and means in this case are not only financial issues but organizational, technical and legal ones as well. They are connected not only with protecting population and employees of the nuclear power plants in the case of breakdown but also with an issue of responsibility in case of radiant incidents.

In order not to cause the breakdown during the stage of building plans of nuclear power plants there are accepted certain procedures and actions. Such safety requirements are:

- potential investment areas,
- project choice,
- materials,
- the quality of work etc.

Project and location of the nuclear power plant is to provide security in case of not only the consequences of natural disasters, but also the fire, air crashes (Ackermann, 1987). That is why in literature one comes across the concept of so - called deep protection. It includes three levels of security. The levels mean securing security during normal exploitation as well as during different incidents e.g., breaking the primary circuit (Celiński, 1984).

The first level of safety includes high quality of equipment and staff qualifications. The second level includes the systems preventing from the development of the breakdown. The third level consists of the systems limiting the consequences of the breakdown.

The first level within deep protection prevents people and the surrounding during normal work of the reactor, the second one disruptions while its working whereas the third one at the time of reactor's breakdown (Celiński, 1992).

The incidents that are also taken into account within deep protection are different kinds of breakdowns. They can be divided into many

ways. The most common example is division because of time and frequency of its occurrence, the range of consequences and because of the type of the breakdown. Because of frequency of their occurrence such breakdowns are rare, „taking place with moderate frequency”, borderline (Celiński, 1984).

Breakdowns because of the range of consequences are the breakdowns defined in the international scale of nuclear incidents - INES. The scale was set up in 1990 and it defines the threats caused by incidents not only in the nuclear power plants but also incidents in nuclear installations.

Event from outside a nuclear facility took place in Goiânia in Brasil in 1987. It was defined at level 5. INES scale and the event is related to elevation means of radioactive medical devices of the old hospital building (INES, 2008; Goiânia 1988). INES scale consists of 7 levels from the lowest zero one to the highest one 7. Scale 0÷3 are incidents whereas scales 4÷7 are breakdowns or accidents. The scale operates in 3 areas: human and environment, radiological impact on the barriers and control system and their defense in depth (PAA; INES, 2008).

Breakdowns because of its type can be defined for each type of reactor in a different way. In literature one can find such definitions: expected, possible and impossible breakdowns. Types of reactors and breakdowns are subordinated to them (INES, 2008; PAA). Apart from that there is so-called maximum project breakdown, which is considered to be loss of cooling through reactor core.

Results

Plans of building nuclear power plant in Poland in the context of energy security in Poland

After social protests as well as breakdown in Chernobyl (1986) the project of building nuclear power plant was abandoned. The first decision concerning suppression the work in Żarnowiec was taken by Tadeusz Mazowiecki government in 1989, and in December 1990 a decision was taken to put the nuclear power plant in Żarnowiec in liquidation state.

The building of nuclear power plant was to be situated in three places, it means: Żarnowiec (then Pomeranian voivodeship), and the remaining potential places were the following places: Klempicz (then Piła voivodship) and Kopań (then Koszalin voivodship). Apart from Żarnowiec the other places were at the stage of discussion and initial research.

The location conditions concerned the place, in which there is a big water reservoir proximity, from which the water would be taken to cool the reactor, seismic, geological and social conditions (the presence of potential recipients and a small number of population close to EJ) (Borucki, 2011).

The process of legislation changes in Poland in terms of creating the conditions to build nuclear power plant is the consequence of internal and external environment. By internal conditions one means: deficit of electricity in Poland connected with prognosis of the increase of demand for electricity by 2030, challenges facing Polish energy sector. According to Ministry of Economy the challenges that Poland is facing now are: ageing energy infrastructure, rising costs of mining coal including lignite, increase in limiting the availability of this raw material. (Polish NPP, 2010), the necessity to import electricity. By external conditions one means: directives of EU concerning reduction of emission of CO₂ into the atmosphere and connected with that adapting Polish energy policy to EU regulations and its political strategy.

Poland has not got a nuclear power plant for commercial reasons. In spite of that there are three nuclear facilities in the country. Quoting the president of National Atomic Agency in Poland there are three nuclear facilities: research reactors Maria and Ewa as well as spent fuel storage. Nuclear facility according to Atomic Law is „ nuclear power plant, research reactor, isotopic enrichment plant, nuclear fuel fabrication plant, plant for the reprocessing of spent nuclear fuel, spent fuel storage installation, as well as indirectly connected with any of such installations and situated in the area a facility for the storage of radioactive waste” (Atomic, 2000).

Ewa research reactor was the first research reactor in Poland. Its operation lasted from 1958 to 1995. In the years 1997÷2002 it was subjected to liquidation. The second research reactor in Poland is the Maria reactor. Maria research reactor operated from 1975 until the present. Spent fuel storage in Poland are in Świerk. There is the Maria reactor pool stored and objects 19 and 19a. (NAEA, 2012).

The necessity to diversify the sources of electricity has forced designing the unified development plans of nuclear energy in Poland. Within the plans there was the whole analysis of energy sector in Poland as well as predicted directions of its development. A comprehensive agenda of works on building in Poland conditions for launching nuclear power plant has been created (Act, 2011; ME).

Polish Energetic Group carried out its own research and came forward with three suggestions

of its location. Those are Choczewo, Żarnowiec and Gąski. All three places are in the Pomerania Region.

Summing up, according to the quoted data one can draw the conclusion that location of nuclear power in Poland coincides with research and initial study which took place during the communist system in Poland (Borucki, 2011).

Radiant incidents and competences of subjects responsible for security in Poland

The basic legal regulation in Poland responsible for population protection in terms of procedures and actions of forces in the case of radiant incidents is Atomic Law from 29th November 2000. There are also other regulations in charge of safety of the country and its population in the case of incidents e.g., act on transporting dangerous products, act on maritime safety or act on technical control as well as appropriate regulations concerning atomic law issued by appropriate ministries.

In the case of threats and contamination of radioactive materials the tasks and responsibilities of subjects in charge at specific stages of crisis management are defined in more details in the *National Crisis Management Plan*, at the voivodeship level the *Voivodeship Crisis Management Plan* appropriate for each voivodeship and the *Voivodeship Plan of Conduct in the case of radiant incidents*. At the local level there is the *Company Emergency Action Plan* which defines tasks and procedures in the case of radiant incidents (Atomic, 2000).

The plans of crisis management include the following levels: national, voivodeship and county or city.

Each plan includes the main plan that comprises:

- threat characteristic,
- assessment of the occurrence of the threats,
- risk map,
- forces and means,
- functioning analysis and public administration efficiency.

Apart from the main plan there are also included procedures of crisis conduct carried out during specific states of emergencies and state of war. The procedures include the number of activities within the area of monitoring the threats, a list of forces and means indispensable to prevent the threats, rules of cooperation of the forces and subjects along with procedures of minimizing the losses and consequences of the incidents. The crisis

management plan include functional attachments defining standard activities defining the activities of subjects in charge of liquidating the consequences of the incidents. Functional attachments include a list of activities when organizing communication, medical care, evacuation, monitoring, informing the population and contamination prevention (Crisis, 2012).

Radiant incident is one of the basic notions connected with radiation protection. Atomic Law defines this type of incident as „*situation connected with threat requiring taking up urgent action in order to protect employees or population.*” This incident is connected with occurrence of radiation, which exposes human health or life. What is the consequence is that it is required to act immediately connected with implementing defined procedures aimed at protecting population and employees currently in the place.

Radiant incidents because of its range of consequences in the light of the quoted law can be divided into local, voivodeship or country incidents.

A local incident according to the law is an incident taking place in the area of a unit and not exceeding the borders of the unit. Such a unit can be any subject carrying out an activity within which we can observe the process, where the ionizing radiation can influence human body.

A voivodeship incident is defined as a voivodeship - wide incident that was caused:

- within the area of an organizational unit,
- outside an organizational unit:
 - while carrying out some work in the area,
 - while transporting:
 - nuclear materials,
 - sources of ionizing radiation,
 - radioactive waste,
 - spent nuclear fuel.

A country-wide incident is a public threat if the range of its consequences exceeds or might exceed the area of one voivodeship. The incident occurs the way it occurs in the case of a voivodeship-wide incident within the area of an organizational unit or beyond this area.

In case of the incidents occurring beyond the country if the range exceeds the country borders, then the incidents are country-wide incidents.

Radiant incidents have an impact on the population, infrastructure, economy and environment. They directly influence the soil, air, surface water, life and health of the population. They cause difficulties with population moving,

their access to food and water, breeding animals and plants as well as results in population moving or the necessity of their evacuation, panic outbreak among the population, water contamination and water and sewage network.

As the reasons of contamination one can mention breakdown of nuclear power plant, the incidents caused by sources of radiation, incidents possible to happen while transporting radioactive material, inappropriate storage of radiation sources.

In case of occurrence of radiant incidents the people in charge of removing the consequences of such incidents are:

- organizational plant manager where there was a radiant incident,
- voivod competent in agreement and in cooperation with a state regional sanitary inspector,
- the minister responsible for internal affairs in cooperation with the President of the National Atomic Energy Agency,
- while transporting the person in charge of safety of the transported substances in cooperation with voivod competent for the place of incident cooperating with a state regional sanitary inspector.

Radiant incidents are removed and liquidated according to *Plans of emergency conduct in case of radiant incidents*. The plans are defined by *Council of Ministers Regulation from 18 January 2005 on emergency conduct plans in case of radiant incidents*. During removing and securing the area where there is a radiant incident one must introduce activities and procedures aimed at securing its people and area. The activities are called intervention actions. There are six types of them:

1. evacuation,
2. order to remain indoors,
3. administration of formulations with active iodine,
4. prohibition or limitation of consumption of contaminated food and water designated to be consumed by people, feeding animals with contaminated substances of feeding animals and watering with contaminated water as well as grazing animals on the contaminated area,
5. temporary resettlement of people,
6. permanent resettlement of people.

The decision about implementing the intervention level must be made by voivod competent if the range of consequences has not exceeded the borders of a given voivodeship. Such a decision is announced through act of local law. When there comes to the situation when the range of consequences exceeds

the area of a voivedoship then the intervention levels are announced in Council of Ministers Regulation.

In the situation when there is radiant contamination the minister responsible for internal affairs in agreement with the minister responsible for transport can limit the traffic within the contaminated area. The minister responsible for internal affairs cooperates as well with the minister responsible for health, the minister responsible for communication and the minister responsible for the national defense.

After implementing a given intervention action the minister responsible for internal affairs is in charge of securing the left possessions of the evacuated or resettled population and provides them with distribution of water, iodine and food in case of order to remain indoors.

His duties include withdrawing contaminated water, food, closing contaminated water intake and free of charge distribution of water among population. In terms of animals' protection the minister provides means of animal food, water, follows the prohibition of animals' grazing on the contaminated area. One of the key elements according to the regulation is cooperation and exchange of information at the level of institutions in charge of removing the consequences and the range of contamination (Council, 2005).

When there is a situation when the voivod or the minister of internal affairs has insufficient means the obligation of personal and tangible benefits according to the rules existing when fighting natural disasters can be introduced.

Stages of emergency management (prevention, preparation, reaction and rebuilding) define the range of tasks and duties for specific subjects (Crisis, 2012).

Activities realized within the specific stages in case of radiant contamination for specific subjects must be divided between leading subjects in charge of removing the threat and supporting subjects.

The leading subject at the stage of prevention from radiant contamination at the national level is the minister responsible for environment. The prevention stage are activities whose effect is elimination or limitation of the incident occurrence, limitation of the consequences of occurred threat.

In crisis management the tasks and duties of subjects at the preparation stage concern making plans of crisis reaction, making conditions for management in crisis situation, creating the supply of forces and means in case of occurrence of crisis situation. Minister of Internal Affairs at the national level is a leading subject at the preparation stage in case of radiant contamination. The activities are

conducted by carrying out according to the *Atomic Law Regulation* periodical exercises aimed at testing the national plan of emergency conduct.

The next discussed stage at the national level is a reaction stage. It occurs in response to occurrence of a real threat or contamination. The aim of reaction stage is prevention or minimizing the damages by activating forces and means to preventive measures. During this stage there is e.g., a necessity to secure the drinkable water intake, food, organization and coordination of activities in terms of humanitarian and psychological aid. Additionally one has to organize and activate evacuation system, accommodation and supplying the population covered by the rescue action as well as rescue teams themselves (Szymonik, 2011).

The Ministry of Internal Affairs is a leading subject at the reaction stage. The supportive subject is Council of Ministries as well as ministers responsible for environment, finances, transport, construction and maritime economy, health, national defense, agriculture and rural development, foreign affairs, administration and digitalization as well as province governors depending on the place of the incident.

The last stage of crisis management is the rebuilding stage. It is based on rebuilding all the elements influenced by the threat to the condition from before the crisis incident. To quote A. Szymonik the stage can be divided into the short - and long - term stage. During that stage one e.g., assesses the damages, acts in connection with activating and functioning of the critical infrastructure and its rebuilding.

At the national level during the rebuilding stage the leading subject is the Minister of Internal Affairs. He is responsible for managing the action connected with removing the threat and reports the information concerning the threat to the Prime Minister.

The supportive subjects of the minister responsible for internal affairs are the ministers responsible for: Environment, Health, Agriculture and Rural Development, Economy, Finances, National Defense and province governors depending on the place of the incident.

The mentioned stages because of their activities are aimed at such activities of public administration that the specific procedures and realized tasks by available forces could return the infrastructure and the area influenced by a radiant incident to its previous condition.

Conclusion

At the moment nuclear energy is an element of politics in the countries with nuclear power plants as well as in countries planning to activate their first nuclear power plants in terms of diversifying sources of energy and energy independence. Nuclear solutions in a civil aspect are a priority for some countries in the field of further economic-political development.

In Poland the assumption undertaken in „Energy Politics for Poland by the year 2030” define the development of energy based not only on renewable sources of energy but also development based on building a nuclear power plant in Poland.

Development of nuclear energy in the world is a derivative of changes on the fuel market (exploiting of current energy resources, their price changes) changes related to environment protection (obligations of specific countries in terms of CO₂ emission).

Despite lack of nuclear power plant for commercial reasons in Poland there are nuclear facilities, which can be the source of radiant threat. That is why there is a must to create such a legal - functional system which could provide security in case of exposure to ionizing radiation and its negative effect. In connection with the plans of building the first nuclear power plant in Poland regulations and legal acts have been adapted to undertaken actions in terms of building and activating a nuclear power plant. The activities are the result of international requirements. The requirements are based on international experience of the countries that have nuclear power plants in terms of radiation protection and population protection. Thanks to that the countries, Poland included, building their first nuclear power plants benefit from experience of other countries.

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