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Basic strategies of public protection in a nuclear power plant beyond—Design basis accident

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Abstract

In the light of the new international requirements on the emergency preparedness and response to nuclear and radiological emergencies, the basics of the strategy of protection of the public in event of beyond design basis accident at a nuclear plant have been reviewed. New international requirements were issued by the IAEA in 2015 taking into account lessons learned from the accident at the NPP Fukushima Daiichi in Japan on 11 March 2011.

The IAEA pays particular attention to the development of safety infrastructure in Member States embarking on a nuclear power programme. In the framework of the national projects of technical cooperation, the IAEA is actively implementing international safety requirements released in the IAEA Safety Standards. Following the IAEA safety standards for these States became mandatory. The key issue of the requirements is a demand to Member State to have a public protection strategy in place before the commissioning the first NPP. The strategy shall be based on the Generic criteria to be used in emergency preparedness and response to protect the people in emergency exposure situation

- to prevent severe deterministic effects, and
- to limit the risk of stochastic health effects on the reasonably achievable level.

The strategy shall include

1. Classification of facilities and areas according to the degree of potential radiological hazard.
2. Classification of emergency planning zones around the hazardous facility.
3. Classification of the status of a facility in event of an emergency.

The Russian Federation takes an active part in the construction of nuclear power plants in those countries that are just embarking on a nuclear power programme, therefore, new international requirements should be considered in the design and construction of the NPPs abroad. Those requirements should be also considered in training of national personnel for the implementation of nuclear power programme.

Keywords: Nuclear emergency; Protection strategy; Safety requirements; Nuclear power plant.

Introduction

In November 2015, the International Atomic Energy Agency (IAEA) issued Part 7 of the General Safety Require-

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ments containing the international requirements pertaining to ensuring emergency preparedness and response to nuclear and radiological emergencies [1]. This document is to replace the IAEA Safety Standards No. GS-R-2 issued in 2002 [2]. Assessment of the Russian system for ensuring protection to the public in case of severe accident at the NPP in the light of the GS-R-2 safety requirements was made in [3]. Main safety requirements as pertains to the strategy of public protection in the case of nuclear or radiological emergency at the NPP as the object of use of nuclear energy are addressed in the present paper.

Strategy of public protection in the case of nuclear or radiological accident

Twelve international organisations participated together with the IAEA in the development of new international requirements on the ensuring emergency preparedness and response in the cases of nuclear or radiological emergencies [1]. Lessons learned from the severe accident at the NPP Fukushima Daiichi, which started in Japan on 11 March 2011 [4], found their reflection in the international requirements on the public protection strategy.

In accordance with the ICRP Recommendations (2007) [5], the international requirements are focused on the generation and development of the state-level optimized strategy of public protection in the emergency exposure situations. In accordance with [1] it is required that strategies of protection of humans, the environment and property from risks associated with radiation accidents were developed, substantiated and optimized during the phase of emergency preparedness. This is required for efficiently undertaking protective and other response actions in cases of nuclear or radiological emergencies (hereinafter referred to in the present paper as the radiation emergencies). Such strategy is based on the general criteria of protection of humans in the emergency exposure and includes classification of the following:

- Facilities, practices and areas according to the degree of their potential hazard;
- Emergency planning areas surrounding the hazardous facilities;
- Conditions of the hazardous facility in case of accident.

The basis of the protection strategy is formed by the generic criteria of protection of humans in the emergency exposure situations developed by the IAEA to be applied in preparedness and response to radiation emergency [6–8]. These generic criteria ensure the following:

- Prevention of development of severe deterministic effects, i.e. such health effects of radiation which are fatal or constitute threat to human life or result in the irreparable damage to health though deterioration of the quality of life;
- Restriction of risk of development of stochastic effects of radiation to reasonably achievable levels.

Criteria intended for assessment of development of severe deterministic effects are presented in Table 1. Values of the criteria are provided in units of the RBE weighted dose in organ or tissue T, AD_T—the new dosimetric quantity determined by the IAEA for the purposes of assessment of risks for development of severe deterministic effects in the situations of high dose external exposure of high level intake of radioactive material. For purposes of the evaluation of consequences of intake of radioactive material, the committed for certain period of time Δ after intake the RBE weighted dose in organ or tissue T, $AD(\Delta)_T$ is used. $AD(\Delta)_T$ is the time integral of the RBE weighted dose rate in the organ or tissue T over the time period Δ due after the intake of radioactive material. The unit of RBE weighed dose is gray (Gy) [1,6,9,10]. These quantities and units are in accordance with the recommendations of the ICRU [9]. It is expected that in case of excess of levels in Table 1 the probability of development of severe deterministic effect will exceed 5% [7,10] which is regarded as unacceptable [6,10].

Values of criteria intended for restriction of risk of development of stochastic effects of radiation are accepted to be equal to the lower boundary of radiation exposure doses for persons belonging to the group numbering more than 100,000 people when it is possible theoretically to detect within such a group additional cases of morbidity or mortality from cancer diseases caused by radiation [8,11]. Exposure situations correspond to the above condition of detectability of the stochastic effects if

$$E < 100\,\text{mSv};\quad H_{\text{Fetus}} < 100\,\text{mSv};\quad H_{\text{Thyroid}} < 50\,\text{mSv},\qquad (1)$$

where E is the effective dose; H_{Fetus} is the equivalent dose of exposure of foetus or embryo; H_{Thyroid} is the equivalent dose of exposure of thyroid gland.

If exposure of persons belonging to the group with any number of people will not exceed the above indicated levels, it will be theoretically impossible to prove using contemporary scientific methodologies the presence in the group of cancer morbidity and mortality caused by radiation exposure in excess the natural background level [12].

In accordance with the ICRP [5], humans appearing in the emergency exposure situation will be protected if radiation doses received by the representative person will not exceed the levels indicated in Table 1 and in (1) [1,8,9]. At the same time human safety will be ensured only when after the accident the defence in depth of the radiation source and, consequently control over the radiation source, will be restored [11,13].

In accordance with [1], it is required for ensuring efficient public protection in event of loss control over the radiation source, the emergency plan of protection of personnel, public, the environment and property must be developed and maintained in active status during the phases of design, construction, operation and decommissioning of the radiation source (facility). Receiving of doses in excess of those indicated in Table 1 in the event of severe nuclear accident similar to the Chernobyl accident may take place within several hours. In such conditions, decisions on the implemen-