APPLICATION OF THE BASIC STANDARDS FOR RADIATION PROTECTION OF 2012 TO KOZLODUY NPP PLC

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Summary: According to the Safe Use Energy Law, the standards and rules for radiation protection for the performance of works related to the use of nuclear energy and sources for ionizing radiation, the RAW management and spent fuel, are defined in the Regulation on basic standards for radiation protection adopted by the Council of Minister proposed by the Chairman of Nuclear Regulatory Agency.

Metrology assurance for the measurement equipment for radiation monitoring at Kozloduy NPP plc is performed by the Ionizing Radiation Measurement Laboratory in the Metrology Assurance Department at Kozloduy NPP plc.

Key words: radiation monitoring, radiation protection , dose limits, dosimetric quantities

1. Regulation on Basic Standards for Radiation Protection (RBSRP)

According to the Safe Use Energy Law, the standards and rules for radiation protection for the performance of works related to the use of nuclear energy and sources for ionizing radiation, the radioactive waste (RAW) management and spent fuel are defined in the *Regulation on basic standards for radiation protection* (BSRP) adopted by the Council of Minister proposed by the Chairman of Nuclear Regulatory Agency.

The current regulation on the BSRP is adopted with Decree No. 229 of the Council of Ministers dated 25 September 2012 , promulgated in the State's Gazette, Issue 76 of 5 October 2012.

The *objective* of the BSRP is the principles of radiation protection, radiation standards, basic limits, secondary limits and limits for the needs of radiation monitoring and planning of the protection, requirements and measures for radiation protection while adhering to the performance of the activities for the use of nuclear energy and sources of ionizing radiation for peaceful purposes;

The *subjective* of the regulation are all occupationally exposed individuals who perform works with sources of ionizing radiation, operate nuclear facilities or perform activities when the exposure to natural sources can not be neglected.

The main objective of the regulation is to avoid the occurrence of the deterministic effects and reduce the probability of occurrence of stochastic effects to the level which is considered acceptable according to the international recommendations.

2. Radiation protection

Radiation protection is a set of organizational and technical measures designed to protect people against the exposure to ionizing radiation including the provision of safety of sources of ionizing radiation and the related activities.

The measures for radiation protection require: Planned exposure (Safety measures and protection can be planned prior to work); in the event of exposure during emergency conditions (in the event of occurrence of incident, accident or another anticipated event) and during existing exposure (the exposure has already existed when the decision for its monitoring has been taken - exposure due to natural sources of ionizing radiation, exposure due to residual radioactive materials from previous practices, exposure due to residual contamination from previous emergency conditions).

3. Radiation protection principles

The radiation protection is based on three *main principles:* Justification of exposure; optimization of radiation protection and definition of the dose limit.

The first two principles - justification and optimization of the radiation protection are oriented to the source and are applied to all cases of exposure (planned, emergency and existing). The activities leading to the exposure to ionizing radiation should be justified in advance in terms of their economic, social and other benefits, thus being of benefit compared to the harm to the human health they can cause.

The principles for definition of the dose limits are oriented to the individual and are applied only to planned exposure. Determination of the dose limits is the sum of the dose received from all the activities with sources of ionizing radiation which should not exceed the limits established in the the BSRP for occupational exposure to individuals, interns, students and the public. The dose limits are defined by the regulator taking into account the international recommendations and are applied to workers and the public in the planned situations.

The BSRP consider the measures and standards for radiation protection for planned and existing situations.

For the optimization of the radiation protection, the individual dose exposure, the number of the exposed individuals and likelihood for exposure during any work leading to exposure should be maintained as low and reasonable as possible below the dose limits defined in the regulation when taking into account of the social and economic conditions. The optimization is applied at all stages of the lifetime of a nuclear power plant: design, construction, operation, decommissioning.

Dose constrain is a limitation established as predicted upper limit of the individual effective dose which can be received from a certain source in case of planned exposure. The dose constrains are lower than the dose limits established in the regulation and are defined for a critical group - a group of individuals from the public that is sufficiently homogeneous in terms of exposure from a certain source and manner of exposure, and is representative for the individuals who received or will receive the highest dose exposure. For occupational exposure the definition of dose constrains is responsibility of the company management, the holder of licence or permit for the use of a certain source.

The dose constrains for occupational exposure of individuals at Kozloduy NPP:

12 *mSv* annual individual effective dose for workers performing works in the controlled area (CA) for Units 5&6; and 6 *mSv* annual individual effective dose for workers performing works in the controlled area of the Spent Fuel Storage Facility, which are defined in the order of the CEO of Kozloduy NPP.

The dose constrain is a not a dose limit, but when exceeded, actions are required in order to clarify the reasons.

For exposure of the public, the dose constrains are the upper limit of the annual doses that the individuals from the public would receive when they fulfil planned operations with a certain source. The dose constrains for the public is an individual effective dose for a critical groups of the public as a result of the activities for RAW management which may not exceed 0,150 *mSv* in any single year for the new installations and 0,250 *mSv* for existing facilities. (*Regulation on safety during RAW management*).

4. Categories of the exposed individuals

A member of the public is any individual in the population except when subject to occupational exposure or medical exposure.

The occupationally exposed individuals are the personnel that have officially declared their consent to perform works with ionizing radiation and during their performance it is possible to receive doses exceeding the dose limits for the public.

In compliance with the risk exposure, the BSRP divide the personnel into two categories:

Category A: Individuals who directly operated sources of ionising radiation (SIR) or visit place where sources of ionizing radiation are located. The dose exposure may exceed 6 *mSv* per year.

Category B: Individuals whose obligations do not include close contact with sources of ionizing radiation but due to the location of their offices there is likelihood of occurrence of cases when these individuals will be exposed to ionizing radiation. The dose exposure may exceed 1 mSv per year.

In Kozloduy NPP

Category A: all individuals who perform work in the CA: These are individuals who handle the sources of ionizing radiation or visit places where sources of ionizing radiation area located in order to perform expert or inspection work, or their working places are located in the areas of increased risk of potential exposure.

Category B: all individuals working at the site of the plant and not included in the category A. These are individuals whose duties do not include a close contact with sources of ionizing radiation but due to the location of their offices may potentially be exposed to the impact of ionizing radiation.

5. Dose limits and dosimetric quantities

The main limits are set in the radiological quantities - effective and equivalent dose.

The effective dose limit for the personnel, category A is 20 *mSv* in any single year. It is accepted that the adherence to this limit will provide sufficient good protection for the whole body against the harmful health effects. The exception is a few organs where although there is adherence to the limit for effective dose, stochastic effects may appear.

Thus, adhering to the limits for effective dose, limits for the annual equivalent dose for the eye lens, skin and extremities are also introduced.

Equivalent dose, HT: For a given type of radiation, this is the absorbed dose in a given organ or tissue multiplied by the relevant (for a given type of radiation) radiation weighting factor, w_R

$$H_T = \sum w_R D_{T,R}$$

In Radiation Protection the main issue is related to the general risk for the life of an individual in spite of the type of radiation, number of irradiations, type of irradiation (external or internal). When more than one organ or tissue is irradiated, the total risk is determined by the risk for all irradiated organs and tissues. However, it should be considered that different organs and tissues have different sensitiveness to exposure. For the risk assessment due to exposure, for the needs of radiation protection the quantity *effective dose*, E, is introduced. By definition, this is the sum of the products of equivalent doses in the organs and tissues multiplied by the corresponding weighting factor, *w*:

$$E = \sum_T w_T H_T$$

The sump of tissue weighting factors, w_T, is equal to one and for even exposure to the whole body; the effective dose is equal to the equivalent dose.

The quantities effective and equivalent doses are used only for the needs of radiation protection. They are not used in terms of deterministic effects, epidemiologic studies, as well as for the need so radiobiological experiments.

The expected dose $D(T_C)$ is introduced to the assessment of the internal exposure due to radionuclides incorporated in the human body. The dose due to the intake of radionuclides is established for a continuous time, even though the intake in the body is instantaneous. Therefore, the quantity for exposure assessment is called expected dose for a given period of time (50 year for grown-ups and 70 years for children).

$$D(T_C) = \int_t^{T_c} \dot{D}(t)dt\ ,$$

whereas: *D* - dose rate.

Dose limits for Category A personnel: annual individual effective dose – 20 *mSv;* annual individual effective dose of eye lens – 20 *mSv;* annual individual effective dose of skin (for 1 cm^2) – 500 *mSv;* annual individual effective dose of extremities– 500 mSv.

Dose limits for Category B personnel: annual individual effective dose – 6 *mSv;* annual individual effective dose of eye lens – 15 *mSv;* annual individual effective dose of skin (for 1 cm^2) – 150 *mSv;* annual individual effective dose of extremities– 150 *mSv.*

The dose limits for the public: annual individual effective dose – 1 *mSv;* annual individual effective dose of eye lens – 15 *mSv;* annual individual effective dose of skin (for 1 cm^2) – 50 *mSv;*

Other limits are for interns and students over 18 years old – as category A ; for interns and students below 18 years old – as category B; pregnant women exposed to occupational exposure of 1 *mSv* for the embryo.

Increased exposure: a specially permitted exposure for which the dose limits defined for the occupationally exposed individuals are either exceeded or may be exceeded. Only for the category A individuals

The used for the needs of radiation protection quantities of equivalent and effective dose are in fact incomparable. Thus, in order to assess them the operational quantities are introduced (quantities that are practically measurable). The role of these quantities is to assess the effective or equivalent dose, and standardize the conditions under which the calibration and metrology check of the dosimeters used for radiation protection are carried out.

For monitoring of the workplace, the ambient dose equivalent H(d) and the directional dose equivalent H'(d, Ω).are used. Sievert, Sv*

For individual monitoring: The personal dose equivalent Hp(d) is the dose equivalent in soft tissue below a specified point on the body, at an appropriate depth d. Sievert, Sv The certain point is selected where the dosimeter is worn. For the assessment of the individual effective dose, $H_p(10)$, $d = 10$ *mm* is used. For the assessment of the individual effective dose of the skin $H_p(0.07)$, $d = 0.07$ *mm* is used.

In general, when a given individual from the personnel or the public is exposed to radiation, (external radiation, inhalation, and absorption), it should be taken into account that the effective dose is based on the external exposure as well as the intakes of a number of radionuclides in the human body.

The limits of the *surface radioactive contamination* are introduced to contamination of the body parts with radioactive substances, where it is possible to receive additional exposure through penetration of radioactive substances through the undamaged parts of the skin; possibility for ingestion or additional exposure of the skin due to beta radiation of the radionuclides, which are present in the contamination.

The BSRP of 2012 (Appendix 2) contains the limits for surface radioactive contamination of the skin of the personnel, personal protective equipment, protective clothing and shoes, surface of the rooms and furniture.

"Surface radioactive contamination", part. $cm^{-2}.min^{-1}$ is the physical quality, adopted for assessment.

The collective dose considers the exposure of the group of people to a certain course at a certain period of time.

The collective effective dose, *S*, for occupational exposure, is calculated as a sum of all individual effective doses for a certain period of time or performance of a given work.

For the public, the collective dose is calculated as $S = \sum \overline{E_i}.N_I$

E_i is the average effective dose for the subgroup of the public, and N_I - the number of individuals in the group.

The unit for collective effective dose is man-Sievertт, *man Sv.*

In the process of optimization, the different measures, which are undertaken for radiation protection and different scenario for performance of the different scenarios for performance of a given work, are compared on the basis of the assessments of the predicted individual and collective doses.

6. Conclusion

The application of the BSRP to the plant facilitates the assessment of the acceptable radiation risk, application of the principles of radiation protection, obtaining the limits of the doses and quantities which are used for assessment of the main requirements for limitation of the personnel exposure.

The metrology assurance for the measurement equipment for radiation quantities for radiation monitoring at Kozloduy NPP plc is performed by Ionizing Radiation Measurement Laboratory in the Metrology Support at Kozloduy NPP plc.

7. Reference

[1]BSRP of 2012.

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