PRESENT STATUS IN THE FIELD OF MANAGEMENT OF TAILINGS FROM URANIUM MINING AND MILLING ACTIVITIES IN THE CZECH REPUBLIC

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Abstract

New criteria accepted in the Czech Republic are described. Many of them are following internationally endorsed standards published in ICRP 60 and BSS. The main attention is devoted a license procedure, a discharges of radionuclides into the environment, limits of irradiation, technical aspects for ensuring radiation protection, monitoring programme, close out of mines and mills and radioactive waste management.

1. INTRODUCTION

The need for changes in the Czech legislation was raised using new internationally endorsed standards in nuclear safety and radiation protection. The result of these changes is new the Czech Act on Peaceful Utilization of Nuclear Energy and Ionizing Radiation (Atomic Law). Basic requirements on ensuring radiation protection given by the Atomic Law are defined more detailed in the Czech regulation on the need to ensure for radiation protection. Does the practical application of these requirements and rules brink some problems?

2. DETAILS FOR ENSURING THE SAFETY OF URANIUM MINES AND MILLS MANAGEMENT

2.1. General conditions for ensuring radiation protection

(I) Licensee has a duty to fulfill the following provision:

(a) Whoever is utilizing nuclear energy or performing radiation practices or interventions to reduce natural exposure or exposure due to radiation accidents must maintain a level of nuclear safety, radiation protection, physical protection and emergency preparedness such that the risk to the life and human health and to the environment shall be kept as low as reasonably achievable, economic and social factors being taken into account. Implementing regulation shall establish the technical and organizational requirements and guidance levels of exposure, which are considered to be sufficient to demonstrate a reasonably achievable level, or an alternative procedure to demonstrate this level.

(b) Licensee must ask for permission for the:

- decommissioning of a nuclear installation or a workplace with significant or very significant ionizing radiation source (uranium mining and milling tailings);
- discharge of radionuclides into the environment; materials, substances or objects may be used outside the work site with ionizing radiation sources, they may be discharged in water or into the atmosphere, they may be stored at dumps or otherwise discharged into the environment without any license under the fulfilling defined conditions (clearance levels);
- ionizing radiation sources management in the extent and in the manner established in an implementing regulation;

– radioactive waste management;

and must submit to regulatory authority the following documentation.

Documentation for the issue of a license for individual stages of decommissioning of a nuclear installation or workplace with significant or very significant ionizing radiation source.

(1) Evidence of availability of finance for decommissioning activities.
(2) Description of changes to local area due to nuclear installation operation.
(3) Description of technical procedures proposed for decommissioning.
(4) Decommissioning time schedule.
(5) Method of dismantling, decontamination, conditioning, transport, storage and elimination of parts of installation contaminated by radionuclides.
(6) Assumed types and activities of radionuclides discharged into the environment and radioactive waste generated.
(7) Method of radioactive waste management, including its disposal.
(8) Limits and conditions for safe management of radioactive waste during decommissioning process.
(9) Safety analyses.
(10) Scope and method of measurement and evaluation of exposure of exposed workers and other persons and contamination of the workplace and its vicinity by radionuclides and ionizing radiation.
(11) On-site emergency plan.
(12) Evidence of provision of physical protection of decommissioned nuclear installation.

Documentation specified under items 8, 10 and 11 shall be subject to approval by the Office.

Documentation for the issue of a license to discharge radionuclides into the environment.

(1) Justification of discharge of radionuclides into the environment.
(2) Types and activities of radionuclides discharged into the environment.
(3) Evaluation of exposure of critical group of the population from discharged radionuclides.
(4) Analysis of a possible accumulation of radionuclides in the environment in the case of long-term discharging.

Documentation for the issue of a license for ionizing radiation source management.

(1) Justification of the radiation practices.
(2) Specification of used radiation sources, their types and accessories.
(3) Description of workplace and its surroundings (schematic plan of the workplace) supplemented by information on shielding and protective facilities and equipment of workplaces.
(4) Evidence of optimization of radiation protection at workplace under Article 4, par. 4 of this Act.
(5) Delineation of controlled area, anticipated number of personnel working in this area and method of preventing entry of unauthorized persons into this area.
(6) Operating instructions for safe handling of ionizing radiation source.
(7) On-site emergency plan.

(8) Scope and method of measurement (monitoring programme) and evaluation of exposure of exposed workers and other persons and contamination of workplace and its vicinity by radionuclides and ionizing radiation.
(9) Assumed types and amount of radionuclides released into the environment and assumed type and amount of radioactive waste generated, and method of disposal of this waste.
(10) Document on the special professional competence of personnel directly manage the working activities with ionizing radiation sources and perform other activities especially important from the radiation protection viewpoint, as laid down in implementing regulation.
(11) Type specification of ionizing radiation sources that are to be manufactured.
(12) Evidence of capability to measure and verify properties of ionizing radiation sources which are to be manufactured, and their conformity with a given type.
(13) Type specification of ionizing radiation sources that are to be imported.
(14) Document demonstrating provision for measurement and verification of properties of ionizing radiation sources that are to be imported and their conformity with a given type.
(15) Type specification of ionizing radiation sources that are to be exported.
(16) For exportation of ionizing radiation sources defined in implementing regulation, additionally a document acknowledged by a competent body in the country of the consignee proving that the consignee fulfils all conditions for ionizing radiation sources management.

Documentation specified under items 5, 7 and 8 shall be subject to approval by the Office.

Documentation for the issue of a license for radioactive waste management.

(1) Description of equipment and technology used.
(2) Information on origin, type, amount, radionuclide structure and activity of radioactive waste.
(3) Method of collection, sorting, storage, processing, conditioning and disposal of radioactive waste.
(4) Assumed amount of radionuclides released into the environment.
(5) Scope and method of measurement (monitoring programme) and evaluation of exposure of exposed workers and other persons and contamination of workplace and its vicinity by radionuclides and ionizing radiation.
(6) Safety analyses.
(7) On-site emergency plan.
(8) Document on the special professional competence of personnel directly manage the working activities with ionizing radiation sources and perform other activities especially important from the radiation protection viewpoint.
(9) Limits and conditions for safe management of radioactive waste.

Documentation specified under items 5, 7 and 9 shall be subject to approval by the Office.

(II) For other persons working in an environment where there is an increased risk of natural irradiation, which applies especially to such cases as, e.g. work in spas, water works, caves, mines, or underground areas, where, even after the implementation of corrective measures, it is impossible, during the performance of work, to reduce the volume activity of radon in the atmosphere to less than 1000 Bq/m^3, the reasonably achievable level of radiation protection is when requirements are applied which refer to work in a controlled area of work sites with ionizing radiation sources.

2.2. Irradiation limits

(I) The radiation limits as binding quantitative indicators, which must not be exceeded from the point of view of radiation protection.

(a) The basic limits for workers with sources are:
- the sum of effective doses from external irradiation and the load of effective doses from internal irradiation, has the value of 100 mSv for a period of five successive calendar years,
- the sum of effective doses from external irradiation and the load of effective doses from internal irradiation, has the value of 50 mSv per calendar year,
- an equivalent dose in an eye lens has the value of 150 mSv per calendar year,
- an average equivalent dose in 1 cm^2 of skin has the value of 500 mSv per calendar year,
- an equivalent dose to arms from fingers to forearms and for legs from feet to ankles has the value of 500 mSv per calendar year.

(b) Derived limits referring to the same irradiation cases as the basic limits for workers do, but expressed in quantities that are easier to measure than the basic limits are used for an evaluation of workers in uranium industry.

When the set derived limits are not exceeded, it is considered a fulfillment of the requirement not to exceed the basic limits for workers with sources. If there are other means of irradiation (e.g. external irradiation, internal irradiation as a result of swallowing radio-nuclides, internal irradiation as a result if inhaling radio-nuclides), observance and maintenance of the basic limits for workers with sources is considered a fulfillment, if the sum of the quotients of irradiation from a single method of irradiation and of the relevant derived limits is less than one.

Derived limits for internal irradiation

(a) a personal dose equivalent in the depth of 0.07 mm has the dose of 500 mSv per calendar year,
(b) a personal dose equivalent in the depth of 10 mm has the value of 20 mSv per calendar year,

(II) The derived limits for internal irradiation, apart from the cases set out in paragraphs 4 and 5, are:

(a) for radio-nuclide intake by swallowing, the values of the quotient of 20 mSv and the conversion factor h_{ing} for the radio-nuclide intake by the swallowing by a worker with sources, are as stated in Table I,
(b) for radio-nuclide intake by inhalation, the values of a quotient of 20 mSv and the conversion factor h_{ing} for the radio-nuclide intake by inhalation by a worker with sources, are as stated in Table I.

(III) Providing there is a simultaneous external and internal irradiation in the course of one calendar year, then, apart from the cases stated in paragraphs 4 and 5, the basic limits for workers are not considered exceeded, if:

TABLE I. COMPOUNDS, LUNG ABSORPTION TYPES AND VALUES OF GUT TRANSFER FACTOR f_1 USED TO CALCULATE COMMITTED EFFECTIVE DOSE PER UNIT INTAKE VIA INHALATION FOR WORKERS

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Beryllium	M	0.005	All unspecified compounds
	S	0.005	Oxides, halides and nitrates
Fluorine	F	1.000	Determined by combining cation
	M	1.000	Determined by combining cation
	S	1.000	Determined by combining cation
Sodium	F	1.000	All compounds
Magnesium	F	0.500	All unspecified compounds
	M	0.500	Oxides, hydroxides, carbides, halides and nitrates
Aluminium	F	0.010	All unspecified compounds
	M	0.010	Oxides, hydroxides, carbides, halides, nitrates and metallic aluminium
Silicon	F	0.010	All unspecified compounds
	M	0.010	Oxides, hydroxides, carbides and nitrates
	S	0.010	Aluminosilicate glass aerosol
Phosphorus	F	0.800	All unspecified compounds
	M	0.800	Some phosphates: determined by combining cation
Sulphur	F	0.800	Sulphides and sulphates: determined by combining cation
	M	0.800	Elemental sulphur. Sulphides and sulphates: determined by combining cation
Chlorine	F	1.000	Determined by combining cation
	M	1.000	Determined by combining cation
Potassium	F	1.000	All compounds
Calcium	M	0.300	All compounds
Scandium	S	$1.0\ 10^{-4}$	All compounds
Titanium	F	0.010	All unspecified compounds
	M	0.010	Oxides, hydroxides, carbides, halides and nitrates
	S	0.010	Strontium titanate ($SrTiO_3$)
Vanadium	F	0.010	All unspecified compounds
	M	0.010	Oxides, hydroxides, carbides and halides
Chromium	F	0.100	All unspecified compounds
	M	0.100	Halides and nitrates
	S	0.100	Oxides and hydroxides

Note: Types F, M and S denote fast, moderate and slow absorption from the lung, respectively.

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Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Manganese	F	0.100	All unspecified compounds
	M	0.100	Oxides, hydroxides, halides and nitrates
Iron	F	0.100	All unspecified compounds
	M	0.100	Oxides, hydroxides and halides
Cobalt	M	0.100	All unspecified compounds
	S	0.050	Oxides, hydroxides, halides and nitrates
Nickel	F	0.050	All unspecified compounds
	M	0.050	Oxides, hydroxides and carbides
Copper	F	0.500	All unspecified inorganic compounds
	M	0.500	Sulphides, halides and nitrates
	S	0.500	Oxides and hydroxides
Zinc	S	0.500	All compounds
Gallium	F	0.001	All unspecified compounds
	M	0.001	Oxides, hydroxides, carbides, halides and nitrates
Germanium	F	1.000	All unspecified compounds
	M	1.000	Oxides, sulphides and halides
Arsenic	M	0.500	All compounds
Selenium	F	0.800	All unspecified inorganic compounds
	M	0.800	Elemental selenium, oxides, hydroxides and carbides
Bromine	F	1.000	Determined by combining cation
	M	1.000	Determined by combining cation
Rubidium	F	1.000	All compounds
Strontium	F	0.300	All unspecified compounds
	S	0.010	Strontium titanate ($SrTiO_3$)
Yttrium	M	$1.0\ 10^{-4}$	All unspecified compounds
	S	$1.0\ 10^{-4}$	Oxides and hydroxides
Zirconium	F	0.002	All unspecified compounds
	M	0.002	Oxides, hydroxides, halides and nitrates
	S	0.002	Zirconium carbide
Niobium	M	0.010	All unspecified compounds
	S	0.010	Oxides and hydroxides
Molybdenum	F	0.800	All unspecified compounds
	S	0.050	Molybdenum sulphide, oxides and hydroxides
Technetium	F	0.800	All unspecified compounds
	M	0.800	Oxides, hydroxides, halides and nitrates

Note: Types F, M and S denote fast, moderate and slow absorption from the lung, respectively.

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Ruthenium	F	0.050	All unspecified compounds
	M	0.050	Halides
	S	0.050	Oxides and hydroxides
Rhodium	F	0.050	All unspecified compounds
	M	0.050	Halides
	S	0.050	Oxides and hydroxides
Palladium	F	0.005	All unspecified compounds
	M	0.005	Nitrates and halides
	S	0.005	Oxides and hydroxides
Silver	F	0.050	All unspecified compounds and metallic silver
	M	0.050	Nitrates and sulphides
	S	0.050	Oxides, hydroxides and carbides
Cadmium	F	0.050	All unspecified compounds
	M	0.050	Sulphides, halides and nitrates
	S	0.050	Oxides and hydroxides
Indium	F	0.020	All unspecified compounds
	M	0.020	Oxides, hydroxides, halides and nitrates
Tin	F	0.020	All unspecified compounds
	M	0.020	Stannic phosphate, sulphides, oxides, hydroxides, halides and nitrates
Antimony	F	0.100	All unspecified compounds
	M	0.010	Oxides, hydroxides, halides, sulphides, sulphates and nitrates
Tellurium	F	0.300	All unspecified compounds
	M	0.300	Oxides, hydroxides and nitrates
Iodine	F	1.000	All compounds
Caesium	F	1.000	All compounds
Barium	F	0.100	All compounds
Lanthanum	F	$5.0\ 10^{-4}$	All unspecified compounds
	M	$5.0\ 10^{-4}$	Oxides and hydroxides
Cerium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$5.0\ 10^{-4}$	Oxides, hydroxides and fluorides
Praseodymium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$5.0\ 10^{-4}$	Oxides, hydroxides, carbides and fluorides
Neodymium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$5.0\ 10^{-4}$	Oxides, hydroxides, carbides and fluorides
Promethium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$5.0\ 10^{-4}$	Oxides, hydroxides, carbides and fluorides

Note: Types F, M and S denote fast, moderate and slow absorption from the lung, respectively.

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Samarium	M	$5.0\ 10^{-4}$	All compounds
Europium	M	$5.0\ 10^{-4}$	All compounds
Gadolinium	F	$5.0\ 10^{-4}$	All unspecified compounds
	M	$5.0\ 10^{-4}$	Oxides, hydroxides and fluorides
Terbium	M	$5.0\ 10^{-4}$	All compounds
Dysprosium	M	$5.0\ 10^{-4}$	All compounds
Holmium	M	$5.0\ 10^{-4}$	All unspecified compounds
Erbium	M	$5.0\ 10^{-4}$	All compounds
Thulium	M	$5.0\ 10^{-4}$	All compounds
Ytterbium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$5.0\ 10^{-4}$	Oxides, hydroxides and fluorides
Lutetium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$5.0\ 10^{-4}$	Oxides, hydroxides and fluorides
Hafnium	F	0.002	All unspecified compounds
	M	0.002	Oxides, hydroxides, halides, carbides and nitrates
Tantalum	M	0.001	All unspecified compounds
	S	0.001	Elemental tantalum, oxides, hydroxides, halides, carbides, nitrates and nitrides
Tungsten	F	0.300	All compounds
Rhenium	F	0.800	All unspecified compounds
	M	0.800	Oxides, hydroxides, halides and nitrates
Osmium	F	0.010	All unspecified compounds
	M	0.010	Halides and nitrates
	S	0.010	Oxides and hydroxides
Iridium	F	0.010	All unspecified compounds
	M	0.010	Metallic iridium, halides and nitrates
	S	0.010	Oxides and hydroxides
Platinum	F	0.010	All compounds
Gold	F	0.100	All unspecified compounds
	M	0.100	Halides and nitrates
	S	0.100	Oxides and hydroxides
Mercury	F	0.020	Sulphates
	M	0.020	Oxides, hydroxides, halides, nitrates and sulphides
Mercury	F	0.400	All organic compounds
Thallium	F	1.000	All compounds

Note: Types F, M and S denote fast, moderate and slow absorption from the lung, respectively.

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Lead	F	0.200	All compounds
Bismuth	F	0.050	Bismuth nitrate
	M	0.050	All unspecified compounds
Polonium	F	0.100	All unspecified compounds
	M	0.100	Oxides, hydroxides and nitrates
Astatine	F	1.000	Determined by combining cation
	M	1.000	Determined by combining cation
Francium	F	1.000	All compounds
Radium	M	0.200	All compounds
Actinium	F	$5.0\ 10^{-4}$	All unspecified compounds
	M	$5.0\ 10^{-4}$	Halides and nitrates
	S	$5.0\ 10^{-4}$	Oxides and hydroxides
Thorium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$2.0\ 10^{-4}$	Oxides and hydroxides
Protactinium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$5.0\ 10^{-4}$	Oxides and hydroxides
Uranium	F	0.020	Most hexavalent compounds, e.g., UF_6 , UO_2F_2 and $UO_2(NO_3)_2$
	M	0.020	Less soluble compounds, e.g., UO_3, UF_4, UCl_4 and most other hexavalent compounds
	S	0.002	Highly insoluble compounds, e.g., UO_2 and U_3O_8
Neptunium	M	$5.0\ 10^{-4}$	All compounds
Plutonium	M	$5.0\ 10^{-4}$	All unspecified compounds
	S	$1.0\ 10^{-5}$	Insoluble oxides
Americium	M	$5.0\ 10^{-4}$	All compounds
Curium	M	$5.0\ 10^{-4}$	All compounds
Berkelium	M	$5.0\ 10^{-4}$	All compounds
Californium	M	$5.0\ 10^{-4}$	All compounds
Einsteinium	M	$5.0\ 10^{-4}$	All compounds
Fermium	M	$5.0\ 10^{-4}$	All compounds
Mendelevium	M	$5.0\ 10^{-4}$	All compounds

Note: Types F, M and S denote fast, moderate and slow absorption from the lung, respectively.

$H_p\,(0.07) \leq 500$ mSv and at the same time

$H_p\,(10) + \Sigma h_{j,inh} I_{j,inh} + \Sigma h_{j,ing} I_{j,ing} \leq 20$ mSv

where:

H_p (0.07), or H_p (10) is a yearly personal dose equivalent in the depth 0.07 mm, or 10 mm,
$I_{j,inh}$, or $I_{j,ing}$ is a yearly intake of j^{-th} radio-nuclide by inhalation or swallowing,
$h_{j,inh}$, or $h_{j,ing}$ is a conversion factor of j^{-th} radio-nuclide by inhalation or swallowing by the worker with sources (see Table I).

(IV) For irradiation by radon reduction products, the derived limit is 3 MBq for a yearly intake of equivalent radon activity (which corresponds to the intake of latent energy of radon transformation products 17mJ) or 2.5 MBq.h.m^{-3} for exposure to radon products or 1260 Bq.m^{-3} for the yearly average equivalent of volume radon activity.

(V) For irradiation by a compound of long-term radio-nuclides emitting alpha radiation of uranium-transformation series, the derived limit is from intake by inhalation 1850 Bq per calendar year.

2.3. Organizational and technical measures for ensuring of radiation protection in uranium industry

A controlled zone is demarcated in all areas, where it is expected that during common operations or during predictable deviations from common operations, irradiation could exceed three tenths of the basic limit for workers. If manipulation with sources of ionizing radiation is not otherwise substantiated by special means, e.g. time limited usage, it is necessary to demarcate a controlled zone in areas where the following is expected:

(a) input of an effective dose per workplace from external irradiation will be higher than 2.5 μSv/h,
(b) the sum of the product of volume activities of individual radio-nuclides in the workplace atmosphere and conversion factors h_{inh}, for intake by inhalation by a worker, according to table I, will be greater than 25 μSv.m^{-3},
(c) surface contamination of the workplace will be greater than 30 kBq.m^{-2}.

If it is not possible to fulfill all requirements for demarcation of controlled zone which are given in other provision of the regulation, controlled zone is not determined. Such work place must be monitored the same way as controlled zone.

2.4. Monitoring programme requirements

The monitoring programme comprises, according to the method of handling of ionizing radiation sources or radioactive wastes, by rule, the following:
(a) workplace monitoring,
(b) personnel monitoring,
(c) monitoring the outlet,
(d) monitoring the surroundings.

The monitoring programme must include, for common operation as well as for predictable deviations from common operation and radioactive incidents and even radioactive accidents, the following:

(a) demarcation of variables to be monitored, methods, extent and frequency of measurements,
(b) manuals for the evaluation of measurement results,
(c) reference values and an overview of precautions in case of their overrun,
(d) specifications of measuring methods,
(e) specifications of parameters for the types of measuring apparatus and accessories that are used.

The monitoring programme must be proposed in such a way and to such an extent that during the operation of a workplace it will enable the verification of radiation limiting requirements; proving that radiation protection is optimized and securing other requirements for safe operation of a workplace with ionizing radiation sources, namely the timely location of deviations from common operation. Monitoring is, according to the nature of the matter, proposed either as systematic (routine), non-stop (continuous), or as regular (periodic) when, in stipulated intervals, it is repeated or is operational during a certain activity with an goal of evaluating and securing the acceptability of this activity from the system limitation standpoint. If changes are made in the arrangement of the workplace, sources of ionizing radiation, methods, and conditions of their handling or in the monitoring method, then the monitoring programme is updated.

Special requirements are addressed to particular part of monitoring programme.

3. CONCLUSIONS

Implementation of basic recommendations from ICRP 60 and BSS to Czech legislative was done as a first step to an improvement of level radiation protection in the Czech Republic. However, the first experiences show us that for better understanding of all the requirements which are given by the Act on Peaceful Utilization of Nuclear Energy and Ionizing Radiation and regulation on the requirements for ensuring of radiation protection, it would be practical to prepare a specific guide for the uranium industry.