ÚOCHB AV ČR
IOCB PRAGUE
Ústav organické chemie a biochemie
Akademie věd České republiky, v. v. i.
Institute of Organic Chemistry and Biochemistry
of the Czech Academy of Sciences

Operation manual for work with radioisotopes in the laboratories of I. category on IOCB CAS

(In compliance with Article 68, par. 1, lett. j) of Czech Atomic Law No. 263/2016)

An internal document for radiation exposed workers

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1. At IOCB have been handled "unsealed" sources of ionizing radiation classified as **"simple" sources** at maximum.

2. Personal responsibilities:

   A) **The Radiation protection officer** (RPO) for IOCB is **Aleš Marek**, Ph.D.
   contact - A.3.82, extension: 395, mobile: 731 194 175

   RPO is responsible for radiation safety and handling of ionizing radiation on IOCB in compliance with current Czech legislation.
   RPO is charged by director of IOCB to communicate with State Office for Nuclear Safety (SÚJB in Czech) in all matters concerning the radiation protection.
   RPO provides radiation safety training to newcomers to IOCB in terms of personal protection and safety, handling of particular radionuclides, management of radioactive waste, etc. Each radiation exposed worker must be by RPO retrained annually.

   Any new experimental arrangement with radioisotopes never used before must be authorized by RPO. RPO is authorized to stop any experiments with radioisotopes in the case of non-compliance.

   B) **Radiation protection experts** (RPE) named by director of IOCB are:
   - Ing. Aleš Zábranský, Ph.D.
     C 4.13/1, extension: 232, E-mail: ales.zabransky@uochb.cas.cz
   - Ing. Břetislav Brož, Ph.D.
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RPO and RPE give consultations about safe handling of radioisotopes and supervise the compliance of radiation protection measures with Czech Atomic Law 263/2016, Radiation Protection bylaw 422/2016 and IOCB internal regulations.

RPE especially supervise:

– record of amount of radioactively labelled compounds and their consumption
– use of prescribed personal protective equipment
– maintaining of laboratory survey program

The RPE is responsible for compliance of the radioisotope handling with the radiation protection regulations in a supervised scientific group.

3. Every IOCB newcomer intended to work with radioisotopes must pass personal radiation safety training by RPO. The training is completed by passing the knowledge test. The protocol about training and the knowledge test results are archived by RPO. Every radiation exposed worker at IOCB must annually pass a periodical on-line training in radiation protection accomplished by a questionnaire.

4. Laboratory of Synthesis of Radiolabeled Compounds keeps record of all unsealed sources of ionizing radiation coming to the IOCB in compliance with the bylaw 422/2016 regulation. Therefore, after arrival of ordered radioactively labelled compound to the IOCB a copy of the Certificate of the Open Radioactive Source accompanying the package must be forwarded to stuff of laboratory of Synthesis of Radiolabeled Compounds without any delay and accompanied with the following information:

– name of receiver of the labelled compound
– the location where the labelled compound is stored (*e.g. Lab C.4.16, freezer*)
– date of arrival to IOCB
– signature

5. A consumption of the sources of ionizing radiation in the work group must be indicated in a balance sheet of ionizing source (activity taken to the experiment, activity disposed as a radioactive waste).

6. When working with radionuclides the following personal protective equipment is obligatory:

To reduce and/or eliminate internal hazards you should do the following:

– use lab coat to prevent a skin contamination
– wear gloves made from nitrile rubber, PVC or latex
– use safety glasses
– do a survey of hands and feet after every use of unsealed radioactive source

An internal radiation exposure when the body is contaminated internally with a radionuclide must to be excluded. When organic radioactive material enters the body, is **metabolized** and

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radionuclide is **distributed to the tissues** according to the chemical properties of the element (^{125}I/thyroid, ^{32}P/bones, etc.).

7. At one workplace the amount of activity worked with must correspond with isolation qualities of the workplace. **The maximal permissible activities A_{max}** for radioisotopes used most often at IOCB are to be found in **ANNEX I**.

   The surface of the workplace is supposed to be protected from the radioactive contamination by a layer of filter paper.

8. **Monitoring of the surface radioactive contamination**

   When the work with radioactivity is finished the radiation exposed worker must check the surface contamination of the workplace. The surface contamination is checked using Surface Contamination Monitor apparatus (e.g. CoMo 170 from Elysia-raytest, Berthold LB 124). If the contamination of the filter paper is higher than 0.4 Bq/1 cm^2 the filter paper is disposed to the **radioactive waste**. When a contamination of workplace by tritium is suspected, the swipes must be carried out and measured by Liquid Scintillation Counting (LSC) (see Part 9). The proper decontamination of the workplace surface is carried out by swiping with the cotton wool pad wet by water or organic solvent in which the labelled compound is well soluble. The efficiency of decontamination is then checked again. If it is not possible to achieve lower than 40 Bq/100 cm^2 level the group leader consults RPE or RPO.

9. **Laboratory survey program**

   A survey must be documented and recorded after **each day** when working with radionuclides.

   The results of surface contamination measurements are recorded in "**Monitoring book**". The radioactivity can be measured either by taking the swipes or the surface can be measured directly with portable Surface Contamination Monitor (CoMo 170) with large window detector. The monitoring and keeping records are performed by dedicated radiation exposed worker appointed by the head of the group. **Reference levels** for surface contamination in the laboratory of I. category are reposted in the **Table 1**.

Tabulka 1: Reference levels of surface contamination in the laboratory of I. category

	laboratory of I. category "Supervised area"
	Bq / 1 cm^2 *)
record level	0.04
investigation level	0.12
action level	**0.4**

*) for all nuclides

If the surface contamination level is lower than **Recording level** the value (in Bq/1 cm^2) is recorded in the Monitoring book.

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In the case the **Investigation level** is surpassed, the person performing the monitoring must inform head of the group. The head of the group starts investigation on origins and possible consequences of the increased level of surface contamination in cooperation with RPE or RPO. The findings are recorded in the Monitoring book in the column "Poznámka" (Notes).

When the surface contamination exceeds the **Action level** the exposed worker responsible for monitoring alerts his co-workers, head of the group and RPE or RPO without delay. Under their guidance the laboratory will be decontaminated. After decontamination the control surfaces are re-checked, and values of residual contamination are recorded to the Monitoring book. The effectuated decontamination is recorded by head of the group in the column "Poznámka" (Notes) in the Monitoring book.

Monitoring of surface contamination using SWIPES (the must for ^{3}H and ^{14}C):

- **Control surface with dimension 10 cm × 10 cm** is regularly wiped in two mutually perpendicular directions by the cotton swab moistened by water.
- The wet swab is transferred into the scintillation vial and 10 mL of the scintillation cocktail is added (the scintillation cocktail for swipes is available in A.3.76). The vial is tightly closed, and the contents is vigorously shaken until the "gel" appearance of the content is achieved.
- Use **TriCarb** instrument - **Method No. 30 "SWIPES ^{3}H-^{14}C"** assigned to swipes assays. As the first vial in rack series must be placed a BLANK – a vial with well shaken clean dry cotton swab in 10 mL of scintillation cocktail. BLANK must be prepared always fresh.

Natural construction materials (such as granite, marble, sand, slag etc.) contain a significant amount portion of long living (primordial) radionuclides, such as potassium, uranium, thorium and its decay daughters (radium). This activity need to be subtracted as a natural stable background before doing lab survey otherwise would not be possible to get below action or investigation level in some cases (granite lab table, corridor surfaces, etc – Picture 1)

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Picture 1. Natural radioisotopes abundance in construction materials across IOCB. Left up – ceramic lab table, right up – granite brick, down – coridor

10. Radioactive waste management

The management of **Radioactive waste** (RW) is provided by laboratory of Synthesis of Radiolabeled Compounds.

Proper segregation of RW results in savings of disposal expenses.

Minimize Waste Generation.

Never mix radionuclides/chemicals – such behavior can lead to **unsafe** work conditions and **very high disposal costs**.

The RW must be sorted according to the instructions given bellow:

Very short-lived waste is sorted according to nuclide type – **^{32}P**, **^{33}P, ^{125}I, ^{35}S** – and then to f ollowing groups:

- solid waste (plastics, cotton wool, tissues, filter papers, glass, aluminium foil etc.)
- water solutions (containing less than 5% of organic material)
- organic liquids and their mixtures
- scintillation cocktails

Low/high level waste – **^{3}H**, **^{14}C** – is sorted into following categories:

- solid waste (plastics, cotton, filter paper)
- organic liquids and their mixtures
- water solutions (containing less than 5% of organic material)
- scintillation cocktails

All categories of solid RW collected at the workplace in PE bags are labelled with the "Radiation hazard" symbol and indication of the type of radionuclide.

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The "Radiation hazard" label on **very short-lived** waste must be removable because after decline of radioactivity bellow "discharge level" this waste will be disposed as a municipal solid waste.

Liquid **RW** is collected at the workplace in PE cans (up to 5 L volume) labelled with the "Radiation hazard" symbol. The category (water solution, organic liquid, scintillation cocktail) and type of radionuclide must be indicated on the PE can label.

The **RW** transferred for disposal to the buffer stock (room B.1.0) must be accompanied with the **"Radioactive Waste Sheet"** Form. The Form is available on intraweb.uochb.cas.cz under Forms/Chemistry. The total activity of the liquid waste should be assayed by LSC. The activity of the solid waste must be approximated from the known activity taken into the experiment.

The material contaminated with radionuclide of activity below its "**discharge level**" is not considered as a radioactive waste. In such case, the material is handled as an ordinary waste. Discharge levels for most frequently used radionuclides are tabulated in **ANNEX II**. Water solutions having volume activity lower than the discharge level indicated in **ANNEX II** can be disposed directly to the laboratory sink.

11. If **loss of control over ionizing radiation source** occurs (e.g. droplets spill, flask breaks after falling on a floor resulting in a spillage of radioactive stock solution over the floor) the prime objective is to stop the spread of radioactive contamination (cover the spillage by absorbing material as a cotton wool, paper tissues etc.) and alert immediately the co-workers. Decontamination of the site is managed by the head of the group and RPE in charge. After sufficient decontamination, the RPE records the accident in Monitoring book.

In Prague, August 9th 2022

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Radiation protection officer

Approved: Prof. RNDr. Jan Konvalinka, CSc.
Director

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ANNEX I

Highest activities A_{max} of radionuclide **^{3}H** authorized for the laboratory of I. category

Characterization of materials and type of work	**A_{max} for standard workplace**			
	radiochemistry fume hood		laboratory bench	
	[TBq]	[Ci]	[GBq]	[mCi]
weighing of dry solid radioactive materials	1.4	39	14	386
manipulation with solutions of nonvolatile radioactively labelled compounds	71.4	1 931	714	19 305
manipulation with tritiated organic liquids	0.024	1	0.24	6

Highest activities A_{max} of radionuclide **^{14}C** authorized for the laboratory of I. category

Characterization of materials and type of work	**A_{max} for standard workplace**			
	radiochemistry fume hood		laboratory bench	
	[GBq]	[Ci]	[GBq]	[mCi]
weighing of dry solid radioactive materials	103	3	1	28
manipulation with solutions of nonvolatile radioactively labelled compounds	5 172	140	52	1 398
manipulation with organic liquids	2	0.05	0.02	0.5

Highest activities A_{max} of radionuclide **^{32}P** authorized for the laboratory of I. category

Characterization of materials and type of work	**A_{max} for standard workplace**			
	radiochemistry fume hood		laboratory bench	
	[GBq]	[mCi]	[MBq]	[mCi]
weighing of dry solid radioactive materials	19	507	188	5
manipulation with solutions of nonvolatile radioactively labelled compounds	938	25 338	9 375	253
manipulation with organic liquids	0.3	8	3.1	0.08

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Highest activities A_{max} of radionuclide **^{33}P** authorized for the laboratory of I. category

Characterization of materials and type of work	**A_{max} for standard workplace**			
	radiochemistry fume hood		laboratory bench	
	[GBq]	[Ci]	[GBq]	[mCi]
weighing of dry solid radioactive materials	43	1	429	12
manipulation with solutions of nonvolatile radioactively labelled compounds	2 143	58	21 429	579
manipulation with organic liquids	1	0.02	7	0.2

Highest activities A_{max} of radionuclide **^{35}S** authorized for the laboratory of I. category

Characterization of materials and type of work	**A_{max} for standard workplace**			
	radiochemistry fume hood		laboratory bench	
	[GBq]	[Ci]	[GBq]	[mCi]
weighing of dry solid radioactive materials	46	1	462	12
manipulation with solutions of nonvolatile radioactively labelled compounds	2 308	62	23 077	624
manipulation with organic liquids	1	0.02	8	0.2

Highest activities A_{max} of radionuclide **^{125}I** authorized for the laboratory of I. category

Characterization of materials and type of work	**A_{max} for standard workplace**			
	radiochemistry fume hood		laboratory bench	
	[GBq]	[mCi]	[GBq]	[mCi]
weighing of dry solid radioactive materials	4	108	40	1
manipulation with solutions of nonvolatile radioactively labelled compounds	200	5 405	2 000	54
solutions with elemental iodine	0.1	2	1	0.02

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ANNEX II

Discharge levels of radionuclides for releasing to the environment

radionuclide	solid waste		liquid waste [3]	
	weight activity [1]	surface activity [2]		
	[kBq/kg]	[Bq/100 cm^2]	[MBq/m^3]	h_{ing} [Sv/Bq]
^{3}H (tritiated water)	1 000 000	40	555.6	1.8E-11
^{3}H (labeled mat.)			238.1	4.2E-11
^{14}C	10 000	40	17.2	5.8E-10
^{32}P	1000	40	4.2	2.4E-09
^{33}P	100 000	40	41.7	2.4E-10
^{35}S (organic)	100 000	40	13.0	7.7E-10
^{35}S (inorganic)			76.9	1.3E-10
^{125}I	1000	40	0.7	1.5E-08
^{51}Cr	1000	40	270.3	3.7E-11
^{54}Mn	10	40	14.1	7.1E-10
^{55}Fe	10 000	40	30.3	3.3E-10
^{63}Ni	100 000	40	66.7	1.5E-10
^{65}Zn	10	40	2.6	3.9E-09
^{90}Sr	100	40	0.4	2.8E-08
^{137}Cs	10	40	0.8	1.3E-08
^{210}Pb	10	40	0.0	6.9E-07
^{99}Mo	100	40	16.7	6.0E-10
^{99m}Tc	100	40	454.5	2.2E-11
^{99}Tc	10 000	40	15.6	6.4E-10
^{133}Ba	100	40	6.7	1.5E-09
$U_{přír}$	1	40	0.0	5.0E-07

1) Materials with activity dispersed evenly. (Annex No. 7 Bylaw 422/2016 Sb.).

2) Activity must not exceed 0.4 Bq/cm^2 on any surface of 300 cm^2 on the disposed item.

3) Maximal permissible released activity per volume. (Annex No. 3 Bylaw No. 422/2016 Sb.)

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