PROCEDURE FOR RADIOACTIVE MATERIAL SEIZURE

Recommendation

The State Office for Nuclear Safety
Prague 2002

RADIATION PROTECTION RECOMMENDATION

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Issued: The State Office for Nuclear Safety
Print: MORAVIATISK Vyškov Ltd.

Publication without language editing

Introduction

In compliance with the Act no. 18/1997 Coll. on Peaceful Utilization of Nuclear Energy and Ionizing Radiation (Atomic Act) **everyone who performs the radiation practices is liable to** keep such a level of radiation protection so that the risk to human life, personal health and to the environment shall be kept as low as reasonably achievable taking into account economic and social factors and to reduce the exposure of persons so that the total exposure from all radiation practices shall not exceed as total the specified exposure limits. The radiation practices means any activity that handles artificial ionizing radiation sources during which the exposure of persons may increase, with the exception of the activities in case of a radiological emergency, and the activity when natural radionuclides are utilized for their radioactive, fission and fertile features, and the activity that is related to the performance with either the increased presence of natural radionuclides or the increased effect of cosmic radiation, and this causes or may cause a significant increase of the exposure of persons.

From the above-mentioned, it is clear that all the events during which radioactive materials are seized, or if there is a suspicion on radioactive material seizure either due to a warning signal from the detection equipment or for a reasonable suspicion based on the other information source, should be subjected to the next analyses. As the basic goal, the analysis of the suspicious package should eliminate any risk of uncontrolled exposure of persons and the illegal discharge of nuclides to the environment. Even if the analysis proves the increased radioactivity, it does not mean a deliberate and illegal transport.

In recent years, a number of radioactive material seizures has been increased (i.e. the materials that contain one or more radionuclides and their activities or mass activities from the point of view of radiation protection are not negligible). This is mainly due to newly installed technical equipment (i.e. the detection systems) that monitors metal scrap during its collection and its entry to metallurgical plants and iron works, waste that enters incinerators, and the means of transport at the state border crossings. Our experience suggests that the majority of events is related to either handling (i.e. collection, sorting and transportation) the secondary (metal) raw material or the use of the machines and equipment that are produced from the contaminated metal materials. The minority of the events relates to the illegal discharge (either intentional or unintentional) of ionizing radiation sources into circulation (i.e. import, export and distribution).

The goal of this Recommendation is to specify the rules for the procedure in the above-mentioned cases. The Recommendation is not a legally binding document, however, the compliance with the Recommendation will reduce the probability of penalties for the persons who own the radioactive material (i.e. material, substance or subject) and do not own the licence for management of such radioactive sources. This Recommendation is mainly intended for the customs officers, fire fighters, policemen, the persons who handle the secondary raw materials and municipal waste. However, the principles of this Recommendation can be applied to all other cases of the seizures of the radionuclide contaminated materials.

The authors of the Recommendation would be grateful for any comments arising from the practical applications of the Recommendation.

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1. Basic terms and abbreviations

All basic terms that are used in this Recommendation are explained in this section. For better understanding, we prefer explaining the terms and the quantities instead of their exact definitions which can be found in the legal rules (for example, the Act no. 18/1997 Coll. on Peaceful Utilization of Nuclear Energy and Ionizing Radiation (Atomic Law) and on amendments and alterations to some acts as amended by the later rules, for instance, in the SÚJB Regulation no. 307/2002 Coll. on Radiation Protection) and the corresponding standards.

Natural radionuclide is a nuclide that has arisen or arises without any human intervention.

Activity is the physical quantity that gives the number of nucleus decays in a certain radionuclide amount per a time unit.

The unit of activity is 1 Bq (becquerel). In a substance with the activity of 1 Bq, one nucleus decays each second. The following multiple factors for activity are used: 1 kBq (1000 Bq), 1 MBq (1000 kBq), 1 GBq (1000 MBq) and 1 TBq (1000 GBq), and the following fractions are used: 1 mBq (0.001 Bq) and 1 μBq (0.001 mBq). Generally, the higher activity means a higher number of released particles and a higher risk accordingly.

The old unit of activity is: 1 Ci (curie), 1 Ci = 37 GBq.

Mass activity is the activity that is related to a mass unit, and the basic unit is 1 Bq/kg. Similarly, **volume activity** is the activity that is related to a volume unit, the basic unit is 1 Bq/m^3; and **surface activity** is the activity that is related to an area unit; the basic unit is 1 Bq/m^2 (1 Bq/cm^2 is also often used).

Dose (absorbed dose) is the energy that is imparted to exposed matter per unit mass (1 kg). The unit of the quantity is 1 Gy (gray), dose of 1 Gy means that energy of 1 J (joule, the basic unit for energy) was absorbed in 1 kg of a substance. The usual fractions used are as follows: 1 mGy (0.001 Gy) and 1 μGy (0.001 mGy).

In case of living tissues or organs, the radiation effect depends not only upon the dose magnitude (i.e. the absorbed dose in unit mass), but also on a spatial dose distribution in the exposed tissue or organ and on the type of radiation to which the tissue or the organ are exposed. Hence, the effect to the tissue or the organ is described by the quantity called **dose equivalent**, with the unit of 1 Sv (sievert) and the same physical dimension as for the dose unit.

The specified quantities that are related to a time unit are called rates, i.e. **dose rate** (usually in mGy/hr or μGy/hr) and dose equivalent rate (mSv/hr or μSv/h). In case of photon radiation, the value of dose rate is numerically identical to that of the dose equivalent rate (1 Gy/hr corresponds to 1 Sv/hr). For simplicity, only dose rate is used in this Recommendation.

Natural background means a value of dose rate, or dose equivalent rate, that is measured at a level of 1 m above the ground. Its values in the Czech Republic move in a range from 0.05 to 0.30 μGy/hr, or μSv/hr.

Radioactive material is a solid or liquid substance or a subject that contains radionuclides or is contaminated by radionuclides to a non-negligible extent from the point of view of radiation protection; this can be a radionuclide source, nuclear material or NORM type material.

Radionuclide source is an object or substance with activity and also mass activity higher than the values given in the Regulation no. 307/2002/Coll. on Radiation Protection, Annex 1 (Annex 1 of this Recommendation).

Nuclear materials are natural uranium, depleted uranium, thorium, enriched uranium, Pu-239 and U-233 in the amount that is specified in Regulation no. 145/1997 Coll. on Accounting for and Control of Nuclear Materials and Their Detailed Specification as amended by the later legal rules.

NORM is the international abbreviation that is used for **the natural origin radioactive material**. In practice, we can directly meet either with the materials (e.g. industrial sands, glass sands and the other raw material) or the objects that are contaminated by NORM (e.g. metal scrap from mining activities).

Clearance level of mass (surface) activity of a particular radionuclide is the value which is critical for releasing the materials, solids and objects to the environment. No SÚJB licence is required if both conditions are achieved at the same time:

- The sum of the quotients of mass activities of the particular radionuclides that are released and the clearance levels of mass activities of the appropriate radionuclides (see Annex 1) shall not be higher than one, and
- The sum of the quotients of surface activities of the particular radionuclides that are released and the clearance levels of surface activities of the appropriate radionuclides (see Annex 2) shall not be higher than one.

Rules for safe transport of radionuclide materials are based on the basic publication of the International Atomic Energy Agency (IAEA), Safety Series No.6 „The IAEA Safety Standard Series – Regulations for Safe Transport of Radioactive Materials“ (ST-1 Revised), and the recommendations for particular transport types are included in the related rules. For road traffic, this is the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) which is valid even for inland transport; for railway transport the Regulations Concerning the International Carriage of Dangerous Goods by Rail (RID) – in the Czech Republic implemented as the Requirements for Transport by Rail, Annex 1, the Special Conditions for Transport of Dangerous Goods (PNZ). Similarly, for river transport RID rules and for air transport IATA/GDR rules.

The method of transport/traffic security of nuclear materials and radionuclide sources is set out in the SÚJB Regulation no. 317/2002 Coll. on Type-Approval and Nuclear Material Transport and Particular Radionuclide Source Transport.

Seizure in this Recommendation means that radioactive material has been revealed or there is a suspicion on radioactive material occurrence during goods transport through a monitoring point where dose equivalent rate is monitored (e.g. board crossings, entries to metallurgical plants, incinerators, scrap yards, etc.).

Finding in this Recommendation means a revelation of radioactive material or a suspicion on radioactive material at any point of the environment, with the exception of transport.

Safety zone is a restricted area near a postponed vehicle or the place of finding where the measure (i.e. operating mode) should be applied. The border for the restricted area is given by a value of dose rate at a level of 10 μGy/hr.

Dangerous zone is an area inside the safety zone in which it is dangerous for persons to stay there. It is possible to enter the dangerous zone only in case of life rescue or the prevention of any development of radiological emergency and the operating mode should be followed here. The limit for the border definition is a value of dose rate of 1 mGy/hr.

AL	Atomic law no. 18/1997 Coll., as amended in the latest wording
FD	Fire department
NM	Nuclear material
IAEA	International Atomic Energy Agency
MG	SÚJB/SÚRO mobile group
EE	Emergency event
CP	The Czech Police
RW	Radioactive waste, i.e. substances, subjects and equipment that contain radionuclides or are contaminated by radionuclides, and it is not supposed that these substances, subjects and equipment will be used anymore
RC SÚJB	Regional Centre of the State Office for Nuclear Safety
RM	Radioactive material, i.e. a solid or liquid substance or an object that contains radionuclides or is contaminated by the radionuclides to an extent that is not negligible from the point of view of radiation protection (i.e. the radioactive substance pursuant to the Atomic law). They can be called radionuclide source (RS), nuclear material or NORM
RS	Radionuclide source
RP	Radiation protection
SDS	Stationary dosimetry system
SÚRO	National Radiation Protection Institute
SÚRAO	Radioactive Waste Depository Authority
IRS	Ionizing radiation source
EN	Environment

2. Technical equipment at check points

The check point is a point where the inspection of transported cargo by dosimetric counting is carried out (e.g. scrap, waste at incinerator entry, cargo at border crossing points, etc.). The counting can be performed automatically by a stationary detection system (SDS) or manually by a portable dosimetric counter that is able to measure the quantities from the background level up to tens to hundreds of mGy/hr.

Each point where SDS is installed should be provided with a suitable portable dosimetric counter for dose rate counting. The check point should be equipped with a telephone set or the other communication device.

The customs officers should be also provided with so-called radiation pagers that alert if ionizing radiation is present. The pagers are also able to localize a source including course dose rate counting. It is recommended that the workers who perform the dosimetric inspection should be provided with the personal operative dosemeters.

The detection equipment should be handled in compliance with the Act no. 505/1990 Coll. (Act on Metrology).

3. Procedure in case of a suspicion on radioactive material presence

It should be clearly specified in a time sequence who and what activities will be done at the check point. The wording of the on-site regulation can be developed on the basis of this Recommendation. We recommend discussing the documentation at the SÚJB Regional Centre; the overview of RC SÚJB contact addresses is listed in Annex 3.

The procedure itself at the point of radionuclide contaminated material seizure and/or ionizing radiation source seizure (further only radioactive material) differs according to the point of seizure even though the goal is always the same, i.e. to prevent handling radioactive material illegally, to avoid illegal radionuclide release to the environment, and to prevent uncontrolled exposure of persons.

In general, we can say that the means of transport must be always postponed (until the arrival of the SÚJB inspector) in the following cases:

- If there is a suspicion on nuclear material seizure (i.e. container, suspicious subject, etc.),
- If there is a suspicion on radionuclide source seizure (a significant non-homogeneity of radiation field has been found),
- Cargo does not comply with the conditions of the regulation for radioactive material transport (see chapter 4),
- The value of dose equivalent rate of 10 μSv/hr is exceeded on the vehicle surface,
- The documents for legal transport of radioactive material are missing, incorrect or insufficient.

The more detailed procedures are given below even for the case when a cargo may be released to continue its next transport. However, the increased value of dose rate itself at the check point is not a sufficient reason without the next operating modes to return the cargo back because this allows uncontrolled movement of the dangerous cargo on the territory of the state. The companies and organizations that are provided with the stationary dosimetric counters (i.e. dosimetric gate) usually adjust their alarm levels at the dosimetric gates by 10% to 30% higher than the current natural background (in practical terms, this means that the alarm is activated if the value of dose equivalent rate achieves about 0.1 μSv/hr, i.e. the current natural background is strongly reduced below the normal level due to shielding by the vehicle). If this level is slightly exceeded, the presence of ionizing source in cargo shall be eliminated only by the next measurements (either intentional or unintentional shielding the ionizing radiation source).

3.1. Procedure during radioactive material seizure at board crossing

(For the chart see Annex 4)

If the counting system at a check point (i.e. SDS or another dosimetric counter) gives a higher dose rate, it is necessary to confirm that this readout is correct (e.g. by verifying with the other portable, operative, or personal dosimetric counter). If the increase is confirmed and:

A) This is a <u>legal transport of radioactive material</u> (the cargo is provided with a valid custom declaration, or there is another legal transport document) and the requirements of the international transport regulations are fulfilled, the means of transport being postponed will **be released to** continue its next transport. The seizure is recorded by the appropriate customs office, and within the approved time, the protocol in the approved form (i.e. its range and transfer time) will be sent to the local RC SÚJB.

B) This is not a <u>legal transport of radioactive material</u> but from the custom declaration is evident that this is the <u>transport of NORM type non-metal materials,</u> i.e. the materials with the increased concentration of natural radionuclides (i.e. industrial fertilizers, foundry sands, glass, ceramics, etc.). The **means of transport is postponed,** and the customs office (or the other authority on the basis of the contract) will perform the detailed counting with the appropriate dosimetric counter.

The detailed counting is performed on the external areas of the means of transport that limit the loading space (further only on vehicle surface). For the NORM type load material, dose rate should be nearly constant on the vehicle surface.

B1: If no points are found on the vehicle surface where dose rate significantly exceeds the average values, the vehicle shall be released, and then follow as per A).

B2: If the detailed counting finds a point on the vehicle surface with significantly higher dose rate, a radiation ionizing source may be hidden in the vehicle (in cargo), and this requires the operating modes from the point of view of radiation protection. The point with the highest dose rate should be marked on the vehicle, and the measurement at a distance of 2 m from the vehicle surface (load) should be also performed. If the driver and passenger were present in the vehicle, dose rate should be measured at their seats.

The counting results are recorded in the schematic layout from which the values of dose rate and the locations of particular points must be clear. The layout is an integral part of the Record (Annex 6A).

1. If load is to enter the territory of the Czech Republic, the **entry is not permitted**. The event is recorded in the form (for the form see Annex 6A) by the customs office at the point of seizure. The form should be immediately sent to RC SÚJB. At the same time, the event must be notify to the Czech Police and to the other customs offices to avoid the entry on the territory of the CR through the other board crossings.
2. If load is to leave the territory of the CR, the customs office (see Annex 6A) records the event and the **event should be immediately notified** to the appropriate RC SÚJB and the Czech Police. The RC SÚJB will decide on the next procedure (i.e. on-site investigation, return to a supplier, etc.).

The SÚJB can require to delimit the safety and/or dangerous zones (further only zones) near the vehicle being postponed. Access into and move in the zones must be controlled. The optimized border is given by a value of dose rate of 10 µGy/hr; i.e. about hundred times higher than the natural background. However, in many cases, this value is too conservative. Hence, it is more feasible to assess the particular situation at the site and to specify the value for the zone border in a range from 10 to 100 µGy/hr depending up on the conditions (e.g. source properties, spatial conditions, the possibility of accessing the public, etc.). In some cases, it is necessary to continue and delimit the dangerous zone border with the dose rate limit of 1 mGy/hr. A supervisor must continuously control the zone border.

C) This is not a legal transport of radionuclide material and it is not transport of non-metal materials of the NORM type and:

C1: If the means of transport (i.e. cargo) is to **enter the territory of the CR**, **the entry will not be permitted,** and then follow as per case B2.1. The seizure is recorded (see Annex 6A) and the event will be **immediately notified to** SÚJB and to the other customs offices to prevent entry to the Czech Republic.

C2: If the means of transport (i.e. cargo) should leave the territory of the CR; the detailed counting will be carried out similarly as per case B, and:

1. If no points where the dose rate values have exceeded the average background are found on the vehicle surface during the detailed counting, **the vehicle will be returned** to the

consignor, and the person who performed the measurement will record the seizure data (see Annex 6A), and he/she will **immediately notify** this event to the local RC SÚJB.

2. If the detailed counting on the vehicle surface has found a point with a significantly higher dose rate (i.e. the value significantly exceeds the average natural background), the vehicle is **postponed.** The point with the highest dose rate value will be marked on the vehicle surface, and the measurement at a distance of 2 m from the vehicle surface (i.e. load) should be done. If the driver and passenger were present in the vehicle, dose rate should be measured at their seats.

The counting results are recorded in the schematic layout from which the values of dose rate and the locations of particular points must be clear. The layout is an integral part of the Record (see Annex 6A).

The person who performed the measurement will immediately fill and send the form to the local RC SÚJB. The RC SÚJB inspector who is charged to investigate the event will decide on the next steps, and he will classify this emergency event (see Annex 7). At the same time, the event should be notified to the Czech Police.

3.2. The procedure during a radioactive material seizure in case of the organizations handling secondary raw material and waste (e.g. metallurgical works, salvage points, incineration plants, etc.)

(for the chart see Annex 5)

If the detection system at the check point (i.e. SDS or other dosimetric counter) alerts increased dose rate, it is necessary to verify the data (e.g. by monitoring the other portable, operative, or personal dosimetric counter). If the increase of dose rate is proved, the detailed counting should be done (similarly as per the seizure at a border crossing, see the case B).

A) If no points with significantly higher dose rates compared to the average background are found during the detailed analysis, the vehicle will **return back** to the consignor, and the person who performs the measurement will record the seizure data (see Annex 6A), and he/she will **immediately notify the event to** the local RC SÚJB.

B) If the detailed measurement on the vehicle surface finds a point with a significantly higher dose rate (i.e. the value significantly exceeds the average natural background), the vehicle will be **postponed.** The point with the highest dose rate value will be marked on the vehicle surface, and the measurement at a distance of 2 m from the vehicle surface (i.e. load) should be done. If the driver and passenger were present in the vehicle, dose rate should be measured at their seats.

The counting results are recorded in the schematic layout from which the values of dose rate and their locations must be clear. The layout is an integral part of the Record (see Annex 6A). The person who performed the measurement will immediately fill and send the form to the local RC SÚJB. The RC SÚJB inspector who is charged to investigate the event will decide on the next steps, and he will classify this emergency event (see Annex 7). At the same time, the event should be notified to the Czech Police.

3.3. The procedure in all other cases of radioactive material finding or seizure

In case of a suspicion on ionizing radiation source or radionuclide contamination, **the finder will immediately notify to the SÚJB and the Czech Police** (see Annex 6B). Then, follow the instructions of SÚJB workers.

If the finder is provided with dose rate counters, he will measure dose rate on the subject surface and at a distance of 2 m from the surface. If, based on the counting, there is a need to define the restricted area (i.e. the zone) to which access must be checked and in which the move should be controlled, follow in the same way as for the seizure at the board crossing in the case B.

4. The specification of safety precautions for the cargo transport with radioactive material

The SÚJB will ensure the safety precautions in case of the radioactive material finding or seizure that is not solved at the point of finding or seizure. The SÚJB inspector will specify under which conditions to return the cargo to the consignor. The conditions are based on the ADR Regulation for road transport, the RID Regulation for railway transport, and the SÚJB Regulation no. 307/2002 Coll. In a simplified fashion, we can say that the cargo can be transported if the following conditions are fulfilled:

- Dose equivalent on the vehicle surface will not exceed 2 mSv/hr.
- Dose equivalent rate at a distance of 2 m from the vehicle surface will not exceed 0.1 mSv/hr.
- Dose equivalent rate on each occupied vehicle seat (including the driver's seat) will not exceed 20 μSv/hr unless the driver and passengers are provided with personal dosemeters.
- Effective doses of the passengers during transport (including the drive to the point of seizure) will not exceed a value of 50 μSv (i.e. dose constraint, 1/20 of the limit for the public, see the SÚJB Regulation no. 307/2002 Coll., Section 17, paragraph 4) unless the passengers are provided with personal dosemeters.

If it is not possible to dismantle the cargo at the site of seizure and the above mentioned conditions are not met, the vehicle transport can be permitted under the following conditions:

- To ensure that effective doses of the passengers during transport (including the drive to the point of seizure), with the exception of the category A and B workers, will not exceed a value of 1 mSv (the limit for the public, see the SÚJB Regulation no. 307/2002 Coll., Section 17, paragraph 4).
- If it is not possible to reduce dose equivalent rate at each occupied seats of the vehicle below a value of 20 μSv/hr (e.g. by shielding with a steel sheet that is assembled behind the driver's cab), it is necessary to provide the driver and the other passengers with electronic personal dosemeters.
- To ensure a category A driver (e.g. from a flaw detection company).
- To ask the police for escort.
- To accompany the cargo by a SÚRO/SÚJB mobile group.

5. Tracking and disposal of radioactive material

In case of the seizure and the tracking of radioactive source at the site **specified by SÚJB** and **in the term set out by SÚJB,** it is necessary to follow the following principles:

- The means of transport which carries a radioactive source or which is suspicious of radioactive material can be only unloaded during **radiation monitoring** which is performed by the entity (i.e. a natural or legal person) which is authorized by the SÚJB licence to perform such activities and which is able to identify the reason for increased dose rate.

- The controlled unload is aimed to find the reason of increased dose rate by the method that does not endanger human health and does not release radionuclides to the environment.
- The consignor is responsible for observing the specified conditions.
- The workers who unload the means of transport will follow the instructions of the entity that ensures radiation monitoring.
- The consignor is also responsible for the disposal of radioactive subjects, substances and materials that have been found in its cargo, and that have a higher dose rate.
- The method of disposal depends on many factors, mainly on radionuclide content in the material or subject, and this method will be specified by the SÚJB (pursuant to Act. no 18/1997 Coll. Section 3, paragraph 2 q) and Section 26, paragraph 3 k)). The SÚJB will also perform the final classification of the event (see Annex 7).
- The radioactive material must be only stored or disposed by an authorized entity. Generally, nuclear materials will be mostly disposed by the authorized entity as radioactive waste. In cases of less serious seizures or findings when the material is not classified as either the radionuclide source or nuclear material, and the disposal of the sources as radioactive waste is not economic or is difficult from the technical point of view, it is possible to store the radioactive source at the entity that tracked it, or at the owner of the radioactive source, or the producer of this subject. If necessary, RC SÚJB will issue (on request) the decision on permission to store the subject and set out the conditions of storing. In general, the following should be ensured:
  - Storing at a secured place, i.e. a locked storage or similar room.
  - Storing in a suitable vessel, for example, cask, polyethylene bag, box, etc.
  - Dose equivalent rate at the border of the restricted area shall be less than 1 μSv/hr and at the same time effective dose within a calendar year for an individual of the population shall be less than 50 μSv.

In individual cases, proceed in the following way:

- <u>Metal material that is contaminated by artificial radionuclides</u> – usually steel with the content of ^{60}Co.
  - If such material fulfils the criteria for release to the environment pursuant to the SÚJB Regulation no. 307/2002 Coll. paragraph 57, it is possible to manage the material without any SÚJB licence.
  - If the material is the source of ionizing radiation pursuant to the SÚJB Regulation no. 307/2002 Coll., paragraph 2, the material should be managed only by virtue of the SÚJB licence. With the exemption of the handover to SÚRAO for disposal, this material can be stored at the appropriate licensee.
  - The radioactive material that is not a radiation ionizing source pursuant to the SÚJB Regulation no. 307/2002 Coll., paragraph 2, and which also does not fulfil the criteria for release to the environment pursuant to the SÚJB Regulation no. 307/2002 Coll., paragraph 57, must be secured against uncontrolled release to the environment. This material can be only released to the environment by virtue of the SÚJB permission.
  - In some cases a contaminated steel subject can be returned to the producer to be stored. For this purpose, the appropriate RC SÚJB will issue the approval. In this way, it is possible to return steel springs of the cultivators to the ROSS Roudnice, even if the enterprise is now going bankrupt. The head of RC SÚJB in Ústí nad

Labem signed the agreement with the trustee in bankruptcy that the springs mentioned will be accepted by virtue of the SÚJB approval.

- Instrument dials, fire detectors, radioactive paints and similar small subjects and substances can be stored by virtue of the SÚJB licence at the appropriate licensee, and then disposed on a massive scale by an authorized entity.

- Metal material contaminated by natural radionuclides, i.e. NORM contamination (usually water pipes, gas pipes, etc.).

  Normally, this is not a radiation ionizing source pursuant to the SÚJB Regulation no. 307/2002 Coll., paragraph 2. The clearance levels in compliance with the SÚJB regulation no. 307/2002 Coll., paragraph 57 do not refer to such materials, however these levels can be used as the guides. The material is usually returned to the place of origin (i.e. the original owner), for example, pipes that are contaminated by the natural radionuclides from mining activities are normally returned back to mines and stored underground. If needed, the SÚJB will issue the licence for storing and set out the conditions for storing.

- Medical material and similar non-metal material that are contaminated by artificial radionuclides. Normally, these are sanitary materials that have been disposed in a wrong way (e.g. from examinations at nuclear medicine department in hospitals) and are seized in an incineration plant of municipal waste. After storing (i.e. a reduction of a short-lived radionuclide activity) in the point of seizure, the material can be handled as municipal waste by virtue of the SÚJB permission.

- All other cases are solved individually.

List of Annexes

Activities and mass activities that specify the radioactive sources

	Activity [Bq]	Mass activity [kBq/kg]
H-3	10^9	10^6
Be-7	10^7	10^3
C-14	10^7	10^4
O-15	10^9	10^2
F-18	10^6	10
Na-22	10^6	10
Na-24	10^5	10
Si-31	10^6	10^3
P-32	10^5	10^3
P-33	10^8	10^5
S-35	10^8	10^5
Cl-36	10^6	10^4
Cl-38	10^5	10
Ar-37	10^8	10^6
Ar-41	10^9	10^2
K-40	10^6	10^2
K-42	10^6	10^2
K-43	10^6	10
Ca-45	10^7	10^4
Ca-47	10^6	10
Sc-46	10^6	10
Sc-47	10^6	10^2
Sc-48	10^5	10
V-48	10^5	10
Cr-51	10^7	10^3
Mn-51	10^5	10
Mn-52	10^5	10
Mn-52m	10^5	10
Mn-53	10^9	10^4
Mn-54	10^6	10
Mn-56	10^5	10
Fe-52	10^6	10
Fe-55	10^6	10^4
Fe-59	10^6	10
Co-55	10^6	10
Co-56	10^5	10
Co-57	10^6	10^2
Co-58	10^6	10
Co-58m	10^7	10^4
Co-60	10^5	10
Co-60m	10^6	10^3
Co-61	10^6	10^2
Co-62m	10^5	10
Ni-59	10^8	10^4

	Activity [Bq]	Mass activity [kBq/kg]
Ni-63	10^8	10^5
Ni-65	10^6	10
Cu-64	10^6	10^2
Zn-65	10^6	10
Zn-69	10^6	10^4
Zn-69m	10^6	10^2
Ga-72	10^5	10
Ge-71	10^8	10^4
As-73	10^7	10^3
As-74	10^6	10
As-76	10^5	10^2
As-77	10^6	10^3
Se-75	10^6	10^2
Br-82	10^6	10
Kr-74	10^9	10^2
Kr-76	10^9	10^2
Kr-77	10^9	10^2
Kr-79	10^5	10^3
Kr-81	10^7	10^4
Kr-83m	10^{12}	10^5
Kr-85	10^4	10^5
Kr-85m	10^{10}	10^3
Kr-87	10^9	10^2
Kr-88	10^9	10^2
Rb-86	10^5	10^2
Sr-85	10^6	10^2
Sr-85m	10^7	10^2
Sr-87m	10^6	10^2
Sr-89	10^6	10^3
Sr-90 [a])	10^4	10^2
Sr-91	10^5	10
Sr-92	10^6	10
Y-90	10^5	10^3
Y-91	10^6	10^3
Y-91m	10^6	10^2
Y-92	10^5	10^2
Y-93	10^5	10^2
Zr-93 [a])	10^7	10^3
Zr-95	10^6	10
Zr-97 [a])	10^5	10
Nb-93m	10^7	10^4
Nb-94	10^6	10
Nb-95	10^6	10
Nb-97	10^6	10

	Activity [Bq]	Mass activity [kBq/kg]
Nb-98	10^5	10
Mo-90	10^6	10
Mo-93	10^8	10^3
Mo-99	10^6	10^2
Mo-101	10^6	10
Tc-96	10^6	10
Tc-96m	10^7	10^3
Tc-97	10^8	10^3
Tc-97m	10^7	10^3
Tc-99	10^7	10^4
Tc-99m	10^7	10^2
Ru-97	10^7	10^2
Ru-103	10^6	10^2
Ru-105	10^6	10
Ru-106 [a])	10^5	10^2
Rh-103m	10^8	10^4
Rh-105	10^7	10^2
Pd-103	10^8	10^3
Pd-109	10^6	10^3
Ag-105	10^6	10^2
Ag-108m [a])	10^6	10
Ag-110m	10^6	10
Ag-111	10^6	10^3
Cd-109	10^6	10^4
Cd-115	10^6	10^2
Cd-115m	10^6	10^3
In-111	10^6	10^2
In-113m	10^6	10^2
In-114m	10^6	10^2
In-115m	10^6	10^2
Sn-113	10^7	10^3
Sn-125	10^5	10^2
Sb-122	10^4	10^2
Sb-124	10^6	10
Sb-125	10^6	10^2
Te-123m	10^7	10^2
Te-125m	10^7	10^3
Te-127	10^6	10^3
Te-127m	10^7	10^3
Te-129	10^6	10^2
Te-129m	10^6	10^3
Te-131	10^5	10^2
Te-131m	10^6	10
Te-132	10^7	10^2
Te-133	10^5	10
Te-133m	10^5	10
Te-134	10^6	10

	Activity [Bq]	Mass activity [kBq/kg]
I-123	10^7	10^2
I-125	10^6	10^3
I-126	10^6	10^2
I-129	10^5	10^2
I-130	10^6	10
I-131	10^6	10^2
I-132	10^5	10
I-133	10^6	10
I-134	10^5	10
I-135	10^6	10
Xe-131m	10^4	10^4
Xe-133	10^4	10^3
Xe-135	10^{10}	10^3
Cs-129	10^5	10^2
Cs-131	10^6	10^3
Cs-132	10^5	10
Cs-134m	10^5	10^3
Cs-134	10^4	10
Cs-135	10^7	10^4
Cs-136	10^5	10
Cs-137 [a])	10^4	10
Cs-138	10^4	10
Ba-131	10^6	10^2
Ba-140 [a])	10^5	10
La-140	10^5	10
Ce-139	10^6	10^2
Ce-141	10^7	10^2
Ce-143	10^6	10^2
Ce-144 [a])	10^5	10^2
Pr-142	10^5	10^2
Pr-143	10^6	10^4
Nd-147	10^6	10^2
Nd-149	10^6	10^2
Pm-147	10^7	10^4
Pm-149	10^6	10^3
Sm-151	10^8	10^4
Sm-153	10^6	10^2
Eu-152	10^6	10
Eu-152m	10^6	10^2
Eu-154	10^6	10
Eu-155	10^7	10^2
Gd-153	10^7	10^2
Gd-159	10^6	10^3
Tb-160	10^6	10
Dy-165	10^6	10^3
Dy-166	10^6	10^3
Ho-166	10^5	10^3

	Activity [Bq]	Mass activity [kBq/kg]
Er-169	10^7	10^4
Er-171	10^6	10^2
Tm-170	10^6	10^3
Tm-171	10^8	10^4
Yb-175	10^7	10^3
Lu-177	10^7	10^3
Hf-181	10^6	10
Ta-182	10^4	10
W-181	10^7	10^3
W-185	10^7	10^4
W-187	10^6	10^2
Re-186	10^6	10^3
Re-188	10^5	10^2
Os-185	10^6	10
Os-191	10^7	10^2
Os-191m	10^7	10^3
Os-193	10^6	10^2
Ir-190	10^6	10
Ir-192	10^4	10
Ir-194	10^5	10^2
Pt-191	10^6	10^2
Pt-193m	10^7	10^3
Pt-197	10^6	10^3
Pt-197m	10^6	10^2
Au-198	10^6	10^2
Au-199	10^6	10^2
Hg-197	10^7	10^2
Hg-197m	10^6	10^2
Hg-203	10^5	10^2
Tl-200	10^6	10
Tl-201	10^6	10^2
Tl-202	10^6	10^2
Tl-204	10^4	10^4
Pb-203	10^6	10^2
Pb-210 [a])	10^4	10
Pb-212 [a])	10^5	10
Bi-206	10^5	10
Bi-207	10^6	10
Bi-210	10^6	10^3
Bi-212 [a])	10^5	10
Po-203	10^6	10
Po-205	10^6	10
Po-207	10^6	10
Po-210	10^4	10
At-211	10^7	10^3
Rn-220 [a])	10^7	10^4
Rn-222 [a])	10^8	10

	Activity [Bq]	Mass activity [kBq/kg]
Ra-223 [a])	10^5	10^2
Ra-224 [a])	10^5	10
Ra-225	10^5	10^2
Ra-226 [a])	10^4	10
Ra-227	10^6	10^2
Ra-228 [a])	10^5	10
Ac-228	10^6	10
Th-226 [a])	10^7	10^3
Th-227	10^4	10
Th-228 [a])	10^4	1
Th-229 [a])	10^3	1
Th-230	10^4	1
Th-231	10^7	10^3
natural Th [a])	10^3	1
Th-234	10^5	10^3
Pa-230	10^6	10
Pa-231	10^3	1
Pa-233	10^7	10^2
U-230 [a])	10^5	10
U-231	10^7	10^2
U-232 [a])	10^3	1
U-233	10^4	10
U-234	10^4	10
U-235 [a])	10^4	10
U-236	10^4	10
U-237	10^6	10^2
U-238 [a])	10^4	10
natural U [a])	10^3	1
U-239	10^6	10^2
U-240	10^7	10^3
U-240 [a])	10^6	10
Np-237 [a])	10^3	1
Np-239	10^7	10^2
Np-240	10^6	10
Pu-234	10^7	10^2
Pu-235	10^7	10^2
Pu-236	10^4	10
Pu-237	10^7	10^3
Pu-238	10^4	1
Pu-239	10^4	1
Pu-240	10^3	1
Pu-241	10^5	10^2
Pu-242	10^4	1
Pu-243	10^7	10^3
Pu-244	10^4	1
Am-241	10^4	1
Am-242	10^6	10^3

	Activity [Bq]	**Mass activity [kBq/kg]**
Am-242m [a])	10^4	1
Am-243 [a])	10^3	1
Cm-242	10^5	10^2
Cm-243	10^4	1
Cm-244	10^4	10
Cm-245	10^3	1
Cm-246	10^3	1
Cm-247	10^4	1
Cm-248	10^3	1
Bk-249	10^6	10^3
Cf-246	10^6	10^3
Cf-248	10^4	10
Cf-249	10^3	1
Cf-250	10^4	10
Cf-251	10^3	1
Cf-252	10^4	10
Cf-253	10^5	10^2
Cf-254	10^3	1
Es-253	10^5	10^2
Es-254	10^4	10
Es-254m	10^6	10^2
Fm-254	10^7	10^4
Fm-255	10^6	10^3

[a]) The values of activities and mass activities are related to the radionuclides that are in the equilibrium with their daughters

The clearance levels of radionuclide contamination and surface radionuclide contamination

Monitored area of contamination	Class of radionuclide according to radiotoxicity				
	1	**2**	**3**	**4**	**5**
	Clearance levels in mass activity for radionuclide contamination [kBq/kg]				
Materials, solids and subjects carried out from the workplaces handling ionizing radiation sources or otherwise released to the environment	0.3	3	30	300	3000
	Clearance levels in surface activities for radionuclide contaminated area [kBq/m^2]				
Material surfaces and subject surfaces that are carried out from the workplaces handling ionizing radiation source or otherwise released to the environment	3	30	300	3000	3.10^4

The classification of radionuclides according to their radiotoxicity

Class	Radionuclide
1	Na-22, Na-24, Mn-54, Co-60, Zn-65, Nb-94, Ag-110m, Sb-124, Cs-134, Cs-137, Eu-152, Pb-210, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, U-238, Np-237, Pu-239, Pu-240, Am-241, Cm-244
2	Co-58, Fe-59, Sr-90, Ru-106, In-111, I-131, Ir-192, Au-198, Po-210
3	Cr-51, Co-57, Tc-99m, I-123, I-125, I-129, Ce-144, Tl-201, Pu-241
4	C-14, P-32, Cl-36, Fe-55, Sr-89, Y-90, Tc-99, Cd-109
5	H-3, S-35, Ca-45, Ni-63, Pm-147

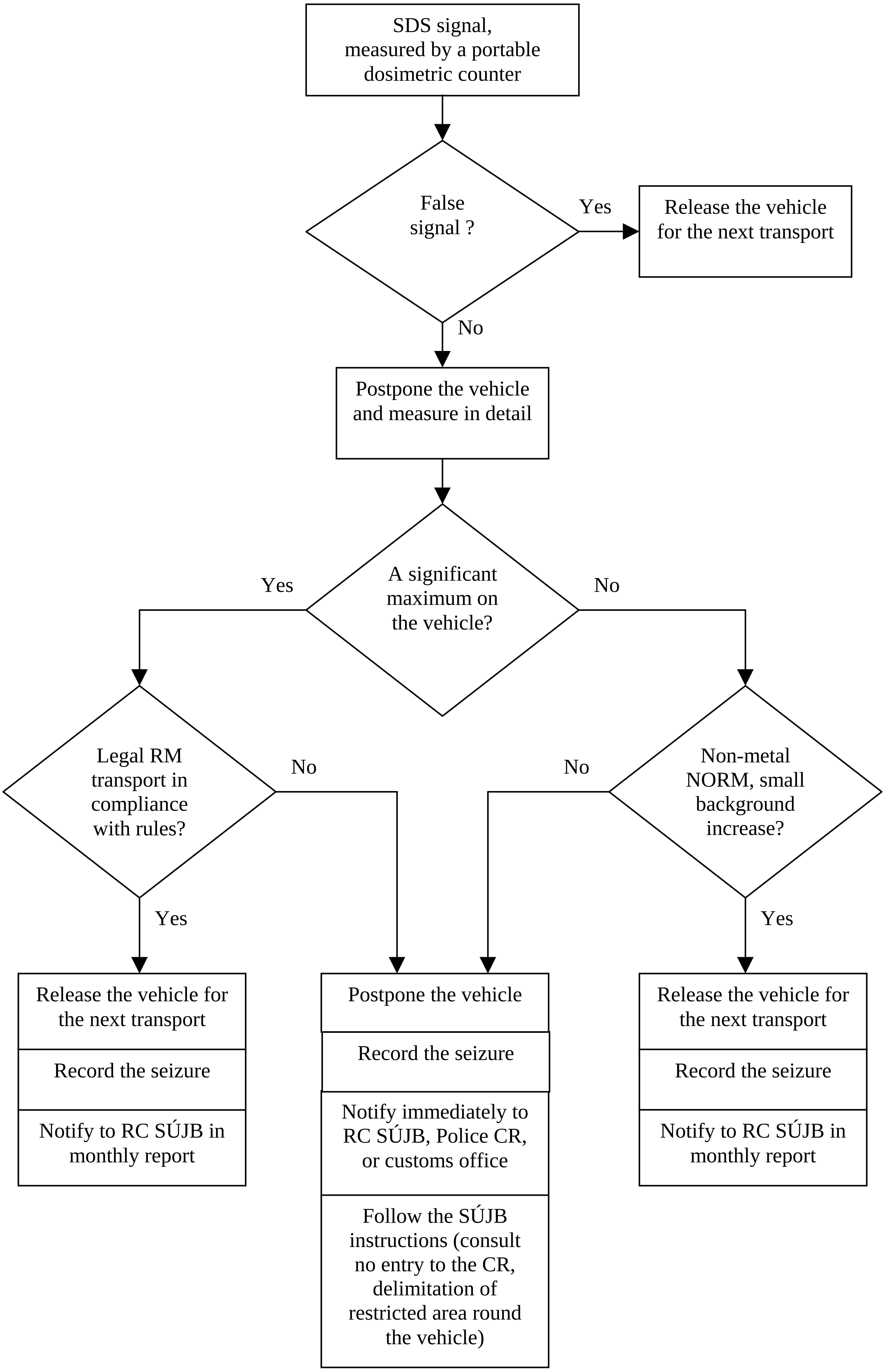
The overview of Regional Centres SÚJB and their contact addresses

SÚJB Office Head	Postal code City Street	Telephone no.	Fax	E - mail	Emergency Notification (out of working hours)
RC Brno **RNDr. Libor Urbančík**	602 00 Brno tř. kpt. Jaroše 5	545 215 092	**545 244 998**	libor.urbancik@sujb.cz	**602 652 297** 725 002 413
RC České Budějovice **Ing. Ladislav Vávra**	370 07 České Budějovice Schneiderova 32, P.Box 10	386 105 221 386 105 220	**386 105 210**	ladislav.vavra@sujb.cz	**602 652 292** 725 002 407
RC Hradec Králové **Ing. Vl. Macháň, CSc.**	500 03 Hradec Králové Piletická 57	495 211 500 495 211 471	**495 211 227**	vladimir.machan@sujb.cz	**602 652 295** 725 002 411
RC Ostrava **Ing. Libor Mrázek**	703 00 Ostrava Syllabova 21	596 782 935	**596 782 934**	libor.mrazek@sujb.cz	**602 652 296** 725 002 412
RC Plzeň **Ing. Pavel Beran, CSc.**	320 11 Plzeň Klatovská 200 f	377 420 943 377 420 944	**377 420 943**	pavel.beran@sujb.cz	**602 652 293** 725 002 408
RC Praha **Ing. Otto Kodl**	110 00 Praha 1 Senovážné nám. 9	221 624 507 221 624 759	**221 624 760**	otto.kodl@sujb.cz	**602 652 291** 725 002 406
RC Ústí nad Labem **RNDr. Čestmír Berčík**	403 40 Ústí nad Labem Habrovice 52	472 743 022	**472 743 033**	cestmir.bercik@sujb.cz	**602 652 294** 725 002 409

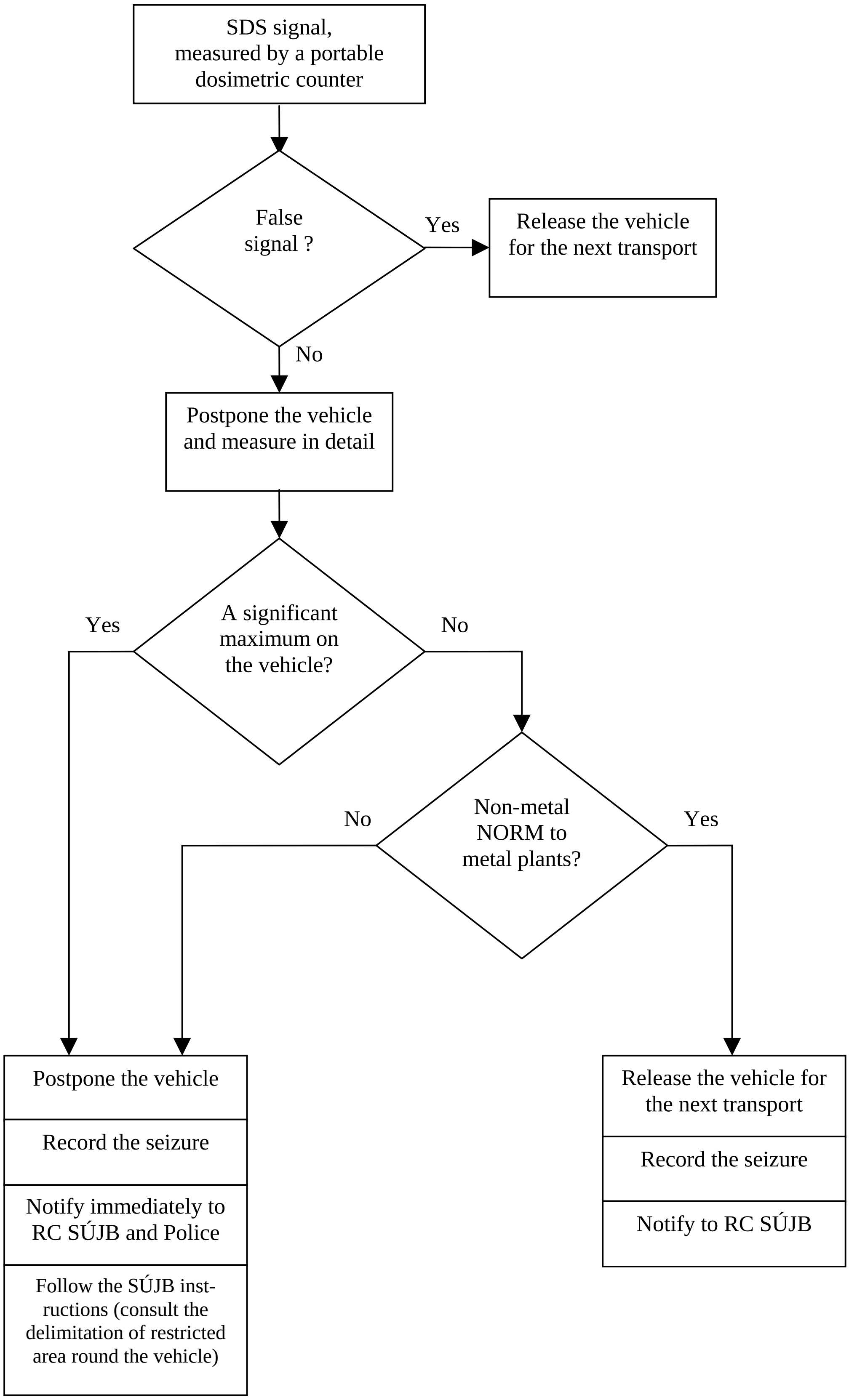
Emergency notification to SÚJB if RC is not available

SÚJB Praha - KKC **Non-stop service**	110 00 Praha 1 Senovážné nám. **9**	224 220 200	**221 624 400**	emergency@erc-cr.cz	

The chart of the radionuclide material seizure procedure at a border crossing



The chart of the radioactive material seizure procedure at the entry to metallurgical works and a plant that handles the secondary raw material and waste



A. The record on radioactive material seizure

The place of seizure[1)]: Border crossing (entry – exit), metallurgical plant, incineration plant, scrap yard, other[2)]

Code MP: *RC/nnn/year* ref. no.:

Date and time of emergency notification:	
Emergency notified by (name and surname)**:**	
Date and time of seizure:	
Place of seizure – Name of physical or legal person, or workplace name (if available)**:** Address (street, postal code, place): Contact person (name and surname, job): Contact (telephone, fax, e-mail):	
Consignor or cargo owner – company name (i.e. physical or legal person)**:** Organization ID (IČO): Address (street, postal code, place): Contact person (name and surname, job): Contact (telephone, fax, e-mail):	
Carrier (differs from the consignor) – company name (physical or legal person)**:** Organization ID (IČO): Address (street, postal code, place): Contact person (name and surname, job): Contact (telephone, fax, e-mail): **Driver** (name and surname): **Vehicle registration no., carriage no.:**	
Declared cargo – specification**:** Declared radioactive material (yes/no): Cargo weight:	
The values measured by a portable operative dosemeters : Background: Maximum on the vehicle surface: At a distance of 2 m from the maximum value on the vehicle surface: At occupied seats (i.e. driver and passenger): Measuring counters used (quantities and units) : Measured performed by (name and surname):	
Released for transport (yes/no)**:** Release decided by (name and surname):	

Destination point or destination address:	

Note:	

[1)] Delete where not applicable
[2)] Specify in note

Note:

- Complete only the framed section
- In case that you have your own form in which all above data is available you can use your own form

B. The record on radioactive material finding

Code MP: *RC/nnn*/year ref. no. *:*

Date and time of emergency notification:	
Emergency notified by : Name and surname: Address (i.e. street, postal code, place): Contact (telephone, fax, e-mail):	
Date and time of finding :	
Finder (if different from the person who notified the emergency)**:** Name and surname: Address (i.e. street, postal code, place): Contact (telephone, fax, e-mail):	
Description of the place of finding: Address (street, postal code, place):	
Description of finding: Subject, substance form, and the types of package, etc. : Quantity, number of pieces:	
Radiation situation – values measured **:** Background: The maximum value on the finding surface (package): At a distance of 2 m from the surface:	
Measuring counters used : (Quantities & units):	
Measured by (name and surname)**:** Address (street, postal code, place): Contact (telephone, fax, e-mail):	
Note:	

Note:

- Complete only the framed section
- In case that you have your own form in which all above data is available you can use your own form

C. The Protocol on the radioactive source tracking in seized or found material*)

Code MP: *RC/nnn/year* ref.no.:

Date and time of tracking:	
Place of tracking (if differs from the point of seizure or finding) name of natural or legal person, or name of workplace**:** Organization ID (IČO): Address (street, postal code, place): Contact person (name and surname, job): Contact (telephone, fax, e-mail):	
Detailed description of the seized load - finding*): (localized ionizing radiation source, surface activity, volume activity, radionuclide, activity estimate, etc.)	
Radiation situation – the values measured**:** Background: Maximum value on the vehicle surface (finding): At a distance of 2 m from the vehicle surface-finding: At occupied seats (i.e. driver, passenger):	
Measuring counters used: (Quantity & units):	
Tracking of ionizing radiation source (i.e. method, tools, etc.)**:**	
Name of physical or legal person who performed tracking: Organization ID (IČO): Address (street, postal code, place): Tracked by (name and surname, signature): Contact (telephone, fax, e-mail):	

The measures proposed (disposed by SÚRAO, stored by an authorized entity, return to the owner if this is the licensee, etc.)**:**

Event conclusion (the assessment of possible radionuclide release to the environment, exposure of persons, safe storing of ionizing radiation source – stored or disposed)**:**

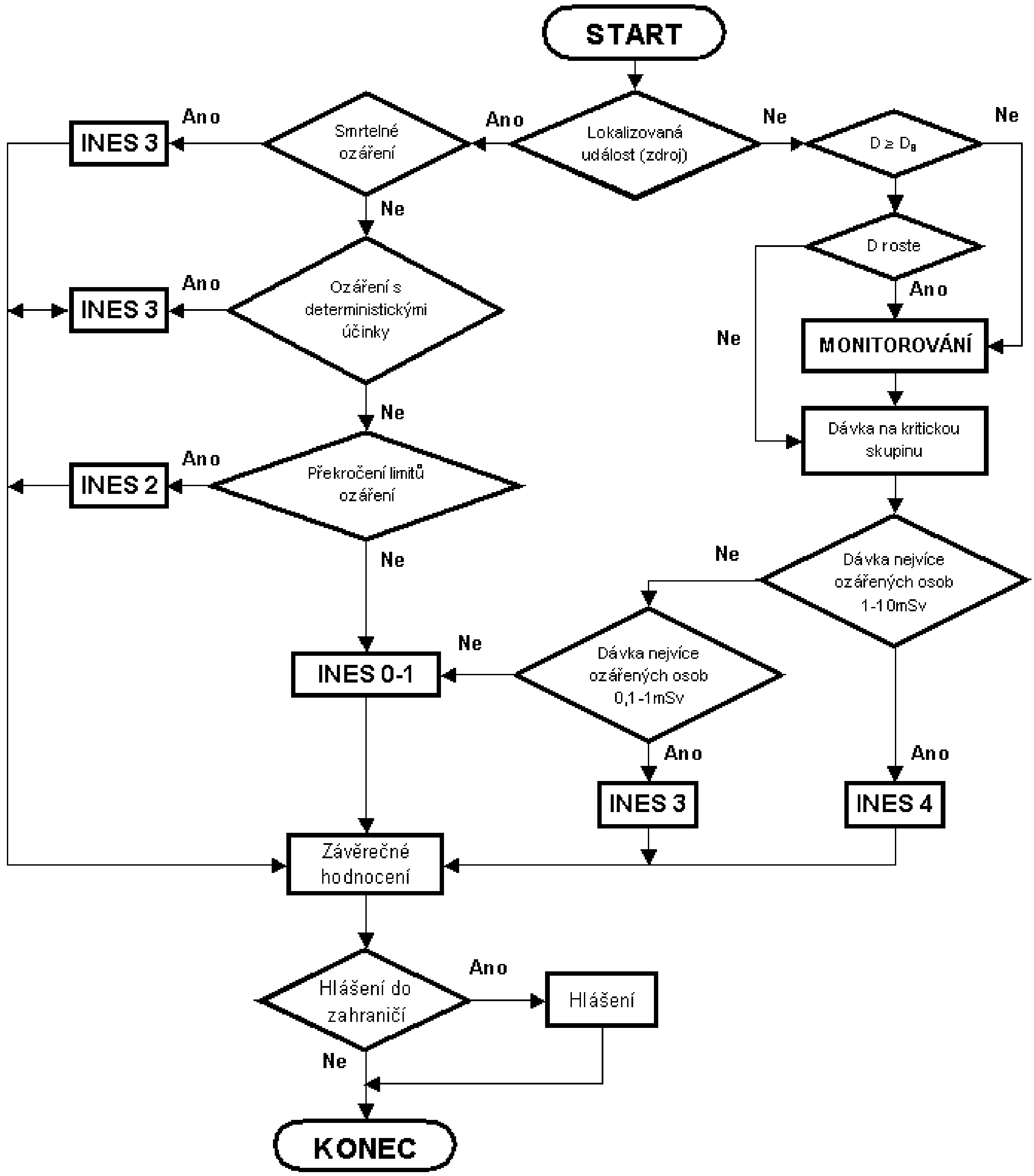
Event classification:

*) Delete where not applicable

Note:

- Complete only the framed section
- In case that you have your own form in which all above data is available you can use your own form

The classification of emergencies



Event classification *)

Below INES scale	–	An insignificant event from the point of view of radiation protection (e.g. a seizure at border crossing with successive release for transport) or an unconfirmed event
INES 0	–	The event that requires the next investigation, however radiation safety is not directly affected
INES 1	–	The event which may require the countermeasures
INES 2	–	The event with radiological consequences (a local discharge to the environment, exposure of workers with limit exceeding – below the threshold of the deterministic effects, the fractions of the limits for the population)
INES 3	–	The radiation accident with limited effects (a limited radionuclide discharge to the environment, the deterministic effects in the workers, the exposure of the population below limits)
INES 4	–	The radiation accident will cause lethal exposure, or during the event the doses of the most exposed persons achieve 1 to 10 mSv.

*) IAEA publication: INES: The International Nuclear Event Scale (1992)

Annex - Figures

In 1996, the "Handbook of Visual Detecting for Radionuclide Sources in Iron Scrap" was published by Jiří Šura. Its purpose was to help the workers of the collection centres, the places of iron scrap reloading, and the entries of scrap in metallurgical plants to recognize the subjects to be suspicious of radionuclide content. Because this handbook proved many times to be a good aid in practice, after the agreement with the author the contents of the handbook was revised, completed and attached to this recommendation.

In practice, it happens that an apparatus or equipment that includes a radionuclide source is disposed in iron scrap, in a better case as a sealed source in an operating container or a transport container (i.e. package). Even if the radionuclide sources are usually detected by ionizing radiation counters, there are also such cases (e.g. nuclear material) when the sources are not always revealed by this method. However, these sources may be identified by even simpler methods, for example, according to the scrap origin, by the visual identification of the suspicious subjects, and on the basis of the worker's experience (for example, during splitting bigger scrap pieces).

The first symptom of the radionuclide source in metal scrap can be the fact that you will find the warning sign with the radiation danger symbol in compliance with ČSN 01 8015 standard (each ionizing radiation source must be marked with this warning sign), or the older warning sign previously used. The symbol may be completed with the warning notice „RADIOACTIVE“, etc. The other warning notice may be also found, for example, „DANGEROUS INVISIBLE RADIATION“, „WORKPLACE HANDLING RADIOACTIVE MATERIALS“, etc. The finding of shielding lead blocks may also indicate a possible ionizing radiation source.

The other symptom may be a higher weight of a subject with relatively small dimensions. The operating and transport containers are normally produced of lead or depleted uranium (which is nuclear material), and hence they are much heavier than steel subjects of the same dimensions and shapes. The shapes of the operating containers are different according to their particular use, and they look very often like electric motors.

The containers (especially transport containers) are constructed from the materials highly resistant against mechanical damage. The resistance of such subjects, e.g. during cutting by hydraulic shears, may be regarded as the other symptom of radionuclide source presence. In such a case, it is necessary to interrupt the work and call for dosimetry inspection. In general, it is necessary to avoid the splitting of suspicious subjects (e.g. by cutting, shearing and especially by flame separation).

The origin of metal scrap is also important information. If scrap originates from a workplace that handles radionuclide sources there is a probable danger that radionuclide sources can either unintentionally, due to carelessness or even intentionally appear in scrap.

Normally, radionuclide sources are hermetically sealed in metal (most often stainless) capsules with the dimensions of a couple of centimetres at most. The probability that an unsealed radionuclide source can appear in scrap or can get to the environment is low, the sealed source will be usually closed in its cavity capsule, operating or transport container, or in its external protective package together with its container (e.g. cask or box). If you find the external package (or container), it is not possible to find out visually that both the container and the source are placed inside. Because the radionuclide sources from a damaged capsule can contaminate both the environment and the persons handling the radionuclides, it is strictly forbidden to separate the containers in any way (e.g. by cutting, shearing, etc.). Even the release of undamaged source itself from the container can seriously endanger health of the persons being present, hence it is necessary to avoid any manipulation with suspicious containers until the dosimetric inspection is done.

In the Annex of this Recommendation, Figures, the types of operating and transport containers most often used for radionuclide sources, system components and the subjects that relate to the application of radionuclides are described. Unless otherwise specified in the figure legends, Jiří Šura is the author or the owner of the copyrights of the pictures.

The individual subjects in the figures are divided into several groups:

- The subjects and the equipment that relate to radionuclide applications, some auxiliary equipment to machines and technological systems,
- Fire detectors,
- Industrial counters and their operating containers,
- Flaw detectors and their components,
- Medical irradiators and sources,
- Packages,
- Examples of radioactive material seizures.
-

1. **The subjects and the equipment that relate to radionuclide applications, some auxiliary equipment to machine and technological systems**

Warning signs and symbols. The sign with the warning symbol of radiation hazard according to the Czech (the former Czechoslovakian) standard ČSN 01 8015 is shown in Fig. no. 1.1. The other variant of the sign is shown in Fig. no. 3.15. The older version of the symbol that warns against radiation and which was used in Czechoslovakia in the 1950s and the 1960s is shown in Fig. no. 1.4. The other warning sign is demonstrated in Fig. no. 1.2. The self-lighting warning signs were (are?) used especially in the OKR deep mines and perhaps in the Civilian Defence underground equipment. These are the plastic signs in which the symbol and the legend that are made of a fluorescent and radioactive substance (e.g. ^{147}Pm, ^{241}Am, and formerly even ^{226}Ra) are encapsulated. The bulbs that are filled with ^{85}Kr (i.e. atomic lamps) have been also exceptionally used.

Lead shielding blocks that are used at the workplaces handling radioactive materials are shown in Fig. 1.6. The shielding blocks are produced in the following arrangement, i.e. "wall", "edge", "corner", the same as per the "bottom" (see in the figure), and possibly in the other arrangements. The newly produced blocks are covered with green metallic coating that protects the operators against abrasion of toxic lead (see Fig. no. 7.1).

The eliminators of electrostatic charge are used in spinning mills, weaving mills, rubber factories, paper mills and at all the places where a large quantity of electrically non-conductive materials is wound up on reels or rolls. The eliminators can be also used in flammable liquid filling rooms. The eliminators ionize the air by radiation, discharge electrostatic charge, and thus reduce fire risk. As a source, a thin metal strip that contains ^{241}Am with activity of a few GBq is often used inside the eliminator. Flat and extended boxes are very often applied that are installed closely to the product being wound (see Fig no. 1.3 to 1.5). More than one eliminator can be used in one machine.

A semi-hot chamber is the equipment that is used in factories to handle sealed sources up to a certain activity. Both the chamber itself and its components should not get to metal scrap by natural way. Fig. no. 1.7 – 1.10 show the example of the semi-hot chamber and some related subjects (e.g. manipulators, containers, etc.).

2. Fire detectors

The fire detectors are mainly used in production halls and high-rise buildings. Radioactive sources are included in the detectors that are installed on ceilings. The detectors are used in a few types that are shown in Fig. no. 2.1 – 2.4. The sources of ^{241}Am (the products of the former Tesla Liberec, now LITES a.s.) or ^{85}Kr (made in the former East Germany, see Fig. no. 2.5) with activity only tens of kBq are used; however, a high number of the detectors is still operating. It is necessary to distinguish the sensors of the similar shape that include only a thermistor sensor from the radiation source detectors.

3. Industrial counters and their operating containers

Level indicators and isotope switching relays. These are the most often used ionizing radiation sources. Their principle is based on the absorption (i.e. shielding) of gamma radiation in transported or stored material. They include a shielded source (Fig. no. 3.1 – 3.5, 3.7) and the detectors (for the probes see Fig. no. 3.6, 3.8 – 3.10) that are installed on the opposite ends of pipe, tank, or belt conveyor. The detectors are most often used at the following locations:

- in mines, power plants and all the places where belt conveyors are available; the detectors signalize clogging at the belt, overflow (see Fig. no. 3.7) and hopper,
- at all the places where liquid and loose materials are stored in reservoirs, silos, bunkers, tanks, etc., and the detectors signalize that the material being stored has reached the detector level. The detectors are very often called level gauges, but in fact they operate as level indicators. It is necessary to emphasize that many variants of the measurement geometry are used so that the radiation source can be anywhere, i.e. outside, inside and even on a float. More than one sources can be installed in one tank in one or more horizontal levels,
- in piping where the detectors signalize the presence of transported substance in piping (e.g. in sugar factories, chemical plants, etc.).

The different sources are assembled in the detectors, mainly ^{60}Co with activities from units of MBq up to tens of GBq and ^{137}Cs with activities from units of MBq to hundreds of GBq. Their occurrence in iron scrap is the most probable of all radiation sources.

Densimeters measure the density of liquids by means of the gamma-radiation absorption. Their applications are in chemical industry, construction industry, sugar industry, fuel industry, etc. The densimeter is attached to a pipe throw which liquid flows (see Fig. no. 3.15). The source is installed on one side and the detector on the other side. The densimeters are available with the high-intensity sources, especially ^{60}Co and ^{137}Cs. The other densimeters are shown in Fig. no. 3.11 – 3.15. See also Hydrometers.

Ash-gauges are used for measuring coal ash content in mining treatment plants, power plants and heating plants. The gauges include a source (usually below a conveyor belt) and the detector above the belt. The ash-gauges include two types of sources: ^{137}Cs (hundreds of MBq) and ^{241}Am (tens of GBq). Their position is shown in Fig. no. 3.16 and 3.17. The operational source shields of the ash-gauges (where lead (Pb) is used) that were made in the former East Germany are shown in Fig. no 3.22 and 3.23. The operational shield of the new ŠKODA – ÚJP ash-gauge (see Fig. no. 3.18 and 3.19) is made of uranium. About 150 ash-gauges have been produced so far, and these are included as a part of many old systems. The laboratory ash-gauge with assembled a Sr/Y source of activity of about 60 MBq was also produced in Tesla Liberec (see Fig. no. 3.20).

Thickness gauges are used in sheet rolling mills, rubber plants, and plastics pressing shops. Beta sources are mainly applied in thickness gauges. The radiation source is always assembled together with the detector somewhere on a product line. The older types of the thickness gauges are shown in Fig. no. 3.24 and 3.25.

Impact counters can be mainly found in mines at shaft landings, at industrial cable railways, and anywhere in line production. The counters incorporate gamma-radiation sources, especially ^{60}Co and ^{137}Cs. In the counters, it is possible to use so-called gamma relays that are shown in Fig. no. 3.8 and 3.9. The same sources as in the level indicators can be also used.

Hydrometers are used for determining moisture of sand and the other materials in construction industry, foundry industry, fuel industry, brickworks, ceramics factory, etc. The hydrometers contain neutron sources. The hydrometer which was made in the former East Germany, and its probe is similar to a radiation logging probe, is shown in Fig. no. 3.26. Some gauges are used not only for moisture measurements, but also for density measurements (e.g. the Czech NZK 201). In such a case, both a neutron source and ^{137}Cs or another gamma source are used. **Radiation density gauges** which are similar to hydrometers are mainly used in highway construction, and these gauges are used for non-destructive testing of bitumen surface and soil consolidation. The gauges involve two sources: ^{137}Cs (hundreds of MBq) and ^{241}Am/Be (units of GBq, plus neutron source).

Radiation logging probes are used in geological surveys to find the different properties of rocks in bores. The probes are usually provided with high-activity gamma radiation and neutron sources. For the new types, the closure with a source is always transported separately from the radiation logging probe, and for the old types, the source may be permanently assembled in the radiation logging probe (for example, the Soviet radiation logging hydrometer, see Fig. no. 3.27). The radiation logging probes are shaped as stainless steel bars with a high diameter and a length from 1 to 3 m, and it is difficult to recognize them in iron scrap.

The applications of ionizing radiation sources in industry and especially at the research institutes are very wide. For instance, glass tube diameter meters (see Fig. no. 3.29), cigarette filler controller (see Fig. no. 3.30) and a part of the conveyor balance (see Fig. no. 3.31) are the examples of **the next radiation source applications**. Attention should be also paid to the shapes of the operational source containers. The ^{170}Tm source can be found, for example, at some mining cutter loaders where the sources are used to check the boundary between waste rock and coal and to control the correct cutter loader move. The operational containers of the Soviet production had in many applications the shape that is demonstrated in Fig. no. 3.13 and 3.28.

The main goal of the **operational container** is to ensure safe work with a source, that is, the operator protection against radiation and the source itself against damage. Radiation penetrates through the container only in the operational direction (for open collimator), while radiation is usually shielded in the other directions. The shape and the dimensions of the operational container are adapted according to the method of using the source. In general, the container is assembled from the outside steel jacket and the inside lead and/or uranium shield. The source itself is usually placed (i.e. welded, pressed, etc.) at the end of the holder (screw) that is screwed into the container. The screw head is sometimes visible on the outer steel jacket. The container should be marked with the warning sign of radiation danger in compliance with the ČSN 01 8015 standard, however, this sign may be missing. In Fig. no. 3.31 – 3.36, the examples of the foreign operational containers are shown. The following types of the operational containers are presented: the Rumanian Ci-type operational containers (Fig. no. 3.31), the Polish transport and operational containers of RT series (Fig. no. 3.32), PrI series (Fig. no. 3.33) and PrO series (Fig. no. 3.34) which can mainly appear in the plants where the Polish technology has been delivered (e.g. sugar plants, etc.), and the Soviet operational containers which have been extensively used for radioisotopic relays (Fig. no. 3.35).

4. Flaw detection counters and their components

Flaw detection counters are used for non-destructive testing of the quality of metal products at the specialized workplaces, foundries, engineering plants (e.g. aviation industry, armament industry, nuclear industry, automotive industry, turbine production, etc.), during weld inspections on gas line construction, etc. They operate in a similar way as x-ray units, however, gamma-ray is exploited, e.g. most often ^{192}Ir, and less often ^{169}Yb, ^{60}Co and ^{75}Se with activity from hundreds of GBq to units of TBq. It is also possible that the other source can be used in the older foreign types (e.g. ^{137}Cs and ^{170}Tm). In the figures, the old portable and movable flaw detector types are shown: GUP (Fig. no. 4.1 – 4.3, 4.6) and RID (Fig. no 4.4, 4.5), MYTED-5 portable flaw detector (ČSSR, Fig. no. 4.7), the Soviet flaw detectors which are called „Molch“(Salamander) for checking M18 and M6 pipe welds, see Fig. no. 4.8 – 4.12, two types of Gammamats (West Germany, Fig. no. 4.13 – 4.15), the older Czechoslovak OK 0.5 gauge (Fig. no. 4.16 – 4.18) and some other subjects that are used in flaw detection. Especially, the obsolete types from the closed plants may appear in scrap (Fig. no. 4.19 – 4.27).

Great attention should be devoted to the holder; please check if the holder can be easily removed or even can dropped off. This holder looks like a very thick-coiled spring or a metal link "bead" with a diameter of about 8 mm, see Fig. 4.28 and 4.29. The source itself can be located at the end. **Do not touch!**

5. Medical irradiators and sources

Therapeutical irradiators. The irradiators are used at oncological departments, and these are usually bulky installations with high-activity sources, mainly ^{60}Co, less often ^{137}Cs with activities up to hundreds of TBq. The source itself is placed in a shield with a weight of several tons. In our country, the possibility that such a source would get to scrap is fully excluded. However in case of scrap import, this danger is not excluded, for example, from the countries at war. The case of the exposure of persons from uncontrolled irradiators has been described abroad.

Therapeutical sources. The sources are used at oncological departments and serve for the local external/internal exposures of patients. The ^{226}Ra source is most often applied, and rarely ^{137}Cs, ^{192}Ir and ^{90}Sr with activities of hundreds of MBq up to units of GBq which are inserted into the capsules made of platinum and iridium. The sources are shaped like needles, tubes or seals (Fig. no. 5.1). The uranium and lead shielding vaults are used for their storing. The incidence of small-scale therapeutical sources on scrap is not probable, perhaps their containers could be found there (Fig. no. 5.8).

A **Ra 66/8 VAULT** is shown in Fig. no. 5.1 and 5.2 which is used for storing ^{226}Ra and ^{137}Cs therapeutical sources in hospitals, with dimensions of 260mm×380 mm (and with the extension 635 mm long), weight of 235 kg (and the extension up to 315 kg). The predecessors of this vault was the container for transport of oncological sets (see Fig no. 5.8). The Chirana M 6102 lead transport container is shown in Fig. no. 5.3 and 5.4, the Chirana 392 type in Fig. no. 5.5 – 5.7.

6. Packages and their components

The packages (i.e. transport containers and their packages) serves for radionuclide source transport. These are heavy steel containers, usually of a cylindrical shape. Their internal shield is made of lead or depleted uranium. They are produced in the standardized sizes, type-approved for individual source types and activities; however in practice, any source can be found which can be inserted into this container. In addition to the type and the content identification, they should be marked with the warning sign of radiation danger according to the ČSN 01 8015 standard. However, all signs and marks can be missing.

The SÚJB Regulation no. 317/2002 Sb. on Type Approval of Packages for Transport, Storage and Disposal of Nuclear Materials and Radioactive Substances, on Type Approval of Ionizing Radiation Sources and on Transport of Nuclear Materials and Specified Radioactive Substances (on type approval and transport) classifies the packages according to their purpose and the activities inside into several types. This Recommendation covers the packages of the following types: A type (class) for transport of nuclear materials; B(U), B(M) and C types for transport of nuclear materials and radioactive substances; and S type that is intended for storing nuclear materials and radioactive substances.

The packages with the uranium shield compared to the lead shield containers are characterized by a high shielding capability even for small dimensions. The shield is produced of depleted uranium, which is nuclear material subjected to SÚJB registration and supervision. Even though the probability of finding such container is low, this case is not fully eliminated.

The package normally consists of the container itself and the transport package. The container is often provided with a stainless steel jacket, sometimes coated. In the shield, there are one or more cavities for storing the sources, mainly in shielded cavity capsules. The older type of the transport package is a wooden box (sometimes a sheet metal box), and the new type of the transport package is a steel cylinder or a steel cask provided with lugs for crane suspension.

The overview of many current and obsolete transport containers (domestic and some foreign containers) including their components is listed in this part (some of them were mentioned in the previous parts). Moreover, the small-scale lead containers that are intended for low-activity sources and that could be found in scrap and municipal waste are also presented.

The type series of **HU-GP-20, 40, 65 and 90** is now the series of the most often used class A transport containers with depleted uranium. The 20 and 40 types are available with tilted lugs, the 65 and 90 types are available with the suspension lugs and catches (see Fig. no. 6.1 and 6.2). Their dimensions and weight are as follows:

HU-GP-20: 128mm $\times$277 mm, 12.5 kg,

HU-GP-40: 128mm $\times$300 mm, 22 kg, Fig. no. 6.4

HU-GP-65: 130mm$\times$310 mm, 45 kg, Fig. no. 6.1 – 6.3, 6.6

HU-GP-90: 156mm$\times$350 mm, 80 kg, Fig. no. 6.5, 6.7.

The containers can accommodate the different sources with activities up to units of MBq (HU-GP-20) or units of GBq (HU-GP-90, for ^{60}Co). The HU-GP-65 type is now produced with a suspension lug as for the 90 type. The outside wooden packages are shown in Fig. no. 6.6 and 6.7 which are now replaced by metal boxes for the 20 and 40 types, see Fig. no. 6.8.

The first two types of the containers mentioned above are very similar to the older containers of A type with depleted uranium that are marked as **TO-ACs-21,** or with the different last digit. (Fig. no. 6.9, 6.10).

The **UK** and **SK** types are the transport containers of A type and B type with the stainless jacket and the depleted uranium shield. The containers are produced in different sizes, especially for the source of ^{192}Ir with activities of tens up to hundreds of GBq. Some containers have more than one source cavities. Their weight ranges from 25 to nearly 100 kg (see Fig. 6.11 – 6.17).

The **UKI 4** and **UKI 10** types are the B type transport containers with the stainless jacket and the uranium shield. The UKI 4 type is available with 4 cavities, and the UKI 10 type with 10 cavities. The total activity of iridium sources can achieve about tens of TBq. The appropriate weight is 41 kg or 103 kg. These containers are shown in Fig. no. 6.18 – 6.22 including their steel transport casks.

KM-47 is the B type container that is used for transport of the different solid and liquid sources with the activity of units of TBq. Its dimensions are 332mm$\times$510mm and weight is 136 kg (Fig. no. 6.23 – 6.25).

CsAm 20 is a small container for simultaneous transport of ^{137}Cs with activity up to 1.8 GBq and ^{241}Am with activity up to 28.8 GBq. This container is used for the sources that are assembled in ENELEX ash-gauges. Dimensions of 160mm×256 mm, weight of 14.6 kg, Fig. no. 6.26, 6.27.

GP-Yb-3×5 is a small container of B type for transport of flaw detection sources, for example, ^{169}Yb with total activity up to 555 GBq. This is mainly used by the users of the MYTED 5 flaw detectors. Dimensions of 110mm×105 mm, weight of 5.2 kg, Fig. no. 4.7.

HPT types are the A type transport and „temporary storage“ containers with the uranium shield, produced by the VZUP. The HPT 6 type was produced for Tesla Liberec, and is not probably used by another user (Fig. no. 6.28., 6.29). HPT-1 and HPT-1/L temporary storage containers were used for temporary storage of the sources during their replacement in industrial gauges (see Fig. no. 6.30, 6.31). The HPT-1/L containers were used in Tesla Liberec for assembling HHT 52 level gauges.

BG – 22 is the B type container in a transport vessel, produced in Germany. It weighs 110 kg and is intended for transporting high-activity sources (Fig. no. 6.32, 6.33).

The Soviet transport containers. The containers are available in different cylinder-shaped vessels made of alloyed steel (for example see Fig. no. 6.34). The transport casks were originally coated grey, however the coating could be changed (for example see Fig. no. 6.35). The KIZ type containers which were used very often are shown in Fig. no. 6.36 and 6.37; and in Fig. no. 6.38, you can see a fragment of the other transport container.

Transport container packages. The older type of transport vessel for a container of unknown origin is shown in Fig. no. 6.39. A transport vessel prototype for bulky containers is shown in Fig. no. 6.39. A vessel that is used at repositories is shown in Fig. no. 6.41.

The internal capsules for radionuclide sources are also called the cavity capsules, the examples are shown in Fig. no. 6.19, 6.21 and 6.42. The atypical internal capsule is shown in Fig. no. 6.43.

The older "manual“ **OK 25 and OK 35 type** transport containers with lead shielding are shown in Fig. no. 6.44 a 6.45, the old type of **lead transport container,** with unknown identification, is shown in Fig. no. 6.46 and 6.47.

Small-scale transport containers for the sources with activities up to hundreds of MBq are used for medicaments and radioisotope labelled substances. Weight up to 1 kg, with a shape and dimensions similar to a hand-grenade – see Fig. no. 6.48 and 6.49. A small container for low-activity ^{137}Cs, made in Germany, is shown in Fig. no. 6.50, its weight is about 1.5 kg. The other containers (Polish production, P 20 and P 30 types) for low-activity sources are shown in Fig. no. 6.51 and 6.52. Their weight is not specified, but we may suppose that their weight is given in units of kg. The other small containers are shown in Fig. no. 6.53, and for transport packages and low-activity source cans see Fig. no. 6.54 and 6.55.

7. Examples of radioactive material seizures

In this part, some subjects that were seized in iron scrap and municipal waste are described. These are the different subjects that contain ^{226}Ra or ^{90}Sr, metallurgical products contaminated by ^{60}Co from randomly melted sources and radionuclide sources from different equipment.

The following subjects are classified as small-scale subjects: vials and ampoules that contain a **luminescent paint** with ^{226}Ra (Fig. no. 7.1. and 7.2), semi-products and clock dials that are coated with a luminescent paint with ^{226}Ra and ^{90}Sr (Fig. no. 7.3 and 7.4) and different military gauges with ^{226}Ra illuminated dials (Fig. no. 7.5 - 7.7). Also, the previously mentioned **fire detectors** with ^{226}Ra or ^{241}Am (Fig. no. 7.8) and cable amplifiers fitted with surge arresters which contain ^{226}Ra (Fig. no. 7.9 and 7.10) are involved in this category.

Pulley, blade and elastic blade holder of the cultivator (Fig. 7.11-7.14) are presented as the examples of the metallurgical products that are contaminated by ^{60}Co from randomly melted sources. (Fig no. 7.11 – 7.14).

The seized **radionuclide sources** are also presented by a thickness gauge with a ^{90}Sr source, a level gauge with ^{60}Co source and ice thickness gauges with ^{90}Sr installed on military aircrafts (Fig. no. 7.15 – 7.18).

The overview of branches and workplaces where radionuclide sources are used

This brief overview of the branches, the workplaces that handle radionuclides and the methods of the most frequent radionuclide applications describes a wide range of radionuclide utilization in the human society. Special attention is devoted to the ionizing radiation sources that are used in industry and health service.

Geological survey: Radiation logging workplaces, laboratory ash-gauges, etc.

Mining: Overflow/clogging alarm detectors on belt conveyors or discharge chutes, carriage impact counters, switch controllers on mine locomotives, signalling at landings, level indicator in bunkers, indicators of filling/emptying trucks and emptying skip car, free depth alarms, direction control of coal cutter loader movement, etc.

Fuel industry: belt conveyor clogging alarm detectors, level indicators in reservoirs, ash-gauges, piping level indicators, coal and coke moisture measurements, etc.

Metallurgic industry: charge control and indoor level indication, sheet thickness indication, casting quality control (i.e. homogeneity), etc.

Building material production: level indicators in reservoirs, raw material moisture measurements, cableway truck counters, etc.

Heavy chemistry: level indicators in reservoirs, plastic and rubber polymerization, plastic depolymerization, pipe medium density measurements, etc.

Civil engineering: consolidation monitoring, especially in highway construction.

Engineering: non-destructive testing – quality control of stressed engineering products, weld checks during piping and boiler construction, etc.; lacquer hardening, thickness inspection of component metal coating in electrical engineering (especially gilding).

Glass industry: glass thickness inspection and glass tube thickness inspection.

Textile and rubber industry: rubber polymerization, coated rubber thickness checks, removal of electrostatic charge in spinning mills and weaving mills, rubber coating product lines, etc.

Paper production: thickness measurement and paper moisture measurements, removal of electrostatic charge.

Sugar industry and other food industry: level indication in tanks and flow level indicators in piping, spice and other food irradiation, radiation sterilization, etc.

Fire protection: fire detectors.

Agriculture: seed corn irradiation, embryo irradiation in line breeding and selective breeding.

Health service: labelled isotope examination, tumour irradiation, etc.

Research: a wide application of sources nearly in all branches.