Qualification Descriptors for the training of Radiation Protection Officer for measurement and control applications of ionizing radiation – sealed sources (RPO MC-S)

Jacoba Beiboer (RUG)
Patricia Bekhuis (TU Delft – location UU)
Hielke Freerk Boersma (RUG)
Arjo Bunskoeke (RUG)
René de Goede (Douane)
Michel Koster (NRG)
Andre Zandvoort (RUG)

Qualification Descriptors training Radiation Protection Officer measurement & control applications – sealed sources

In the Netherlands, a relatively large number of sealed sources are used for both mobile and immobile measurement, control and inspection applications.

For all these applications the possession and application are subject to the Decree on Basic Safety Standards Radiation Protection (Dutch: *Besluit Basisveiligheidsnormen Stralingsbescherming* (Bbs)) and underlying regulations. This means, among other things, that the person using or supervising the source must be adequately trained for this. The current inspection system has the requirement for these sources to follow the training for Radiation Protection Officer (in short: RPO) for measurement and control applications, abbreviated RPO MC (art. 5.22, paragraph 1, sub i of the Regulation Basic Safety Standards Radiation Protection (Dutch: *Regeling Basisveiligheidsnormen Stralingsbescherming* (Rbs)). However, there is no direct link in the regulations between the specific application and the training to be followed by the intended RPO. In many cases this is clear from the used nomenclature (as with dentists who apply Cone-Beam equipment), but this is not the case for measuring and control applications.

In licenses issued under the Decree on Radiation Protection that was effective until February 6, 2018, a distinction was made between low and moderate risk applications on the one hand and the number of low risk applications on the other hand. The gradual approach used in the creation of the Bbs has led to a control system in which a distinction is made between devices that exempt and devices that are subject to registration or licensing. When asking for which applications the RPO MC-S training program should be intended, it is therefore obvious to take the practices mentioned in the Bbs as a starting point. As exempted and registration-based applications generally result in a low risk, it can be assumed that they fall in that category in any case. We note here that for exempted applications, training for RPO MC-S is (too) much asked given the actual risk. Furthermore, in our opinion, also for a few applications requiring a license, an RPO who is trained at the RPO MC-S level may suffice. The following table lists the practices with sealed sources for which, according to this advice, at least the RPO MC-S training should be followed.

Description	Based on Bbs art.	Restrictions	Remarks
Exempted sealed sources	3.17 par. 1	See Bbs art. 3.17 par. 2	for example calibration sources in measuring equipment
Sealed sources in devices and appliances	3.18 par. 1 sub a	Dose rate < 1 μSv/h at 0.1 m distance and approved by ANVS	approved smoke detector
Practices with sealed sources for which $\Sigma A/D$[1] < 0.01	3.10 par. sub b	Except if subject to license cf. Bbs art. 3.8 par. 3	
Practices with sealed sources for educational or scientific purposes	3.8 par. 3 sub f	Provided in a permanent measurement set-up and exposure at regular use is < 1 mSv/y for employee	
Practices with a highly-active source	3.8 par. 3 sub g	Provided in a permanent measurement set-up and exposure at regular use is < 1	

[1] 'Dangerous quantities of radioactive material (D-values)', IAEA, 2006 (IAEA-EPR-D-Values 2006)

		mSv/y for employee	
Other Practices with sealed sources in a permanent measurement set-up	3.8 par. 3 sub i	Provided exposure at regular use is < 1 mSv/y for employee	
Practices with neutron generators for measurement and control purposes	3.8 par. 2 sub j	Provided the regular use of the neutron generator cannot lead to exposure of more than 1 mSv/y for employees; Note: for neutron generators also MC-D[2] must be followed	

The RPO for measurement and control applications often does this part-time, for example as a measurement & control technician, maintenance engineer, safety expert, quality officer or production manager. In common situations, he/she can fall back on a (whether or not hired in) radiation protection expert. The recommended preliminary education level is at least European Qualifications Framework (EQF) level 2[3].

In the current Qualification Descriptors RPO MC, (core) tasks have been formulated by the working group led by Helderop that form the basis for the RPO training. The main focus was on the differences between the two levels of expertise (the former N5 and N4) and the need to take this into account in the new situation. The working group felt that, given the size of the target group, there was no need for a separate training or additional module to replace the N4 training for which the radiation protection level 4 training applied in the old system. This is despite the fact that the ENETRAP II research group (WD 3.1) makes a distinction in their report between basic scenarios and complex scenarios. The working group suggested in this case to regard 'complex scenario' as a possible supplement to the training course 'radiation protection measure and control sources' (basic) with an extension for complex scenarios (higher risk), with emphasis on deepening knowledge and extra attention for supervisory duties and the organizational, procedural and administrative (OPA) aspects. This has not been worked out further in the recent period, possibly because such scenarios either do not exist or are covered by radiation protection experts.

We therefore recommend that for more complex situations than those for which the above table applies, the education level of radiation protection expert is required at the level of coordinating Radiation Protection Expert.

For the RPO MC-S training - just as for the current RPO MC training - it is recommended to use a level in accordance with EQF level 4[4] and to use at least one day every five years as a minimum requirement for adequate additional training.

[2] MC-D: Measurement and Control applications - Devices

[3] EQF: European Qualification Framework – level 2 roughly corresponds to pre-vocational secondary training ('VMBO')

[4] EQF level 4 roughly corresponds to vocational education and training ('MBO-4')

Core competencies.

Core competency 1

The Radiation Protection Officer (RPO) performs practices and/or supervises the implementation of practices, such that the practices are performed responsibly and safely to prevent unnecessary exposure of himself and others. Hereby the stipulated rules and guidelines, justification, optimization (ALARA principle) and the dose limits are taken into account.

In this context, it is important that the RPO:

1. Supervises risk reduction in accordance with the ALARA principle and the practical implementation thereof (such as time, distance and shielding). He/she will adequately and convincingly propagate and implement this principle.
2. Ensures a safe and responsible use of the application, by following the stipulated rules, guidelines and instructions.
3. Ensures the correct use of (personal) protective equipment and, if necessary, sets up special work areas.
4. Is able to monitor compliance with the provisions in the care system and work agreements made.
5. Takes additional measures if this is necessary because of the protection.
6. Recognizes incidents, responds to them correctly and initiates improvement actions.

Therefore it is necessary that the RPO:

7. Has sufficient knowledge of the properties of ionizing radiation and radioactivity.
8. Has sufficient knowledge of the units of radioactivity and contamination.
9. Has sufficient knowledge of external and internal exposure and is able to interpret the units of measurement.
10. Has some knowledge of the biological effects of radiation at high and low doses.
11. Has some knowledge of the concepts of absorbed dose, equivalent dose, effective dose and environmental dose equivalent.
12. Has sufficient knowledge of the legal requirements and guidelines for measurement and control applications with sources.
13. Is familiar with the basic principles of radiation protection (justification, ALARA and dose limits) and is able to apply them.
14. Has sufficient knowledge of radiation measuring equipment, dose monitors and protective equipment, and is able to use and maintain it in a responsible manner.
15. Knows the principle of dose reduction: duration, distance and shielding.
16. Is familiar with the working and application of personal dosimetry.
17. Is familiar with how to act in the event of incidents and emergencies.

Core competency 2

The radiation protection officer (RPO) ensures that the administration for managing and using the application is up to date in accordance with the applicable legislation. He/she knows when it is necessary to consult experts and follows further training to keep the knowledge up to date.

Further characterization of the context:

The radiation protection officer is responsible for ensuring that work is carried out safely in accordance with legislation and regulations, and must provide written and oral instructions for employees. He/she is responsible for the use of the correct measuring equipment and protective equipment. He/she makes sure that a proper administration is maintained and knows when he/she should consult the radiation protection expert, for example for the preparation or approval of the risk inventory and evaluation (RI&E). He/she takes care of a thorough administration such as with regard to the exposure of employees and third parties. He/she is responsible for the quality of the radiation protection management system.

In this context, it is important that the RPO:

18. Knows the limits of his/her own knowledge and expertise.
19. Knows the role of the radiation protection expert and asks him for support if necessary.
20. Maintains a well-arranged administrative management system, including an up-to-date Nuclear Energy Act file, and prepares a radiation-based annual report of the application.
21. Ensures the presence of an adequate RI&E approved by a radiation protection expert, related to the intended use, taking environmental conditions into account.
22. Supervises the planning and execution of the acceptance test(s) before commissioning a device that contains a sealed source, the periodic maintenance of the device, and ensures adequate disposal of sealed sources.
23. Ensures that leakage tests are carried out by an authorized person and that the results are assessed by a radiation protection expert.
24. Ensures the periodic inspection of radiation measuring equipment.
25. Establishes / assesses clear work protocols and monitors compliance with them.
26. Ensures a safe working environment that is set up and indicated according to legal regulations.
27. Knows where and how to consult the relevant laws and regulations and keeps abreast of relevant changes.
28. Ensures that ALARA measures are implemented and that dose limits are not exceeded.
29. Knows personal protective equipment and realizes that they are usually not necessary in his/her practice.
30. Can assess whether personal dosimetry is required for the application.
31. Implements improvements based of the results of an RI&E and/or inspection.

Therefore it is necessary that the RPO:

32. Knows the applicable laws and regulations.
33. Is familiar with the basic rules in the field of transport of radioactive sources (class 7).
34. Has sufficient knowledge of safety regulations and signs.
35. Knows in which cases the RPO is responsible and in which cases the radiation protection expert.
36. Understands the own Nuclear Energy Act license or registration, and knows how he/she submits an application for this, often in consultation with the radiation protection expert.
37. Has some knowledge of the applications of measuring & control equipment in the form of sealed sources.
38. Has good administrative skills.
39. Keeps his knowledge and skills up to date.

Core competency 3

The radiation protection officer has communication skills to convincingly provide, both solicited and unsolicited, substantive adequate advice and instructions on how to work safely with ionizing radiation, and to ask for advice or assistance if the situation demands it.

In this context, it is important that the RPO:

40. Is familiar with the duties and authorizations of the RPO and the radiation protection expert.
41. Ensures that the employees involved receive sufficient information and instruction with regard to the hazardous aspects and exposure risks of (the use of) sealed sources.
42. Has sufficient knowledge of any necessary protective equipment.
43. Consults sufficiently the radiation protection expert about reports, registrations and notifications, and conducts consultations in case of deviations or if otherwise necessary.
44. Can provide an explanation of the experimental results of both radiation measurements and dosimetry.
45. Reports incidents.

Therefore it is necessary that the RPO:

46. Has knowledge of the applicable regulations, guidelines and instructions, and the legal context thereof.
47. Has knowledge of the duties and authorities that the relevant organization assigns to the RPO.
48. Has knowledge of risk perception.
49. Has sufficient communication and didactic skills to provide adequate information and instruction.
50. Is able to communicate the requirements for radiation protection within the organization and can report to the radiation protection expert and management.

Learning outcomes for radiation practicals

Due to the importance of a lab practical in the training course, a summary of the specific and minimal practical learning outcomes based on the stated qualification descriptors is given.

The RPO:

- can use measuring equipment for measuring radiation from devices
- can make a shield for the application
- performs reliable dose (rate) measurements
- measures influence on the dose at different distances from the source
- can apply a source safely
- measures direct and scattered radiation

Examination

To be eligible for a RPO MC-D diploma, a candidate must have obtained at least a pass for at least the components:

1. the written exam;
2. a practical part;

The details of the assessment and general procedure are laid down in the examination regulations of the accredited training institute.

In addition, testing of skills such as being able to inform, advise, write a protocol, etc. can take place, for example, by assessing submitted (practical) assignments, lectures to be held, active (and compulsory) participation in discussion meetings (360-degree feedback), role playing etc.

Re 1
On the basis of a written exam, ready knowledge and understanding of the curriculum offered is tested. The candidate achieves a pass if the predetermined criteria (described in the examination regulation) are met.

Re 2
Based on, for example, observations and assuming 100% participation, the qualification is insufficient / sufficient according to the predetermined criteria, as described in the examination regulation.

Appendix 1: Table of keywords from the lesson material RPO MC-S

This table should only be viewed as a whole in the context of this report and cannot be used or cited as an independent entity. The table does not pretend to be complete but gives a minimum number of subjects that should be addressed in the training program. The column headings K, S and C stand for Knowledge, Skills and Competencies. These three categories are listed hierarchically: K<S<C. Thus without knowledge, there can be no skills and without skills there can be no competencies. This hierarchy should be applied with some reservation. To be competent in some subjects, one must also have a professional attitude. Therefore, the three categories are sometimes given as Knowledge, Skills and Attitudes. In this document, we adhere to the definition of competencies as is given by the IAEA : 'Competence is the ability to apply skills, knowledge and attitudes in order to perform an activity or a job to specified standards in an effective and efficient manner'. Additionally, one also asks to what measure the RPO MC-D must be able to explain the subject to his colleagues while giving instruction - this is also listed under the category 'Competencies'. From a historical perspective and to keep uniformity with other tables, we have chosen to keep the K<S<C designations.

This list is based on the similar list from the document that led to the Qualification Descriptors TMS VRS-D in 2016 [5]. This list gives a gradation in 3 levels with 1 the lowest (global knowledge) and 3 the highest (detailed knowledge). Given the above, it will be clear that in any case level 3 cannot always be translated one-on-one into Competence.

[5] H.F. Boersma et al., "Eindtermen voor de opleiding tot toezichthouder stralingsbescherming voor verspreidbare radioactieve stoffen – Niveau D", September 2016 (te be downloaded via this link)

General	**K**	**S**	**C**
atom structure	X		
ionization, excitation	X		
proton / neutron ratio	X		
radioactive decay, half-life	X	X	
decay formulas and decay constant	X	X	
mother-daughter connections (qualitative)	X		
specific activity	X		
α-, β-, γ-decay, electron capture, internal conversion	X		
characteristic X-ray radiation	X		
Bremsstrahlung radiation	X		
decay schemes	X		
energy spectra α-, β-, γ-emitters and Bremsstrahlung	X		
range	X		
inverse square law	X	X	
half-thickness	X		
interaction mechanisms for α-, β-, γ-emitters	X		
nuclear reactions and neutron activation (qualitative)	X		

General – *sealed sources*	**K**	**S**	**C**
applications of sealed sources			
- calibration of measing equipment	X		
- gas chromatography	X		
- thickness and liquid-level measurements	X		
- neutron production	X		
- industrial radiography	X		
- other applications	X		

Basic competencies	**K**	**S**	**C**
physics (including electromagnetic radiation, duality, wave/particle)	X		
biology (human anatomy, physiology, DNA, cell division)	X		
epidemiology (risks)	X		
justification	X	X	
optimalisation/ALARA	X	X	
dose limits	X		
exposure situations (planned, existing, incident)	X		

Natural radioactivity	**K**	**S**	**C**
U- and Th-decay chains	X		
cosmic radiation, terrestrial radiation	X		
doses as a consequence of natural radioactivity	X		
radon	X		

Detection	**K**	**S**	**C**
gas-filled detectors	X		
- ionization chambers	X		
- proportional counters	X		
- Geiger-Müller counters	X		
scintillation detectors	X		
- Na(I)	X		
- plastic scintillators	X		
- liquid scintillation counters	X		
- thermoluminescence detectors	X		
semi-conductor detectors such as Ge, Si, CCD, etc.	X		
dead time	X		
counting efficiency, (intrinsic-)	X		

counting statistics	X		
minimal detectable activity / counting rate	X		
spectrometry, pulse height analysis	X		
measuring devices for dose and dose rate	X	X	
personal control devices (both active and passive)	X	X	
Dosimetry	**K**	**S**	**C**
exposure	X		
absorbed dose	X	X	
weighting factors	X		
equivalent dose	X		
effective dose	X		
ambient dose equivalent	X		
personal dose equivalent	X		
rules of thumb average energy β-particles	X	X	
rules of thumb regarding β- and γ-dosimetry	X	X	
rules of thumb range β-particles	X	X	
principle protection measures (time, distance, shielding)	X	X	X
source constant	X		
interpretation of measurement results	X	X	
Biological consequences of radiation	**K**	**S**	**C**
stochastic effects and tissue reactions	X		
factors that influence the biological effect:			
- tissue properties and environmental factors	X		
irradiation of the entire body and partial irradiation	X		
free radicals, DNA-damage, repair mechanisms	X		
genetic effects	X		
teratogenic effects	X		
risk estimates	X		
risk numbers	X		
Organization and legislation	**K**	**S**	**C**
norms and legal regulations, (inter)national organizations	X		
(inter)national organizations with regards to radiation safety, consistency	X		
historical developments	X		
legislation			
- Directives European Union	X		
- Nuclear Energy Act (Kew)	X		
- Decree on Basic Safety Standards Radiation Protection (Bbs)	X		
- Decree on Transport Fissile Materials, Ores, and Radioactive materials	X		
- underlying relevant ministerial regulations and ordinances	X		
justification, optimization (ALARA) and dose limits	X		
exemption / clearance	X		
how to apply for license or registration	X		
source-oriented approach	X	X	
radiotoxicity equivant (Re)	X		
supervised and controlled zones	X		
determination of yearly dose for rooms, workers and others	X		
exposed A and B workers	X		
definition sealed source	X		
ISO 2919 for requirements on closed sources	X		
practical implementation for transport of radioactive materials	X		
Organizational aspects radiation protection	**K**	**S**	**C**
responsibilities within the radiation protection organization	X	X	
Nuclear Energy Act file	X	X	

disposal of sources	X	X	
External irradiation	**K**	**S**	**C**
small beam and broad beam geometries and build-up factor for photon radiation	X		
choice of material for shielding as a function of photon energy	X		
simple dose calculations, also for scattered radiation	X	X	
use of graphs and tables with regards to attenuation and transmission for sources	X		
shielding of neutron radiation (qualitative)	X		
Internal contamination	**K**	**S**	**C**
inhalation and ingestion	X		
simple calculation using e(50)	X		
Practical aspects	**K**	**S**	**C**
protection measures	X	X	
retrospective inventory and evaluation of incidents	X		
practical skills in measuring dose rates	X	X	
knowledge and practical skills of different cordoning off levels (map, tape, barricade)	X	X	
position COVRA	X		
Risk-inventory and evaluation	**K**	**S**	**C**
RI&E-description	X	X	
Communication	**K**	**S**	**C**
give short, succinct and target-group oriented knowledge transfer	X	X	
write work protocols / internal protocols	X	X	
determinants of risk perception	X		
supporting and informing the Radiation Protection Unit	X	X	