# Qualification Descriptors
# for the training of
# Radiation Protection Officers
# in
# Dispersible Radioactive Materials
# Level C
# (RPO-DRM C)


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## Foreword

The Authority for Nuclear Safety and Radiation Protection (ANVS) requested the field to revise the training system for Radiation Protection Officers. The core of these revisions which derive from the European Basic Safety Standards (EU-BSS)[1] is that the training for Radiation Protection Officers should be application specific. During the past two years, a start has been made on these revisions[2]. As an outcome of these revisions, the University of Groningen has decided to form a workgroup whose task is to formulate the qualification descriptors for the training of Radiation Protection Officers of Dispersible Radioactive Materials, abbreviated as RPO-DRM. The content of this document is in part borrowed from the document that was submitted to the government in 2013 regarding the qualification descriptors for the training of – as it is now known – Coordinating Radiation Protection Expert (RPE)[3].

The qualification descriptors are meant for the tasks of the Radiation Protection Officers of Radioactive Materials in dispersible form in unlimited quantities. Unlimited here refers to "all permits that relate to radioactive materials in dispersible form, regardless of the licensed activity". The definition and tasks of the Radiation Protection Officer are given in the Radiation Protection Decree. The definition reads: "A Radiation Protection Officer is an expert that performs or conducts work, or under whose supervision an act or work is carried out (art. 1)". The description of the tasks can be found in Articles 9 through 11 and 13 of the Radiation Protection Decree (Bs)[4].
Radioactive materials in dispersible form are applied or play a role in the following areas:

- Research, analysis and material research
- Production of radioactive materials in dispersible form
- Human radiodiagnostics, radiotherapy and nuclear medicine
- Nuclear installations and decommissioning thereof
- Accelerators and the decommissioning thereof
- Use and handling of NORM material
- Veterinary radiodiagnostics, radiotherapy and nuclear medicine

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[1] Council Directives 96/29/Euratom (13 May 1996) and 2013/59/Euratom (5 December 2013)
[2] See B.C. Godthelp and A.M.T.I. Vermeulen, Ned. Tijdschrift voor Stralingshygiëne, jg.6, nr.3 (2015), p.9 and references therein
[3] S. van Dullemen and group members, 'Eindtermen voor de opleiding Stralingsbeschermings-deskundige', 17 January 2013.
[4] Radiation Protection Decree 16 July 2001, Staatsblad 397 (2001), http://wetten.overheid.nl/BWBR0012702/2015-01-01/0

- Performance of leakage testing on encapsulated (or other “closed”) radioactive sources

The present qualification descriptors are primarily meant for the first three categories on the understanding that a RPO-DRM can supervise in the medical sector as long as radioactive materials are not applied to the patient (no direct patient contact). Should this be the case, then the supervisor should have successfully completed a training for Radiation Protection Officer for Medical Applications.
The workgroup recommends enabling an easy transition from RPO-DRM to the relevant RPO-MA in situations in which patient contact remains limited. In addition, the performance of leakage tests should be done by the RPO-DRM or under his/her supervision.
The RPO-DRM can be the responsible party for releasing material, waste, equipment and the performance of control measurements on any residual contamination in the laboratory. The RPE is actually responsible for the release of the entire laboratory, including technical facilities outside of the lab such as sewer pipes and ventilation systems. The release or dismantling of rooms and technical facilities (during decommissioning) where there is a risk of activated material also falls under the responsibility of a RPE.
In many radionuclide laboratories, small calibration sources are present. The qualification descriptors for RPO-DRM C should also be sufficient to function as a Radiation Protection Officer for these sources.
The ANVS is currently working on an adjusted system of permits, registrations and notifications to comply with the new Decree on Basic Safety Standards for Radiation Protection (Bbs) and the implementation of the new EU-BSS. The implementation of this project strives for a gradation approach, which is to say that the requirements increase as the risk of the application becomes greater.
In light of this, the workgroup is of the opinion that a two- to three-fold division in the level of RPO-DRM is desirable, and for pragmatic reasons it is proposed to hold to the limits of the Directive Radionuclide Laboratories[5], which in any case adheres to the gradual approach for regular applications:

1. RPO-DRM B for radionuclide laboratories at B-level ($A_{max}$ = 2000 $Re_{inh}$*)
2. RPO-DRM C for radionuclide laboratories at C-level under the direct repsonsibility of a RPE ($A_{max}$ = 20 $Re_{inh}$*)
3. RPO-DRM D for radionuclide laboratories at D-level under the direct repsonsibility of a RPE ($A_{max}$ = 0,2 $Re_{inh}$*)

(*: for p=-1 and the highest possible q value, for storage p=0 can be chosen)

[5] Richtlijn Radionucliden-laboratoria, Min. van VROM, Hoofdinspectie Milieuhygiëne, Publicatie 94-02, 1994 – withdrawn in 2002; relevant portions are incorporated into many permits.

A RPO-DRM will, in many situations regarding radiation protection, work under the direct "responsibility" of a RPE. A RPE generally possesses a broad expertise in the area of radiation protection and functions as the first contact point for the RPO-DRM for incidents, etc.

A RPO-DRM works mostly alone and occasionally must quickly make a decision in the monitoring organization based on the relevant radiation risks. In such a situation, the RPE is mostly hired in and has limited tasks as minimally defined by law in the Bs. More is expected from the RPO-DRM, such as quickly making decisions during incidents. The workgroup believes that the difference between these two situations is mainly a distinction in the basic knowledge of a RPO-DRM B with respect to a RPO-DRM C and D. A solitarily-operating RPO-DRM should thus be trained to the RPO-DRM B level.

The EU-BSS states that a Radiation Protection Expert can perform the tasks of a Radiation Protection Officer. Beginning with the assumption that this implies that in the Bbs the tasks from a RPO may be performed by a RPE, then there is no reason to formulate separate qualification descriptors for an RPO-DRM Level B – this person should successfully complete the training for a RPE. The workgroup recommends to state explicitly in regulations that, cf. Article 9.2 of the current Bs, the application-specific portion of the training for a RPO-DRM C counts as appropriate training in radiation protection for a RPO-DRM B.

*In light of the above, we assume for the qualification descriptors stated in this document that the RPO-DRM works under the substantive responsibility of the RPE within the organization.*

In this document, we limit ourselves to the qualification descriptors for **RPO-DRM C**, which we will refer to as RPO-DRM. Qualification descriptors for RPO-DRM D will be given in a separate document.

The field of radiation protection in fact encompasses multiple disciplines, including such diverse subjects as radiation physics, radiobiology, dosimetry of internal and external contamination, radiation safety, medical and industrial applications of ionizing radiation, and laws and regulations. The RPO-DRM fulfills diverse rolls:

- Supervisor of daily operations
- Advisor / instructor
- Risk inventory evaluator
- Producer of work procedures / protocols
- Implementer
- Intermediary between worker and RPE
- Oracle

In addition to the above-mentioned roles, it is desirable that the expert possess skills such as organization, and a feel for social and especially internal relationships. In addition, an awareness of risk perception is required.

The RPO-DRM is an expert in the correct way of measuring activity, radiation levels, (skin) contamination, etc, and in interpreting measurements, making a dose estimate and placing it in the context of limits and any dose constraints, (potential) health damage and the measures to be taken. The RPO-DRM can perform higher than basic level dose and shielding calculations. This requires an appropriate amount of current, ready knowledge and understanding (knowledge) from both professional aspects of the field (such as basic hard core physics) as well as organizational, procedural and administrative matters (indicated with the acronym OPA-aspects); skills that the expert in consultation with the RPE can apply in an appropriate manner within the organization and can implement matters; and insight and professional expertise (competence). This last concept integrates knowledge, insight, skills and a professional attitude. The training for a RPO-DRM is an HBO-level education. The prerequisites for a course participant will in many cases be MBO or HBO level with a profile in the exact sciences (physics and health, or physics and technical) from secondary school. The point of formulating competencies is to form a better picture of what the tasks are, in which context they must be performed and the quality with which someone must be able to do them. A competent professional is someone who can perform specific tasks in a particular context with a high degree of quality. In looking at the context in which the RPO-DRM works, a distinction can be made between three important work situations.

- The RPO-DRM supervises and enforces the relevant laws and regulations in the area of ionizing radiation, enforces the rules from the local permits and work instructions, and gives content-appropriate advice to an organization in consultation with the RPE.

- The RPO-DRM contributes appropriately to the processing by the RPE of a (threatened) incident or undesired happening.
- The RPO-DRM works actively on the maintenance of his own expertise and that of others within the applications for which he is responsible.

The draft qualification descriptors for the basic competencies of an RPO-DRM are therefore grouped in four clusters: ***Prevention (proactive), Crisis Management (reactive), Professionalization and Information, and Specialization (open sources),*** for the different tasks of the expert, such as informing, supervising, monitoring and measuring, making work protocols, managing a comprehensive KEW administration system, contributing to risk analysis and incident processing, classifying exposed workers, and matters concerning the Nuclear Energy Act permit, etc. In addition, draft qualification descriptors have been formulated for the application-specific competencies of the RPO-DRM.

When drafting the qualification descriptors, the workgroup realized that the former Level 4B training is from origin the training for workers who in large part may work independently in radionuclide laboratories and may even occasionally be deployed as an RPO. One can assume therefore that there will be a large overlap with the qualification descriptors of the training Radiation Expert Level 4B[6]. The length of the course should be about 10-12 days. This nominal training period can vary per educational institute according to the didactic interpretation (schedule, contact hours versus self study, contact hours versus e-learning/blended-learning, the use of web lectures, etc), the combination with other courses for RPO, the entry level of the participants (prerequisites), and the extra packets offered in addition to the minimally required packet. The radiation practical should consist of two to three days out of the total course length and the professional attitudes section should comprise about one to one-and-a-half days.

The draft qualification descriptors and an appendix in which the key terms from the material are listed follow.

[6] Appendix 3.2, Uitvoeringsregeling Stralingsbescherming EZ 2013 (Staatscourant 2013, 32478)

## Qualification descriptors

**Core competency 1:**

**The RPO-DRM supervises and enforces (for the applications for which he[7] is responsible) the relevant laws and regulations in the area of ionizing radiation and gives content appropriate advice to the workers and the organization in consultation with the RPE.**

**Further characterization of the context**

This work is for the most part performed in or near the laboratory. The work also includes administrative tasks and participation in regular consultations. For the RPO-DRM, this is generally an important secondary component of his remaining work. The RPO-DRM involves the RPE for those tasks that the RPE is responsible for and proceeds within the framework specified by the RPE. The RPO-DRM consults with him professionally if necessary to safeguard the quality of the radiation protection for the application for which he is responsible.

**In this context, it is important that the RPO-DRM:**

1. contributes to the drafting of an appropriate risk inventory and evaluation (RI&E), related to the entity's goal and taking into account the worker's interests; is aware of the tension between different interests and that, in practice, remains supple and flexible without losing sight of the desired goal (a safe work place);
2. sets, evaluates and improves appropriate working protocols and procedures, thereby taking into account the organizational-specific features/risks/application possibilities/experts present and applying the principle of a Plan-Do-Check-Act (PDCA) cycle;
3. implements a source-oriented practical approach;
4. gives advice (both requested and unsolicited) for policy focused on risk limitation and the practical implications thereof for employees, visitors of the organization, and the environment, and implements this policy appropriately and convincingly in the organization;
5. manages appropriately the tension between the application of the optimization/ALARA-principle and the costs associated therewith;
6. realizes his position within the department and/or organization (organizational sensitivity) and therefore acts appropriately;

[7] In the explanation of the qualification descriptors, the masculine pronoun “he” is used, but of course we mean “he or she”.

7. realizes his position within the radiation protection organization and his relation to the RPE and therefore acts appropriately;
8. advises on and assesses the use/application of certain work methods for radiation sources, based on the knowledge of various detection methods;
9. contributes advice on the desired structural facilities and design with regards to radiation protection for new buildings and remodeling;
10. reliably and reproducibly measures the radiation level, surface contamination, the activity (for example, in excretions) and the dose (rate) using measuring techniques and statistics;
11. knows how to periodically check measuring instruments for their proper functioning;
12. contributes to instituting regular quality monitoring systems for PDCA cycles:
13. advises on the appropriate personal protective devices for distinct activities/actions (manner of exposure) and situations;
14. estimates risks for pregnant (exposed) workers and gives appropriate advice in consultation with a RPE and radiation physician when necessary;
15. issues and manages the most suitable form of personal dose monitors to exposed workers;
16. interprets obtained measurement data and relates it in context to dose contraints and limits;
17. performs correct shielding calculations, determines exposure pathways and derived operating limits, and calculates the effective (committed) dose for external irradiation and internal contamination

**Therefore it is necessary that the expert:**

18. has knowledge of the mathematics, physics and chemistry at the exam level of at least HAVO or equivalent;
19. has the basic skills to be able to read and apply specialist literature (mathematics, statistics, calculation skills, working with spreadsheets, etc.);
20. has knowledge of the three main principles of radiation protection (justification, optimization/ALARA, limits);
21. possesses knowledge of basic human anatomy and physiology;
22. makes shielding calculations for all the relevant radiation types;
23. interprets the issued Nuclear Energy Act permit and knows when this should be changed;
24. contributes to the calculation of the dose at the site boundary and the doses of employees and visitors;
25. has knowledge of the current and relevant legislation and regulations;
26. possesses general knowledge to secure radioactive sources;
27. contributes to a permit application or change in permit;
28. understands all the dose concepts and other related concepts stated in the current regulations and permits and is able to work with them;

29. knows the requirements that are set in the Nuclear Energy Act file and the remaining administrative requirements and can apply these to his work situation;
30. knows the rules and applies them to the appropriate portion of the lifecycle/logistics manangement chain of radioactive materials (including radioactive waste);
31. contributes to the division of supervised and controlled zones, including the description of required structural facilities (laboratory design) and access procedures;
32. is familiar with transport regulations (ADR) with regards to radioactive materials, determines whether the requirements of ADR class 7 are applicable, recognizes labels, performs a transport index determination and correctly completes a transport document;
33. knows the ICRP models for internal contamination calculations and can perform simple calculations;
34. applies the optimization/ALARA principle to operations and activities of differing complexity;
35. is familiar with the nuclide chart and can use the given data in calculations;
36. has sufficient knowledge and insight in radiobiology to make risk estimates and thereby give advice to (exposed) workers;
37. gives appropriate and effective, goal-oriented work instructions and information, both to individuals and groups; records the contents of and participants in these instructions or information in the KEW (Nuclear Energy Act) file;
38. possesses knowledge of the physical and radiobiological properties of alpha-radiation, beta-radiation, positrons and photons, and a minimal knowledge of neutrons and protons;
39. has knowledge of the relevant detection methods and their suitableness for applications of radioactive materials of various kinds;
40. has knowledge of the secondary effects of radiation (bremsstrahlung);
41. has general knowledge of background radiation (nature, type, origin, dose load per path).

**Core competency 2:**

**De RPO-DRM contributes to the appropriate management of an unintentional event or (imminent) incident for the applications for which he is responsible.**

**Further characterization of the context**

Appropriate prevention and precautions do not eliminate the possibility that an incident, in which radiation plays a role, will threaten to develop or actually does occur. In such a situation, it is expected that the RPO-DRM undertakes first line actions, informs the RPE and subsequently follows his instructions.

**In this context, it is important that the expert:**

42. makes an appropriate estimate of the urgency/risk for an (imminent) incident;
43. knows or applies the suitable measures, detection and measuring methods, and interprets the derived measuring results;
44. actively takes responsibility for his role;
45. contributes to the normalization of a deviant situation;
46. gives timely dose estimates based on measured values and data reported in the Handbook of Radionuclides (or similar);
47. contributes to appropriate direction of and cooperation with other experts and disciplines (for examply, with the department Communication/Public Relations), including any reports to the Inspectorate;
48. contributes to the evaluation of the incident and the translation of the outcome to policy and internal procedures.

**Therefore it is necessary that the expert:**

49. quickly reviews the situation because he is familiar with the sources, locations, and procedures, and has knowledge of the risk inventory and evalution;
50. knows the practical rules of thumb for both internal contamination and external irradiation and can quickly apply them;
51. estimates when acute medical help is required as a result of radiation incidents, when possible in consulation with the RPE but when necessary independently;
52. informs exposed (or those who think they are exposed) people appropriately based on factual information.

**Core competency: 3**

**The RPO-DRM actively works on furthering his own expertise and those of others for whom he is responsible.**

**Further characterization of the context**

Knowledge can become quickly outdated, especially with regards to regulations and work methods/applications, and therefore must be continually updated and expanded. This not only applies for the expert himself but also for the workers who are under his supervision. The RPO-DRM has legal repsonsibilities (Decree on radiation protection) with regards to the information and instruction of (exposed) workers (whether or not they are pregnant).
The RPO-DRM will also be involved in disaster drills and contribute to the preparation and guidance of governmental inspections as directed by the RPE.

**In this context, it is important that the expert:**

53. effectively communicates about radiation risks, work precedures, etc, with all involved parties (his own workers and the RPE);
54. sufficiently oversees his own area regarding radiation protection and acquires a certain depth so that he is actually seen as an expert and therefore can give convincing and factual advice and information;
55. places radiation risks in a social context;
56. compares the relationship between radiation risks and those of other agents and risks on the work floor with the occupational health and safety risk policy, and therefore take into account the differences in risk perception;
57. composes and assesses understandable work protocols;
58. reflects on his own norms and values, integrity and ethics;
59. recognizes the limits of his own expertise and expands his training;
60. is open to, or should he doubt his own expertise, actively seeks intervision, critical feedback or advice from the RPE;
61. reflects on his own risk perception regarding radiation exposure.

**Therefore it is necessary that the expert:**

62. gives practical interpretation on the system of radiation protection within his application;
63. is familiar with the training possibilities and sufficiently familiar with the literature and internet in order to keep his knowledge current;
64. is aware of the critical success factors in (risk) communication tailored to different target groups;
65. is aware of (the limits of) his own skills and competencies.

**Core competency 4:**

**The RPO-DRM possesses knowledge, skills, attitudes and competencies that specifically apply to radioactive materials in**

| |
|---|
| **dispersible form.** |

**Further characterization of the context**

Core competencies 1 through 3 generically describe the basic competencies that RPO-DRM should have. The elaboration of these competencies is in most cases - but not all - general in nature. The RPO-DRM should have specific knowledge with regards to the dispersible character of radiactive materials.

**In this context, it is important that the expert:**

66. stays current on the best practices and appropriate measures to prevent dispersion of radioactive materials, and acts on them;
67. during unforeseen events or incidents, prevents (further) contamination of the environment by applying the correct measures, contributes to the composition of a decontamination plan and enacts this or has it enacted;
68. sufficiently oversees the focus "working with radioactive materials in dispersible form";
69. applies RI&E methods for dispersible radioactive materials;
70. contributes to setting up or purchasing and implementing an administrative system for radioactive materials;
71. initiates contamination surveys and performs them or has them performed.

**Therefore it is necessary that the expert:**

72. is generally familiar with applications of radioactive materials in dispersible form in research, and in medical or industrial settings;
73. has knowledge of (the working of) the applied measuring devices such as contamination monitors and liquid scintillation counters, and can use them;
74. has knowledge of the relevant RI&E methods and can take these into account;
75. has knowledge of and possesses skills to use (external) decontamination methods for people and material;
76. possesses good organizations skills for the administration of purchasing, use, waste disposal and inventory of radioactive materials.

**Learning outcomes for radiation practicals**

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

The Radiation Protection Officer:

- has command of various measuring techniques such as liquid scintillation counting and common detectors (Geiger-Müller counters, proportional counters, NaI, ionization chambers, gammaspectroscopy, etc.);
- works with contamination monitors;
- performs reliable dose rate measurements;
- identifies radionuclides;
- decontaminates objects;
- uses radioactive sources in a safe manner;
- performs wipe tests and/or leakage testing;
- understands physical properties and generic radiation characteristics of radioactive materials (penetration, penetration power, spectral distribution, shielding of beta-, gamma-, and alpha-radiation and Bremsstrahlung radiation) and can apply these.

## Testing

In order to qualify for a diploma RPO-DRM C, a successful candidate must have achieved a sufficient grade for at least the following:

1. the exam;
2. the radiation practical;

The details of the assessment procedure and method are established in the exam regulations from the authorized organization.

In addition, skills such as instructing, advising, writing protocols, etc., may also be assessed through submitted (practical) assignments, giving talks, active (and required) participation in discussion meetings (360 degree feedback), etc.

**Ad 1**

The exams test in an objective manner the learning outcomes, including ready knowledge; calculation skills; analytical thinking; understanding and insight in many aspects of physics, and being able to apply them; dosimetry and practical aspects of radiation protection. The methods of testing can be both multiple choice questions as well as open questions on practical case studies.

**Ad 2**

The assessment (including practical reports, answered questions, observations or presentations, and required participation) will be judged either sufficient or insufficient based on established criteria as described in the exam regulations.

## Appendix 1: Table of keywords from the lesson material

*This table should only be viewed 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[8]: "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-DRM must explain the subject to his colleagues while giving instruction. In this case, instruction 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 has been aligned, with a few amendments, with the list for the former Level 4B training program as described in the Implementation regulation radiation protection EZ. This list gives a gradation in 3 levels of which 1 is the lowest (general knowledge) and 3 is the highest (specific knowledge). As will be seen, level 3 can not always be translated directly into competency.*

[8] https://www.iaea.org/km/documents/05_W_Kossilov_2226Aug05.pdf

| *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 | X | | |
| specific activity | X | X | |
| α-, β, γ-decay, electron capture, internal conversion | X | X | |
| characteristic X-ray radiation, auger electrons | X | | |
| Bremsstrahlung radiation | X | X | |
| decay schemes | X | X | |
| particle fluence and energy fluence | X | X | |
| nuclear reactions, cross-sections | X | | |
| energy spectra α-, β-, γ-emitters and Bremsstrahlung | X | | |
| LET, stopping power | X | | |
| penetrance, half-value thickness | X | X | |
| inverse square law | X | X | |
| attenuation coefficients | X | X | |
| interaction mechanisms for photons and the relationship with Z and E | X | X | |
| | | | |
| *Basic competencies* | **K** | **V** | **C** |
| physics (including electromagnetic radiation, duality, wave/particle) | X | X | |
| biology (human anatomy, physiology, DNA, cell division) | X | X | |
| epidemiology (risks) | X | | |
| epidemiologiscal data as basis for stochatic effects, Life Span Study | X | | |
| justification | X | X | |
| optimalisation/ALARA | X | X | |
| dose limits | X | | |
| exposures (planned, existing, incident) | X | | |
| procedures /work situation | X | | |
| | | | |
| *Natural radioactivity* | **K** | **V** | **C** |
| U- and Th- decay chains | X | | |
| natural radionuclides | X | | |
| cosmic radiation, terrestrial radiation | X | | |
| doses as a consequence of natural radioactivity | X | | |
| radon | X | | |
| | | | |
| *Detection* | **K** | **V** | **C** |
| gas-filled detectors | X | | |
| - ionisation chambers | X | | |
| - proportional counters | X | | |
| - Geiger-Müller counters | X | | |
| scintillation detectors | X | | |
| - ZnS | X | | |
| - plastic scintillators | X | | |
| - liquid scintillation counters | X | | |
| semi-conductor detectors | X | | |
| thermoluminescence detectors | X | | |
| dead time, geometry, self-absorption | X | X | |
| counting efficiency, (intrinsic-) | X | X | |
| counting statistics | X | X | |

| | K | V | C |
|---|---|---|---|
| minimal detectable activity / counting rate | X | X | |
| spectrometry, pulse height analysis | X | X | |
| total body counters | X | | |
| measuring devices for surface contamination | X | X | |
| measuring devices for dose rate | X | X | |
| cumulative dose | X | X | |
| personal control devices (both active and passive) | X | X | |
| | | | |
| *Dosimetry* | **K** | **V** | **C** |
| absorbed dose | X | X | |
| RBE, weighting factors | X | X | |
| equivalent dose | X | X | |
| kerma | X | | |
| collective dose (according to ICRP-60, ICRP-103) | X | | |
| committed dose | X | X | |
| effective (committed) dose | X | X | |
| exposure (qualitative) | X | | |
| ambient dose equivalent | X | | |
| personal dose equivalent (d = 0,07, 3 en 10) | X | | |
| ICRU-sphere | X | | |
| ICRU-slab | X | | |
| rules of thumb average energy bèta-emitters | X | X | |
| rules of thumb penetration bèta-emitters | X | X | |
| rules of thumb fraction Bremsstrahlung relative to incoming energy (g-factor) | X | X | |
| rules of thumb regarding β-dosimetry | X | X | |
| rules of thumb regarding γ-dosimetry | X | X | |
| principle protection regulations (time, distance, shielding) | X | X | X |
| estimate H*(10) on the basis of the transport index (for example) | X | X | |
| specific h/k-radiation constant | | X | |
| conversion factors personal dose equivalent to effective dose voor gamma-radiation | X | | |
| conversion factors ambient dose equivalent to kerma for gamma-radiation | X | | |
| interpretation of measurements | X | X | |
| | | | |
| *Biological consequences of radiation* | **K** | **V** | **C** |
| stochastic/deterministic effects | X | | |
| factors that influence the biological effect: | X | | |
| - radiation conditions, tissue properties and environmental factors | X | | |
| radiation of the entire body and partial radiation | X | | |
| direct/indirect effects, free radicals, DNA-damage, repair mechanisms | X | | |
| hormesis | X | | |
| genetic effects | X | | |
| teratogenic effects | X | | |
| dose-effect relations | X | | |
| risk estimates | X | | |
| risk numbers | X | X | |
| | | | |
| *Organization and legislation* | **K** | **V** | **C** |
| norms and legal regulations, (inter)national organizations | X | X | |
| (inter)national organizations with regards to radiation safety; ICRP, BEIR, UNSCEAR, NVS | X | | |
| historical developments | X | | |
| legislation: | | | |
| - Directives European Union | X | | |
| - ADR, class 7 | X | X | |

| | K | V | C |
|---|---|---|---|
| - Nuclear Energy Act (Kew) | X | X | |
| - Decision Radiation Protection (Bs) | X | X | |
| - Decision transport fissionable materials, ores, and radioactive materials | X | X | |
| - Environmental Management Act | X | | |
| - Dutch Occupational Health and Safety Act | X | | |
| ministerial regulations: | | | |
| - Implementation regulation SB EZ | X | X | |
| - MR for the provision of radiation protection workers | X | X | |
| - MR publication justification of use of ionizing radiation | X | X | |
| justification, optimization (ALARA) and dose limits | X | X | |
| permit application (document ANVS) | X | X | |
| use of justification for permit application | X | X | |
| use of optimazation/ALARA for permit application | X | X | |
| knowledge of standard permits | X | | |
| procedures/work activities | X | X | |
| source-oriented approach | X | X | |
| exclusion/exemption | X | X | |
| radiotoxicity equivant, Re | X | X | |
| supervised and controlled zones | X | X | |
| determination of yearly dose for rooms, workers and others | X | X | |
| A and B workers | X | X | |
| definition closed source | X | | |
| ISO 2919 for requirements on closed sources | X | | |
| practical implementation for transport of radioactive materials | X | X | |
| | | | |
| *Organizational aspects radiation protection* | **K** | **V** | **C** |
| responsibilities within the radiation protection unit | X | X | |
| Nuclear Energy Act file (i.e. from Directive on radionuclides or analogs) | X | X | |
| disposal routes | X | X | |
| dose calculations for simple cases (Implementation regulation SB EZ, appendix 1.5, part I) | X | X | |
| | | | |
| *External irradiation* | **K** | **V** | **C** |
| small beam and broad beam geometries for photon radiation | X | X | |
| build-up factor for non-composite materials | X | X | |
| choice of material for shielding as a function of photon energy | X | X | |
| calculation of radiation scattering by objects | X | | |
| use of graphs and tables with regards to attenuation and transmission for sources | X | X | |
| shielding of neutron radiation (qualitative) | X | X | |
| | | | |
| *Internal contamination* | **K** | **V** | **C** |
| incorporation routes; retention and excretion | X | | |
| standard human, man and woman | X | | |
| general transport model of the ICRP, transfer coefficient | X | | |
| dosimetry models of the ICRP: | X | | |
| · general | X | | |
| · lungs | X | | |
| · gastro-intestinal tract | X | | |
| · "submersion" | X | | |
| inhalation and ingestion | X | | |
| wound contamination | X | | |
| AMAD, particle size | X | | |
| F-, M-, S-classes | X | | |
| SR0-, SR1-, SR2-classes | X | | |

| | | | |
|---|---|---|---|
| selection e(50) from the Handbook of Radionuclides or analogs | X | X | |
| determination of E(50) by inhalation or ingestion on the basis of a TLT-measurement or excretion measurement | X | X | |
| | | | |
| *Practical aspects* | **K** | **V** | **C** |
| maximal permissable surface contamination | X | X | |
| personal protection measures | X | X | |
| control methods: | X | X | |
| - surface contamination | X | X | |
| - air contamination | X | X | |
| - discharges | X | X | |
| - air filtration | X | X | |
| retrospective inventory and evaluation of incidents | X | X | |
| practical skills in contamination measuring | X | X | |
| practical skills in release of contaminated work areas / laboratories | X | X | |
| practical skills in release of contaminated people | X | X | |
| knowledge and practical skills of different cordoning off levels (map, tape, barricade) | X | X | |
| waste handling | X | X | |
| discharge standards according to regulations and permits | X | X | |
| release of rooms | X | X | |
| position COVRA | X | | |
| | | | |
| *Risk-inventory and evaluation* | **K** | **V** | **C** |
| - open sources | X | X | X |
| - p,q,r-formula | X | X | X |
| - RI&E-description | X | X | X |
| - control of risks during procedures with open sources in laboratories | X | X | X |
| - perform leakage tests on closed sources | X | X | |
| | | | |
| *Organizational* | **K** | **V** | **C** |
| give short, succinct and target-group oriented presentations/knowledge transfer | X | X | |
| write work protocols/internal protocols | X | X | |
| establish and perform audits; check lists | X | X | |
| determination of risk perception | X | X | |
| organizational behavior (formal/informal organisation; organization structure, role of the expert, role of the RPE) | X | X | |
| support and inform the RPE | X | X | |
| communication pitfalls (do’s and don’ts, miscommunication, empathy, listening skills) | X | X | |