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Comparison Table for Training Material

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ENETRAP II WD 5.1

A comparison table for training material

Under the contract of EU

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Summary

To maintain a high level of competency in Europe regarding radiation protection and to facilitate harmonisation and (mutual) recognition of Radiation Protection Experts (RPEs) and Officers (RPOs) quality assurance and quality control might play an important role. The ENETRAPII project (FP7-EURATOM) aims at developing European high-quality 'reference standards' and good practices for education and training in radiation protection. In Work Package 5 (WP5) the quality issue is addressed. Therefore, WP5 deals with the development and application of mechanisms for the evaluation of training material, training events and training providers by means of a transparent and objective methodology. The results can be used by regulatory authorities to benchmark their national radiation protection training programme and will be communicated to other networks, e.g. EUTERP. Deliverable WD5.1addresses the comparison table of training material (books and duplicated lecture notes).
A comparison table is developed for training material, consisting of a list of knowledge based events. The knowledge based events are compared on a grading system from 0 (no awareness) up to 3 (detailed understanding).

To have a first impression if the table can be used for the evaluation of training material it was tested in an evaluation with two Dutch text books. One of the text books is for RPE training and the other one is used for RPO training. The evaluation showed that the demanded content of the RPE education is covered by both books on most of the subjects. For the remaining subjects, e.g. math, additional material has to be used.

Since the end of the ENETRAP2 project, the table with learning outcomes of the ERTS can be used as a list of knowledge based learning outcomes. The EQF grades can be used to define the level of knowledge that is reached by studying the material.

1 Introduction

Today's challenge in the field of radiation protection involves measures to make the work in radiation protection more attractive for young people and to provide attractive career opportunities. In addition, young students and professionals should be supported in their need to gain and maintain high level knowledge in radiation protection. These objectives can be reached by the development and implementation of a high-quality European standard for initial education and continuous professional development for Radiation Protection Experts (RPEs) and Radiation Protection Officers (RPOs).

The FP7 European Network for Education and Training in Radiation Protection II (ENETRAPII) project is a specific tool for EURATOM policy for E&T implementation in the radiation protection field. In addition, the project is a tool towards a mutual recognition of professional qualifications.
For the purposes of this project the Radiation Protection Expert can be defined as:
“An individual having the knowledge, training and experience needed to give radiation protection advice in order to ensure effective protection of individuals, whose capacity to act is recognized by the competent authorities.”
and the Radiation Protection Officer as:
“An individual technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant or licensee to oversee the application of the requirement of the Standards”.
These are the definitions as proposed during the second EUTERP workshop in Lithuania in 2008.
To reach high-quality European standards for initial education and continuous professional development, there has to be an agreement between the European countries concerning the duties and responsibilities of both RPEs and the RPOs. These standards are developed in Work Packages 3 and 4 (WP3 and WP4) of the ENETRAPII project.
As soon as these standards are set, each country will be able to access and benchmark their own education and training against the European standards. It will also be possible for a country to benchmark an RPE or RPO, educated and trained in another country, to their national standards. Shortcomings of education and training materials, events and providers, become clear when it is possible to compare national standards of education levels to the European standards. Therefore one of the cornerstone work packages in ENETRAPII is work package 5 (WP5), entitled: Develop and apply mechanisms for the evaluation of training material, events and providers.
In the first deliverable of WP5 (WD 5.1) the comparison table of training material is presented, together with a first test of the table with two books used in the Netherlands for education of the RPE and RPO.

2 Material

The inventory has started with the subjects addressed in the syllabus EG133 (EC, 1998), the IAEA syllabus (IAEA, 2002), the ENETRAP training scheme (WD 06 ENETRAP, www.sckcen.be/enetrap), the existing tables of subjects for education and training in radiation protection and similar tables used in different countries. This will lead to a common reference table, which can be used to compare training material. Training material in WP5 is defined to be a text book or duplicated lecture notes.

2.1 IAEA Basic Syllabus PGEC

The IAEA basic syllabus [1] can be used for post graduate students to become a qualified expert. The basic syllabus is split up in 11 modules, which cover the whole basic radiation protection. The duration of the course is 18 weeks.
Each module is divided in main subjects and these are subdivided in more detailed subjects. Only for the modules the number of hours spent is clear. For each main subject lecture notes and practical exercises are given.

2.2 EG Basic Syllabus 98/C133/03

In its communication 98/C133/03 [2] the European Council guides the European countries in how to implement the basic safety standards 96/29/EURATOM in their own legislation. In this document the basic syllabus for the qualified expert in radiation protection is published as a list of subjects to be addressed in radiation protection training. Most of the subjects mentioned in the basic syllabus are not subdivided in detail. No information can be found about the hours spent on the different subjects, except for the statement: “the depth to which topics of the syllabus should be covered, should depend on the level of advice/input required from the qualified expert”.
The listed subjects cover the basic radiation protection training and additional training in five different fields: nuclear installations, general industries, research and training, medical applications, and accelerators.

2.3 ENETRAP training scheme

The ENETRAP training scheme of the ENETRAP 6th FP project is based on the IAEA syllabus, the European basic syllabus, the EUTERP recommendations and other ENETRAP output. The scheme consists of different modules. The first three modules are the basic modules. Afterwards at least one

additional module has to be followed, concerning the area of interest. This area can be Nuclear power plants or research reactors, waste management and decommissioning, non-nuclear research or oil and gas, medical, or NORM.
The ENETRAP training scheme modules are divided in main subjects, with the numbers of hours spent on all the main subjects. The main subjects are subdivided in more detail. It is not clear which level of education is required to enter the ENETRAP training scheme. The duration of the whole course is 42 days.

2.4 European credit Transfer system for Vocational E&T (ECVET)

ECVET [3], [4] is a European system of accumulation (capitalisation) and transfer of credits designed for Vocational Education and Training (VET) in Europe. It enables the attesting and recording of the learning achievement/learning outcomes of an individual engaged in a learning pathway leading to a qualification, a vocational diploma or certificate.

It enables the documentation, validation and recognition of achieved learning outcomes acquired abroad, in both formal VET or in non-formal contexts. It is focused on the individual, based on the validation and the accumulation of his/her learning outcomes, defined in terms of the knowledge, skills and competences necessary for achieving a qualification. ECVET is a system designed to operate at the European level, interfacing with national systems and arrangements for credit accumulation and transfer.

To work within the ECVET framework a Memorandum of Understanding (MoU), must be developed between the employer of the participant and the training provider. The learning outcomes are explicitly stated in this MoU. When the education or training is finished the MoU is evaluated against the learning outcomes achieved. Credits are awarded for each of the learning outcome. Depending on the field of education and training the credits can be summed together or the credits stay apart to form two separate subjects.

For the evaluation of training material, the learning outcomes have to be considered only in the knowledge field, and not in the field of skills and competences (see also glossary in Appendix C).

2.5 European Qualification Framework for lifelong learning

The EQF [5] aims to relate different countries' national qualifications systems to a common European reference framework. Individuals and employers will be able to use the EQF to better understand and compare the qualifications levels of different countries and different education and training systems.

Agreed upon by the European institutions in 2008, the EQF is being put in practice across Europe. It encourages countries to relate their national qualifications systems to the EQF so that all new qualifications issued from 2012 carry a reference to an appropriate EQF level. An EQF national coordination point has been designated for this purpose in each country.

The core of the EQF concerns eight reference levels describing what a learner knows, understands and is able to do – 'learning outcomes'. Levels of national qualifications will be placed at one of the central reference levels, ranging from basic (Level 1) to advanced (Level 8), see Appendix C. This will enable a much easier comparison between national qualifications and should also mean that people do not have to repeat their learning if they move to another country.

The EQF applies to all types of education, training and qualifications, from school education to academic, professional and vocational. This approach shifts the focus from the traditional system which emphasises 'learning inputs', such as the length of a learning experience, or type of institution. It also encourages lifelong learning by promoting the validation of non-formal and informal learning.

2.6 Tables of issues in radiation protection training

In the Netherlands a reference table (the first and the two last columns in Table 2) is used since 1984 for different levels of training in radiation protection. This table is divided in main subjects and subdivided in more detail. There are no numbers of spent hours in this table, but only a characterisation of the level of detail at which the detailed subjects are covered during the training, together with its training goal (Table 1). The advantage of using grades above hours spent on the different subjects is that the entrance level of students doesn't have to be set. Theoretical people with different levels can enter all courses. The full table can be seen in Appendix A.

Table 1 Grades at which subjects are covered in training material

Grade	Covered	goal
0	not covered	-
1	global, qualitative	aware of the subject
2	important subjects covered, quantitative	understanding of the subject
3	Detailed, quantitative	detailed understanding of the subject and able to work with it

3 Results

With respect to the main subjects, the different syllabi and reference tables are more or less the same. We preferred the reference table of the Netherlands, because of the usefulness of its format.
As explained above, in this table grades are used, corresponding to the grades in Table 1, and not hours or pages spent on different subjects. The advantage is that the entrance level of students and the number of pages spent on a topic do not matter. At the time of the research to come to a comparison table for the evaluation of material, the EQF was not known by the ENETRAP2 project. Nowadays the EQF grades 1-8 are preferred above the grades in the Dutch reference table.
The Dutch reference table can be used for the comparison of training material and for the comparison of training courses. Filling in the demands for the RPE, RPO and radiation worker (RW), results in a clear overview of which material should be used for each course and whether, additional material is needed
To use this table next to the ENETRAP training scheme (WD 06 of ENETRAP), the Dutch reference table is rearranged like the ENETRAP training scheme. Subjects mentioned within the ENETRAP training scheme, but were not present in the Dutch reference table, are added which resulted in the proposed table (Appendix B). At the end of the ENETRAP2 project, the learning outcomes of the European reference training scheme are developed in ECVET style, with grading in EQF numbering (Appendix C). Therefore it makes more sense to use the EQF numbering instead of the grades of Table 1.

3.1 A first comparison

The Dutch reference table is applied in a comparison of training material, i.e. two Dutch text books, to determine whether this table is suitable for this purpose. The first part of the comparison table can be seen in Table 2. In the first column the main subjects and more detailed subjects can be found. In the second and third column the grade of the different subject can be found for respectively book A and book B. These grades are given by the users of the books, i.e. training providers. Both books are written to train student in radiation protection to the same end level. In the fourth and fifth column the demands for RPE are displayed for respectively small and large ‘users’ in the Netherlands.
The table shows that the books cover most of the items as asked for by the Dutch government (column 4). This can be concluded, because the grades of the books are equal or higher than the grades asked by the Dutch government. There are some minor deviations between the books, caused by the interest of the authors. Instead of the grades asked for by the Dutch government, the books can be compared to other grades, e.g. defined by the ERTS.

Table 2 the first part of the comparison table of training material. Book A and book B are compared to each other and to the demands in knowledge of the different RPE functions in the Netherlands.

Subjects of basic radiation protection training

grade	covered	Goal
0	not covered	-
1	global, qualitative	aware of the subject
2	important subjects covered, quantitative	understanding of the subject
3	Detailed, quantitative	detailed understanding of the subject and able to work with it

	level of competence			
	book A	book B	3 (RPE of small institutes)	2 (RPE of large institutes)
Math				
- Differentiate, integrate, differential equations	0	0	2	2
- Exponential function	0	0	2	2
- Graphs (linear and logarithmic axis)	0	0	3	3
- Statistics (distribution, standard deviation)	2	2	2	2
General physical and chemical subjects				
- Composition of the matter	3	3	3	3
- Ionisation, excitation	3	3	3	3
- Nuclide Chart	3	2	3	3

Radioactivity				
- Proton - neutron ratio	3	3	2	2
- Radioactive decay, half-live	3	3	3	3
- Decay formula and –constant	3	3	3	3
- Mother - daughter relation	3	3	2	2
- Specific activity	3	3	3	3
- α-, β-, γ-decay, electron capture	3	3	2	2
- X-rays, Auger electrons	3	3	2	2
- Decay schemes	3	3	3	3
- Particle- and energy fluence and density	2	3	2	3
Activity from natural sources				
- U- and Th-decay diagram	3	2	2	2
- Cosmic radionuclides	2	2	2	2
- Other natural radionuclides	2	2	2	2
- Cosmic radiation	2	2	2	2
- Dose due to natural radioactivity	2	2	2	2
Artificial radioactivity				
- Nuclear fission, fission products	1	1	1	2
- Nuclear reactions, cross section	2	2	2	2
- Other sources	1	1	1	2
- Dose due to artificial radioactivity	2	2	1	2

An exception is the mathematics which is not covered by either book. Therefore, an additional book has to be used during the training course.

In reality however, there is a difference between the levels of the books. This does not become clear after filling in the Dutch reference table, but is caused by the more detailed description of the topics covered in book B. Book A is used as study material for basic level RPE in small companies or institutions while book B is used for a more advanced level in large companies or institutions. Therefore the reference table should be adjusted.

4 Discussion and conclusions

The proposed table is now a reshuffled and extended version of the Dutch reference table, so it can be used as a comparison table, it can be used together with the ENETRAP training scheme.
All main subjects of the different materials can be compared in detail with regard to the main subjects and materials of the different additional modules can be put into this table.
The table can be used to determine which book can be used during each part of the training modules for RPE, RPO and RW by filling in how detailed the subjects have to be known by RPEs, RPOs and RW.

At the end of the ENETRAP2 project, the table with learning outcomes of the ERTS can be used as a list of knowledge based learning outcomes. The EQF grades can be used to define the level of knowledge that is reached by studying the material. The mechanism as described above with using the Dutch reference table and its grades can still be used, when applying the other tables and grades.

References

[1] International atomic energy agency, IAEA PGEC basic syllabus; Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources, standard syllabus; training course series no 18; IAEA; 2002.

[2] European Commission, EG Basic syllabus; Communication from the Commission concerting the implementation of Council Directive 96/29/Euratom laying down basic safety standards for the protection of the health of the workers and the general public against the dangers from ionising radiation; EC; 98/C 133/03; 1998.

[3] ECVET; http://www.ecvet-team.eu/

[4] ECVET; http://ec.europa.eu/education/lifelong-learning-policy/doc50_en.htm

[5] EQF; http://ec.europa.eu/education/lifelong-learning-policy/eqf_en.htm

Appendix A Radiation Protection scheme in the Netherlands

Subjects of basic radiation protection training

Math

- Differentiate, integrate, differential equations
- Exponential function
- Graphs (linear and logarithmic axis)
- Statistics (distribution, standard deviation)

General physical and chemical subjects
- Composition of matter
- Ionisation, excitation
- Nuclide Chart

Radioactivity
- Proton - neutron ratio
- Radioactive decay, half-live
- Decay formula and -constant
- Mother - daughter relation
- Specific activity
- α-, β-, γ-decay, electron capture
- X-rays, Auger electrons
- Decay schemes
- Particle- and energy fluence and density

Activity from natural sources
- U- and Th-decay diagram
- Cosmic radionuclides
- Other natural radionuclides
- Cosmic radiation
- Dose due to natural radioactivity

Artificial radioactivity
- Nuclear fission, fission products
- Nuclear reactions, cross section
- Other sources
- Dose due to artificial radioactivity

β- and electron radiation
- Energy spectrum β-emitter
- Interaction with other substances (ionising capacity, LET, stopping power)
- Range
- Bremsstrahlung
- Electron accelerators

X-rays and γ-radiation
- Electromagnetic radiation, dual character, energy spectrum
- inverse-square law
- Interaction processes with other substances
- Energy dependent effect
- Attenuation coefficients
- Half-value layer

Generate X-rays:
- X-ray tube
- Energy spectrum
- Radiation quality
- Influence of tube voltage, anode material and filters

Heavy charged particles
- Interaction processes with matter
- Range
- Nuclear reactions, cross section
- Particle accelerator

Neutrons
- Kind of neutrons
- Interaction processes with matter
- Neutron sources and -generators

Detection methods

Gaseous detectors:
- Connection pulse height and tube voltage
- Ionization chambers
- Proportional counter
- Geiger-Müller counter

Scintillation counter:
- Anorganic and organic crystals
- Liquid scintillation counters
- Semiconductor detector
- Detection method based on photografic effects
- Thermoluminescence detection
- Neutron detection methods
- Dead time, geometry, self-absorption
- Counting efficiency, (intrinsic-)
- Counting statistics
- Spectrometry, pulse height analysis
- Whole body counters

Dosimetry

Absorbed dose
- RBE, weighting factors
- Equivalent dose
- Electron equilibrium
- Kerma
- Integral, cumulative, collective dose
- Commited dose

- Effective dose
- Exposure

Dose meters
- Ionization chambers
- Calorimeters
- Chemical dose meters
- Film dose meters
- TLD (thermoluminesence detection meter)
- Radio photoluminescence dose meters
- Activation dose meters
- Energy dependent dose meters
- Calibration methods for dose meters and monitors
- β-dosimetry
- Rule of thumb in relation to β-dosimetry
- γ-dosimetry
- Exposure and absorbed energy in different materials
- Rule of thumb in relation to γ-dosimetry
- Bragg-Gray principle
- Specific Γ constant
- Neutron dosimetry
- Accident dosimetry

Biological consequences of radiation
- Somatic/genetic - early/late - stochastic/deterministic effects
- Factors influencing biological effects:
  radiation conditions, tissue features and ambient factors
- Somatic effects:
  early effects after global or partial irradiation
- Late effects
- Genetic effect
- Epidemiological data
- Dose-effect relations
- Risk assessment

Standards and lawful agreements, (inter)national organisations
- (Inter)national organisation in relation to radiation safety
- Historical development

ICRP recommendations:
- In general
- Internal exposure

International agreements applying to the Netherlands:
- European community guidelines
- Dutch legislation
- Nuclear energy Act (in dutch KEW)
- Radiation protection decree
- Decree on Transport of radioactive and fissile material and ores
- Ministerial agreements
- Agreement analysis of the consequence of ionizing radiation (MR-AGIS)

Practical radiation protection; safety measures
a) external exposure

1. *Theory*

- Principle protection measures (time, distance, shielding)
  shielding from charged particles
- Electrons
- Heavy particles

Shielding gamma radiation / X rays:
- Small-beam geometry
- Broad-beam geometry; point source, build up factor
- Material choice in relation to photon energy
- Calculation of radiation scattering
- Use of graphs regarding attenuation and transmission
- Shielding neutron radiation

2. *Practical aspects*

- Reduction in exposure (factors: time-distance-shielding)

Practical implementation of shielding from:
- Charged particles
- Photons
- Neutrons

Specific shielding measures for:
- Strong γ-sources; sources used for radiography
- X-ray machine
- Particle accelerator
- Nuclear installation
- Personal control devices

b) Internal exposure
1. *Theory*
- Incorporation routes; metabolism, concentration, retention and excretion
- Reference man
- General transport model from the ICRP, transfer coefficients,
  dosimetry models from the ICRP:
  · general
  · lungs
  · gastro-intestinal
  · bone
  · "submersion"

- Background and use of tables and other data from the ICRP
  on dose calculations for:
  · chronic and acute inhalation and ingestion
  · wound contamination
  · "submersion"
- Use of retention and excretion models from the ICRP
- Classification of radionuclides based on radiotoxicity

2. *Practical aspects*
- Reduction of exposure, general principles
- Classification of activities based on radiotoxicity and possibility of spreading used nuclides
- Classification of radionuclide laboratories
- Maximal allowed surface contamination
- Demands on radionuclide laboratory inventory
- Personal protection measures
- Working methods / protection measures
- Waste treatment, standards for discharging waste
- Decontamination methods
- Control methods:
  - surface contamination
  - air contamination
  - discharge
  - leak test sealed sources
- Air filtration

c) Transport of radioactive material

d) Risc evaluation in relation to:
- Sealed sources
- X-ray machines
- Particle accelerators
- Open sources
- Nuclear installations

e) Measurements during accidents
Personal radiation accidents:
- External exposure
- Contamination of clothing and skin; decontamination
- Internal exposure
- Organisation measures, internal and external

f) Organizational aspects
- Tasks and responsibilities of the radiation expert
- Administration and management

Appendix B Comparison table for material

Subjects of basic radiation protection training

grade	covered	Objectives
0	not covered	-
1	global, quantitative	familiar with the subject
2	important subjects covered, quantitative	to be able to work with the subject
3	Detailed, quantitative	Good knowledge of the subject and able to work with it

module	Subject	Grade
module 1	**Basics** Goal of the module: To understand the physical aspect of ionising radiations, the biological bases of radiological protection To describe and use the principal type of radiation detectors To describe the different usages of ionising radiations in the different domains and to know the type and range of used radioactive sources	
1.1	Inaugural conference	
1.2	Radioactivity and nuclear physics	
	Composition of matter	
	Proton-Neutron ratio, ionisation, excitation	
	Alpha decay	
	Beta minus decay	
	- Energy spectrum β-emitter	
	Beta pus decay and electron capture	
	Electronic shell rearrangement	
	- Consequence of a vacancy	
	- Amount of energy available	
	- Consequence of the electron capture	
	Gamma emission and internal conversion	
	Evolution of the activity	
	- Exponential law	
	- Decay chain with two isotopes	
	- Decay chain with one isotopes	
	- Activity law	
	- Activity, special activity and mass activity	
	Producing radionuclides by nuclear reaction	
	-Cross section	
	- Production of artificial radioactive substances	
	- Nuclear fission, fission products	
	Nuclide Chart	
	- Decay schemes and mother - daughter relation	
1.3	Interaction of radiation with matter	
	Directly ionising radiations	

module	Subject	Grade
	Heavy charged particles	
	- Range	
	- Nuclear reactions, cross section	
	Light charged particles	
	- Ionising capacity, LET, stopping power	
	- Range	
	- Bremsstrahlung	
	- LET	
	- Case of the positrons	
	- Application: principle of the X ray tube	
	Non directly ionising radiations	
	Electromagnetic radiation	
	- Energy dependent effect	
	- Attenuation coefficients, half-value layer	
	- General principle of building: build up factor coefficients	
	Neutrons	
	- Kind of neutrons	
1.4	Dosimetry	
	Physical and dosimetric quantities	
	- Radiometric description of radiation field	
	- Particle- and energy fluency and density	
	- Electron equilibrium	
	- Kerma	
	- Dosimetric quantities	
	- Relationships between radiometric and dosimetric quantities	
	- Calculation of absorbed dose	
	- Inverse-square law	
	Radiation protection dosimetry	
	- Need for protection quantities	
	- New approach in ICRP 103, 60, ICRU 51 and EC directives	
	- Collective dose	
	- Neutron dosimetry	
	- Accident dosimetry	
1.5	Biological effects of radiations	
	Basic biology	
	Cellular and molecular effects	
	- Factors influencing biological effects: radiation conditions, tissue features and ambient factors	
	- Dose-effect relations	
	- Somatic/genetic - early/late - stochastic/deterministic effects	
	Deterministic effects	
	Stochastic effects	
	Early effects after global or partial irradiation	

module	Subject	Grade
	Exposure of pregnant woman and foetus	
	Epidemiology	
	- Risk assessment	
1.6	Physical principles of detection	
	General principle of detection	
	- Measurement of chain, efficiency, dead-time, detection threshold, background and noise	
	- Uncertainty of a measurement	
	Ionisation of gas	
	Luminescence phenomenon	
	Ionisation into solids	
	Physical and chemical phenomenon	
	Detector functioning	
	Bragg-Gray principle	
	Whole body counters	

module 2	**Foundation: operational radiation protection and regulatory context** Goal of the module: To estimate the doserate to different distances from a radioactive point source (beta or photon) To determine the collective and individual protective means both for external and internal exposure To assess individual dose for both external and internal exposure To determine the features of a dose monitoring program (area and individual) To explain the process from ICRP, IAEA recommendations to a national regulatory	
2.1	Radiation protection external dosimetry	
	Dose assessment for external exposure	
	Calibration of a radiation protection device to measure external exposure	
2.2	Protection against external exposure	
	- Radiation protection principles	
	Shielding from charged particles, neutron and gamma radiation and X rays	
	Shielding gamma radiation / X rays:	
	- Small and broad-beam geometry; point source, build up factor	
	- Material choice in relation to photon energy	
	- Calculation of radiation scattering	
	- Use of graphs regarding attenuation and transmission	
	- Extremity exposure	
	- Use of calculation codes	
	- Personal control devices	
2.3	Protection against internal exposure	
	- Reduction of exposure, general principles	

module	Subject	Grade
	- Classification of activities based on radio toxicity and possibility of spreading used nuclides	
	- Maximal allowed surface contamination	
	Modes of intake	
	- Reference man	
	- General transport-model from the ICRP, transfer coefficients, dosimetry models from the ICRP	
	- Background and use of tables and other data from the ICRP on dose calculations for:	
	· Chronic and acute inhalation and ingestion	
	· Wound contamination	
	· "Submersion"	
	- Use of retention and excretion models from the ICRP	
	- Classification of radionuclides based on radio toxicity	
	Collective protection	
	Individual protection	
	- Working methods / protection measures	
	- Waste treatment, standards for discharging waste	
	- Decontamination methods	
	- Control methods:	
	· Leak test sealed sources	
	- Air filtration	
	Risk evaluation of open sources	
2.4	Dose monitoring	
	Area monitoring	
	- Regulatory requirements	
	- Operation-, environmental-, and surface monitoring	
	- Design of a monitoring program	
	- Classification of areas	
	- Utilisation of detectors	
	Individual monitoring	
	- External exposure	
2.5	Regulatory context	
	Basic principles of radiation protection	
	ICRP recommendations	
	IAEA safety fundamentals, requirements and guidelines	
	EC directives, practices and interventions	
	ALARA principles	
	Individual work on national regulation of learners country	
2.6	Natural sources of ionising radiation	
	- Natural radionuclides	
	- Case of radon	

module	Subject	Grade
	- External irradiation and cosmic radiation	
	- Internal irradiation	
	- NORM industries	
	- Dose due to natural radioactivity	
2.7	Public and environmental radiation protection	
	Public radiation protection	
	- Dose limits and constraints	
	- UNSCEAR overview of exposure levels from artificial sources	
	- Principles of dispersion models in air and water	
	Environmental radiation protection	
	-ICRP system of environmental RP	
	Medical exposure	
2.8	Ethical considerations on the application of radioactivity and radiation protection	

module 3	**Foundation+** Goal of the module: To know the regulatory process in order to complete transportation of radioactive material at this level, to mitigate the consequences of an accident or emergency issues To integrate the alara principles and a safety culture in his practices To know the principles of waste management and decommissioning	
3.1	Transport	
	- Regulation of the transportation of hazardous material in relation to the transport of radioactive materials	
	- Presentation of the ADR	
	- Types of packages, transport index, signalisation and labelling, measurements	
3.2	Design issues	
	Choice of materials	
	Maintainability of installation	
	Work places, hot cells, glove boxes	
	Specific shielding measures for nuclear installations	
3.3	Accidents and emergency issues	
	Accidents: feedback experience	
	Medical management in accidental situation	
	Management of populations	
	Measurements during accidents	
	Personal radiation accidents:	
	- External exposure	

module	Subject	Grade
	- Contamination of clothing and skin; decontamination	
	- Internal exposure	
	- Organisation measures, internal and external	
3.4	Safety culture	
	Interface radiation protection and safety	
	Risk evaluation in relation to nuclear installations	
3.5	ALARA	
	Justification and optimisation: dose constraints: new ICRP recommendations	
3.6	Principles of decommissioning	
	Strategies, techniques and implementation	
3.7	Principles of waste management	
	Regulatory context, classification and techniques	
3.8	Communication public, medias	
further	Organizational aspects	
	- Tasks and responsibilities of the radiation expert	
	- Administration and management	

Module 4	**Occupational radiation protection: specificities of the nuclear installations, power plants and fuel cycle** Goal of the module: To know the specificities of radiation protection in the fields of NPPs, fuel cycle facilities To perform the classification of areas (controlled and supervised) To be aware of accidental situations (causes and consequences)	
4.1	Main types of nuclear reactors	
	- General principle - basics on neutron physics, nuclear fission, criticality	
	- Visit NPP if possible	
4.2	The fusion	
	- General principle	
	- Visit if possible	
4.3	The fuel cycle	
	- Lectures (radiation protection in front end and in back end)	
	- Visit of an enrichment plant, a fuel processing plant or a reprocessing plant if possible	
4.4	Dose monitoring and regulatory controls	

module	Subject	Grade
	Environmental monitoring and controls around a nuclear installation	
	Activation	
4.5	Safety culture - interface radiation protection and safety	
	- Basic concept of safety culture	
	- Safety of the pressurized water reactors and interface with protection against radiation- prevention of risks	
	- Organisation, task and responsibilities of RPE, daily RP and RP during annual outage, equipments, dosimetry	
4.6	Accidental situations	
	- Lessons learnt from nuclear accidents	
	- Emergency procedures and interventions, report	
	- Management of the populations and medical aspects	
	Principles and countermeasures	
	Particular case of iodine	
	- Medical management in accidental situation	
	Dosimetry evaluation and reconstitution	
	- Lessons learnt from nuclear accidents	
	- Emergency procedures and interventions, report	
	- Management of the populations and medical aspects	
	Principles and countermeasures	
	Particular case of iodine	
	- Medical management in accidental situation	
	Dosimetry evaluation and reconstitution	

Module 5	**Occupational radiation protection: specificities of waste management and decommissioning** Goal of the module: To implement principles of radioactive waste management and their basic techniques To implement principles of decommissioning and related strategies To understand the principle of ventilation and filtration in waste management and decommissioning field To perform the classification of areas (controlled and supervised)	
5.1	Waste management	
	- Legal aspects, waste preparation and collection	
	- Waste classification and strategies for waste conditioning	
	- Radiation protection during combustion, bituminising and vitrification of radioactive waste	
	- Radiation protection aspects in a final storage facility	
	- Risk evaluation in relation to waste management	
	Environmental monitoring and controls around waste storage facility	
	- Visit a waste storage facility (if possible)	

module	Subject	Grade
5.2	Decommissioning	
	- Strategies, radiation protection planning and organisation	
	- Techniques for disassembling, dismantling and safe handling	
	- Decontamination and measuring techniques for release of materials from controlled areas	
	- Planning and implementation of these techniques	
	- Visit a facility under decommissioning (if possible)	
5.3	Ventilation and filtration	
	- Basics of aerosol physics, granulometry, principles of ventilation and filtration, mains types of protection	
	- Air renewal, measurements of air rate, optimisation of the position of air sampling, seek for leakage	
	- Protective clothing (different types), work in a contaminated area and maintenance on a clove box	
5.4	Transport	
	- European regulations (ADR): responsibilities, types of packages	
	- Transport index, signalisation and labelling, RP measurements, documentation	
	- Practical examples, lessons learned from accidents	

Module 6	**Occupational radiation protection: specificities of non-nuclear industries, research laboratories, Oil & Gas** Goal of the module: To apply a radiation protection program in activities where sealed and / or unsealed radioactive sources are used To perform the classification of areas (controlled and supervised) To react in incidental or accidental situations	
6.1	Irradiators, generators, Accelerators, Gauges	
	- Technical principles of these equipments	
	- Radiation protection adapted to these equipments + regulatory controls	
	- Case study	
	- Visit of an accelerator or industrial irradiation facility (if possible)	
	- Risk evaluation	
6.2	Industrial radiography	
	- Technical principles of these equipments: gammagraphy and X-ray generators	
	- Radiation protection adapted to these equipments + regulatory controls	
	- Case study	
	- Risk evaluation	

module	Subject	Grade
6.3	Unsealed sources	
	- Sources management	
	- Specific shielding measures	
	- Regulatory controls	
	- Ventilation and filtration	
	- Waste management	
	- Transport	
	- Management of a contamination (surface or person) - Practical work	
	- Case study	
	- Risk evaluation	
6.4	Potential accidents	
	- Emergency procedures and interventions, report	
	- Lessons learnt from radiological accidents	

Module 7	**Occupational radiation protection: specificities of the medical activities** Goal of the module: To apply a radiation protection program in a medical field (except for radiation protection of patient) To establish the classification of areas (controlled and supervised)	
7.1	Technology of the equipments	
	For diagnosis purpose	
	- Conventional and numeric radiology	
	- Mammography	
	- Computerised tomography	
	- Interventional radiology	
	- Nuclear medicine including positron emission tomography	
	For therapy	
	- External beam therapy	
	- Brachytherapy	
	- Nuclear medicine (Iodine 131)	
	- Therapy using heavy particles or neutrons	
	Visits of hospitals or medical industries	
7.2	Occupational radiation protection: specificities	
	- Regulatory context (Directive EC 97/43….)	
	- Conception of the premises (therapy treatment room, nuclear medicine lab, classification of the areas)	
	- Radiation protection of the operators in the interventional radiology	
	- Radiation protection of the operators in brachytherapy	
	- Radiation protection of the operators in the hot lab	

module	Subject	Grade
	- Regulatory controls of the sources and their shielding, maintenance	
	- Management of the sources (brachytherapy and nuclear medicine)	
	- Waste management (nuclear medicine)	
	- Transport of radioactive sources	
	- Management of a contamination (surface or person) - Practical work	
	- Individual monitoring	
	- Risk evaluation	
7.3	Potential accidents	
	- Emergency procedures and interventions, report	
	- Lessons learnt from radiological accidents	

module 8	**Radiation protection for naturally occurring radioactive material (NORM)** Goal of the module: To know what are activities where NORM are present To participate at the evaluation of population and workers exposures	
8.1	Different activities where NORM are present	
	- The combustion of coal in thermal power stations	
	- The processing of ores of tin, aluminium, copper, titanium, niobium, bismuth, thorium…	
	- The activities of glassware, foundry, steel industry and metallurgy	
	- The production or usage of compounds using thorium	
	- The production of zircon and baddaleyite, and the activities of foundry and metallurgy	
	- The production of fertiliser with phosphates and the production of phosphoric acid	
	- The processing of the titanium dioxide	
	- The processing of the rare earths and the production of pigments	
	- The processing of underground water by filtration intended to the production:	
	* of waters intended to human consumption	
	* of mineral waters	
8.2	Evaluation of dose for exposed workers	
8.3	Evaluation of the exposure of population	
8.4	Implementation of the protective measures and the corrective actions in NORM activities	
	Visits	

Appendix C The European Qualifications Framework for Lifelong Learning

	KNOWLEDGE	SKILLS	COMPETENCE
	In the context of EQF, knowledge is described as theoretical and/or factual.	*In the context of EQF, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments).*	*In the context of EQF, competence is described in terms of responsibility and autonomy.*
LEVEL 1	• basic general knowledge	• basic skills required to carry out simple tasks	• work or study under direct supervision in a structured context
LEVEL 2	• basic factual knowledge of a field of work or study	• basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools	• work or study under supervision with some autonomy
LEVEL 3	• knowledge of facts, principles, processes and general concepts, in a field of work or study	• a range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying basic methods, tools, materials and information	• take responsibility for completion of tasks in work or study • adapt own behaviour to circumstances in solving problems
LEVEL 4	• factual and theoretical knowledge in broad contexts within a field of work or study	• a range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study	• exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change • supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities
LEVEL 5[1]	• comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	• a comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems	• exercise management and supervision in contexts of work or study activities where there is unpredictable change • review and develop performance of self and others

The Framework for Qualifications of the European Higher Education Area provides descriptors for cycles. Each cycle descriptor offers a generic statement of typical expectations of achievements and abilities associated with qualifications that represent the end of that cycle.

[1] The descriptor for the higher education short cycle (within or linked to the first cycle), developed by the Joint Quality Initiative as part of the Bologna process, corresponds to the learning outcomes for EQF level 5.

LEVEL 6[2]	• advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	• advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	• manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts • take responsibility for managing professional development of individuals and groups
LEVEL 7[3]	• highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research • critical awareness of knowledge issues in a field and at the interface between different fields	• specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	• manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches • take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams
LEVEL 8[4]	• knowledge at the most advanced frontier of a field of work or study and at the interface between fields	• the most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice	• demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research

[2] The descriptor for the first cycle in the Framework for Qualifications of the European Higher Education Area agreed by the ministers responsible for higher education at their meeting in Bergen in May 2005 in the framework of the Bologna process corresponds to the learning outcomes for EQF level 6.
[3] The descriptor for the second cycle in the Framework for Qualifications of the European Higher Education Area agreed by the ministers responsible for higher education at their meeting in Bergen in May 2005 in the framework of the Bologna process corresponds to the learning outcomes for EQF level 7.
[4] The descriptor for the third cycle in the Framework for Qualifications of the European Higher Education Area agreed by the ministers responsible for higher education at their meeting in Bergen in May 2005 in the framework of the Bologna process corresponds to the learning outcomes for EQF level 8.

Appendix D Glossary[i]

accreditation (of programmes, institutions)
Process of accrediting an institution of education or training, a programme of study, or a service, showing it has been approved by the relevant legislative and professional authorities by having met predetermined standards. [EQF]

assessment
The sum of methods and processes used to evaluate the attainments (knowledge, know-how, skills and competences) of an individual, and typically leading to certification. [EQF]

certificate/diploma
An official document, issued by an awarding body, which records the achievements of an individual following a standard assessment procedure. [EQF]

certification (of knowledge, skills and competences)
The process of formally validating knowledge, know-how and/or skills and competences acquired by an individual, following a standard assessment procedure. Certificates or diplomas are issued by accredited awarding bodies. [EQF]

comparability of qualifications
The extent to which it is possible to establish equivalence between the level and content of formal qualifications (certificates or diplomas) at sectorial, regional, national or international levels. [EQF]

competence
Competence includes: i) cognitive competence involving the use of theory and concepts, as well as informal tacit knowledge gained experientially; ii) functional competence (skills or knowhow), those things that a person should be able to do when they are functioning in a given area of work, learning or social activity; iii) personal competence involving knowing how to conduct oneself in a specific situation; and iv) ethical competence involving the possession of certain personal and professional values. [TWG ECVET]

credit points (or credits)
Credit points are allocated to qualifications and to the units that constitute them. By agreement, they represent, in numerical form the volume of learning outcomes, the relative importance of each of the units that make up a qualification, in relation to the expected results, i.e. the knowledge, skills and competences that must be acquired and assessed, regardless of the learning pathway. [TWG ECVET]

credit system
A system of credits makes it possible to break down a qualification or the objectives of a programme of vocational education and training into units. Each unit is defined in terms of knowledge, competences and skills. It may be characterised by its size and relative importance, expressed in general by credit points (or credits) or other factors. Each unit can be validated and awarded separately. [TWG ECVET]

ECTS
The European Credit Transfer and Accumulation System (ECTS **Fout! Verwijzingsbron niet gevonden.**) is a standard for comparing the study attainment and performance of students of higher education across the European Union and other collaborating European countries. For successfully completed studies, ECTS credits are awarded. One academic year corresponds to 60 ECTS-credits that are equivalent to 1500–1800 hours of study in all countries irrespective of standard or qualification type and is used to facilitate transfer and progression throughout the Union.

ECVET
The European credit Transfer system for Vocational Education and training is a European system of accumulation (capitalisation) and transfer of credits designed for Vocational Education and Training (VET) in Europe. It enables the attesting and recording of the learning achievement/learning outcomes of an individual engaged in a learning pathway leading to a qualification, a vocational diploma or certificate.

EQF
The European Qualifications Framework is a common European reference framework which links countries' qualifications systems together, acting as a translation device to make qualifications more readable and understandable across different countries and systems in Europe. It has two principal aims: to promote citizens' mobility between countries and to facilitate their lifelong learning. The EQF has eight reference levels

formal learning
Learning that occurs in an organised and structured environment (in a school/training centre or on the job) and is explicitly designated as learning (in terms of objectives, time or resources). Formal learning is intentional from the learner's point of view. It typically leads to certification. [EQF]

informal learning
Learning resulting from daily activities related to work, family or leisure. It is not organised or structured in terms of objectives, time or learning support. Informal learning is in most cases unintentional from the learner's perspective. It typically does not lead to certification. [EQF]

knowledge
The facts, feelings or experiences known by a person or a group of people [EQF]

learning outcomes
Learning outcomes are statements of what a learner is expected to know, understand and/or be able to do, or is able to demonstrate, after completion of any learning process or at the end of a period of learning. [TWG ECVET]

mobility
The ability of an individual to move and adapt to a new occupational environment. [CEDEFOP]
module
A self-contained, formally structured learning experience. It should have a coherent and explicit set of learning outcomes, expressed in terms of competences to be obtained, and appropriate assessment criteria. [ECTS]

non formal learning
Learning which is embedded in planned activities not explicitly designated as learning (in terms of learning objectives, learning time or learning support), but which contain an important learning element. Non-formal learning is intentional from the learner's point of view. It normally does not lead to certification. [EQF]

qualifications
Qualifications are a formal expression of knowledge, skills and wider competences of the individuals. They are recognised at local, national or sectorial level and, in certain cases, at international level.
A qualification is achieved when a competent body determines that an individual's learning has reached a specified standard of knowledge, skills and wider competences. The standard of learning outcomes is confirmed by means of an assessment process or the successful completion of a course of study. Learning and assessment for a qualification can take place through a programme of study and/or work place experience and/or any type of formal, non-formal or informal learning pathway. A qualification confers official recognition of value in the labour market and in further education and training. A qualification can be a legal entitlement to practice a trade. [TWG ECVET]

recognition
Formal recognition: the process of granting official status to skills and competences either -through the award of certificates or -through the grant of equivalence, credit units, validation of gained skills and/or competences and/or (b) social recognition: the acknowledgement of the value of skills and/or competences by economic and social stakeholders. [EQF]

skill
The knowledge and experience needed to perform a specific task or job. [EQF]

transparency of qualification
The degree to which the value of qualifications can be identified and compared on the (sectoral, regional, national or international) labour and training markets. [EQF]

unit
A unit is part of a qualification. It can be the smallest part of the qualification that can be evaluated, validated or certified. A unit can be specific to one particular qualification or common to several qualifications. The knowledge, skills and competences that make up the credit form the basis for the assessment and validation of people's outcomes. Units are validated at the end of the assessment of outcomes, the results of which must comply with the requirements of the qualification. [TWG ECVET]

validation (of non-formal and informal learning)
The process of assessing and recognising a wide range of knowledge, know-how, skills and competences, which people develop throughout their lives within different environments, for example through education, work and leisure activities. [EQF]

valuing learning
The process of recognising participation in and outcomes of (formal or non-formal) learning, in order to raise awareness of its intrinsic worth and to reward learning. [EQF]

vocational education and training
Education and training which aims to equip people with skills and competences that can be used on the labour market. [CEDEFOP]

workload
The workload includes all learning activities required for the achievement of the learning outcomes (i.e., lectures, practical work, information retrieval, private study, etc.). [ECTS]

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[i] (from **Fout! Verwijzingsbron niet gevonden.**)
[CEDEFOP] CEDEFOP (Philippe Tissot), Terminology of vocational training policy. A multilingual glossary for an enlarged Europe, Luxembourg 2004
[ECTS] Directorate-General for Education and Culture, ECTS users' guide. European Credit Transfer and Accumulation System and the Diploma Supplement, Brussels 2005
[EQF] Commission of the European Communities, Commission Staff Working Document. Towards a European Qualifications Framework for Lifelong Learning, 2005
[TWG ECVET] European Credit System for VET (ECVET). Technical Specifications (Report 2005 of the Credit Transfer Technical Working Group)