Abstract:

All persons exposed to ionizing radiation without being patients are mandatory being monitored by personnel dosimetry. The objective of the monitoring is to guarantee that thresholds are not exceeded, e.g. 20 mSv per year for the effective dose for occupationally exposed personal. Further regulations are effective for the monitoring of organ doses like those of the skin or the eye lens.

For some clinical disciplines, especially those being involved in interventional procedures, the permitted annual dose levels might limit the clinical involvement of the exposed personal. Further a detailed knowledge of the organ doses as well as effective doses resulting from different procedures is extremely useful in optimizing clinical processes as well as the related patient care. For an efficient use of occupational dosimetry in optimization and management processes it is essential to have a profound understanding of the existing dosimetry systems in use, especially their pro and cons. The physical and technical processes of the available dosimetry systems differ significantly. Measurement uncertainties, sensitivity to disruptive factors and their field of application vary considerably.

The occupational dosimetry is not unquestioned among users. There are several million persons monitored by occupational dosimetry in Europe each year. From these, less than 5% are exposed to levels of more than 1 mSv per year. Occupational doses for the extremities as well as eye lenses are even less often at a critical height. Thus, a lot of effort and money is spent continuously without any benefit. This lack of benefit to the individual often results in reluctance in cooperation in personal dosimetry. The is also fostered in the case that actual dose received, resulting consequences or achieved improvements are not communicated actively and discussed in the team.

Within this course dealing with “Personnel dosimetry” we will cover the whole facets of personal dosimetry, starting from epidemiological and dosimetric basics, working with and understanding of relevant dosemeters and ending with discussions how to motivate occupational dosimetry to different groups or how to achieve maximum outcome from the effort spend.

The course is being delivered as blended course, starting with an online course phase of 5 days followed by an onsite phase of 5 days. The onsite phase will be held in Braunschweig / Germany. In the online phase of the course the necessary knowledge will be presented. The intention of this part is to reach a level of theoretical knowledge among the participants, which enables a good learning outcome at the onsite phase. Within the onsite phase the theoretical topics will be repeated and extended by lectures being held by experts in the individual field. The main part of the onsite phase, however, is related to gain practical knowledge, skills and competences in the use of the different dosimetric systems, understand their limitations and to investigate the doses and exposure conditions at different work places within hospitals.

The online and onsite phase start with fundamental information on epidemiological facts. In this part we provide all information, needed for the participants to have a well-founded understanding on the different radiation effects and their relevance at different work places. Basic knowledge on deterministic and stochastic effects will be repeated. In addition, in particular the currently available information on eye lens doses will be presented and critically discussed with the participants. The consequences resulting from these facts for a possible introduction of surveillance of the dose to the eye will be illuminated. Intentionally, at the end of the module all participants have a thorough knowledge on the basic radiobiology to reasonably rate and apply personal dosimetry on their own for larger groups, exposed to different levels of ionizing radiation.

The main part of the course is related to dosimetry and dosimetric systems relevant for personnel dosimetry. A fundamental necessity of systems being used in personal dosimetry is that they provide information on biologically relevant dose quantities. These quantities, like $H_p(10)$, $H^*(0.07)$ or $H_p(3)$ are not directly accessible. The methods in use to estimate the body related dose quantities from the signal, which is measured by the dosemeter, will be worked out. The participants shall realize the limitations of the current approaches especially for $H_p(3)$, where an uniquely defined dosimetric definition of this measurement quantity still is work in progress.

After establishing a solid basis of dosimetric understanding, the detection principles of passive, e.g. film, OSL or TLD based, and active electronic dosimeter systems will be discussed deeply. The participants shall understand the general principles of these systems as well as their energy and angular response. In addition, new approaches will be discussed that intend to overcome limitations of systems currently in use.

Uncertainty budgets to be expected from dosimetric measurements in lab and real use situations will be worked out. For this we include some basic information on how to assess uncertainties reasonably with state of the art approaches like the GUM in the online phase. In the onsite part of the module we will deepen this knowledge and extend it by practical applications.

Within the onsite phase of the course extended practicals on the response of different types of personnel dosimeters will be performed. The focus will be on active dosimetry systems. In addition to the influencing factors that relevant for all personnel dosimetry systems these systems in particular suffer from a dose rate dependence of their response. It is essential that participants understand the response characteristic of these systems to use them within real life situations. To facilitate an even deeper understanding of the role and limitations of active personal dosemeters, a visit of the “Physikalisch-Technische Bundesanstalt” (PTB), the main metrological institute of Germany, is foreseen. At the PTB we will find the worlds first reference source for pulsed radiation. This unit tackles the challenge of dosimeter response at high dose rates as will be found at pulsed X-ray sources.

All practicals in the onsite phase will be conducted within guided groups of four to guarantee best possible learning outcome. At the end of each practical the groups are asked to share and discuss their results with the other groups that work on different topics.

Personal dosimetry is not only a problem related to natural science and technique. Because of the afore mentioned biological effects of radiation the topic area is extensively in the focus of legal regulations. Within the module the relevant recommendations from scientific organizations, mainly the ICRP, and their implementation in European and national legislation will be worked out. The pro and cons of the realization schemes currently found among Europe will be compared and discussed.

With the in-depth knowledge on dosimetry it is possible to investigate closely the exposure situations of different X-ray related work places. In the online part and especially within the onsite phase of the course exposure situations and related doses to the whole body as well as to the extremities and eye lenses are assessed – at the onsite phase with onsite practicals in different clinics. Within hospitals there is a wide bandwidth of workplaces, with personal exposed to radiation doses of clearly different height. Further the spatial distribution of the fields might be completely different. Each situation has to be considered independently to set up a useful, cost efficient and widely accepted personal dosimetry system. For an example, the situation and necessities in a pediatric care unit differ clearly from the ones in an urology or vascular surgery. Necessities in an angio suite or cardiology are clearly different from exposures at intensive care units. The participants have to get a well-founded knowledge and experience of the radiation fields present at the different work places, the related exposures to the body and the resulting needs for personal dosimetry. At several work places radiation protection shields are in use. Limitations of dosimetric approaches, which e.g. result from only partially representative exposures of dosemeters will be assessed. At the end of this part of the course the participants are expected to have a deep understanding of (partial)-body exposures at different work places, related reasonable dosimetry approaches and their inherent uncertainties.

On the market software tools are available, which can be used to assess facets of the field of personal dosimetry independent of practical measurements. One group of tools facilitates the simulation of radiation fields close to X-ray sources. Based on these simulations dosimetric quantities for persons in vicinity to the sources can be calculated. Within the onsite phase of the course example cases of these software tools will be demonstrated.

Personal dosimetry everywhere comes along with a huge effort. In compensation it has the intention to provide safety to persons exposed to X-rays. In a lot of cases it unfortunately turns out, that the persons, who are asked to wear personal dosemeters show up no specific interests in being monitored. Using the knowledge provided in the module, motivation and communication strategies to promote and motivate personal dosimetry will be presented in the online phase and discussed extensively in the onsite phase. Also approaches to optimize the dosimetry to most efficient use the existing resources will be compiled.

In summary, the participants of the course will leave the module with a comprehensive knowledge on personnel dosimetry as well as skills and competences to apply their knowledge to real life situation at their institutions. This includes knowledge on the underlying epidemiological basics, the dosimetry and developed dosimetry systems, the exposure situations and resulting needs on site. Finally, the participants will be enabled to communicate and discuss these topics to hospital managements, the scientific community and political interest groups.