DANISH HEALTH AUTHORITY
Radiation Protection

February 2018

Dose to the lens of the eye

Reduced limit for dose to the lens of the eye

On 6 February 2018, new legislation on ionising radiation and radiation protection entered into force. Among other things, the legislation means that the dose limit for equivalent dose to the lens of the eye is reduced from 150 mSv/year to 20 mSv/year. The reduction is based on recommendations from the International Commission on Radiological Protection, ICRP.

The new legislation requires that workers who are likely to receive a dose of more than 15 mSv/year to the lens of the eye must be dose monitored. It is the responsibility of the undertaking to ensure that workers are dose monitored and to document compliance with the dose limits.

Below is a brief description of the challenges and possibilities for determining the dose to the lens of the eye. Reference is also made to IAEA TECDOC No. 1731 for a more detailed account of the significance of the new dose limits for dose monitoring of workers exposed to radiation.

Shoulder dosimeter

For assessment of radiation doses to the lens of the eye, the Danish Health Authority's Personal Dosimetry Laboratory offers personal dosimeters which can be placed at shoulder height, close to the collar bone or neck, on the side where the greatest radiation exposure is expected. The dosimeter, referred to as a shoulder dosimeter, is not technically different from the dosimeters used for whole body dosimetry; however, when used at shoulder height, the result is reported as eye dose (dose to the lens of the eye).

Shoulder dosimeters are supplied for a measurement period of one month and can be ordered via a web form on the Danish Health Authority's website under Personal dosimetry[1].

The following pages describe in more detail the dose monitoring of the lens of the eye, including the results of the study on the practical use of the shoulder dosimeter and its technical characteristics.

Measurement of radiation doses to the lens of the eye cannot yet be offered as an accredited service. We are working on having the service accredited by DANAK according to the standard DS/EN ISO/IEC 17025. Reference is also made to ISO 15382:2015 in relation to applicable standards for measuring radiation doses to the lens of the eye.

[1] https://www.sst.dk/en/english/Expertise-and-guidance/Radiation-and-radon/Personal-dosimetry

Who must be dose monitored?

Most of those who are currently dose monitored already gets reported values for effective dose and equivalent dose to the skin. These could be used as a starting point to assess whether there is a risk that the dose to the lens of the eye may exceed 15 mSv/year and whether there therefore could be a need to also monitor the dose to the lens of the eye. There may be factors that could mean that the dose to the eye could be significantly higher than the doses mentioned above. This is particularly true for workers who wear lead rubber aprons, are exposed to beta radiation, are inhomogeneously irradiated or have their head close to the radiation source. The assessment of the dose to the lens of the eye must therefore include these factors as a minimum. Similarly, the assessment must include consideration of the significance of the type of radiation source used, the given work procedures and whether protective equipment in the form of shields, goggles, etc. is used. It should be noted that there may be other factors, in addition to those mentioned above, that must be included in the assessment of any supplementary monitoring of the lens of the eye.

It is internationally recognised that radiation doses to the lens of the eye can be measured by placing dosimeters on the forehead or at shoulder height. We have performed such measurements in clinical situations at several workplaces in Denmark. For these measurements so-called forehead dosimeters were used together with ordinary whole body dosimeters placed at shoulder height. The measurement results show that a dosimeter placed at the shoulder can provide a measure of the dose exposure to the lens of the eye. Based on the dose measured with a shoulder dosimeter, it is thus possible to assess whether there is a risk of exceeding the dose limit to the lens of the eye and thus whether further measures need to be taken - including shielding.

When recording large doses measured with a shoulder dosimeter, and where protective equipment, such as lead glasses, which do not allow direct measurement of the dose to the lens of the eye, is used simultaneously, it is necessary to determine the protection factor of the protective equipment used. This factor depends on the attenuation of the lead glass (half value layer) and on the design of the goggles.

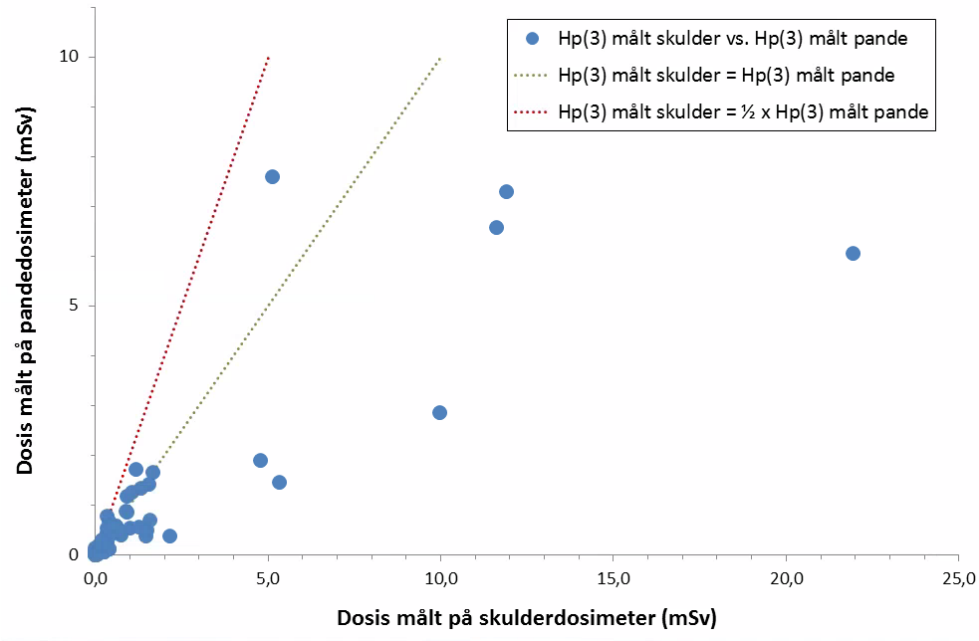
The next section describes in more detail the comparison of the measurements with the two types of dosimeters and the use of the dose measured with the shoulder dosimeter as a measure of the dose to the lens of the eye.

Comparison of measurements made with shoulder and forehead dosimeters

In order to assess the practical use of the shoulder dosimeter, we have over a period of time measured doses to a group of selected workers who have been employed in interventional radiology etc. In interventional radiology, for example, it is necessary for the staff performing the procedure to stand close to the patient while the patient is being radiographed. During the period, almost 200 pairs of measurements have been carried out where the worker has worn both a shoulder dosimeter and a dosimeter placed on the forehead. The forehead dosimeter was developed by Public Health England, PHE[2]. The figure below shows the measurement of the dose, $H_{\mathrm{p}}(3)$, measured with a forehead dosimeter compared to the dose, $H_{\mathrm{p}}(3)$, measured with our shoulder dosimeter. There is international consensus that the measurable personal

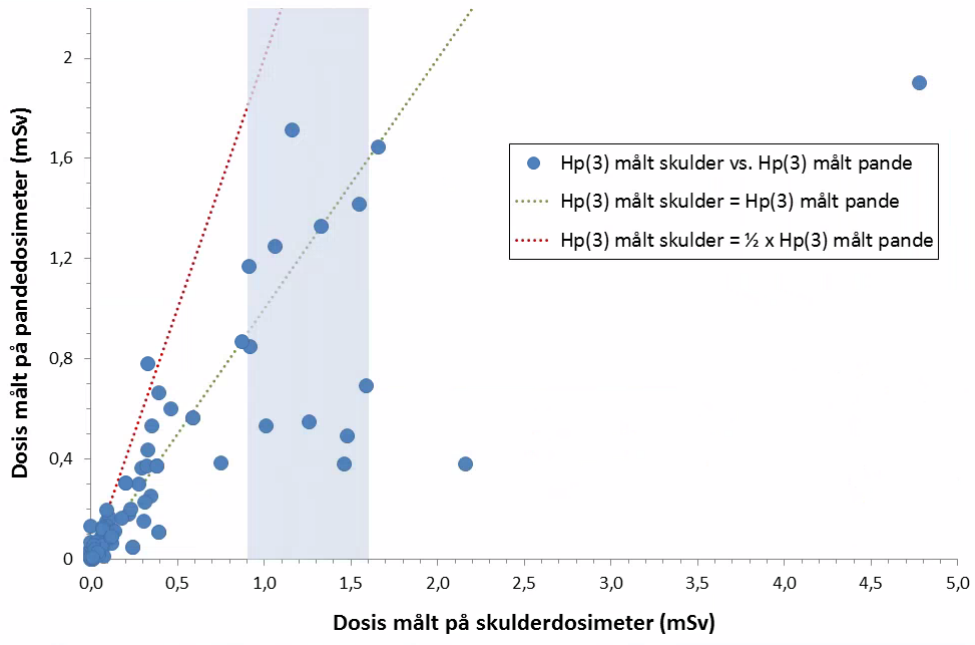
[2] The technical specifications of the PHE headband dosimeter can be read in this leaflet: https://www.ukhsa-protection-services.org.uk/cms/assets/gfx/content/resource_2974cs6788076842.pdf

dose equivalent, $H_{\mathrm{p}}(3)$, can be used as a measure of dose to the lens of the eye. $H_{\mathrm{p}}(3)$ measured on the shoulder has in some cases been above 20 mSv while $H_{\mathrm{p}}(3)$ measured on the forehead has been below 10 mSv for all measurements.



The measurements thus indicate that $H_{\mathrm{p}}(3)$ measured on the shoulder in many cases overestimates $H_{\mathrm{p}}(3)$ measured on the forehead. This result is not surprising, as some of the personnel have used different types of protective equipment. It is also seen that there is no simple correlation between the doses measured with the two different dosimeters. However, it is found that over 95% of the doses measured at the forehead are less than half the corresponding dose measured at the shoulder.

It can also be seen that many of the measured doses are relatively small and therefore do not give rise to an expected exceedance of the dose limit of 20 mSv/year. This is shown more clearly in the figure below, where the highest measured doses are omitted. It also shows a shaded area that can be used to assess the significance of monthly $H_{\mathrm{p}}(3)$, measured with a shoulder dosimeter. This is further elaborated in the following section.



In the following, reference is therefore made only to the measurement of dose given as $H_{\mathrm{p}}(3)$, measured using shoulder dosimeters.

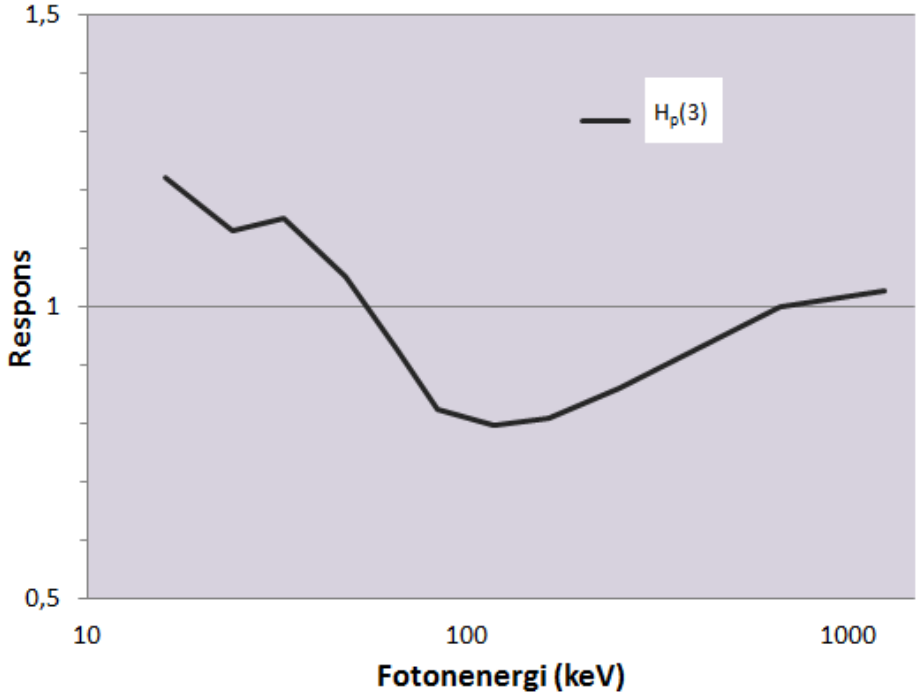
When several of a person's measured monthly doses are either significantly or consistently lower than the shaded area shown above, i.e. below approx. 0,8 mSv, the more certain it is that the dose limit for the lens of the eye is not exceeded. This must, of course, always be considered in conjunction with any changes in procedures and accident risk assessment.

For measured monthly personal doses above the shaded area, i.e. above approx. 1,6 mSv, there is a correspondingly greater risk of exceeding the annual dose limit. In these cases, consideration should be given to the need to take measures in the form of glasses or other shielding. A reservation must of course be made that any protection factor from shielding may not be reflected in the measured dose, for example when using lead glasses.

Similarly, further investigation of radiation doses may be needed in cases where the average monthly dose is within the shaded area, 0,8 mSv to 1,6 mSv. Please contact us in case of doubt.

Technical specifications of the shoulder dosimeter

The shoulder dosimeter is calibrated to measure the personal dose equivalent $H_{\mathrm{p}}(3)$, which is used as a measure of the dose to the lens of the eye. The response curve of the dosimeter for photon energies between 16 keV and 1,3 MeV is shown below. The response is given as the measured dose, $H_{\mathrm{p}}(3)$, on the shoulder dosimeter divided by the known dose, $H_{\mathrm{p}}(3)$, to which the dosimeter is exposed.



High energy beta particles (electrons) can also penetrate the outer part of the eye and strike the lens of the eye. Below is the $H_p(3)$ response curve for beta particles from a $^{90}Sr/^{90}Y$ source with a maximum energy of 2,3 MeV. The response is shown for irradiation angles up to ±60°.