STUK

GUIDE **ST 7.1** / 14 August 2014

MONITORING OF RADIATION EXPOSURE

This Guide is valid as of 1 October 2014 until further notice.
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Authorization

Under section 70, paragraph 2, of the Radiation Act (592/1991), STUK – Radiation and Nuclear Safety Authority (Finland) issues general instructions, known as Radiation Safety Guides (ST Guides), concerning the use of radiation and operations involving radiation.

The Radiation Act stipulates that the party running a radiation practice is responsible for the safety of the operations. The responsible party is obliged to ensure that the level of safety specified in the ST Guides is attained and maintained.

Translation. Original text in Finnish.

This Guide includes the requirements relating to the implementation of Council Directive 96/29/Euratom; OJ No. L 159, 29.6.1996, p. 1.

1 General

The duties of the party running a radiation practice (hereafter the responsible party) include arranging radiation protection of workers engaged in radiation work as prescribed in chapter 9 of the Radiation Act (592/1991). The fundamentals of radiation exposure monitoring are prescribed in greater detail in chapter 3 of the Radiation Decree (1512/1991). Pursuant to section 32 of the Act, the Radiation and Nuclear Safety Authority (STUK) issues more specific requirements and guidelines for monitoring radiation exposure.

This ST Guide presents the requirements for monitoring radiation exposure and defines the associated concepts. It also states when radiation exposure monitoring is necessary and how it must be arranged.

This ST Guide applies both to workers engaged in radiation work and to students and apprentices who are involved in the use of radiation sources.

This Guide also governs monitoring of exposure to natural radiation when this is separately ordered by STUK, pursuant to section 46 of the Radiation Act and section 28 of the Radiation Decree.

Radiation exposure monitoring is also governed by Guides ST 12.1 and ST 12.4 with respect to natural radiation and by Guide YVL C.2 with respect to use of nuclear energy. The classification of workers in radiation work is discussed in Guide ST 1.6, organization of medical surveillance is discussed in Guide ST 7.5, and radiation measurements and quantities associated with radiation practices are discussed in Guides ST 1.9 and ST 7.2.

2 Definitions

Radiation work means work in which the radiation exposure of a worker may exceed any of the dose limits for members of the public prescribed in section 6 of the Radiation Decree.

External radiation means radiation directed to the human body from outside of the body.

Internal radiation means radiation that is emitted by radioactive substances that have entered the body and directed at the body itself.

Monitoring of radiation exposure refers to **individual monitoring** and to **monitoring of working conditions.**

Monitoring of working conditions means monitoring of various factors in the working environment that affect exposure to radiation. Monitoring of working conditions also includes keeping records of measurement results.

Individual monitoring means measuring and determining the personal dose due to internal or external radiation. Individual monitoring also includes keeping records of doses that have been determined.

Approved dosimetric service denotes an operating unit or service provider that is responsible for measuring and determining personal radiation doses as part of the process of monitoring the radiation exposure of workers, the competence of which for the said function has been verified by STUK.

Investigation level means an operation-specific limiting value imposed by the responsible party for dose, activity or some other regularly monitored radiation quantity. When the limiting value is exceeded the responsible party takes predetermined measures to investigate the reason for the excessively high value. The limiting value is normally imposed for an individual measurement result.

Outside worker means a worker or self-employed person who participates in radiation work ordered by the responsible party while not in the service of the said responsible party.

3 General requirements

A responsible party must arrange radiation exposure monitoring in the manner required by the nature and scope of the practice so that individual monitoring is arranged for each category A worker and the doses of category B workers may be determined when necessary.

Persons under 18 years of age may not engage in radiation work. If a person over 16 but under 18 years of age is involved in using radiation sources as part of his or her vocational training then radiation exposure monitoring shall be arranged in the same way as for other employees.

Before radiation work commences the responsible party shall procure details of the worker's previous radiation exposure, for example from

a reliable summary obtained from the worker or from the worker's previous employer to be able to ensure that dose limits are not exceeded. The responsible party must maintain records of radiation exposure monitoring results for its workers. The responsible party must also ensure that radiation exposure monitoring is arranged for any employees of outside enterprises who work for the responsible party. The outside enterprise, as an employer, must ensure that radiation exposure monitoring has been arranged.

The identity details of workers subject to individual monitoring and their personal radiation doses sustained at work must be notified to STUK for entry in the Dose Register as specified in Guide ST 7.4.

3.1 Monitoring of working conditions

Monitoring of working conditions must be arranged at all workplaces where radiation work is done. The results of monitoring measurements must be recorded and saved so that they may subsequently be used as necessary to determine personal radiation doses where some special need for doing so arises. Such needs may arise, for example, in the event of radiation exposure due to an abnormal incident, of a dosemeter breakdown, or of circumstances in which an error is suspected in dose determination.

Monitoring of working conditions must be arranged by some expedient method. The requirements for measurement methods are set out in Guide ST 1.9.

3.2 Individual monitoring

Individual monitoring is utilized to determine the radiation dose that each worker has received. It must be arranged for all category A workers. It is also often expedient to arrange individual monitoring for category B workers, as well.

The doses due to both internal and external radiation that are submitted for recording in the Dose Register must be determined by an approved dosimetric service. Individual monitoring must be based on individual measurements.

The dose due to internal radiation must be monitored if quantities of radioactive substances that are significant from the point of view of exposure to radiation can enter the body of the worker. No determination of the dose due to internal radiation is generally necessary when safe working methods are used for handling unsealed sources, regular contamination measurements are made and contamination remains minor. The dose to the skin must also be determined when the work causes skin contamination that is significant from the point of view of radiation exposure.

Chapter 5 of this ST Guide lists examples of duties for which individual monitoring must be arranged.

If an individual dose cannot be measured, for example due to a dosemeter breakdown, or if an error in dose determination is suspected, then the radiation dose must be estimated by calculation, for example based on measurements taken for monitoring of working conditions or on measurements concerning other monitored workers. The responsible party is responsible for making dose estimations. The estimated dose and the manner of estimation must be notified to the Dose Register.

3.3 Documentation and storage of documents

A responsible party must save the results of monitoring of working conditions and individual monitoring so that they are available for monitoring and improving the safety of the practice in line with the principles of limitation and optimization.

Either the monitoring results of individual monitoring periods or annual summaries of these results must be stored from the results of individual monitoring of workers for the entire duration of the worker's service. Important details pertaining to determining the personal radiation dose of a worker, such as the results of thyroid and skin contamination measurements, must likewise be stored. The results of monitoring of working conditions must be saved for not less than five years and for as long as is necessary for improving working methods.

The responsible party must save the details pertaining to individual monitoring for as long as the worker remains in the service of the responsible party. Any details that may help in monitoring the safety of the practice, in optimization and in assessing working methods

must also be saved after the worker's employment has ended.

The safekeeping of data is also governed by the Personal Data Act (523/1999).

4 Monitoring of working conditions

The purpose of monitoring of working conditions is to detect changes that occur in the working environment and to assess their impact on radiation exposure. Monitoring of working conditions enables prompt detection of unpredictable nonconformities in factors that affect the radiation exposure of workers. Monitoring of working conditions includes measuring the dose rate of external radiation, measuring contamination in the workplace, and observing whether safety devices are working in the intended manner.

The results of monitoring of working conditions may be used to investigate the need for individual monitoring and to enable verification that workers have been appropriately classified into categories A and B. Measurements taken for the purpose of monitoring of working conditions must enable the radiation exposure of workers to be determined when necessary.

4.1 Group dosemeters

Group dosemeters may only be used for monitoring of working conditions. In this case several persons use one dosemeter. Records must be kept of the persons using the dosemeter and of their working hours. Group dosemeters are not suitable for use in individual monitoring, and may not be used for determining personal doses. A group dosemeter is typically used in association with a certain appliance by a person, who suffers the greatest exposure while working in the vicinity of this appliance and for whom no individual monitoring has been arranged. The group dosemeter is used in all radiation work performed using the said appliance and the results are applied for investigating the need for individual monitoring.

4.2 Data to be stored from monitoring of working conditions

The following details are recorded from monitoring measurements of working conditions according to the practice in question:

- the time of the measurements
- the measured dose or the external radiation dose rates, in which case the type of radiation and energy or the radionuclide used are also notified
- the contaminating radioactive substance, its activity in air and at surfaces, and its physical and chemical form
- the duration of worker exposure where this is necessary for calculating the dose
- an indication where no external radiation or contamination was found
- records of group dosemeter use enabling an estimate of worker radiation exposure and conclusions as to the need for individual monitoring.

5 Need for individual monitoring

When considering the need for individual monitoring attention must be paid to the total radiation exposure arising from work, i.e. to all work and sources causing exposure to radiation, from which the worker may suffer exposure. The dose arising from both external and internal radiation must be considered when comparing the radiation dose sustained by the worker to the dose limits prescribed in section 3 of the Radiation Decree.

The need for individual monitoring must always be considered in the light of local working conditions and the degree of radiation exposure. Individual monitoring must always be arranged for category A workers. Guide YVL C.2 governs the arrangements for individual monitoring of workers at nuclear power plants.

5.1 External radiation

Individual monitoring of exposure to external radiation must generally be arranged in at least

the following duties involving use of radiation:

1. medical or veterinary X-ray examinations when radiation is used regularly or repeatedly in a controlled area
2. radiotherapy and the performance of quality control measurements on radiotherapy equipment
3. nuclear medicine treatments and care of patients who have undergone such treatments, except in the case of patients treated with radiopharmaceuticals emitting beta radiation only
4. handling of unsealed sources:
   - if the activity of gamma radiation sources handled at any one time exceeds 100 MBq
   - if the activity of beta radiation sources (of maximum energy exceeding 300 keV) handled at any one time exceeds 10 MBq
5. industrial radiography, except in cases of sealed installation
6. installation, repair and servicing work involving a risk of exposure to radiation
7. work with particle accelerators
8. other duties involving the use of radiation sources when individual monitoring is required by the terms of a safety licence or on some other grounds.

Individual monitoring to determine the dose due to neutron radiation must be arranged using a dosemeter that is suitable for this purpose if the dose is or may be greater than 0.2 mSv per month.

Individual monitoring is generally not required in the following duties involving use of radiation:

1. X-ray examinations, when the X-ray equipment operator is in a separate control room that is well shielded and has not been classified as a controlled area (see Guide ST 1.6 for further details of controlled areas)
2. mammography examinations
3. dental X-ray examinations (panoramic imaging and imaging on an intra-oral image receptor), where performed at the dental surgery
4. measurement of bone mineral density
5. work on premises using well shielded radiation appliances or sources, where access to the radiation beam is barred, for example radiometric appliances in industrial facilities
6. handling of unsealed sources:
   - if the activity of gamma radiation sources handled at any one time is less than 100 MBq
   - if the activity of beta radiation sources (of maximum energy exceeding 300 keV) handled at any one time is less than 10 MBq
   - if only beta radiation sources of maximum energy less than 300 keV are handled.

5.2 Internal radiation

The need for individual monitoring of internal radiation must be investigated when there is a risk of radioactive substances entering the body or of skin contamination. This need depends on the working conditions, on the type of work, and on the nature and activity of any radionuclides handled, and their physical and chemical properties. The need for individual monitoring is investigated by estimating internal radiation doses as specified in Guide ST 7.3 using measurements taken for monitoring of working conditions.

Individual monitoring of exposure to internal radiation must generally be arranged in at least the following duties involving use of radiation:

- work in laboratories of type A
- handling of radioactive substances in an easily volatile or dusty form, and in quantities that are significant for radiation exposure
- handling of unsealed sources containing iodine isotopes (especially ^{131}I, ^{125}I and ^{123}I) in quantities that are significant for radiation exposure
- work in rooms where radionuclides or radiopharmaceuticals are manufactured
- other duties in which individual monitoring is required under the terms of a safety licence or on other grounds.

To determine the committed effective dose or the equivalent dose to some organ due to internal radiation, the activity of radioactive substances in the body is measured directly from the body, from a part thereof, or from excretions thereof, and the dose is estimated from the measurement result. The amount of radioactive substances entering the body through the airways may be

estimated using a personal air sampler. The dose is then calculated on the basis of the exposure time.

It may also be necessary to determine the dose caused by internal radiation following an abnormal incident in order to be able to decide on any further actions warranted by the incident and on optimization of radiation protection measures.

6 Individual monitoring

6.1 External radiation

6.1.1 Monitoring period

The monitoring period is not more than one month for category A workers, and not more than three months for others. The monitoring period may be longer than one month if a worker has been classified as a category A worker solely due to a risk of abnormal exposure (potential radiation exposure). The worker must then use an electronic dosemeter with continuous read-out, suitable for the purpose, or an alarm dosemeter that can detect abnormal exposure.

A new monitoring period must begin at once for a worker who has notified her pregnancy so that the dose to the foetus can be monitored. A pregnant worker may not continue to perform the duties of a category A worker.

6.1.2 Use of alarm dosemeters and alarming survey meters

In addition to a personal dosemeter, an alarm dosemeter or an alarming survey meter must be used in industrial radiography or in work carried out in an irradiation plant or in comparable installations. These alarm devices must be used in addition to personal dosemeters in installation, repair and servicing work if the work involves a risk of exposure to the primary radiation beam of a device.

The alarm emitted by the alarm device must be clear enough to be certainly noticed regardless of environmental conditions and protective devices (such as hearing protectors).

6.1.3 Dosemeter location

The dosemeter must be positioned on the body so that it is not shielded by any part of the body and is optimally perpendicular to the direction of incident radiation. The best location is usually on the chest of clothing worn at work. For practical reasons when there is no need to measure beta radiation, the dosemeter may be kept in the breast pocket of this clothing.

Part of the body is shielded from radiation when using a protective apron or other personal protective devices in health care and veterinary medicine. The dosemeter must then be placed outside of the protective device so that the same dosemeter may be used for estimating the dose to the body and to the eyes where necessary.

In health care duties involving the use of X-radiation in which exposure may be high (dosemeter readings exceeding 20 mSv per year) a second dosemeter must be worn under the protective apron. The responsible party must then estimate the effective dose having regard to such factors as shielding, working methods and working conditions.

6.1.4 Doses to hands and fingers

The doses to a worker's hands and fingers may be significant in interventional radiology, certain repair and servicing duties, and when unsealed sources are handled, such as industrial indicator tests, labelling of a radiopharmaceutical, or injecting it into a patient.

Doses to the hands (fingers) must be investigated in particular when new working methods or radioactive substances are taken into use causing hitherto insufficiently well-known exposure. Doses to the hands must also be investigated when a new worker begins working with unsealed sources.

The finger dosemeter is generally placed at the base of the middle finger with the detector on the side from which the radiation is incident. The dosemeter may also be placed at some other point where there is cause to presume that the dose to the hands is substantially larger at another point.

6.1.5 Dose to the eyes

When exposure to photon radiation occurs the dose to the eyes may be estimated as necessary from the personal dose equivalent $H_p(0.07)$ measured by a personal dosemeter. When using personal protective devices the dose to the eyes is estimated from $H_p(0.07)$ measured outside of the device on the individual's chest.

Separate measurement of the dose to the eye is necessary in certain special cases, for example when the dose to the eye cannot be estimated with sufficient accuracy from the dose measured on an apron. A dosemeter attached to a headband may then be used, for example.

6.2 Internal radiation

6.2.1 Alpha and beta radiation

Radionuclides emitting only alpha radiation or low-energy beta radiation (of maximum energy not exceeding 300 keV) cause radiation exposure in practice only on contact with the skin or when ingested or inhaled. Individual monitoring must then be arranged, for example so that the activity is measured by analyzing urine samples or other biological specimens, with the dose due to radiation estimated on the basis of the measurement result.

6.2.2 Gamma radiation

The activity of gamma emitters in the body is determined using measuring devices that are suited to this purpose, such as a whole body counter or gamma camera, with the dose estimated on the basis of the measurement result.

6.2.3 Dose to the thyroid

The amount of radioactive substances accumulating in the thyroid must be monitored when iodine isotopes are handled in a readily volatile form. A sufficiently sensitive radiation meter suitable for this purpose must be used for the measurements. A NaI(Tl) detector is suitable, for example.

The quantity of radioactive substance accumulating in the thyroid may be significant when performing labelling work with radioactive iodine. If labelling work is done more often than once a month, then the amount of iodine accumulating in the worker's thyroid must be monitored every two weeks. If labelling work is done once a month or less frequently, then the monitoring measurement must be made after each labelling occasion. It is then recommended that the measurement be performed 24 hours after the labelling work ends.

A record must be kept of the measurement results. If the activity found in the thyroid exceeds 5 kBq, then the radiation dose caused by this must be determined and the result must be notified to STUK for recording in the Dose Register.

7 Setting and use of investigation levels

The responsible party must forecast the anticipated radiation exposure of workers in ordinary operations. This forecast may rely on such factors as previous results of monitoring radiation exposure where no changes have occurred in exposure conditions.

Based on the forecast, the responsible party must set investigation levels for individual monitoring. Investigation levels should also be set for monitoring of working conditions where possible. Investigation levels may be used for ensuring safety, and for optimization and quality assurance.

For example, the investigation levels for individual monitoring should be set for specific duties so that the anticipated doses of persons performing the said duties at the workplace in question fall below the investigation level.

The radiation work guidelines must specify the practical actions to be taken if investigation levels are exceeded. Unexpected exposure may be due, for example, to a faulty appliance or to methods of working or operation that differ from those planned. The reasons for exceeding investigation levels must be investigated and any defects must be rectified.

8 Radiation exposure due to abnormal incidents

The responsible party must immediately notify STUK of the matter when a measured radiation dose is noticeably large (approaching or exceeding the annual dose limit). The result of measurement must be verified and the equivalent doses and effective dose must be estimated.

Other directions for managing abnormal incidents are provided in Guide ST 1.6.

9 Outside workers

When using outside workers the responsible party must ensure that monitoring of radiation exposure and medical surveillance have been arranged for these workers in accordance with sections 32 and 33 of the Radiation Act. The employer of outside workers may organize monitoring of radiation exposure and medical surveillance. If no monitoring of radiation exposure or medical surveillance has been arranged, then the responsible party shall arrange these in the same way as for its own employees. However, no parallel individual monitoring need be arranged for outside workers with personal dosemeters of their own.

The responsible party must check the radiation exposure details of outside workers engaged in radiation work before radiation work commences. A radiation passbook is used for checking details of radiation exposure in Member States of the European Union. At the end of the work the responsible party (or an approved dosimetric service) must enter details of the duration of radiation work, radiation exposure during the said work and any health reviews in the radiation passbook of foreign workers.

10 Working abroad

Individual monitoring when working abroad will be arranged in a manner approved by the radiation protection authorities of the State in question. The local responsible party is responsible for arranging individual monitoring when working in European Union countries.

When working abroad for a Finnish employer, the said employer must ensure that individual monitoring is properly arranged where the work so requires. Alternatively, a Finnish dosimetric service may then be used. This is often the most effective way to work, particularly in short-period employment. Only one dosemeter must be used at a time.

A Finnish employer must also ensure that radiation doses sustained by a worker abroad are notified to the Dose Register in Finland. Notification to the Dose Register of radiation work performed abroad is governed by section 35 of the Radiation Act, and further directions have been issued in Guide ST 7.4.

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