STUK

GUIDE **ST 5.3** / 4 MAY 2007

USE OF IONIZING RADIATION IN THE TEACHING OF PHYSICS AND CHEMISTRY

This ST Guide is valid as of 1 June 2007 until further notice. It replaces Guide ST 5.3 Use of Ionising Radiation in the Teaching of Physics and Chemistry, issued on 17 February 1999.

Helsinki 2007
ISSN 0789-4619
ISBN 978-952-478-269-2 (pdf)
ISBN 978-952-478-270-8 (html)

STUK • **SÄTEILYTURVAKESKUS**
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Osoite/Address • Laippatie 4, 00880 Helsinki
Postiosoite / Postal address • PL / P.O.Box 14, FIN-00881 Helsinki, FINLAND
Puh./Tel. (09) 759 881, +358 9 759 881 • Fax (09) 759 88 500, +358 9 759 88 500 • www.stuk.fi

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

1 General

Apparatus producing ionizing radiation for use in school education is generally of low power and the amount of radioactive material used as a radiation source is minimal. It is nevertheless important to exercise caution and comply with operating instructions during demonstrations and student practical exercises to avoid any radiation exposure of the students or teacher.

Using apparatus of good quality and ondition and complying with regulations on the storage and disposal of radioactive materials are mportant for ensuring radiation safety. It is also essential for any radiation meters used in teaching to be sufficiently sensitive to register even minimal radiation doses or dose rates.

This guide sets out the safety requirements for using radiation in school education and the principles under which radiation sources may be used without the safety licence referred to in section 16 of the Radiation Act (592/1991). It covers the use of radiation sources emitting ionizing radiation in comprehensive schools and high schools, and the use of radiation in the teaching of physics and chemistry at vocational training institutions and corresponding educational facilities. The radiation sources used at universities and other institutes of higher education are generally of such high activity and power that their use requires a safety licence. If radiation sources that are exempt from safety licensing are used at universities and other institutes of higher education, then their use may be arranged in accordance with this guide.

The guide does not apply to electrically operated appliances generating ionising radiation at a voltage of less than 5000 volts.

2 Safety licences and exemption from licensing

Under section 16 of the Radiation Act (592/1991), the use of radiation is generally not permitted without a safety licence.

Under section 17 of the Act, certain practices are exempt from the safety licence requirement. The Radiation and Nuclear Safety Authority (STUK) may exempt other types of radiation use from safety licensing if it can be verified with sufficient reliability that this use of radiation causes no health hazard. The basic criteria for exempting a use of radiation from safety licensing are set out in Guide ST 1.5.

It is recommended that the use of radiation in school education be arranged in a manner that does not require a safety licence.

3 Safety licence-exempt use of radiation

3.1 Radiation sources approved for educational use

Radiation sources may be used in school education without a safety licence if they have been inspected by STUK and thereby discharged from the safety licence requirement and approved for educational use.

By decision no. 30/310/07 STUK has, subject to certain conditions, exempted from safety licensing the use of teaching aids that generate ionizing radiation electrically or that contain radioactive substances when these aids are used for teaching physics or chemistry in schools, vocational training institutes or corresponding educational institutions. The exemption decision sets the following conditions for granting an exemption from safety licensing:

- The radiation source, or type of source, must either have been inspected by STUK and approved for educational use with respect to its radiation safety properties, or it must have been inspected and approved elsewhere for educational use in the manner required by an international treaty that Finland has signed. The radiation source must be labelled in a manner showing that it has been approved.
- The educational institution must appoint a person responsible for radiation safety to supervise compliance with radiation safety regulations and instructions when the institution uses and stores radiation sources and when it disposes of radioactive waste.

- Any broken or disused radiation sources containing radioactive substances must be treated as radioactive waste.

Applications for the foregoing approval will generally be lodged by the manufacturer or importer of the radiation source.

3.2 Radiation appliances for use as consumer goods and exemption values

Under the Radiation Act or decisions of STUK, no safety licence is required for the following practices:

- The use of radiation appliances that are used as consumer goods. Such appliances include smoke detectors for domestic use and compasses containing radioluminous paint.
- The use of radiation appliances that have been exempted from control due to the very minimal radiation exposure that they cause. Such appliances include those containing a sealed source of activity not exceeding the exemption value.
- The use and possession of radioactive substances where the activity or activity concentration held on any single occasion falls below the exemption value.
- The use of mineral and rock samples containing naturally occurring radioactive substances.

No safety licence is required for a mixture of radionuclides or more than one radionuclide if the following condition is met:

$$\sum_k \frac{A_k}{A_{E,k}} \leq 1 \quad \text{or} \quad \sum_k \frac{C_k}{C_{E,k}} \leq 1$$

Where:

A_k is the activity of radionuclide k,

$A_{E,k}$ is the exemption value for radionuclide k,

C_k is the activity concentration of radionuclide k, and

$C_{E,k}$ is the activity concentration exemption value for radionuclide k.

The exemption values for radionuclides are set out in Guide ST 1.5. They apply equally to both sealed and unsealed sources. The exemption values of the most commonly used radionuclides are as follows:

Radionuclide	Exemption value	
	Activity (kBq)	Activity concentration (kBq/kg)
Co-60	100	10
Sr-90	10	100
Cs-137	10	10
Ra-226	10	10
Am-241	10	1

Use of radioactive substances as unsealed sources should be avoided unless there is a particular educational need for such use.

4 Responsible persons and their duties

The person referred to in section 3.1, who is appointed to be responsible for radiation use, should have the necessary knowledge and ability to serve in this capacity. In practice th responsible person is generally the teacher of physics or chemistry who is otherwise responsible for educational use of the radiation sources.

The responsible person must study the radiation safety regulations and instructions governing radiation sources for use as educational aids. The said person shall also ensure that:

- the inventory of radiation sources is up to date
- the radiation sources are labelled in the correct manner
- the radiation sources and their radiation shielding are in good condition
- operating and safety instructions that are adequate for the demonstration, and the special mandatory regulations stipulated in the documents discharging the radiation sources from the licensing requirement or elsewhere, are available to the teacher
- storage of radiation sources has been arranged in accordance with safety requirements
- disused radiation sources (radioactive wastes) are managed in an appropriate manner.

No serious radiological emergencies can generally arise from the use of radiation sources that are intended for use in school education. Even though there would be no need for special radiation protection measures in the case of unusual event, it is advisable to prepare instructions on how to respond in cases of incident, accident, malfunction and misuse. These instructions should at least include a description of the immediate measures to be taken when the event is discovered, and of the procedures for contacting the responsible persons at the school and STUK.

It is advisable to prepare a summary of the main instructions and radiation safety aspects, and to ensure that this is available in the physics or chemistry classroom or in the place where radiation sources are stored. An example of such a summary can be found in Appendix A.

5 Licensed use of radiation

An educational institution, or the organisation that is responsible for its operations, must apply for a safety licence in accordance with section 16 of the Radiation Act if it intends to use radiation sources other than the licence-exempt sources referred to in section 3. The licence application must be submitted to STUK in the manner prescribed in chapter 4 of the Radiation Decree (1512/1991).

Depending on the nature and extent of the use of radiation, the application must provide sufficient detail regarding such matters as the place where the radiation will be used, the radiation sources, any protection and alarm systems to be used, any arrangements for monitoring radiation exposure, and the manner of handling radioactive waste and rendering it harmless.

The Radiation Safety Officer referred to in section 18 of the Radiation Act, who is responsible for safety in the use of radiation, must be appointed for any licensed use of radiation. Candidates for the position of Radiation Safety Officer must satisfy the qualification requirements set out in Guide ST 1.8. The safety requirements governing the licensed use of radiation are set out in other ST Guides on the specific radiation practices concerned.

6 Safety requirements for licence-exempt uses of radiation

6.1 Limitation of radiation exposure

The general principles of radiation protection require exposure to radiation to be kept as low as is reasonably achievable.

Uses of radiation in school education must be planned and implemented in a manner ensuring that:

- the effective annual dose caused to teaching staff, students and other persons does not exceed 0.3 mSv
- the dose caused to any student by a single demonstration does not exceed 0.03 mSv.

6.2 Labelling and storage of radiation sources

Radiation sources must bear an ionizing radiation warning label. Appliances containing radioactive substances must also bear a label specifying the radionuclide in question, its activity, and the date when the activity was determined.

Radiation sources must be returned to their place of storage immediately after the lesson. The place of storage must be lockable, and the person responsible for radiation safety must give permission for any access to or opening of such a storage place. Any storeroom or cupboard in which radioactive substances are stored must bear an ionizing radiation hazard warning sign.

A list must be kept of all radiation sources in the possession of the educational institution, indicating the identifying details of the radiation source, such as its manufacturer, type, serial number, radionuclide, activity, and the date when this activity was determined.

6.3 Decommissioning of radiation sources

A radiation source that has become unnecessary must be promptly decommissioned. It is not acceptable to store such sources on the premises of an educational institution.

The provisions of Guide ST 6.2, Radioactive wastes and discharges, must be observed when a disused radiation source constitutes radioactive waste.

If a licence-exempt radiation source that has become unnecessary to an educational institution may still be used for teaching physics and chemistry, then the source may be transferred to another educational institution for this purpose. A certificate of the transfer signed by both parties must be prepared, specifying the radiation source transferred, and the time of transferring ownership, custody and responsibility with respect to the said radiation source.

An entry must be made in the list of radiation sources indicating that a radiation source has been removed from use, and specifying the time of removal and details of the place to which the radioactive waste was delivered or the source was transferred.

6.4 Directions for protection

The teacher must ensure that use of a radiation source continues for no longer than is educationally essential, and that students do not handle the radiation source needlessly or without supervision.

The intensity of radiation is inversely proportional to the square of the distance from the radiation source. This means that radiation exposure is easily reduced by increasing the distance from the radiation source.

A radiation source may not be needlessly kept outside of its shielding. A radiation source that has been removed from its shielding must be handled in a manner that prevents unnecessary exposure of any part of the body to radiation.

7 Restrictions of use

Use of unshielded X-ray appliances in school education is prohibited. X-ray appliances are only approved for use in education when the primary radiation beam is so well shielded that there is no need to impede further access to the area directly in front of the primary beam.

Cold cathode type discharge tubes are liable to generate X-radiation. This X-radiation causes no hazard if the discharge tube voltage does not exceed 5000 volts. No adjustable voltage source with a maximum voltage exceeding 5 kV may therefore be used with a discharge tube unless there is also a voltmeter or some other means of ensuring that the voltage does not exceed 5 kV.

The foregoing discharge tubes include the following:

- a Crookes tube for demonstrating how cathode rays bend in a magnetic field
- a Braun tube
- cathode-ray tubes containing fluorescent material
- a Maltese cross tube
- a tube for demonstrating the pressure of cathode rays
- a tube for demonstrating the thermal effect of cathode rays
- a canal ray tube.

A spark inductor may not be used as a voltage source for appliances that generate X-radiation, as there is no guarantee that the voltage will remain below 5 kV.

No ^{226}Ra source that is more than ten years old may be used unless it has been verified that the source remains securely sealed.

Bibliography

1 International Commission on Radiological Protection. Protection against Ionizing Radiation in the Teaching of Science. ICRP Publication 36. Oxford: Pergamon Press; 1983.

2 International Commission on Radiological Protection. 1990 Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Oxford: Pergamon Press; 1991.

APPENDIX (EXAMPLE)

RADIATION SAFETY WHEN USING DEMONSTRATION AIDS

Ensure that the radiation sources are not damaged and that their safety mechanisms are in working order.

Familiarise yourself with the operating instructions for the appliances and follow these instructions.

Use radiation sources only for as long as is necessary for educational purposes.

Ensure that nobody is directly in front of the primary beam of an X-ray appliance during a demonstration, and that students do not handle radiation sources needlessly or without supervision.

Do not keep a radiation source needlessly outside of its shielding. Always handle an unshielded radiation source in a manner ensuring that no part of the body is needlessly exposed to radiation.

Return radiation sources to their lockable storage place immediately after the demonstration.

Notify the person responsible for radiation safety at once of any radiation source that is defective or missing.

Further information on the use of radiation is available from the Radiation and Nuclear Safety Authority (STUK), telephone (09) 759 881.

THE PERSON RESPONSIBLE FOR RADIATION SOURCES USED IN TEACHING PHYSICS AND CHEMISTRY AT THIS SCHOOL AND FOR THEIR SAFETY INSTRUCTIONS IS

_____

ST GUIDES (9 August 2007)

General Guides

ST 1.1 Safety Fundamentals in Radiation Practices, 23 May 2005 (in Finnish)
ST 1.3 Warning Signs for Radiation Sources, 16 May 2006
ST 1.4 Radiation User's Organization, 16 April 2004
ST 1.5 Exemption of the Use of Radiation from the Safety Licence and Reporting Obligation, 1 July 1999
ST 1.6 Operational Radiation Protection, 29 December 1999
ST 1.7 Radiation Protection Training in Health Care, 17 February 2003
ST 1.8 Qualifications of Persons Working in Radiation User's Organization and Radiation Protection Training Required for Competence, 16 April 2004

Radiation Therapy

ST 2.1 Quality Assurance in Radiotherapy, 22 May 2003
ST 2.2 Radiation Safety of Radiotherapy Equipment and Treatment Rooms, 2 February 2001.

Diagnostic Radiology

ST 3.1 Use and Regulatory Control of Dental X-ray Installations, 27 May 1999
ST 3.2 Mammography Equipment and Their Use, 13 August 2001
ST 3.3 X-ray Examinations in Health Care, 20 March 2006
ST 3.6 Radiation Safety in X-ray Facilities, 24 September 2001.
ST 3.7 Breast Cancer Screening Based on Mammography, 28 March 2001

Industry, Research, Education and Commerce

ST 5.1 Radiation Safety of Sealed Sources and Equipment Containing Them, 17 February 1999
ST 5.3 Use of Ionising Radiation in the Teaching of Physics and Chemistry, 4 May 2007
ST 5.4 Trade in Radiation Sources, 2 October 2000
ST 5.6 Radiation Safety in Industrial Radiography, 17 February 1999
ST 5.8 Installation, Repair and Servicing of Radiation Appliances, 17 February 1999

Unsealed Sources and Radioactive Wastes

ST 6.1 Radiation Safety Requirements for Radionuclide Laboratories, 1 July 1999
ST 6.2 Radioactive Wastes and Discharges, 1 July 1999
ST 6.3 Use of Radiation in Nuclear Medicine, 18 March 2003

Radiation Doses and Health Surveillance

ST 7.1 Monitoring of Radiation Exposure, 2 August 2007
ST 7.2 Application of Maximum Values for Radiation Exposure and Principles for the Calculation of Radiation Dose, 9 August 2007
ST 7.3 Calculation of the Dose Caused by Internal Radiation, 1 July 1999
ST 7.4 Registration of Radiation Doses, 25 February 2000
ST 7.5 Medical Surveillance of Occupationally Exposed Workers, 4 May 2007

Non-Ionizing Radiation

ST 9.1 Radiation Safety Requirements and Regulatory Control of Tanning Appliances 1 December 2003 (in Finnish)
ST 9.2 Radiation Safety of Pulsed Radars, 2 September 2003 (in Finnish)
ST 9.3 Radiation Safety during Work on Masts at FM and TV Stations, 2 September 2003 (in Finnish)
ST 9.4 Radiation Safety of High Power Display Lasers, 28 February 2007 (in Finnish)

Natural Radiation

ST 12.1 Radiation Safety in Practices Causing Exposure to Natural Radiation, 6 April 2000
ST 12.2 The Radioactivity of Building Materials and Ash, 8 October 2003
ST 12.3 Radioactivity of Household Water, 9 August 1993
ST 12.4 Radiation safety in aviation, 20 June 2005.