Abstract. The current state and need for radiation protection training in Finland have been surveyed by the Radiation and Nuclear Safety Authority – STUK. The survey sought to determine whether the current requirements for radiation protection training had been met, and to promote radiation protection training. Details of the scope and quality of present radiation protection training were requested from all educational institutes and organizations providing radiation protection training. The survey covered both basic and further training, special training of radiation safety officers, and supplementary training. The questionnaire was sent to 77 educational organization units, 66 per cent of which responded. Radiation workers and radiation safety officers were asked about radiation protection knowledge and needs for additional training. The questionnaire was sent to 880 radiation users and 170 radiation safety officers, 70 per cent of whom responded. The survey covered all professional groups and fields of the use of ionizing radiation except nuclear energy. The amount of radiation protection training in basic and further (specialization) training in the same vocational or academic degree varied remarkably by educational organization. The average amounts of radiation protection included in most professional degrees met the requirements. 32 per cent of workers considered their radiation protection training inadequate for their duties, and 48 per cent had completed no supplementary training in radiation protection over the last five years. Nurses working in public sector hospitals and physicians working in health centres had the greatest need for radiation protection training. 78 per cent of radiation workers in industry felt that they had sufficient radiation protection training. Co-operation between educational organizations is necessary to harmonize radiation protection training. Guidance of the Ministry of Education (the competent authority for education) is needed in this area, and the Radiation and Nuclear Safety Authority – STUK should also be involved.

1. Introduction

New requirements for radiation protection training and education of radiation workers have been issued in recent years in Finland, as in the whole of the European Union.

Council Directive 96/29/Euratom (the BSS Directive) lays down the basic safety standards for health protection of the general public and workers against the dangers of ionizing radiation. It also defines the concept of a qualified expert and establishes requirements for the training, experience and recognition thereof. The BSS Directive was transposed into Finnish legislation by a 1998 amendment to the Radiation Act. Further requirements have been defined in the radiation safety guides issued by STUK.

Council Directive 97/43/Euratom (the MED Directive) has been implemented in Finland by the 1998 amendment to the Radiation Act and by the Decree of the Ministry of Social Affairs and Health on the Medical Use of Radiation (no. 423 of 2000). The Decree specifies the requirements for the training and qualifications of health care professionals involved in medical exposures. Details of the content and minimum amount of radiation protection training for radiation workers in health care are set out in radiation safety guide ST 1.7 issued by STUK. These reference values are based on the EU Commission publication Radiation Protection 116. The requirements for training and qualifications must be met in Finland by the end of 2004.

The use of radiation in Finland is subject to licensing (safety licence) except where exempt. The safety licence is granted by STUK on application. According to the Radiation Act, a party responsible for the use of radiation is also responsible for the radiation protection training of workers. For the use of ionizing radiation, the responsible party must appoint a radiation safety officer. STUK will approve a radiation safety officer on request of the responsible party. The methods and requirements for the training and recognition of a radiation safety officer in Finland are broadly similar to those of a qualified expert specified in BSS Directive.
2. Training organizations

The universities, polytechnics, vocational schools and other educational organizations that provide education leading to qualification for occupations involving the use of ionizing radiation are also responsible for the radiation protection training included in basic and further training.

Training, education and accreditation of radiation safety officers may only be performed by an organization authorized by STUK.

Supplementary training in radiation protection is provided by universities, polytechnics, professional organizations or other training or educational organizations. A party responsible for radiation practices may also itself provide supplementary training in radiation protection.

The Ministry of Education is the competent authority in the education and training sector in Finland. According to the Radiation Act, STUK is the competent authority for the use of radiation. STUK issues qualification criteria and defines the content and amount of radiation safety training of radiation safety officers and radiation workers. STUK issues these criteria in its radiation safety guides.

3. The aim of the survey

The aim of this survey was to determine the amount and content of present radiation protection training, and to see how satisfied radiation workers and radiation safety officers are with their own radiation protection knowledge and radiation protection training, especially in the context of their duties. The aim was to clarify the situation in all fields involving the use of radiation, excluding nuclear energy.

3.1. The present state of radiation protection training

The survey sought answers to the following questions:

- How much radiation protection training is included in the basic and further studies leading to qualifications in occupations involving the use of ionizing radiation?
- What are the proportions of study credits in five separately prescribed radiation protection subject areas (fundamentals of radiation physics, fundamentals of radiation biology, radiation protection provisions, operational radiation protection, use of radiation in one's own duties)?
- How many hours of radiation protection training are included in the training of radiation safety officers for various fields of radiation use?
- In which fields of radiation use is supplementary radiation protection training provided by training organizations?
- How many persons participate in supplementary training of radiation workers each year?
- How many persons pass the examination for a radiation safety officer each year?

The survey included all qualifications of universities, polytechnics and vocational schools leading to occupations involving the use of ionizing radiation.

3.2. Radiation protection knowledge and the need for additional training

The survey sought answers to the following questions:

- What is the radiation protection knowledge of radiation workers and radiation safety officers in their own view?
- Is the amount of radiation protection training adequate in their own opinion?
- Do they need additional training in radiation protection?
- In which fields involving the use of radiation, and among which professional groups, is the need for additional training in radiation protection greatest?
- How many hours of supplementary training in radiation protection have radiation workers and radiation safety officers received over the last five years?
4. Methods

Questionnaires concerning the amount and content of training and education in radiation protection were sent by mail to:

• universities and higher education institutes providing radiation protection training and education (25 units),
• polytechnics (22 units) and some vocational schools (7 unit) providing qualifications leading to occupations involving the use of ionizing radiation,
• professional organizations providing supplementary training in radiation protection and educational organizations providing training for radiation safety officers (23 units).

Questionnaires concerning knowledge of and needs for radiation protection training were mailed to 880 radiation workers and 170 radiation safety officers. The radiation safety officers were randomly sampled from the Radiation Safety Licence Register maintained by STUK. 112 of them worked in health care and 58 in industry. Questionnaires to radiation workers were sent to unnamed recipients through contact persons responsible for radiation monitoring in workplaces. The contact persons were asked to forward the questionnaires to the representatives of various professional groups specified on the questionnaires. Radiation workers in the Dose Register are divided into various professional groups. Randomly sampled workers from 24 groups representing all fields of radiation use were involved in the survey. Dental surgeons were randomly sampled from the Dental Units Register at STUK.

The questionnaire divided radiation protection knowledge into the following five areas:

• Fundamentals of radiation physics
• Fundamentals of radiation biology
• Radiation protection provisions
• Operational radiation protection
• Use of radiation in one's own duties.

The subjects on which the radiation workers and radiation safety officers were asked to comment included the following:

• working sector (industry, research and education, health care, other)
• field of radiation use (X-ray diagnostics, nuclear medicine, radiotherapy, dental radiography, veterinary radiography, use of unsealed sources in industry, research and education, use of sealed sources in industry, research and education, industrial radiography, trade in radioactive material, service and maintenance)
• sufficiency of the respondent's own radiation protection training (inadequate, appropriate, too broad, don’t know)
• knowledge in five subject areas of radiation protection (less than basic knowledge, basic knowledge, good knowledge, in-depth knowledge, don’t know)
• amount of supplementary training in radiation protection over the last five years
• need for additional training in the five subject areas of radiation protection (no need, minor need, some need, great need, don’t know).
5. Results

5.1. Radiation protection training

5.1.1. Training of radiation workers

The response rate of educational organization units was 66 per cent. The number of educational organizations that responded and the amount of radiation protection training in basic and further (specialization) training in universities, polytechnics and vocational schools are shown in Table 1.

Table 1. Amount of radiation protection training (hours) in basic and further studies compared to reference values in radiation safety guide ST 1.7 and recommendations in Radiation Protection 116.

<table>
<thead>
<tr>
<th>Degree</th>
<th>Number of organizations</th>
<th>Mean (min-max)</th>
<th>Guide ST 1.7</th>
<th>Radiation Protection 116</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Universities - basic training in health care</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physician</td>
<td>5</td>
<td>70 (40–100)</td>
<td>40</td>
<td>15–20</td>
</tr>
<tr>
<td>Dentist</td>
<td>2</td>
<td>40</td>
<td>40</td>
<td>10–15</td>
</tr>
<tr>
<td>M. Sc. (Health Science)</td>
<td>1</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veterinarian</td>
<td>1</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Universities - further training</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiologist</td>
<td>5</td>
<td>75 (20–160)</td>
<td>40</td>
<td>30–50</td>
</tr>
<tr>
<td>Oncologist</td>
<td>2</td>
<td>90 (20–160)</td>
<td>40</td>
<td>40–60</td>
</tr>
<tr>
<td>Nuclear medicine specialist</td>
<td>2</td>
<td>40</td>
<td>40</td>
<td>30–50</td>
</tr>
<tr>
<td>Cardiologist</td>
<td>2</td>
<td>45 (10–80)</td>
<td>20</td>
<td>20–40</td>
</tr>
<tr>
<td>Specialist in dental radiography</td>
<td>3</td>
<td>40 (0–80)</td>
<td>20</td>
<td>10–15</td>
</tr>
<tr>
<td>Clinical chemist</td>
<td>2</td>
<td>100 (40–160)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital physicist</td>
<td>3</td>
<td>110 (80–160)</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td><strong>Polytechnics - social and health care sector</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiographer</td>
<td>6</td>
<td>650 (200–1,120)</td>
<td>120</td>
<td>40–100</td>
</tr>
<tr>
<td>Nurse</td>
<td>7</td>
<td>30 (20–80)</td>
<td>40</td>
<td>10–15</td>
</tr>
<tr>
<td>Paramedic</td>
<td>2</td>
<td>60 (40–80)</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Laboratory technician</td>
<td>5</td>
<td>60 (40–80)</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Dental hygienist</td>
<td>5</td>
<td>50 (20–100)</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td><strong>Polytechnics - technology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineer</td>
<td>4</td>
<td>35 (10–100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory technician</td>
<td>2</td>
<td>40 (40–42)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vocational school - primary health care training</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practical nurse</td>
<td>3</td>
<td>20 (2–40)</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

5.1.2. Training of radiation safety officers

Certain universities offer qualification as a radiation safety officer as part of the study programmes. Only one university stated that it arranges a separate radiation safety officer course.

Six organizations indicated that they provide separate radiation safety officer studies in various fields of radiation use. Course lengths varied between 15 and 45 hours, but were mainly 20 hours.

A total of eleven training organizations stated that they arrange examinations for radiation safety officers. Five of these indicated that 0–15 persons pass the exam annually, five indicated an annual graduating class of 20–40 persons and one stated that 80 persons qualify each year.
5.1.3. Supplementary training in radiation protection

A total of 16 organizations stated that they provide supplementary training in radiation protection. Some of these arranged training in more than one field of the radiation use, and some operated in only one sector. Five arranged supplementary training for between 3 and 20 persons annually, five for between 20 and 100 persons, five for between 100 and 600 and one for more than 1,000 persons each year.

5.2. Knowledge of radiation protection, adequacy of radiation protection training and need for additional training

5.2.1. Radiation workers

The response rate for radiation workers including radiation safety officers was 70 per cent. Figure 1 shows the opinions of radiation workers (including radiation safety officers) concerning their knowledge of radiation protection in the five subject areas. Figure 2 shows the opinions of radiation workers in various fields of the radiation use concerning the adequacy of their own radiation protection training. Figure 3 shows the adequacy of radiation protection training for certain professional groups. Figure 4 shows the need for radiation protection training of the same professional groups.

32 per cent of radiation workers (including radiation safety officers) considered their radiation protection training inadequate for their duties, 64 per cent felt it appropriate. 48 per cent of the radiation workers (including radiation safety officers) answered (about 730) had completed no supplementary radiation protection training over the last five years, and 30 per cent had completed less than 10 hours. The proportions of workers with no supplementary training at all over the last five years were 77 per cent in dental radiography, 71 per cent in veterinary radiography, 59 per cent in service and maintenance, 54 per cent in use of unsealed sources, 52 per cent in use of sealed sources, 50 per cent in industrial radiography, 42 per cent in x-ray diagnostics, 32 per cent in nuclear medicine and 32 per cent in radiotherapy. A large proportion (64 per cent) of interventional cardiologists, interventional radiologists, gastroenterologists and orthopaedists had completed no radiation protection training over the last five years. This professional group also suffers the greatest exposure in health care.

Occupational groups in which more than 20 per cent of workers had less than basic knowledge of radiation protection were nurses, dental hygienists, support staff, laboratory technicians, animal attendants, cardiologists, interventional cardiologists, urologists, orthopaedists and maintenance staff.

Occupational groups in which more than 20 per cent of workers had a great need for radiation protection training were nurses in cardiology, gastroenterology and operating theatres, orthopaedists, nuclear medicine specialists, clinical chemists and laboratory technicians.

78 per cent of radiation workers in industry felt that their radiation protection training was adequate for their duties. Knowledge of radiation protection was at an average level in industry, and the need for additional training was quite small, including the case of workers who had completed no supplementary radiation protection training whatsoever over the last five years.
FIG. 1. Knowledge of radiation protection among radiation workers (including radiation safety officers) in their own view (n=730).

FIG. 2. Adequacy of radiation protection training of radiation workers (including radiation safety officers) in various fields of radiation use.
FIG. 3. Knowledge of radiation protection of radiologists (n=33), radiographers (n=87), nurses (n=75) and industrial radiographers (n=14) in five subject areas of radiation protection (area 1 = fundamentals of radiation physics, area 2 = fundamentals of radiation biology, area 3 = radiation protection provisions, area 4 = operational radiation protection and area 5 = use of radiation in one’s own duties).
FIG. 4. Need for additional training in radiation protection of radiologists (n=33), radiographers (n=87), nurses (n=75) and industrial radiographers (n=14) in various radiation protection subject areas (area 1 = fundamentals of radiation physics, area 2 = fundamentals of radiation biology, area 3 = radiation protection provisions, area 4 = operational radiation protection and area 5 = use of radiation in one's own duties).
5.2.2. Radiation safety officers

The response rate of radiation safety officers was 61 per cent. 26 per cent of respondents felt that their radiation protection training was inadequate for their duties. The corresponding proportions of respondents in various fields of radiation use who felt that their radiation protection training was inadequate were 50 per cent in service and maintenance, 37 per cent in x-ray diagnostics, 36 per cent in the use of unsealed sources, 22 per cent in nuclear medicine, 19 per cent in veterinary radiography and 10 per cent in the use of sealed sources. All radiation safety officers working in radiotherapy felt that their radiation protection training was adequate.

A total of 36 per cent of radiation safety officers had completed no supplementary radiation protection training at all over the last five years. The breakdown of this finding by fields of radiation use was 62 per cent in veterinary radiography, 57 per cent in the use of unsealed sources, 50 per cent in the use of sealed sources, 44 per cent in radiotherapy, 38 per cent in service and maintenance, 22 per cent in nuclear medicine and 18 per cent in x-ray diagnostics.

2–10 per cent of radiation safety officers (n=102) felt that they had less than basic knowledge, 24–54 per cent basic knowledge, 24–55 per cent good knowledge and 7–21 per cent in-depth knowledge in five subject areas of radiation protection.

12–23 per cent of radiation safety officers had no need for additional training; 33–47 per cent had minor need, 34–48 per cent some need and 2–7 per cent great need in five subject areas of radiation protection.

6. Concluding remarks

6.1. State of radiation protection training

The average studying hours in radiation protection training included in most health care professional degree courses were in line with radiation safety guide ST 1.7 issued by STUK, but the number of hours of study varied a great deal between organizations. In the studies of radiographers, for example, the amount of radiation protection training was between 200 and 1,120 hours, while the corresponding figure for physician specialization studies in radiology was between 20 and 160 hours.

The great range of results for the amount of radiation protection training included in basic and further education cannot be directly interpreted in terms of differences in degree requirements in universities or vocational schools. Radiation protection training is often distributed across other subjects of study, which hampers any assessment of the real amount of radiation protection training. There could even be differences of interpretation as to what counts as real radiation protection training, even though a list of subjects included in five subject areas of radiation protection was appended to the questionnaires. Differing interpretation as to such matters as excursions, exercise work and periods of on-the-job training (e.g. periods spent working in health centres and hospitals in physician specialization studies) also probably caused differences in reported study credits. It must also be noted that the number of responses concerning physician specialization studies in areas other than radiology was very small.

According to radiation safety guide ST 1.7, the minimum amount of radiation protection training in basic and further education is 20–120 hours, depending on the professional group concerned. The amount of radiation protection training fails to meet this requirement in some educational organizations, e.g. in the case of practical nurses, dental hygienists, general nurses and specialization studies in radiology, cardiology and oncology. In the Commission publication Radiation Protection 116 the recommended amounts varied between 10 and 100 hours, depending on the professional group concerned.
6.2. Knowledge of radiation protection and the need for additional training

32 per cent of radiation workers (including radiation safety officers) felt that their radiation protection training was inadequate for their duties. 48 per cent of all respondents had completed no radiation protection training over the last five years. This indicates a considerable need for radiation protection training in Finland. The survey provides the best overview for groups working in public hospitals, as more than half of all respondents worked in such situations. The greatest need for extra training was among nurses in public hospitals and physicians in health centres. The survey showed that training of laboratory staff in the research and education sector should also be emphasized. Special care should also be addressed to radiation safety officer training in health centres and in service and maintenance work.

The need for training was above average in the case of radiographers. On the other hand, the members of this group felt that they had an above average knowledge of radiation protection, and they had received quite a lot of radiation protection training over the last five years.

Co-operation between training organizations is needed in order to harmonise the amount and content of radiation protection training included in professional degrees involving the use of radiation in Finland. The Ministry of Education and STUK should be involved in this co-operation.

There is a great need for radiation protection training in Finland. This need is not necessarily in professional groups that are subject to large doses or which have completed no supplementary training in radiation protection. The professional groups in most urgent need of training should be defined and encouraged to participate in radiation protection training.

A separate radiation protection course would be needed, at least in studies leading to qualifications for occupations most involving the use of radiation. The duties of the same professional groups involving the use of radiation are usually the same in different workplaces and countries. Ideally their knowledge of radiation protection should also be the same. The goal is for radiation protection subjects to be taught in the same way for the same degrees in various training organizations. Training and education of radiation safety officers in particular should be implemented through a separate radiation protection course in order to clarify more effectively the duties and responsibilities of a radiation safety officer and to promote a culture of safety in workplaces.

7. References

3. Decree of the Ministry of Social Affairs and Health on the Medical Use of Radiation (no. 423 of 2000).