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Implementation of the IAEA Code of Conduct on the Safety and Security of Radioactive Sources and its supplementary Import/Export Guidance

Statens strålevern
Norwegian Radiation Protection Authority

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Key words:
Radioactive sources, safety and security, import/export, national register of sources, orphan sources, outphasing of gamma blood irradiators.

Abstract:
This report outlines the Norwegian legislative and regulatory systems of radiation protection. It describes functions and responsibilities of the national regulatory body. Furthermore it describes services and facilities available for persons authorized to manage radioactive sources, the national source register, orphan sources in Norway and outphasing of gamma blood irradiators.

Referanse:
Implementering av IAEA Code of Conduct on the Safety and Security of Radioactive Sources og tilhørende Import/Export Guidance, nasjonal rapport fra Norge til IAEA International Conference on the Safety and Security of Radioactive Sources: Maintaining the Continuous Global Control of Sources throughout their Life Cycle, Abu Dhabi, De forente arabiske emirater, 27–31 oktober 2013.
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Radioaktive kilder, strålevern, sikring av kilder, import/eksport, nasjonalt register for strålekilder, kilder på avveier, utfasing av gammabaserte blodbestrålingsanlegg.

Resymé:
Rapporten beskriver strålevernslovgivningen i Norge. Den beskriver funksjonene og ansvaret til landets strålevernsmyndighet. Videre beskriver rapporten de tjenester og lokaliteter som er tilgjengelig for strålebrukere, det nasjonale kilderegisteret, kilder på avveier i Norge og utfasingen av gammabaserte blodbestrålingsanlegg.

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Approved:

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Implementation of the *IAEA Code of Conduct on the Safety and Security of Radioactive Sources* and its supplementary *Import/Export Guidance*

National Report from Norway to the IAEA International Conference on the Safety and Security of Radioactive Sources: *Maintaining the Continuous Global Control of Sources throughout their Life Cycle,* Abu Dhabi, United Arab Emirates, 27–31 October 2013

Statens strålevern

Norwegian Radiation Protection Authority
Østerås, 2008

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1 Summary

This is the Norwegian Report to the IAEA International Conference on the Safety and Security of Radioactive Sources: *Maintaining the Continuous Global Control of Sources throughout their Life Cycle*, Abu Dhabi, United Arab Emirates, 27–31 October 2013.

This report outlines the Norwegian legislative and regulatory systems of radiation protection. It describes functions and responsibilities of the national regulatory body, to show that the Norwegian radiation protection system is well developed and in accordance with the *IAEA Code of Conduct on the Safety and Security of Radioactive Sources*. However, the Norwegian authorities will aim to improve the radiation protection policy to further enhance safety and security of radioactive sources, in line with the Code and its supplementary *Guidance on the Import and Export of Radioactive Sources*.

In Norway both services and facilities are available for persons authorized to manage radioactive sources. The national source register is a combined electronic register and notification system for users of radiation sources. Presently the system is being improved to be able to give geographical overviews, to make it possible to search for serial numbers of radiation sources and to make it easier to keep the information in the system updated at any time. These improvements will both contribute to prevent loss of control of radioactive sources and to help in situations with orphan sources. Norway has a radioactive waste management system that is working well.

The general current status is emphasized in this report, along with more specific examples and a short account for the new national administrative practice regarding outphasing of gamma blood irradiators.

2 Legislative and Regulatory Systems

Norway is a constitutional monarchy formally headed by the King as head of State and the Prime Minister as appointed head of Government. The Prime Minister is supported by a council (cabinet), appointed by him with the approval of the Norwegian Parliament. Statutes are passed by the Parliament and sanctioned by the King in Council. Regulations, directives, orders and certain licenses are generally adopted by the King in Council or the Ministries upon the advice of ministries and directorates of the Ministries.

All nuclear activities, including transboundary movements, are regulated by three legal instruments: *the Act on Radiation Protection and Use of Radiation*, *the Act Concerning Protection against Radioactive Pollution and Waste* and *the Act on Nuclear Energy Activities*, all with regulations. In the following the act and regulations on radiation protection are described.

2.1 Act on Radiation Protection and Use of Radiation

The Act on Radiation Protection and Use of Radiation of 12 May 2000 constitutes the legal basis for regulating the use of ionizing and non-ionizing radiation and radiation protection requirements, both in the medical/ non-medical fields and contingency planning. The Act itself establishes the framework, which is spelt out in further detail by the regulations. Pursuant to the Act, two regulations have been adopted:

- Regulations on Radiation Protection and Use of Radiation of 29 October 2010.
- Regulations on the Applicability of the Act on Radiation Protection and Use of Radiation on Svalbard and Jan Mayen of 9 May 2003.
- Furthermore, Regulations relating to Systematic Health, Environmental and Safety Activities in Enterprises of 6 December 1996 is adopted pursuant to several acts concerning health and safety issues, among them the Radiation Protection Act.

The purpose of the Act is to prevent harmful effects of radiation on human health and contribute to the protection of the environment. The Act applies to any manufacture, import, export, transport, transfer, possession, installation, use and handling of radiation sources. The Act will also apply to human activity causing increased natural ionizing radiation from the surroundings, and to planning and preparedness for accidents.

2.2 Regulations on Radiation Protection and Use of Radiation

The Regulations on Radiation Protection and Use of Radiation (Radiation Protection Regulations) establish requirements on authorizations, notifications, internal control, competence, safety equipment, emergency preparedness etc. for users of radiation sources. The Norwegian Radiation Protection Authority (NRPA) also develops guidance documents for the different areas of application.

2.2.1 Authorization

Undertakings intending to engage in the activities that involve use of ionizing radiation in various areas of application, including use of all kind of IAEA category 1 and 2 sources, shall hold an authorization from the Norwegian Radiation Protection Authority.

In the authorization the NRPA may set further conditions to assure proper use of radiation and protect against harmful effects of radiation on human health. These further requirements may include conditions for radiation use, notification, reporting, competence, physical protection, use of measuring equipment, maintenance routines, quality control of apparatus and equipment for medical radiation use, return schemes, financial guarantees, import and export, emergency preparedness and design of premises.

In the case of authorization, application must be made in writing and requisite information must be given to enable the NRPA to evaluate whether authorization should be granted and what conditions should be set.

2.2.2 Notification

According to the regulations, undertakings that procure, use or handle x-ray apparatus, accelerators and radioactive sources above the defined exemption limits shall notify the NRPA.

Also various other radiation sources shall be notified, like solariums, class 4 laser products and IPL's. The radiation sources cannot be procured, used or handled before the undertaking has received confirmation that notification has been received.

Undertakings shall as far as possible give notification by electronic means, through the national electronically source register.

2.2.3 Radiation Protection Coordinator

The regulations states that undertakings which are subject to authorization or notification shall designate one or more persons who shall be able to carry out or order measurements and assessments to determine radiation doses. Furthermore to guide the employees in the safe use of the radiation sources as well as the use of protective and measuring equipment.

The radiation protection coordinator shall work to ensure that the undertaking meets the requirements for health, environment and safety as stated in the radiation protection legislation. The number of radiation protection coordinators and their organization will depend on structure of the undertaking and the complexity of the radiation use.

In the case of particularly extensive use or other handling of ionizing radiation sources, the radiation protection coordinator must be able to carry out or order physical, technical and radiochemical measurements and assessments in order to determine radiation doses, and must also be able to assess health risks and consequences of various accidents, incidents and abnormal events which may occur.

2.2.4 Internal control – competence, instructions and procedures

The duty for the undertaking with regard to internal control appears from the Regulations of 6 December 1996 no. 1127 relating to systematic health, environment and safety duties in enterprises.

The undertakings shall ensure that employees and other associated persons who install or work with radiation sources, or who may

become exposed to radiation, have sufficient competence in the field of radiation protection, including safe handling of radiation sources and measuring and protective equipment.

The undertaking shall prepare instructions and work procedures in writing that ensure proper radiation protection and prevent persons from being exposed to levels that exceed dose limits or exposure limits pursuant to these regulations, applicable standards or international guidelines.

2.2.5 Risk assessment and preventive measures

Undertakings which plan to use or handle radiation sources shall identify and assess the risk factors associated with the radiation. New activities involving radiation sources shall not be initiated before the risk has been assessed and necessary preventive measures implemented. The risk assessment shall be documented in writing.

If the assessment shows that employees or other persons are at risk, or that radiation sources may be orphaned, the undertaking shall take measures to prevent such risk, including

- preparation of appropriate work routines
- utilising appropriate protective equipment and materials
- protection of the radioactive radiation sources against theft, sabotage and damage, including fire and water damage
- give the employees the necessary information and training.

2.2.6 Source inventory and security measures

An undertaking has the obligation to maintain an overview of and control over ionizing radiation sources. The same applies to strong non-ionizing sources. This duty implies inter alia that information concerning location, source type and temporary relocations shall be registered. For radioactive radiation sources, specification of radioactive substances and activity shall also be registered, as well as the serial number or other data able to uniquely identify the source. For open radioactive radiation sources it is sufficient for the undertaking to have updated lists of radionuclides and activity quantities. For other radiation sources the serial number, manufacturer/model or other data able to uniquely identify the source shall be registered.

The undertaking is responsible for safe and proper storage of radioactive radiation sources. This entails for sealed sources inter alia that

- an inventory description of radiation sources, including activity levels, shall be available at the storage site
- the storage site shall be secured against access by unauthorised persons
- the storage site shall be marked with an ionizing radiation warning sign
- the radiation level outside the storage site shall not exceed 7.5 μSv/h
- radioactive radiation sources shall not be stored together with explosives, highly flammable substances or in a corrosive environment.

For certain kind of sources, like Cs-137 based blood irradiators and high activity brachy therapy sources, the NRPA set further conditions in the authorization in order to assure proper physical protection against theft and sabotage.

2.2.7 Emergency preparedness

In order to reduce possible consequences of accidents and abnormal events, the undertaking shall, based on the risk assessment, draw up an emergency preparedness plan and implement measures that maintain the ability to handle accidents and abnormal events.

The undertaking shall immediately give notice of accidents and abnormal events to the NRPA. A written report shall be sent by the responsible undertaking to the NRPA as soon as possible and within 3 days at the latest.

2.2.8 Import and export of radioactive sources

Starting with the entry into force of the revised Radiation Protection Regulations 1 January 2011 all import and export of IAEA category 1 and 2 sources require an authorization from the NRPA. In general export authorizations mainly concern export of disused category 1 and 2

sources back to the producer, and the export is mainly done through Norwegian dealer or agent.

According to the Guidance on the Import and Export of Radioactive Sources a point of contact for the purpose of facilitating the export and/or import of radioactive sources has been nominated.

Norway has written to the IAEA Director General and indicated that we are working towards following the guidance contained in the Code.

3 Regulatory Body

The NRPA is the Government's competent authority on matters concerning radiation protection and nuclear safety and security. It is organized as a directorate under the Ministry of Health and Care Services, from which it receives about half of its funding. The NRPA is also a directorate under the Ministry of the Environment with respect to releases of radioactivity to the environment and waste from nuclear and non-nuclear industries, and under the Ministry of Foreign Affairs with respect to implementing safety measures in Russia under the Action Plan for Nuclear Safety in North West Russia. The NRPA also provides assistance and advice to other ministries on matters related to radiation, radiation protection, waste management, nuclear safety and security.

As defined in the Act on Radiation Protection and Use of Radiation, the regulatory body is the NRPA. The NRPA is also regulatory body for the Act on Nuclear Energy Activities and the Act Concerning Protection against Radioactive Pollution and Waste.

The NRPA may at any time independently inspect undertakings and also communicate regulatory requirements, decisions and opinions to the public. It will, as appropriate, liaise with the regulatory bodies of other countries and with international organizations for co-operation and exchange of regulatory information. The IAEA Safety Standards Series are followed and implemented to the largest extent possible.

3.1 Organization of Regulatory Body

The NRPA has a total staff of 130 persons and a total annual budget of approximately 150 MNOK (19 M€). The NRPA is organised in four departments, which are further divided into specialised sections:

- The Department of Radiation Applications
- The Department of Nuclear Safety, Emergency Preparedness and Environmental Radioactivity
- The Department of Monitoring and Research
- The Department for Planning and Administration

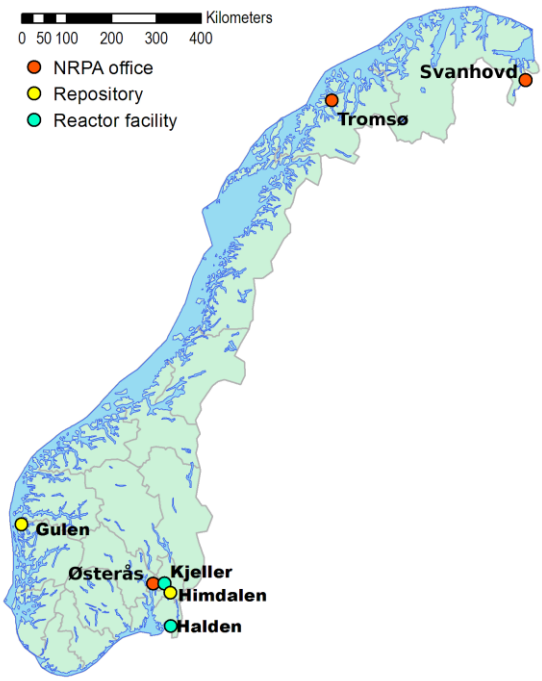
The Department of Radiation Applications deals with the safety and security of radiation sources used for industrial, research and medical purposes, including licensing of import and export of radioactive material. The department will carry out inspections and audits to ensure that regulations and license requirements are fulfilled and complied with. The personal dosimetry service at the NRPA is also organizes under this department.

The Department of Nuclear Safety, Emergency Preparedness and Environmental Radioactivity acts as the secretariat for organising emergency preparedness against nuclear accidents. The department has an Emergency Preparedness Unit at Svanhovd in Sør-Varanger near the Russian border in the far north-east, and an Environmental Unit at the Fram Centre in Tromsø in northern Norway

The department is responsible for the processing and approval of discharge licenses and environmental management in the industrial and medical sector, including the three nuclear facilities in Norway.

The department is also responsible for the State System of Accountancy and Control under the Safeguards Agreement between Norway and the IAEA. The NRPA is authorized through legislation to enter nuclear installations and surrounding area, at any time, and to request the information necessary for the purpose of the inspection.

The Department of Monitoring and Research is responsible for assessment of environmental and health consequences of discharges of radioactive substances from nuclear, industrial and medical facilities. The department carries out annual measurements of radiation and radioactive substances in order to maintain an overview of radiation doses to the environment, foodstuffs and the population. The NRPA is responsible for programmes monitoring radioactivity in the marine and terrestrial environment, and also monitors ultraviolet radiation from the sun. A network of UV-monitoring stations provides data to environmental and health authorities on long term trends. The NRPA has advanced laboratories that can analyse alpha, beta, gamma and UV-radiation in Østerås, Tromsø and Svanhovd, as well as a mobile laboratory facility. The NRPA is also responsible for standard dosimetry in Norway.



Map of Norway with relevant sites

3.2 Competence of staff in Regulatory Body

The staff in the regulatory body is a mix of personnel with higher education in natural or social science, or with law degrees. Emergency preparedness exercises, participation in internal and external arranged courses, participation on relevant national and international seminars and workshops are common practice at the NRPA, and sometimes further education at university level. Formalization of the education program for the NRPA inspectors is under development.

4 Available services and facilities

According to the Radiation Protection Regulations undertakings shall have the necessary competence, equipment and emergency preparedness plans to independently manage emergency situations to some extent. In case of accidents or incidents the NRPA shall always be informed. If radioactive sources are missing or searched for or in the event of an accident, the NRPA will directly participate, lead the situation or advise in such situations. The NRPA can be reached on an Emergency Telephone at any time (24h – 7 days a week).

4.1 Assistance in case of an accident

The NRPA has capacity to provide assistance in case of an accident, in search for missing radioactive sources and to secure orphaned sources. Furthermore the NRPA has capacity for mobile radiation measurements from a car or on foot, using handheld instruments. Collaborating partners make air monitoring data available. Advanced laboratories that analyze alpha, beta and gamma radiation and the mobile laboratory are a crucial part of the emergency preparedness in case of a nuclear incident.

The Norwegian Civil Defense is the State's reinforcement for the emergency and rescue departments in the event of major accidents and special incidents, and will play an important role in the case of a serious incident involving radioactive sources or radioactive contamination. There are also nongovernmental undertakings which can be hired in such situations. Norway has emergency response organizations meant to intervene in case of a malicious act.

4.2 Laboratory and measuring services

The NRPA has a personal dosimetry laboratory offering customers measurement of occupational doses. For the time being, the laboratory only offers measurement of whole-body doses (Hp[10] and Hp[0.07]) on a regular basis. The service is intended to assist Norwegian undertakings in need of personal dosimetry readings for occupational exposed personnel. The personal dosimetry service at the NRPA includes customers engaged in medical use of radiation, and the use of radiation in industry and research. Medical personnel are the largest group of occupational exposed workers.

The NRPA's Secondary Standard Dosimetry Laboratory calibrates dosimeters on behalf of hospitals and other radiation users. The main users are the radiation therapy units together with undertakings offering x-ray diagnostics. Hand monitors for use in radiation protection in hospitals, industry or for emergency response can be calibrated by the dosimetry laboratory. Hand monitors used in the industry is normally more roughly calibrated by the dealers of the monitors.

The NRPA's nationwide network of automatic air stations continuously monitors radioactivity in our surroundings. The network operates on a 24-hour basis, and alerts at an early stage if levels rise and/or radioactive fallout is expected to reach Norway. The NRPA also carry out annual measurements of radiation and radioactive substances in order to maintain an overview of radiation doses to the environment, foodstuffs and the population.

4.3 The disposal and storage facility

Norway has a combined disposal and storage facility in Himdalen. The builder and owner is the Public Construction and Property Management, which is organised under the Ministry of Government Administration, Reform and Church Affairs.

5 National Register of Radioactive Sources

The national source register is an electronic register for all sealed radioactive sources above IAEA exemption limits, X-ray apparatus used in industry and research, veterinary, medical and dental X-ray equipment, medical MR machines, class 4 lasers and even solariums. This register also provides a web-based notification system which enables the owners and users of radiation sources to make notifications to the NRPA directly on the web. Owners and users are also able to check and verify the NRPA register.

This combined electronic register and notification system has been developed during many years and is continuously being improved. Presently the system is being improved to be able to give geographical overviews, to make it possible to search for serial numbers of radiation sources and to make it easier to keep the information in the system updated at any time. In the longer term the system might be developed to be a more complete administration system which also includes the administration of in- and outgoing letters in connection with authorizations and inspections.

Approximately 3500 sealed sources are registered in the system today, mostly low category sources like industrial gauges. Presumably this number covers the majority of all sealed sources that are in use in Norway. Still, it is fully possible, and also likely, that many old sources taken out of use years ago are not registered. The register is not equally complete in all areas, for instance, far from all solariums and lasers are registered. Through the NRPA inspections new radiation sources are constantly being identified and the register consequently updated.

The system is valuable for the NRPA in the preparation phase of inspections, in order to find the owner of orphaned sources and provide statistical information.

The system is intuitively easy to use; it is an easy and fast way for the user to send notifications to the authority. The user has its own account where all user-specific information like registered sources and notifications is visible, thus the user also

satisfies the Radiation Protection Regulations requirement on source inventory.

6 Orphan sources in Norway

Several licensees do not inform the regulatory authorities when operations are closed down and installations are being decommissioned. Thus, the NRPA has noted several incidents where sources have been removed or sent to other companies without proper notification, as stipulated by the regulations in force.

If an orphan source is found, the normal procedure is that the NRPA attempts to find the owner, order a secure and safe management of the orphaned source regardless of costs, and, if relevant, to search until they find other orphaned sources. It is standard procedure to publish a short summery of the incident on the NRPAs web-page. If relevant, the case will also be reported to the police.

Industrial gauges discovered at an abandon mine in the north-western part of Norway in June 2013. The mine shut down almost thirty years ago and the buildings are in poor condition. Photo: Øivind Syversen, NRPA

Only three of five discovered boxes included gauges, and two of totally seven boxes in the original shipment where missing. Photo: Øivind Syversen, NRPA

In Norway there are approximately three to five incidents every year of this kind. The orphan sources are often old industrial gauges taken out of use several years ago. In June 2013 the NRPA handled a situation where several boxes with Co-60 sources accidentally were discovered in buildings belonging to an abandoned mine. The buildings are in poor condition and are almost falling to pieces.

Generally the NRPA is able to identify the responsible owner, but if the owner is not found, the NRPA makes sure the source is being handled properly as radioactive waste. If the source is found to be orphaned, deliberately or by an act of negligence, the police will consider prosecution and further reactions. Fines up to NOK 2 million (€ 250 000) have been given by the prosecuting authority.

At the Storskog border point (Norway–Russia) a monitoring portal has been in operation for almost eight years. The customs have portable measuring equipment at their stations across the country. Several other governmental organizations have similar handheld equipment, for example the Coast Guard and the Civil Defence organizations. The NRPA assists them (second-line services) in case of alarms. Most private companies dealing with scrap metal or other businesses that might receive contaminated waste have monitoring portals or handhelds. This prevents radioactive sources from being sent into shredder facilities or being melted down in foundries. Several orphan sources have been detected this way.

7 Managing radioactive sources at the end of their life cycles

Undertakings that procure, use or dispose sealed radioactive radiation sources have a duty to assure that a return scheme exists in the country of origin and to utilize that scheme. Furthermore, the undertaking has a duty to inform the NRPA of the return scheme in connection with authorization or notification.

Distributors of radioactive sources are required to have authorization from the NRPA. When the NRPA issues authorizations for companies to buy, sell or use sealed sources, it is with the requirement that disused sources are to be returned to the manufacturer. However, if no viable return options are available, the NRPA may decide that that the source is to be stored in a Norwegian waste management facility.

It is the responsibility of the license holder to ensure that disused sealed sources are handled in a safe manner and that they are ultimately returned to the manufacturer or sent to a Norwegian waste management facility. If the license holder is in financial difficulty or out of business, safe and proper disposal of the disused sealed sources will be handled on a case-by-case basis. The NRPA may take the responsibility for the source(s). License holders are generally not required to provide financial assurance for the decommissioning of their facility and disposal of disused sources when applying for a license. So far this has not caused any major problems in Norway.

7.1 Radioactive waste management facilities

At Institute for Energy Technology (IFE) at Kjeller the following facilities are in operation:

Radioactive Waste Facility: This is a facility for receiving, sorting, handling, treatment and conditioning of radioactive waste, and is the only facility of this type in Norway. It receives all low and intermediate-level waste (LILW) except NORM, generated by Norwegian industry, hospitals, universities, research organizations and the defense.

Storage Building 1: This building is 434 m^2 in size and is used for the storage of conditioned waste packages.

Storage Building 2: In this building, there is an area (430 m^2) which may be used for storage of conditioned waste packages. A separate part of the building contains the storage for non-irradiated uranium.

KLDRA Himdalen: This is the Combined Disposal and Storage facility for low and intermediate-level waste in Himdalen, in Aurskog-Høland municipality. It has been in operation since March 1999. The main purpose of the facility is direct disposal of conditioned waste packages.

The owner pays for the treatment and storage at IFE Kjeller. The cost for disposal at Himdalen is covered by government funding. The Ministry of Trade and Industry has a separate agreement with IFE for the operation of the Himdalen facility and general waste handling.

Norway also has a repository for NORM waste from the oil and gas industry.

Norwegian authorities allow re-import of disused sealed sources on a case-by-case basis. Norwegian-produced instruments with sealed sources, which may are produced in a third country, are permitted re-entry.

8 Outphasing of traditional gamma blood irradiators

Blood irradiators containing radioactive sources are among the strongest radioactive sources in Norway. The NRPA will contribute to phase out this type of radioactive sources for the benefit of almost risk-free blood irradiators based on X-ray technology. In line with general radiation protection principles the NRPA emphasize that X-ray technology should be used instead of radioactive sources when feasible. New administrative practice facilitates outphasing of traditional blood irradiators in connection with acquisition of new blood irradiators.

8.1 Substitution and justification

The outphasing of gamma based blood irradiators has the legal basis in the Radiation Protection Regulations. The users of ionizing radiation are required to consider alternative technologies. Specifically shall non-ionizing alternatives be used instead of ionizing radiation and X-rays shall be used instead of radioactive sources when feasible. Furthermore, all use of radiation shall be justified. Existing areas of applications and methods shall be reassessed if new information about their justification appears.

8.2 Blood irradiators in Norwegian hospitals and in other European countries

Today there are eleven Cs-137 Gammacell blood irradiators from MDS Nordion placed in ten different hospitals in Norway. The source activity is between 15 – 70 TBq. In addition there are three X-ray based blood irradiators installed and in operation.

On request from the NRPA regarding future plans for substitution of blood irradiators, seven out of ten hospitals said their gamma based irradiators will be replaced by X-ray irradiators in connection with acquisition of new blood irradiators. Two hospitals did not specifically mention if they wanted gamma or X-ray based blood irradiators, and one hospital reported that they wanted to acquire new gamma based irradiators in the future.

The three X-ray based blood irradiators in Norway were installed in 2012–2013. The experiences with X-ray based irradiators in Norway are thus limited. Yet, the general impression after an inspection at one of the sites was that the hospital was satisfied and that the equipment was well functioning.

As valuable input to the NRPA considerations regarding outphasing of gamma based blood irradiators, the members of the European Radiation Protection Authorities Network (ERPAN) were inquired to share their experiences with X-ray based blood irradiators. Based on the response through the ERPAN network and information through meetings with other Nordic countries we could sum up the following:

Nine of the responding countries had blood irradiators. All of these countries had gamma based irradiators and three countries had in addition X-ray based irradiators. One country had started substitution of gamma based irradiators with X-ray a few years ago and all gamma based irradiators will be replaced. The impression from the feedback was that X-ray based irradiators are well functioning, but there are some disadvantages. There are more breakdowns when installed in warm areas due to higher temperature in the surroundings, the equipment needs maintenance which is expensive, and the system needs continuous power supply which makes it essential to make sure the power supply and fuses can cope with the fluctuations that occur.

8.3 Conclusions on blood irradiators

Based on information from Norwegian hospitals and radiation protection authorities in other European countries, the NRPA has concluded that it is feasible to install and use X-ray blood irradiators instead of gamma based irradiators. X-ray irradiators are more vulnerable for breakdowns than the gamma based irradiators are, and increased maintenance and more down time must be counted for. Still, having in mind that the gamma based irradiators are placed in category 1 or 2 according to the IAEA category system, which means they are considered to be extremely dangerous, and taking the severe social consequences due to a potential malevolent act against this type of sources into consideration, the few technical disadvantages related to X-ray technology is considered to be of minor importance.

The NRPAs conclusion is that the almost risk free X-ray blood irradiators is an adequate alternative to gamma based irradiators. A new administrative practice facilitates that traditional gamma based blood irradiators will be phased out in connection with acquisition of new blood irradiators. Acquisition and use of new gamma based blood irradiators will not be authorized unless special situations exist.

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