Improved security measures for radiation sources in Norway – A case study of irradiation facilities in hospitals

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Abstract. The main focus in this article is on the recently improved security requirements on high activity radioactive sources. A number of these sources represents significant risk and are placed in non-nuclear facilities such as hospitals. This article describes the process going from a regulatory regime where security was mainly associated with nuclear facilities, to a regime including more dedicated security measures also outside typical nuclear facilities. Concerns for the security of hazardous radioactive material led to assessments of the impact of a hypothetical malevolent act at one of the typical commercial high activity source used in a hospital environment. The result from these considerations was a significant enhancement of the regulatory activities in relation to security. This includes i.a. regulatory orders to improve security at irradiation facilities in hospitals, and an improved register for the control and overview of sources in use in industrial and medical applications. The regulatory orders will also be followed up by an intensified inspection program. This process has been influenced by international efforts in this field, such as the IAEA Code of Conduct on the Safety and Security of Radioactive Sources, the EU HASS directive and other IAEA documents.

Irradiation facilities in Norway

Radioactive sources have a large range of applications in industry, research and medicine. Most of the radioactive sources in Norway are radionuclide gauges in permanent installations that are used for taking measurements or for process control. There are approximately 2500 sources of this kind, classified as IAEA category 3 – 4 sources. There are also roughly estimated about 100 IAEA category 3 sources in Norway at all times due to well logging activities. The number can vary since the international well logging companies continuously relocate their radioactive sources between Norwegian sites and sites abroad. In the industry, the use of radioactive sources with high activity, typically IAEA category 2 sources, is mainly related to industrial radiography. This activity is first of all connected to the oil industry, and the range of use is relatively comprehensive. More than 200 gamma radiography containers are registered, divided on about 50 licensees. However, the highest active radioactive sources, the IAEA category 1 sources, are placed in irradiation facilities used for blood irradiation, sterilization or research purposes.

In the later years it has been an increased focus on security of radioactive material. Consideration of the security of the radioactive sources in different applications has shown that especially the blood irradiators have been insufficiently secured.

Cesium – 137 blood irradiators

The purpose of blood irradiation is to destroy T-lymphocytes, a type of white blood cells, which may cause transfusion associated graft versus host disease (GVHD). GVHD is a severe transfusion complication that might occur when the T-lymphocytes

from the donor attack the recipient's tissue**.** If sufficiently irradiated, the T-lymphocytes in the transfusion blood are hindered from replication and proliferation, and GVHD is thus prevented [1]. Irradiated blood is used in cases with strong immunosuppressant's patients, premature children, patients with severe immune defects and at transplantations [2]**.** To assure rapid supply of recently irradiated blood with high quality, blood irradiators in Norway are located at hospitals and blood banks, and not in centralized blood centers. This means that the blood irradiators are spread over a large geographic area as single units.

Cesium-137 blood irradiators can be replaced by less hazardous alternatives, like metallic cobalt – 60 irradiators or x-ray irradiators. These alternatives are, or has been, commercial available. On one side, cobalt - 60 has considerable resistance to dispersion and the solubility is limited. On the other side, cobalt - 60 requires more shielding, which means increased weight, which in turn would require installation at the bottom-floor of the building. The half-life of cobalt is also much shorter than the half-life of cesium, which means a shortened useful life of the irradiator. Commercial x-ray blood irradiators are another alternative that can deliver the necessary radiation dose with sufficient uniformity and stability[3]. However, both alternatives are considered to be more expensive than the standard cesium – 137 blood irradiator. Other possible alternatives, like using different material forms of cesium-137, like cesium containing ceramic etc., have so far not become commercial available.

There are in total thirteen self shielded cesium blood irradiators in Norway, located in hospitals or in blood banks in conjunction with hospitals. The source activities range from 14 TBq to almost 200 TBq. Among these irradiators, one is an IBL 437C from CIS-US Inc. while the remaining twelve are Gammacell irradiators from MDS Nordion.

Figure 1: IBL 437C. Foto: NRPA
Photo: NRPA

Figure 2: Gammacell 3000 Elan.

Based on concerns for the security in combination with few or none good alternatives, the Norwegian authorities decided in 2006 to improve the security requirements at blood irradiation facilities placed in hospital environment instead of replacing them.

Other irradiators

In addition to commercial blood irradiators, a few other types of high activity irradiators are in use for research, calibration, sterilization and radiotherapy purposes. One of these facilities is a cobalt panoramic dry source storage irradiator, mainly used for sterilization and research purposes. Two high activity cobalt sources are used for research and calibration, and there is one cobalt Gamma Knife machine used for radiosurgery.

National and international regulatory framework

Security has traditionally been associated with nuclear facilities. This comprehension has changed, and the security of radiation sources placed outside nuclear facilities is now implemented in the new Norwegian regulations. The process developing new regulations was influenced by the international framework in this field, such as the IAEA Code of Conduct on the Safety and Security of Radioactive Sources [4].

Following several serious incidents and accidents involving radioactive sources in the 80-ties and 90-ties, the first international conference on the safety of radiation sources and the security of radioactive materials was held in Dijon, France in 1998. The major findings of the conference led in turn to the International Atomic Energy Agency (IAEA) developing an action plan for the safety of radiation sources and the security of radioactive materials, which was approved by the board of governors and endorsed by the general conference in 1999 [5]. The Action Plan called for the development of a Code of Conduct on the Safety and Security of Radioactive Sources, which was first published by the IAEA in 2001. Following the events of 11 September 2001 more attention was given to the security of radioactive sources against malicious acts, and as a consequence the *International Conference on Security of Radioactive Sources* was held in Vienna in 2003. The findings from this conference in turn led to the Code of Conduct being revised, and approved by the IAEA Board of Governors in September 2003 [6].

One of the seven points of the Action Plan was to develop a document on the categorization of sources on the basis of their associated potential for exposures and radioactive contamination. This categorization system has now been published as an IAEA Safety Guide. Among the goals for the categorization system was to provide more coherent regulatory and security measures for radioactive sources representing similar potential harm to human health. The categorization system has placed the cesium-137 sources used in blood irradiators in category 1, the most ‘dangerous’ category, which can pose a very high risk to human health if not managed safely and securely [7].

In parallel to this international process, new regulations on radiation protection were in development in Norway. Following the new Norwegian Act on Radiation Protection and Use of Radiation in 2000 [8], new regulations were needed and the Code of Conduct provided input to this effort. New Norwegian Radiation Protection and Use of Radiation regulations went into effect from 2004 [9], for the first time setting requirements to the security of radioactive sources. While the Norwegian Atomic Energy Act [10] had set requirements to security at nuclear installations for a long time, the earlier regulations covering radioactive sources had less focus on security.

Upgrading security for blood irradiators in Norway

Blood irradiators represent the only high activity self shielded irradiators in Norway. While other irradiation facilities used for research and calibration/dosimetry has had security features (such as access control and a secure location) implemented as a consequence of their stringent safety requirements, no special provisions were given to the blood irradiators since they were not considered to represent any safety issues. The physical weight of the blood irradiators also meant that theft was seen as a highly unlikely scenario.

In 2006 an order was issued from the Norwegian Radiation Protection Authority (NRPA) requiring all blood irradiators in Norway to strengthen their security measures. This action originated partially as a consequence of the high-lighting of blood irradiators in the work towards a categorization system for radioactive sources, but mainly because of new considerations when it came to the possible threats from malevolent acts such as sabotage or other targeted attacks against these installations.

Previous requirements stated two independent security measures; access control to the department where the blood irradiator was placed and that use of the blood irradiator required a key or a code. To strengthen the security, the order of 2006 required an extra physical barrier to prevent sabotage. This physical barrier meant that the irradiator should be placed in a separate room with access control. At present there are in total two physical independent barriers that must be passed to reach the irradiator, in addition to the code or key that is needed to start/use the device. However, physical barriers are not enough alone to secure the irradiator properly. A possible inside threat must also be taken into account. To reduce the threat of an insider, it was required in the order of 2006 to make a reliability check of users of the irradiator. In addition it was stressed that strict access control should be practised. Only users of the blood irradiator should have access to the irradiator.

Along with requirements in the Act and Regulations on Radiation Protection, the licensees were imposed to make a thorough evaluation of the justification of use and assess the x-ray blood irradiator as an alternative. Results from the assessments showed that is was a general comprehension that x-ray irradiators were more expensive than the caesium irradiator, and that it was important to be able to provide irradiated blood within a certain time window. Transportation over large distances that would delay the delivery was not ideal. These were acceptable arguments for the NRPA.

At present, all the licensees have given a written statement that the necessary measures have been carried out in order to fulfill the new requirements. The process has taken some time because most of the licensees had to go through some time-consuming work in order to comply with the new requirements, making changes in building constructions etc.
The next step in the process is to complete the recently started site inspection program.

Register for sources in industrial and medical applications

The Code of Conduct on the Safety and Security of Radioactive Sources states that all states should establish a national register for radioactive sources. Earlier practice at the NRPA was that radiation sources of all categories above the national exemption levels (typically IAEA categories 1-4) were registered through paper forms submitted by end-users, some of this information was in turn transferred to internal database systems. This process, however, required much work and was error prone. As a consequence, the NRPA started developing and using a web-based source registration tool. Here, end-users are able to register and update information about themselves, such as contact information, and their sources. This information is then verified by NRPA personnel. The web-based interface will enable the NRPA as well as the end user to have access to the same information about their registered sources, something which will hopefully improve the quality of the register. The register covers not only radioactive sources, but also x-ray, UV- and laser sources.

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