Improvement of National Regulations on Radiation Protection by Implementing IAEA General Safety Requirements (GSR Part 3)

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1. Introduction

The Pakistan Nuclear Regulatory Authority (PNRA) is an independent regulatory body, established in 2001, to regulate nuclear, and radiation facilities in Pakistan. The mandate of the PNRA is to ensure the safe operation of nuclear and radiation facilities by preparing and enforcing licensing requirements. The facilities regulated by the PNRA include nuclear power plants, research reactors, manufacturers of nuclear safety class equipment and components, and medical and industrial facilities. Currently, the PNRA supervises and controls four operational nuclear power plants, two research reactors, and more than four thousand radiation facilities as shown in Figure 1.

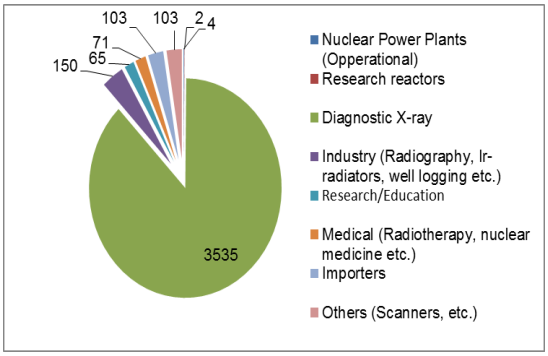

Fig. 1. Nuclear and Radiation Facilities licensed by PNRA

The PNRA Regulations on Radiation Protection (PAK/904) were published in 2004 [1] and are based on the IAEA recommendations as in the document Basic Safety Standard (BSS-115). The PNRA Regulations PAK/904 describes mandatory regulatory requirements for radiation protection that apply to nuclear and radiation facilities operated in Pakistan. In 2007, the International Commission on Radiological Protection provided the suggestions for radiation protection and safety of sources in its publication named ICRP 103. Therefore in 2014, the IAEA amended the document on Radiation Protection and Safety of Radiation Sources and published the new document titled IAEA General Safety Requirements (GSR Part 3). Furthermore, the IAEA also has performed an Integrated Regulatory Review Service (IRRS) mission in Pakistan that provided some recommendations and suggestions to revise the national requirements for radiation protection. On the basis of the IAEA publication GSR Part 3, the current PNRA Regulations on Radiation Protections PAK/904 also requires revision and amendments in order to incorporate and fulfill the new IAEA requirements in Pakistan. In this paper, the regulatory requirements of the PNRA Regulations (PAK/904) are compared with the IAEA GSR Part 3 and perform the gap analysis. Furthermore, the gap analysis and the method how to implement the gaps into the national regulations could provide useful information for future enhancement of the regulations on radiation protection.

2. Methods and Results

The method followed to incorporate the IAEA GSR Part 3 requirements into national regulations consist of the detailed analysis of the GSR Part 3, identifications of new requirements, comparison of existing national regulations with the GSR part 3 requirements, and feasibility of implementation of new GSR part 3 requirements. The discussion on the results of the gap analysis of the GSR Part 3 and PAK/904 is described in this section.

The main gap between the two documents is the new concept of exposure situations which is described in the GSR Part 3 and the requirements for existing exposure situations which are not described in detail in existing national regulations PAK/904.

2.1 Designations of Exposure Situations

GSR Part 3 introduces the concept of three types of exposure situations [2]. The first type is the planned exposure situation, where in advance an operator can plan radiation protection and can predict radiation exposure. The second type is the existing exposure situation, which already exists in the environment, such as traces of radon. The third type is the emergency exposure situation, which arises as a result of an accident or any unforeseen situations like nuclear power plant accidents due to the degradation of safety or any other natural disaster. The ICRP 2007 [3] recommendations addressed three kinds of exposure situations that are later adopted by the IAEA to the GSR Part 3. These new concepts are easy to understand and

implement. Therefore, for the implementation of the principles of radiation protection, the PNRA should incorporate the concept of exposure situations into PAK/904.

2.2 Dose Constraints and Dose Limits

Dose constraints are a part of the optimization process. The dose constraints are an important tool to control occupational exposure for radiation protection. There is a requirement for licensees to set the dose constraint value for their facility, and this value should be included in the radiation protection program of the facility. If the actual dose received is higher than the dose constraints, investigations should proceed according to the radiation protection program of the facility. Therefore, the dose constraint should be addressed in the national regulations PAK/904. The dose limit for the eye lens has changed in the GSR Part 3 based on the new dose limit introduced in ICRP publication 118. For lens of eye protection, the new dose limit should be included in national regulations on radiation protection.

2.3 Investigations and Feedback of Information on Operating Experience

For the protection of workers, the general public, and the environment, abnormal or accidental conditions (equipment failure, occupational or medical overexposure, and the release of activity) require proper investigation. The licensees should have a proper mechanism for the investigation of unusual events. Furthermore, they should write a detailed report describing all corrective actions, and then send it to the authority within a specified time. Such requirements need to be included in the national regulations, and the licensees are responsible for its implementation. In the GSR Part 3, for the safety of sources, the responsibilities of manufacturers and source suppliers are clearly mentioned. Such requirements need to be included in the national regulations.

2.4 Human Imaging

The use of radiation in human imaging for security purposes has extensively increased in the world. In Pakistan, different scanning machines are used for various security purposes. The requirements for human imaging such as justification and quality assurance need to be incorporated into the national regulations (PAK/904). For non-medical purposes, human imaging needs detailed analysis with proper justifications of merits and demerits. According to the ICRP, the human exposure needs to be justifiable and could apply only with unavailable alternative techniques. Human imaging for detection of hidden objects inside the human body, which can pose a threat to the national security, is decided by the national government, and applicable radiation protection measures should be applied before its use. The use of human imaging at airports, at national borders, and at different locations within a country need to be decided case by case based on the comparison of radiation risk and the net benefit to the society. In Pakistan, the PNRA is responsible for such decisions concerning the justifications of human imaging for security purposes. The dose constraints for human imaging should be incorporated in the national regulations, and such dose constraint values must be lower than the diagnostic reference levels.

2.5 Authorization or Approval of Service Providers

The PNRA Regulations on Radiation Protection, PAK/904 requires the use of dosimeter for personal and workplace monitoring. Calibration of radiation monitoring equipment and processing of personal passive dosimeters such as film badge or thermo luminescent dosimeter are required for a specified time period, according to the radiation protection program of the facility. In Pakistan, the dosimeter service providers are operating without being licensed by the PNRA. The GSR Part 3 provides complete information for the authorization and approval of such dosimeter service providers. The specific requirements for authorization or approval of service provider must be incorporated into the national regulations for adequate quality assurance of radiation monitoring equipment.

2.6 Dosimetry of Patients

Control of patient doses in medical exposure is an important requirement for the patient's safety. The aim is to reduce the radiation doses to achieve required results of the treatment, and with minimum harmful effects to healthy cells. Exposure to a high radiation dose can seriously harm or damage the healthy tissues. The radiation dose of tumor cells is usually given in small fractions to protect healthy tissues. As the cell survival factor of tumor cells is less than that of normal healthy tissues, so the dose is given in small fractions. Patient dosimetry is an important component in diagnostic radiology. Patient dosimetry information is helpful in modifying diagnostic reference levels. For patient protection, dosimetry requirements as mentioned in GSR Part 3 need a clear addition into national regulations. For its implementation, the licensee is responsible for calculating patient doses in these procedures.

2.7 Pregnant and Breast Feeding Patients

GSR Part 3 addresses the requirements for pregnant and breast-feeding patients for medical exposure. According to ICRP 103, "if radiation dose is greater than 100 milli gray (mGy), then there is a great risk to

embryo or fetus" [3]. Therefore, the medical professionals should pay proper attention to pregnant women while conducting diagnostic and therapeutic examinations. Before proceeding to give medical treatment, the patient should be asked about pregnancy. The patient must be given complete information about the risk to the embryo or fetus involving such procedures. An alternative procedure must be considered if the patient is pregnant or breast-feeding. However, to save the life of the patient, if it is mandatory to perform a medical procedure with ionizing radiation, such procedure should be performed with great care and accuracy, and the medical staff should have proper training. Therefore, for protection and safety of patients who undergo medical examinations, the detailed requirements for breast-feeding and pregnant patients need to be addressed in the national regulations PAK/904.

2.8 Handling of Deceased Persons

The GSR Part 3 gives detailed information about the issue of handling deceased patients having radioactive material inside the body. The ICRP 103 defines the cremation requirements for such persons such as "cremation can allow for 12 months for I-125 and 3 months for Pd-103" [3]. However, rare cases occur in which a patient may die during or after treatment having radioactive material inside the body. The social and cultural factors should be considered before handling of deceased persons. The requirements for handling of deceased persons should be clearly addressed in the national regulations. For public safety and security, the licensee should take responsibility under national regulations to guide the guardians about the proper handling of deceased patients.

2.9 Radon in Indoors

The GSR Part 3 gives detailed information about the radon exposure. Radon exposure is classified both as occupational and public exposures. People are exposed to radon due to building material used in homes. The radon concentration is normally high in the basement of the building. The proper ventilation is mandatory to minimize the exposure due to radon. Exposure to radon is usually high in the underground mines, where workers do mining operations. The exposures of such workers are classified as an occupational exposure. According to epidemiological studies, long-term radon exposure can cause lung cancer. As per UNSCEAR Report 2008, the world average dose due to background radiation is 2.4mSv that is mainly due to radon [4]. In the ICRP 103, the reference level is expressed in activity levels that are 1500 Bq/m3 for workplaces and 600 Bq/m3 for homes. Whereas, in the GSR Part 3, the activity levels of 1000 Bq/m3 for an occupational exposure, and 300 Bq/m3 for the public exposure is suggested. GSR Part 3 and ICRP 103 propose each country to develop the national reference levels for radon exposure. For an implementation of the GSR Part 3 requirements, the PNRA should conduct a national radon survey. At the national level, the radon survey program is in progress. After the results, a proper plan for protection of workers and public can be introduced.

2.9 Exposure of Aircrew and Space Crew Members

Exposure to cosmic rays to aircrew and space crew is categorized as an occupational exposure. However, the exposure of other passengers is considered as a public exposure. Many countries in Europe regulate the exposure of aircrew members. The computer codes can be used to calculate the exposure of aircrew by calculating the number of hours of flight operation and the altitudes achieved during flight. Considering the high number of flight hours and increase in altitude, the PNRA should develop a national strategy to control the exposure of aircrew members. To control the exposure of aircrew members, civil aviation should be responsible to inform workers about the risks and doses they receive. After the survey, the PNRA should include the requirements for protection of workers in the national regulations.

3. Conclusions

In Pakistan, the PNRA ensures the safety of the people and the environment through various means. However, the basic component of ensuring safety is to formulate the regulatory framework, as described by the IAEA fundamental safety principles. The PNRA Regulations on Radiation Protections PAK/904 provides the national requirements for radiation protection. In this paper, the gap between PAK/904 and GSR Part 3 is identified through detail analysis. Furthermore, the importance to incorporate the new IAEA requirements in national regulations and its implementation in Pakistan is discussed in detail. As the new requirements are essential from the perspective of radiation protection, the discussions about the mechanism of implementation are useful for the regulatory bodies, which are in the process of revising their national requirements after the IAEA GSR Part 3 publication. The IAEA GSR Part 3 is a new document. Consequently, experience feedback and mechanism for GSR Part 3 implementation is not available, and is still under debate in many countries including Pakistan. The PNRA fully complies with international standards and requirements, especially the IAEA standards. Therefore, the new requirements highlighted in this paper need to be considered and included in national regulations. As stated in the introduction section, the gap analysis and the method how to implement the gaps into the national regulations could provide useful information for future enhancement of the regulations on radiation protection.

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