

Regulatory Standards and Guidelines for Radiation Protection

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Abstract: The use of radiation is important in different medical procedures, and to ensure a high level of good medical practice, radiation protection (RP) should be seen as a very important subject.

This review article examines the various regulatory standards and guidelines established for radiation protection across different sectors. It highlights the importance of these regulations in safeguarding public health and the environment from the harmful effects of ionizing radiation. The article discusses key organizations involved in setting these standards, such as the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO), and outlines the principles of radiation protection, including justification, optimization, and dose limitation.

A systematic Research was performed, using Google scholar, PubMed, Radiopaedia, hand scanning journals and the internet. Data was retrieved from all of the research studies that were included in this analysis. The investigation was carried out on a conceptual level. This paper explores the regulatory standards and guidelines established by international and national organizations to govern radiation safety. Key regulatory bodies, such as the International Atomic Energy Agency (IAEA), the International Commission on Radiological Protection (ICRP), and the United States Environmental Protection Agency (EPA), play a pivotal role in defining exposure limits, monitoring protocols, and risk mitigation strategies. The paper examines fundamental principles of radiation protection, including justification, optimization, and dose limitation, alongside the implementation of regulatory frameworks across different sectors, such as healthcare, nuclear energy, and industrial applications. , it discusses recent advancements in radiation safety regulations, emerging challenges, and the need for continuous improvements in policies to address evolving risks. By highlighting best practices and compliance measures, maintaining a balance between technological progress

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INTRODUCTION

Radiation protection, also known as radiological protection, is defined by the International Atomic Energy Agency (IAEA) as "The protection of people from harmful effects of exposure to ionizing radiation, and the means for achieving this". Exposure can be from a source of radiation external to the human body or due to internal irradiation caused by the ingestion of radioactive contamination. Ionizing radiation is commonly utilized in both industry and medicine, but it can pose a significant health risk by causing microscopic damage to living tissues. There are two primary categories of health effects associated with ionizing radiation. At high exposure levels, it can lead to "tissue" effects, known as "deterministic" effects because they are certain to occur, typically measured in grays and can result in acute radiation syndrome. In contrast, low-level exposures may lead to statistically increased risks of radiation induced cancer, referred to as "stochastic effects" due to the uncertainty of their occurrence, which are conventionally measured in sieverts. Soon after the discovery of X rays by Roentgen in 1895 and of natural radioactivity by Becquerel in 1896 it became apparent that ionizing radiation was not only useful for the diagnosis and treatment of disease but also harmful to human tissues.

Radiation safety is a concern for patients, physicians, and staff in many departments, including radiology, interventional cardiology, and surgery. Radiation emitted during fluoroscopic procedures is responsible for the greatest radiation dose for medical staff. Radiation from diagnostic imaging

modalities, such as computed tomography, mammography, and nuclear imaging, are minor contributors to the cumulative dose exposures of healthcare personnel.

However, any radiation exposure poses a potential risk to both patients and healthcare workers alike. Radiation protection aims to reduce unnecessary radiation exposure with a goal to minimize the harmful effects of ionizing radiation. In the medical field, ionizing radiation has become an inescapable tool used for the diagnosis and treatment of a variety of medical conditions. As its use has evolved, so have the cumulative doses of lifetime radiation that both patients and medical providers receive. Most radiation exposure in medical settings arises from fluoroscopic imaging, which uses x-rays to obtain dynamic and cinematic functional imaging. Formal radiation protection training helps reduce radiation exposure to medical staff and patients.

The purpose of radiation protection is to provide an appropriate level of protection for humans without unduly limiting the beneficial actions giving rise to radiation exposure. Radiation protection is to prevent the occurrence of harmful deterministic effects and to reduce the probability of occurrence of stochastic effects (e.g. cancer and hereditary effects). Radiation hazards to humans are well documented. To minimize their risks, international and national organizations have been established to set guidelines for safe handling of radiations. Fundamental to radiation protection is the avoidance or reduction of dose using the simple protective measures of time, distance and shielding. The duration of exposure should be limited to that necessary, the distance from the source of radiation should be maximized, and the source or the target shielded wherever possible. To measure personal dose uptake in occupational or emergency exposure, for external radiation personal dosimeters are used, and for internal dose due to ingestion of radioactive contamination, bioassay techniques are applied.

DOSE LIMITATIONS

PART OF THE BODY	OCCUPATIONAL EXPOSURE	PUBLIC EXPOSURE
Whole body (effective dose)	20 mSv/year averaged over 5 consecutive years; 30 msv in any single year	5 msv/year
lens of eyes (equivalent dose)	150 mSv in a year	15 msv/year
Skin	500 msv in a year	50 msv/year

There are three basic principles of radiation protection in ICRP international commission on radiological protection): justification, optimization, and dose limitation:

Justification, involves an appreciation for the benefits and risks of using radiation for procedures or treatments. Physicians, surgeons, and radiologic personnel all play a key role in educating patients on the potential adverse effects of radiation exposure. The benefits of exposure should be well known and accepted by the medical community. Often, procedures that expose patients to relatively higher doses of radiation—for example, interventional vascular procedures—are medically necessary, and thus the benefits outweigh the risks.

Optimization, The As Low as Reasonably Achievable (ALARA) principle, defined by the code of federal regulations, was created to ensure that all measures to reduce radiation exposure have been taken while acknowledging that radiation is an integral part of diagnosing and treating patients. Any amount of radiation exposure will increase the risk of stochastic effects, namely the chances of developing malignancy following radiation exposure. These effects are thought to occur as a linear model in which there is no specific threshold to predict whether or not malignancy will develop reliably. For these reasons, the radiologic community teaches protection practices under the ALARA principle.

Dose limitations (never exceed dose limits), The normal exposure of individuals resulting from all relevant practices should be subject to dose limits to ensure that no individual is exposed to a risk that is judged to be unacceptable.

WHO(World health organization) guidelines for radiation protection :

(equivalent dose)		
Extremities hands and feet (equivalent dose)	500 msv in a year	

For pregnant radiation workers, after declaration of pregnancy 1 mSv on the embryo/fetus should not exceed.

Where,

Occupational Exposure - Radiation Exposure to worker involved in a practice in which he/she is exposed due to handling of radioactive source or radiation generating equipment.

Public Exposure - Radiation Exposure to public due to above practices.

Basic Three Factors for Radiation Protection (Working Personnel & Public)

Time:

- Exposure from radiation source is directly proportional to time
- Reduce period of exposure to radiation to reduce the dose received from source. Distance:
- Increase distance from source to decrease exposure rate.
- $I_1 d_1^2 = I_2 d_2^2$ (Inverse square law)
- Double the distance from the source; dose-rate falls to ¼ the original value.
- Halve the distance from the source; dose-rate increase to 4 times the original value.
- More the distance from source -Lesser the radiation

Shielding:

- Use an appropriate shielding material or protection devices
- Shielding reduces exposure rate:

$$I = I_0 e^{-\mu t}$$

μ - linear attenuation coefficient of shielding material

t – Thickness of shielding material

I_0 – Initial exposure rate

I – Exposure rate after transmission from shielding

material

Use large shielding thickness (High Z materials eg Lead, Steel, Concrete, etc) - reduce the exposure rate of gamma/X-ray radiation.

DISCUSSION

A vital component of protecting people, employees, and the environment from the damaging effects of ionizing radiation is radiation protection. To reduce radiation hazards and ensure its safe use in industrial, medicinal, and research applications, a number of national and international regulatory authorities have set standards and recommendations. The International Commission on Radiological Protection (ICRP) is one of the most important organizations in radiation protection. Based on scientific research, the ICRP makes recommendations for risk assessment, exposure control, and radiation dose limitations. The International Atomic Energy Agency (IAEA) creates safety guidelines that act as a worldwide standard for radiation protection in addition to the ICRP's work. These recommendations are especially crucial for nations working on nuclear energy projects or those using radiation for medical imaging and therapy.

National regulatory agencies, in addition to international organizations, are essential in upholding radiation safety regulations. In the US, organizations like the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), and the U.S. Nuclear Regulatory Commission (NRC) establish rules to restrict radiation exposure in the environment and at work. In a similar vein, the European Atomic Energy Community (EURATOM) sets radiation safety regulations for all EU member states. These groups make sure that businesses follow safety regulations, keep up with radiation monitoring equipment, and give workers handling radioactive materials the proper training. Justification, optimization, and dosage limitation are the three main tenets of radiation protection. Any radiation-related action must have a net benefit in order to be justified. Notwithstanding these strict laws and technical developments, there are still difficulties in guaranteeing adherence and implementing radiation safety precautions over the world. Lack of funding, poor training, and a lack of regulatory monitoring may make it difficult for

developing nations to enforce radiation safety regulations. Thus, international cooperation and information exchange are crucial for advancing radiation safety globally.

CONCLUSION

Personnel stand near patients for long times, and angulated geometries with C-arm equipment may result in high personnel doses from backscatter. For all procedures, judicious applications of time, distance, and shielding affect dose. Appropriate use includes collimating properly, optimizing beam-on time, minimizing distances between image intensifier and patient, ensuring sufficient distance between patient and x-ray tube, and optimizing exposure rates for image quality and dose. Although dose limits typically regulate maximum whole-body dose, protective clothing worn by fluoroscopists reduces personnel risks; weighting factors can be applied to estimate effective dose equivalent. Pregnant personnel have lower limits, which apply only with voluntary declaration of pregnancy. With appropriate precautions, fetal doses can typically remain within recommended limits without changes in occupational tasks. Radiation workers in each state must ensure that regulations are appropriate.

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