Revelation and Science
Vol. 12, No. 02 (1444H/2022) 1-10

Radiation Protection for Worker- A Short Review

Siti Nursyakirah Idris, Siti Amira Othman and Nur Syafiqa Abdul Halim
Faculty of Applied Sciences and Technology,
Universiti Tun Hussein Onn Malaysia,
84600, Pagoh, Johor.

Abstract

Employee comfort and safety must be properly maintained in every workplace. Workers' safety refers to providing safe atmospheres, equipment, and processes in the workplace to protect the overall health and safety of employees. For radiation workers, radiation protection is critical to avoid the occurrence of hazardous deterministic effects and lower the likelihood of the development of stochastic consequences. This is due to the fact that onsite employees may be exposed to either artificial radiation, or naturally occurring radioactive substances. The health consequences are determined by the amount of radiation absorbed by the body, the kind of radiation, and the length of time the individual was exposed. A series of solid precautions may be considered to safeguard employees from such exposure. Proper monitoring, safety equipment, and counter measures such as shielding are some examples of precautions. Radiation protection, referred to as radiological assurance, is characterized by the International Atomic Energy Agency (IAEA) as "the insurance of individuals from hurtful impacts of openness to ionizing radiation, and the means for accomplishing this". The reason for radiation assurance or radiation protection is to enforce a suitable degree of security. The International Labour Organization (ILO) supports the dynamic contribution of managers' and laborers' associations in the improvement of worldwide guidelines on word related radiation security, as well as in the execution of the word related radiation principles, at both the public and venture levels.

Keywords: radiation, radiation protection, worker, workplace, safety

Abstrak

Keselesaan dan keselamatan pekerja mesti dijaga di setiap tempat kerja. Keselamatan pekerja merujuk kepada menyediakan suasana yang selamat, peralatan yang selamat dan proses yang selamat di tempat kerja untuk melindungi kesihatan dan keselamatan pekerja. Bagi pekerja sinarann, perlindungan sinaran adalah penting untuk mengelakkan berlakunya kesan penentuan berbahaya dan mengurangkan kemungkinan perkembangan akibat stokastik. Ini disebabkan oleh fakta bahawa pekerja mungkin terdedah kepada sama ada sinaran buatan atau bahan radioaktif semula jadi. Akibat kesihatan ditentukan oleh jumlah sinaran yang diserap oleh badan, jenis sinaran, dan tempoh masa individu terdedah. Beberapa langkah berjaga-jaga yang kukuh mungkin dilakukan untuk melindungi mereka daripada pendedahan sedemikian. Pemantauan yang betul, peralatan keselamatan, dan langkah balas seperti perisai adalah contoh perkara ini. Perlindungan sinaran, atau dipanggil jaminan radiologi, dicirikan oleh Agensi Tenaga Atom Antarabangsa (IAEA) sebagai "insurans individu daripada kesan keterbukaan yang menyakitkan terhadap sinaran mengion, dan cara untuk mencapainya". Sebab jaminan sinaran atau perlindungan sinaran adalah untuk memberikan tahap keselamatan yang sesuai. Pertubuhan Buruh Antarabangsa (ILO) menyokong dan memajukan sumbangan dinamik persatuan pengurus dan pekerja dalam penambahbaikan garis panduan sedunia mengenai keselamatan sinaran berkaitan perkataan dan dalam pelaksanaan prinsip sinaran berkaitan perkataan di peringkat awam dan juga usaha niaga.

Kata kunci: sinaran, perlindungan sinaran, pekerja, tempat kerja, keselamatan

**Corresponding author:*
Siti Amira Othman
Faculty of Applied Sciences and Technology,
Universiti Tun Hussein Onn Malaysia,
84600, Pagoh, Johor
Email: sitiamira@uthm.edu.my

Introduction

Safety is a major topic that is regularly considered and reviewed on a frequent basis. This also applies for the overall safety of employees. Natural sources of radiation are aspects of the environment. Therefore, radioactivity is a naturally-occurring phenomenon. Radiation and radioactive compounds have a wide range of positive applications, from power generation to medical, industrial, and agricultural applications. The radiation dangers that these applications may pose to employees, the general public, and the surrounding environment, must be evaluated and regulated (IAEA, 2018). Exposure to ionizing radiation has the potential to harm cells in the human body. Low-level radiation exposure has no obvious health consequences, but can produce an increased risk of cancer over a lifetime in the long term. Individuals exposed to radiation have been the subject of salient studies in the literature. Those who have been exposed to radiation, such as atomic bomb survivors and personnel in the radiation industry, fall under this category. The findings reveal that when radiation exposure increases, one's chance of developing cancer also increases (USEPA, 2014). Generally, one of the ways to safeguard employees against radiation is to restrict the length of time they spend in places where they may be potentially exposed. Additionally, it is important to keep staff a safe distance away from radiation, and to use proper shielding to protect them from it (Chris Kilbourne, 2008).

Overview of Radiation

Radiation may be found everywhere. The vast majority occurs naturally, while a small fraction is induced by humans. Radiation, also known as radiant energy, is energy in the form of waves or particles travelling across space. Radiation can be seen as visible light, heat, radio waves, and alpha particles. For example, when individuals feel warm from the sun, they are really receiving radiant energy emitted by the sun. Radiation in the form of electromagnetic waves, such as gamma rays, ultraviolet light, and radio waves, is known as electromagnetic radiation. Particle radiation, unlike the former one, is radiation in the form of particles, such as alpha and beta particles (Energy, 2020). The mechanism in which radiation interacts with materials also determines whether it is ionising or non-ionizing radiation, which is described hereafter (Canadian Nuclear Safety Commission, 2012).

Non-Ionizing Radiation

Non-ionizing radiation has less energy compared to ionising radiation, and is incapable of producing ions. Without displacing electrons, this type of radiation bounces off or passes through matter. Visible light, infrared waves, radio waves, microwaves, and sunshine are all examples of non-ionizing radiation.

Ionizing Radiation

An atom typically has an equal amount of protons and electrons. Nevertheless, ionisation allows atoms to lose or receive electrons. Ionizing radiation may discard electrons out of their orbits around atoms, causing the electron/proton equilibrium to be disrupted, and the atom to gain a positive charge. Radiation emitted by both natural and man-made radioactive materials is classified as ionising radiation. This type of radiation has the ability to alter the chemical state of matter, resulting in biological damage; hence, poses a risk to human health and the surrounding environment. Ionizing radiation comes in a variety of forms. Figure 1 depicts the penetrating capability of the primary kinds of ionising radiation.

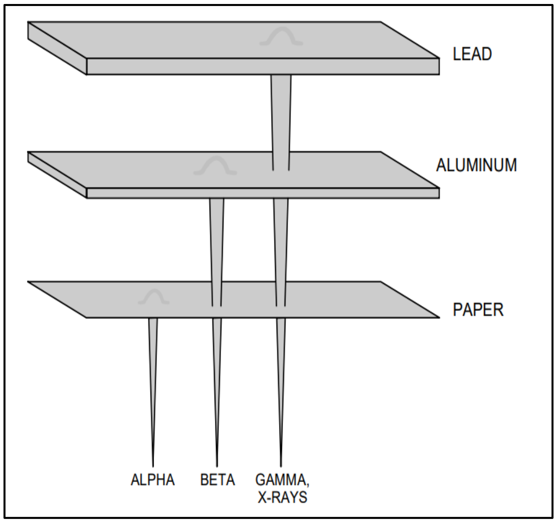

Figure 1 Penetrating Capability of Several Types of Ionising Radiation [4].

Radiation Protection for Workers

Governing agencies have implemented a variety of laws and safety measures in response to the harmful impacts that radiation workers may suffer. Consequently, not only should employees follow enforced safety standards, but the company's management should also have an active role in preventing unintended consequences. Some general principles for the radiation protection of workers are discussed hereafter:

Information and Training

The supply of relevant information on radiation protection, as well as training in this area, should be regarded an essential component of any programme that aims to implement protection optimization principles in the control of both normal and prospective exposures (ICRP, 1997). All employees who work where radiation sources are utilised, from the most senior management, down to the most junior staff member, should be given general knowledge about the radiation sources employed and the threats that they pose. Workers must also be made aware of their needs to promptly notify their supervisors or other designated individuals if any unanticipated incident occurs concerning radiation. Periodic testing is a good measure to test the extent of employee awareness and knowledge when faced with unforeseen incidents.

Personal Protective Clothing and Equipment

Personal protective equipment, referred to as "PPE," is clothing that is worn to reduce exposure to risks that might result in significant occupational illness or injury. To enhance protection against infectious illness, personal protective equipment must be put on, and then taken off, in the specified sequences, which may differ by facility. Physical protection such as gloves, masks, eye protection, face shields, and gowns may be used by radiologists, radiographers, and other imaging department staff. They'll require a lead apron, thyroid shields, and personal radiation dosimeters to protect themselves against ionising radiation (Moore and Bickle, 2002). Figure 2 depicts an example of the required personal protective equipment for employees.

Figure 2 Required Personal Protective Equipment [8].

Designation of Areas

The classification of workplaces into two primary groups, controlled areas and supervised areas, simplifies and improves occupational exposure control. Working with radioactive material necessitates the use of designated areas in order to be compliant with the Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations

2010. This Standard Operating Procedure (SOP) aims to control the amount of radiation exposure by identifying and separating higher-risk activities from lower-risk ones (IKN, 2018).

a) Controlled Area: A controlled area is a restricted access location wherein employees are exposed to radiation on the job under the supervision of a radiation protection officer (RPO). This means that radiation protection requires the strict monitoring to access, occupancy, and working conditions. Workers are not allowed to enter this area, unless they have been assigned to it, or have been given permission to do so by the RPO. For safety reasons, places that are designated as regulated zones, such as radiation treatment, diagnostic radiology, and nuclear medicine, should be guided by proper signs and placards (Majeed and Gupta, 2021). Figure 3 illustrates the Radiation warning symbol that is commonly found in controlled areas.

b) Supervised Areas: These places are classed as supervised areas, which are not controlled, but in which a worker's yearly effective dosage exceeds 1 mSv, the equivalent dose to the lens of the eye exceeds 15 mSv, or the equivalent dose to the hands, feet, or skin exceeds 50 mSv. In other words, although particular protective measures and safety standards are not generally enforced, the occupational exposure circumstances are maintained under evaluation (STUK, 2009). When working with unsealed sources in this space, contamination measures must be taken on a regular basis. Workers must also be provided with information on how to operate in the monitored areas, how to utilise radiation sources, and how to avoid the radiation dangers that stem from these sources [11].

Figure 3: Radiation Warning Symbol.

Emergency Exposure and Radiation Contamination

Someone who was exposed to or polluted by radiation is unlikely to detect the exposure. This is due to the fact that radiation cannot be seen, smelled, touched, or tasted. Internal contamination and radioactive contamination are the two main forms of contamination. The former occurs when humans consume radioactive materials by swallowing them or breathing them in, or when radioactive elements are absorbed through the skin or penetrate through an open wound. The latter happens once radioactive material is deposited on or in an object or person

(Centers for Disease Control and Prevention, 2021). Employers or incident commanders must take all necessary precautions to reduce dosage and provide proper protection to responders in any scenario where they may be exposed to ionising radiation (United States Department of Labor, 2016). However, the contamination that occurs can be limited by several important measures:

i. Move away from the local vicinity as soon as possible. Enter the nearest safe building or a location indicated by enforcement agencies or health professionals.

ii. Remove any outside garments that may have been exposed to radiation. Removing these reduces the chance of external contamination, while also lowering the risk of internal contamination. This will also shorten the amount of time a person is exposed to radiation.

iii. It is best to keep the clothes in a sealed plastic bag, or place them in a place that is not exposed to others.

iv. To eliminate contamination, cleanse all exposed regions of the body with soap and lukewarm water. This is known as decontamination.

v. Get an examination from the medical team, and in case of internal contamination, taking the medicine given is important to reduce the radioactive material in the body.

Radiation Exposure

Radiation is energy that stems from a source, transforms through space, and might have the option to infiltrate different materials. Light, radio, and micro waves are types of radiation that are non-ionizing (Amin, 2010).

Radiation protection, otherwise called radiological assurance, is characterized by the International Atomic Energy Agency (IAEA) as "The insurance of individuals from hurtful impacts of exposure to ionizing radiation, and the means for accomplishing this". Exposure can be from a wellspring of radiation external to the human body, or because of inner illumination brought about by the ingestion of radioactive pollution.

Radiation exposure from various source (Health Physics Society, 2016).

Source	Exposure (U.S. Average)
External Background Radiation	0.54 mSv/ y
Natural K-40 and Other Radioactivity in Body	0.29 mSv/ y
Air Travel Round Trip (NY-LA)	0.05 mSv
Chest X-Ray Effective Dose	0.10 mSv per film
Radon in the Home	2.28 mSv/ y
Man-Made (medical x rays, etc.)	3.14 mSv/ y

Ionizing radiation is produced by unstable atoms, which differ from stable atoms they atoms have an excess of energy or mass, or both. Radiation can also be produced by high-voltage devices such as X-ray machines.

Atoms with unstable nuclei are said to be radioactive. To reach stability, these atoms give off or emit excess energy. These emissions are referred to as radiation. These types of radiation are electromagnetic (such as light) and particulate (i.e., mass given off with the energy of motion). Gamma radiation and x-rays are examples of electromagnetic radiation (Michael, 2003). Gamma radiation originates in the nucleus, while x rays originate from the electronic part of the atom.

Beta and alpha radiation are examples of particulate radiation.

ILO (International Labour Organization)

The reason for radiation assurance or protection is to offer a suitable degree of security for people, without unduly restricting the advantageous activities leading to radiation openness. Radiation assurance aims to forestall the events of unsafe deterministic impact, and to diminish the possibility of event of a stochastic impact (for example, malignant growth and innate impacts) (Hans, 1984).

Radiation assurance is crucial for the fields of the ILO's activity on the insurance of laborers against infection, sickness and injury emerging out of work, as commanded by the Organization's constitution. The ILO's program of activity on word related wellbeing utilizes, in a planned manner, the various methods for activity accessible to the ILO to give legislatures, employers and employees associations the vital assistance in drawing up and executing programs for the improvement of working conditions. These methods consider worldwide guidelines for the type of shows and suggestions, codes of training, dispersal of data and specialized collaborations.

The ILO's exercises on radiation assurance cover the insurance of laborers against both ionizing and non-ionizing radiation (Paolo et al., 2007). The ILO was created throughout various long term approach instruments on radiation assurance which incorporate conventions and proposals (e,g. Show No. 115 and Recommendation No. 114), codes of training, reasonable aides and reports. A portion of these instruments and distributions were created and advanced in a joint effort with other worldwide associations such as the IAEA and WHO, as well as with global expert bodies such as the IRPA, ICRP and ICNIRP.

The ILO supports and advances the dynamic contribution of managers' and laborers' associations in the improvement of worldwide guidelines on word related radiation security and in the execution of the word related radiation principles at both the public and venture levels.

ALARA - As Low As Reasonably Achievable

The guiding principle of radiation safety is “ALARA”, which stands for “as low as reasonably achievable” (Yeung, 2009). This rule implies that, regardless of whether it is a little portion, assuming getting that portion has no immediate advantage, you should attempt to stay away from it.

To do this, you can utilize three fundamental defensive measures in radiation security: time, distance, and shielding.

1. Time

"Time" essentially alludes to the measure of time you spend with a radioactive source. It is recommended to limit your time being close to a radioactive source. Assuming that you are in a space with high radiation levels, finish your work as fast possible. Afterward, leave the area immediately.

2. Distance

"Distance" alludes to the fact that you are in close proximity to a radioactive source. It is recommended to move away from the source as much as possible. This is a simple method for minimizing the risk of exposure. If you are too close, attempt to decrease the source of radiation, if possible.

3. Shielding

To shield yourself from a radioactive source, place an object between you and the radiation source. The best shielding will rely upon what sort of radiation the source emits. Some radionuclides produce more than one sort of radiation.

Radiation effect on human body

Certain body parts are explicitly impacted by openness to various types of radiation sources (Michael, 2007). Several variables are associated with deciding the potential impact of exposure to radiation. These include:

- The size of the portion (amount of energy saved in the body),
- The capacity of the radiation to hurt human tissue, and
- The organs impacted.

The primary component is the measure of the portion that is kept in your body. The more energy consumed by cells, the more prominent the natural harm (David et al., 2018). Wellbeing physicists allude to the measure of energy consumed by the body as the radiation portion. The assimilated portion, the measure of energy retained per gram of body tissue, is generally measured in units called rads. Another unit of radiation is the rem. To change rads to rems, the quantity of rads is increased by a number that reflects the potential for harm brought about by a type of radiation. For beta, gamma and X-ray radiation, this number is for the most part one.

Dose (rem)	Effects
5-20	Possible late effects; possible chromosomal damage.
20-100	Temporary reduction in white blood cells.
100-200	Mild radiation sickness within a few hours: vomiting, diarrhea, fatigue; reduction in resistance to infection.
200-300	Serious radiation sickness effects as in 100-200 rem and hemorrhage; exposure is a Lethal Dose to 10-35% of the population after 30 days (LD 10-35/30).
300-400	Serious radiation sickness; also marrow and intestine destruction; LD 50-70/30.
400-1000	Acute illness, early death; LD 60-95/30.
1000-5000	Acute illness, early death in days; LD 100/10.

1. **Hair**

The rapid loss of hair and in clusters occurs with radiation openness at 200 rems or higher.

2. **Cerebrum**

Since synapses do not repeat, they will not be harmed directly except if the openness is 5,000 rems or more. Similar to the heart, radiation kills nerve cells and veins, and can cause seizures and even death.

3. **Thyroid**

Certain body parts are more impacted by openness to various kinds of radiation sources than others. The thyroid organ is powerless to radioactive iodine. In an adequate amount, radioactive iodine can annihilate all or part of the thyroid. Taking potassium iodide can decrease the impact of openness.

4. **Blood System**

At the point when an individual is presented to around 100 rems, the blood's lymphocyte cell count will be decreased, leaving the casualty more vulnerable to contamination. This is regularly alluded to as gentle radiation affliction. Early side effects of radiation ailment impersonate those of influenza, and may go unrecognized except if the blood count is done. According to Hiroshima and Nagasaki, indications might be persevered for as long as 10 years, and may result in leukemia and lymphoma (Hsu et al., 2013).

5. Heart

Exceptional openness to radioactive material at 1,000 to 5,000 rems would harm little veins and presumably cause cardiovascular breakdown and immediate death.

6. Gastrointestinal Tract

Radiation harm to the digestive system covering causes sickness. This occurs when the casualty's openness is 200 rems or more. The radiation starts to obliterate the cells in the body that partition quickly. These including blood, GI parcel, and hair cells, and at finally damages their DNA and RNA of enduring cells.

7. Conceptive Tract

Since conceptive lot cells partition quickly, these areas of the body can be harmed at rem levels as low as 200. Some radiation ailment casualties will become sterile in the long term.

Conclusion

As a radiation worker, safety is a top priority in any situation. It is important to be aware of the adverse effects of radiation contamination which might lead to death. Therefore, various security measures need to be revised from time to time by the responsible parties, especially the management. Employees also need to play an active role by complying with all the rules that have been enforced for their own safety.

Molecules comprised different parts; the core contains minute particles called protons and neutrons, and the iota's external shell contains different particles called electrons. The core conveys a positive electrical charge, while the electrons convey a negative electrical charge. These powers inside the molecule pursue a solid, stable equilibrium by the disposing of overabundance nuclear energy (radioactivity). In that cycle, temperamental cores might discharge an amount of energy, and this unconstrained outflow is radiation.

References

Amin J. Mirhadi. (2010). 25 - Overview of Radiation Therapy Terms and Procedures in the Management of Thoracic Malignancies, Editor(s): Michael I. Lewis, Robert J. McKenna, Jeremy A. Falk, George E. Chaux, Medical Management of the Thoracic Surgery Patient, W.B. Saunders, 252-262, https://doi.org/10.1016/B978-1-4160-3993-8.00025-8.

Chris Kilbourne. (2008). 3 Keys to Reducing Workplace Radiation Exposure, EHS Daily Advisor.https://ehsdailyadvisor.blr.com/2008/11/3-keys-to-reducing-workplace-radiation-exposure/

David A. Elliott, Nima Nabavizadeh, Steven K. Seung, Eric K. Hansen, John M. Holland. (2018). 13 - Radiation Therapy, Editor(s): R. Bryan Bell, Rui P. Fernandes, Peter E. Andersen, Oral, Head and Neck Oncology and Reconstructive Surgery, Elsevier, 268-290, https://doi.org/10.1016/B978-0-323-26568-3.00013-0.

Energy. (2020). Introduction To Radiation, Revision 3. 1-7.

Guardian Safety & Supply is the Industrial Strength Solution for Your Safety and Supply Needs (2018).

Hans Svensson. (1984). Quality assurance in radiation therapy: Physical aspects, International *Journal of Radiation Oncology*Biology*Physics*. 10(1): 59-65, https://doi.org/10.1016/0360-3016(84)90449-8.

Health Physics Society. (2016). Radiation Exposure From Radiation Sources. Specialist in Radiation Protection. Retrieved from http://hps.org/publicinformation/ate/faqs/whatisradiation.html.

Hsu WL, Preston DL, Soda M, Sugiyama H, Funamoto S, Kodama K, Kimura A, Kamada N, Dohy H, Tomonaga M, Iwanaga M, Miyazaki Y, Cullings HM, Suyama A, Ozasa

Canadian Nuclear Safety Commission. (2012). Introduction to Radiation. 1-44.

Centers for Disease Control and Prevention. (2021). Contamination and Exposure

K, Shore RE, Mabuchi K. (2013). The incidence of leukemia, lymphoma and multiple myeloma among atomic bomb survivors: 1950-2001. Radiat Res. 2013 Mar;179(3):361-82. doi: 10.1667/RR2892.1.

Institut Kanser Negara (IKN). (2018). IKN-RS-SOP-09: Area Classification. Prosedur Operasi Standard (SOP)

International Atomic Energy Agency (IAEA). (2018). Occupational Radiation Protection, IAEA Safety Standards Series No. GSG-7. 1-335.

Majeed H, Gupta V. (2021). Adverse Effects Of Radiation Therapy. Bookshelf NCBI.

Michael F. L'annunziata. (2003). 9 - Cherenkov Counting, Editor(s): Michael F. L'Annunziata, Handbook of Radioactivity Analysis (Second Edition), *Academic Press*, 719-797, https://doi.org/10.1016/B978-012436603-9/50014-4.

Michael F. L'Annunziata. (2007). 2 - Beta Radiation, Editor(s): Michael F. L'Annunziata, Radioactivity, Elsevier Science B.V.,119-140, https://doi.org/10.1016/B978-044452715-8.50005-0.

Moore, C., Bickle, I. (2002). Personal protective equipment. Reference article. Radiopaedia.org. https://doi.org/10.53347/rID-75964.

Paolo Vecchia, Maila Hietanen, Bruce E. Stuck Emilie van Deventer, Shengli Niu. (2007). Protecting Workers from Ultraviolet Radiation. *International Commission on Non-Ionizing Radiation Protection* 1-110.

STUK. (2009). Operational Radiation Safety. Guide ST. 1-22.

The International Commission on Radiological Protection (ICRP). (1997). General Principle for the Radiation Protection of Workers. ICRP Publication 75. 1-70.

United States Department of Labor. (2016). Radiation Emergency Preparedness and Response.

United States Environmental Protection Agency (USEPA). (2014). Radiation Health Effects, *US EPA*. https://www.epa.gov/radiation/radiation-health-effects

Yeung A. W. K. (2019). The "As Low As Reasonably Achievable" (ALARA) principle: a brief historical overview and a bibliometric analysis of the most cited publications. Radioprotection, 54 (2):103-109. https://doi.org/10.1051/radiopro/2019016.

Article History

Received: 16/03/2022

Accepted: 25/08/2022