International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 5, July-August 2021 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Study of Health and Safety at Nuclear Installations

M. N. Islam[1], M. S. Alam[1], M. A. S. Haque[1], H. Akhter[2], M. Kamal[3]

[1]Institute of Electronics, Atomic Energy Research Establishment,
Bangladesh Atomic Energy Commission, Dhaka, Bangladesh
[2]Electronics Division, Atomic Energy Centre,
Bangladesh Atomic Energy Commission, Dhaka, Bangladesh
[3]Physical Science Division, Bangladesh Atomic Energy Commission, Dhaka, Bangladesh

ABSTRACT

A study of health and safety at nuclear installations has been presented in this article. The main provision in this context is to set up Health and Safety Commission and Health and Safety Executive to administer regulations concerning the health and safety of persons at work, and of other persons who may be put at risk by the activities of persons at work. Man-made sources of radiation including occupational exposures from nuclear reactors and accelerators, natural radiation sources also have been presented. Summary of UK Regulations has been presented as well.

KEYWORDS: *Man-made Radiation, Natural Radiation, Radiological Parameters and Legislation and Regulation*

How to cite this paper: M. N. Islam | M. S. Alam | M. A. S. Haque | H. Akhter | M. Kamal "Study of Health and Safety at Nuclear Installations" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-5, August 2021, pp.547-550, URL: www.ijtsrd.com/papers/ijtsrd29362.pdf

IJTSRD29362

1. INTRODUCTION

Health and Safety issues play a very vital role at any nuclear installations for the health and safety of the personnel concerned considering both man-made and natural radiation related activities. Exposer to radiation for radiation workers is inevitable but whether it is within the permissible limit or not that may cause health hazard or biological damage or risk to be investigated regularly. The radiological parameters such as radiation dose rate (Svh^{-1}) would to be estimated during personal and surface monitoring in workplaces. Activity ($Bq.kg^{-1}$), The absorbed dose rate ($nGyh^{-1}$) in air one meter above the ground surface, The annual effective dose equivalent D_{eff} from outdoor terrestrial gamma radiation, Radium Equivalent Dose ($Bq.kg^{-1}$), Representative Level Index ($Bq.kg^{-1}$), Transfer Factor (TF) and External Radiation Hazard Index (H_{ex}) also to be determined in environment especially for food and environmental samples as they enter into food chain. The guidelines and/or recommendations to be followed formulated by The Nuclear Installation Acts (NIA) , Health and Safety at Work (HSW) Act , The Atomic Energy Act, Radiological Protection Act, and The Radioactive Substance Act. Moreover, the updates from International Commission on Radiation Units and Measurements (ICRU) which approves the radiation units (gray and sievert) and International Commission on Radiation Protection (ICRP) that provides recommendations regarding radiation units and limits of annual effective radiation dose rate for workers and public should be taken into consideration.

2. Methodology

2.1. Man-made Radiation Sources

The early experiences of man-made sources of radiation involved X-rays and various uses of radium. As early as 1986 a letter appeared in Nature describing the effects of repeated exposure of the hands to X-rays and during 15 years many more cases were reported. These sources are: diagnostic radiology, therapeutic radiology, use of isotopes in medicine, radioactive waste, fall-out from nuclear weapon tests, and occupational exposures from nuclear reactors and accelerators.

Sl.	Source	Dose (Sv/year)
1.	Diagnostic radiology	220
2.	Therapeutic radiology	30
3.	Use of isotopes in medicine	2
4.	Radioactive waste	2
5.	Fall-out from nuclear weapons	10
6.	Occupationally exposed persons	9
7.	Other sources	12
	Total: (Approx.)	285

Table 1: Average annual doses due to man-made radiation in the UK

2.1.1. Diagnostic radiology
It has been observed that 90 percent of the total exposure of the population from medical uses of radiation comes from the diagnostic use of X-rays. Irradiation of the gonads and pregnant woman are important because possibility of genetic damage and physical and mental damage to the child respectively.

2.1.2. Therapeutic radiology
In most countries the average dose to the population from therapeutic radiology is much less than that from diagnostic radiology. Although quite large exposures may be used in certain treatments, only a small number of people are involved.

2.1.3. Use of isotopes in medicine
Radioisotopes are used in medicine to give a means of tracing the path and location of specific chemicals in the body. By counting methods the location of the active, and hence of the ordinary non-active, isotopes of the element may be determined.

2.1.4. Radioactive waste
The increasing use of radioisotopes and, more particularly, the development of the nuclear power industry results in an ever-growing quantity of radioactive waste. Continued disposal of low and intermediate levels of radioactive waste to the environment means that numbers of general population will receive an increasing exposure from this source. At present, contribution to the total exposure of the population from waste disposal is very low, about 2 Sv/year.

2.1.5. Fall-out from weapons testing
The nuclides of concern in radioactive fall-out from nuclear weapons testing are similar to those arising from the operation of nuclear power stations. The most important radionuclides are strontium-90 (half-life 28.8years) and caesium-137(half-life 30 years).

2.1.6. Occupational exposure
The dose from all occupational exposure, both research and production is very small when averaged over the whole population. The estimated dose in the United Kingdom is about 9 Sv/year, of which atomic energy workers contribute about 40 percent. The remainder is due to uses of radiation in industry and medicine.

Dose limit of occupational exposure is 20 mSv per year averaged over five consecutive years but an effective dose of 50 mSv may be in any single year. An effective dose to the lens of the eye is 150 mSv in a year. And an equivalent dose to the extremities (hands and feet) or the skin is 500 mSv in a year [3].

2.2. Natural Radiation Sources
Natural radiation sources contributors are the three natural radioactive series, called the thorium, uranium-radium and actinium series. Also included in this table is the neptunium series which does not occur in nature because the half-life of its longest member is only 2.2 10^6 years which is much smaller than the age of the universe (3 10^9 years). These four series are called the heavy disintegration series [1].

Sl. No.	Series Name	Final Stable Nucleus	Longest-lived Member
1.	Thorium	^{208}Pb	^{232}Th ($T_{1/2}$ = 1.39x10^{10} years)
2.	Uranium-radium	^{206}Pb	^{238}U ($T_{1/2}$ = 4.50x10^9 years)
3.	Actinium	^{207}Pb	^{235}U ($T_{1/2}$ = 8.52x10^8 years)
4.	Neptunium	^{209}Bi	^{237}Np ($T_{1/2}$ = 2.20 x10^6 years)

Table 2: Natural radiation sources contributors the thorium, the uranium-radium, the actinium and the neptunium series.

Annual effective dose of 1 mSv per year recommended by the ICRP for general public. In special circumstances, an effective dose of up to 5 mSv in a single year provided that average dose over five consecutive years does not exceed 1 mSv per year. An equivalent dose to the lens of the eye of 15 mSv per year. And an equivalent dose to the skin of 50 mSv in a year.

Limits of radionuclide (Cesium 137) concentration in milk powder and dairy products and other food materials are 95 Bq.kg^{-1} and 50 Bq.kg^{-1} respectively[2, 3].

2.3. Legislation and Regulation
2.3.1. Nuclear Installations Act
The 1965 Nuclear Installations Act (the 1965 Act) deals with liability and governs the construction and

safe operation of nuclear plants. The 1965 Act makes provision for licensing, liability and insurance in relation to the installation and operation of nuclear reactors and nuclear installations in general. The 1965 Act is supported by the Ionizing Radiations Regulations 1999 which require employers to ensure radiation exposure of workers and the general public remains within specified safe limits [4]. It provides for control, via permit, of processes for the enrichment of uranium and the extraction of plutonium or uranium from irradiated matter and the application of associated security measures. It provides a special legal regime to govern the liability of nuclear site.

2.3.2. Health and Safety at Work Act

The HSW Act places a fundamental duty on employers to ensure, as low as reasonably practicable (ALARP), the health, safety and welfare at work of all their employees. It also imposes a duty on employers to ensure, that persons not in their employment are not exposed to risks to their health or safety as a result of the activities undertaken. HSW Act's requirements is governed by the principles of proportionality in applying the law and securing compliance; consistency of approach; targeting of enforcement action; transparency about how the enforcing authorities operate and what those regulated may expect; and accountability for its actions. This code applies when regulators determine their general policies or principles about how they exercise their regulatory functions and when they set standards or give general guidance [5].

2.3.3. Atomic Energy Act

In 1946, the Atomic Energy Act was enacted which empowered the appropriate minister (now the secretary of state for energy) to promote and control the development of atomic energy.

2.3.4. Radiation Protection Act

The main purpose of Radiation Protection Act was to establish a single national point of authoritative reference in the field of radiological protection. The setting up a National Radiological Protection Board (NRPB) and an Advisory Committee. The functions of the NRPB are to advance the acquisition of knowledge about the protection of mankind against radiation hazards and to provide advice and information on that subject. The services provided by the NRPB include both external and internal dose assessment of the sources of exposure of the population as a whole. It also carries out research in various fields related to radiation protection and accidental releases from nuclear facilities. The duties of the Advisory Committee are to advise the Board on the practical aspects of applying current knowledge to the control of radiation hazards and also to bring to the Board's notice any international agreement or internationally recommended standards relevant to radiation protection.

2.3.5. Radioactive Substance Act

The Radioactive Substance Act 1960 by the Radiochemical Inspectorate of the Department of the Environment. It was introduce to control the disposal and accumulation of radioactive waste. The Act provides for the registration of users radioactive materials and mobile radioactive apparatus and prohibits the accumulation or disposal of radioactive waste except in accordance with an authorization granted by the Secretary of State.

International Commission on Radiation Units and Measurements (ICRU) approve the radiation units (gray and sievert) and International Commission on Radiation Protection (ICRP) provides recommendations regarding radiation units and limits of annual effective radiation dose.

Sl. No.	Regulation	Main Provisions
1.	Atomic Energy Act(1946)	Promotion development and control of atomic energy
2.	Radioactive Substances Act (1948)	Control of radioactive substances and radiation apparatus
3.	Radioactive Substances Act (1960)	Regulations on keeping and use of radioactive material and the disposal of radioactive waste
4.	Nuclear Installations Act (1965,1969)	Deals with licensing and insurance of specified sites which have substantial radiological hazards
5.	Radiological Protection Act (1970)	Set up NRPB and Advisory Committee to provide various national services in the radiation protection field.
6.	Health and Safety at Work etc. Act (1974)	Set up Health and Safety Commission and Health and Safety Executive to administer regulations concerning the health and safety of persons at work, and of other persons who may be put at risk by the activities of persons at work.
7.	The Ionizing Regulations (1999) Radiations	The regulatory package consists of the regulations and an approved code of practice, with more detailed guidance notes on certain specific items.

Table 3: Summary of UK Regulations.

3. Conclusion

An ample study about the health and safety at nuclear installations has been presented in this paper. Firstly, the contributor of man-made radiation sources has been presented elaborately. Secondly, the contributor of natural radioactive sources has been provided. Significant radiological parameters and regulations along with main provisions for them also have been presented. This study would be helpful for guidelines regarding detecting radiation hazards which will ensure health and safety of the workers and public.

Acknowledgement

Authors wish to express deep gratitude to Mr. Mahbubul Hoq, Chairman; Mr. Masud Kamal, Member (Physical Science); Dr. Imtiaz Kamal, Member (Planning and Development); Dr. Md. Sanowar Hossain, Member (Bio-Science) and Engr. Md. Abdus Salam, Member (Engineering), Bangladesh Atomic Energy Commission, Dhaka for their support and cooperation in the research.

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