Course title: Atomic and Nuclear Physics

Week # 15

Main Topics: Radiation Protection apparatus for Laboratories

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Lecture Learning Outcomes:

At the end of the lecture, you will be able to:

(i) Have a basic idea about the radiation protection principles
(ii) Explain the protocols and methods of radiation protection
(iii) Familiar with radiation protection apparatus for laboratories

Radiation Protection

It has long been recognized that large and persisting doses of ionizing radiation can damage human tissues. Over the decades, as more has been learned, scientists became increasingly concerned about the potentially detrimental effects of exposure to large doses of radiations. The need to regulate exposure to radiation prompted the formation of a number of expert bodies to consider what is needed to be done. In 1928, an independent non-governmental body of experts in the field, the International X-ray and Radium Protection Committee was established. It was later renamed as the International Commission on Radiological Protection (ICRP). Its purpose was to establish basic principles for, and issue recommendations on, radiation protection for vulnerable areas.

These principles and recommendations were framed for the protection of human beings form the basis for regulations governing the exposure of radiation workers and members of the public. Incorporated with the International Atomic Energy Agency (IAEA) into its Basic Safety Standards for Radiation Protection jointly with the World Health Organization (WHO), International Labour Organization (ILO), and the OECD Nuclear Energy Agency (NEA) framed the safety standards and protocols. These standards are used worldwide to ensure safety and radiation protection of radiation workers and the general public.

An intergovernmental body was formed in 1955 by the General Assembly of the United Nations as the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). UNSCEAR is directed to assemble, study and disseminate information on observed levels of ionizing radiation and radioactivity (natural and man-made) in the environment, and on the effects of such radiation on man and the environment.

Basic approaches to radiation protection are consistent all over the world. The ICRP recommends that any exposure above the natural background radiation should be kept as low as reasonably achievable, but below the individual dose limits. The individual dose limit for radiation workers averaged over 5 years is 100 mSv, and for members of the general public, is 1 mSv per year. These dose limits have been established based on a prudent approach by assuming that there is no threshold dose below which there would be no effect. It means that any additional dose will cause a proportional increase in the chance of a health effect. This relationship has not yet been established in the low dose range where the dose limits have been set.

There are many high natural background radiation areas around the world where the annual radiation dose received by members of the general public is several times higher than the ICRP dose limit for radiation workers. The numbers of people exposed are too small to expect to detect any increases in health effects epidemiologically. Still the fact that there is no evidence so far of any increase does not mean the risk is being totally disregarded.

The ICRP and the IAEA recommend the individual dose must be kept as low as reasonably achievable, and consideration must be given to the presence of other sources which may cause simultaneous radiation exposure to the same group of the public. Also, allowance for future sources or practices must be kept in mind so that the total dose received by an individual member of the public does not exceed the dose limit.

In general, the average annual dose received by radiation workers is found to be considerably lower than the individual dose limits. Good radiation protection practice can thus result in low radiation exposure to workers.

At what level is radiation harmful?

The effects of radiation at high doses and dose rates are reasonably well documented. A very large dose delivered to the whole body over a short time will result in the death of the exposed person within days. Much has been learned by studying the health records of the survivors of the bombing of Hiroshima and Nagasaki.

We know from these that some of the health effects of exposure to radiation do not appear unless a certain quite large dose is absorbed. However, many other effects, especially cancers are readily detectable and occur more often in those with moderate doses. At lower doses and dose rates, there is a degree of recovery in cells and in tissues.

However, at low doses of radiation, there is still considerable uncertainty about the overall effects. It is presumed that exposure to radiation, even at the levels of natural background, may involve some additional risk of cancer.

However, this has yet to be established. To determine precisely the risk at low doses by epidemiology would mean observing millions of people at higher and lower dose levels. Such an analysis would be complicated by the absence of a control group which had not been exposed to any radiation. In addition, there are thousands of substances in our everyday life besides radiation that can also cause cancer, including tobacco smoke, ultraviolet light, asbestos, some chemical dyes, fungal toxins in food, viruses, and even heat. Only in exceptional cases is it possible to identify conclusively the cause of a particular cancer.

There is also experimental evidence from animal studies that exposure to radiation can cause genetic effects. However, the studies of the survivors of Hiroshima and Nagasaki give no indication of this for humans. Again, if there were any hereditary effects of exposure to low-level radiation, they could be detected only by careful analysis of a large volume of statistical data.

Moreover, they would have to be distinguished from those of a number of other agents which might also cause genetic disorders, but whose effect may not be recognised until the damage has been done (thalidomide, once prescribed for pregnant women as a tranquilizer, is one example). It is likely that the resolution of the scientific debate will not come via epidemiology but from an understanding of the mechanisms through molecular biology.

With all the knowledge so far collected on effects of radiation, there is still no definite conclusion as to whether exposure due to natural background carries a health risk, even though it has been demonstrated for exposure at a level a few times higher.

Risks and Benefits

We all face risks in everyday life. It is impossible to eliminate them all, but it is possible to reduce them. The use of coal, oil, and nuclear energy for electricity production, for example, is associated with some sort of risk to health, however small. In general, society accepts the associated risk in order to derive the relevant benefits. Any individual exposed to carcinogenic pollutants will carry some risk of getting cancer. Strenuous attempts are made in the nuclear industry to reduce such risks to as low as reasonably achievable.

Radiation protection sets examples for other safety disciplines in two unique respects. First, there is the assumption that any increased level of radiation above natural background will carry some risk of harm to health. Second, it aims to protect future generations from activities conducted today.

The use of radiation and nuclear techniques in medicine, industry, agriculture, energy and other scientific and technological fields has brought tremendous benefits to society. The benefits in medicine for diagnosis and treatment in terms of human lives saved are enormous. Radiation is a key tool in the treatment of certain kinds of cancer. Three out of every four patients hospitalized in the industrial countries benefit from some form of nuclear medicine. The beneficial impacts in other fields are similar.

No human activity or practice is totally devoid of associated risks. Radiation should be viewed from the perspective that the benefit from it to mankind is less harmful than from many other agents.

Radiation Protection Apparatus

Radiation protection apparatus used in laboratories are meant for minimizing exposure to ionizing radiation. Some common radiation protection equipment and measures used in laboratories are discussed here.

Personal Protective Equipment (PPE):

These are the apparatus used to protect the radiation workers, engineers and technicians by minimising the possibility of radiation exposure.

1. Lead Aprons and Shields: These are used by personnel during procedures involving radiation to protect the body, particularly the torso, from direct exposure.
2. Lead Gloves and Thyroid Shields: Provide protection for hands and the thyroid gland from scattered radiation during procedures.
3. Protective Eyewear: Specialized glasses or goggles with leaded lenses to shield the eyes from radiation exposure.

Radiation Monitoring Devices:

Apart from protection, we need to monitor the levels of radiation in the work settings. This is necessary to reduce the risks and also to take remedial measures if necessary.

1. Dosimeters: Worn by individuals working with radiation, these devices measure and record the amount of radiation exposure over time.
2. Geiger Counters and Survey Meters: Used to detect and measure radiation levels in the laboratory environment.

Radiation Shielding:

There should be permanent barriers wherever high active radio-isotopes are stored for research and development. Radioactive materials for diagnosis and radiation therapy are to be shelved safely to safeguard the personnels handling them.

1. Lead-Lined Walls and Barriers: Used in laboratory construction to contain and shield radiation.
2. Lead Bricks or Blocks: Positioned strategically to create barriers against radiation.
3. Radiation-Resistant Glass: Windows or observation panels made of special materials to reduce radiation exposure.

Ventilation and Containment:

Spaces where radionuclides and isotopes are handled need to have excellent ventilation to get rid of the accumulation of the radioactive gases and fumes.

1. Fume Hoods: Enclosed workspaces with ventilation systems to protect workers from inhaling or being exposed to radioactive particles or gases.
2. Isolation and Containment Units: Used for handling radioactive materials to prevent their spread and limit exposure.

Proper Handling and Storage:

Radioactive materials are to be preserved in proper containers with unambiguous labels carrying all pieces of information.

1. Lead-Lined Containers: Used for the safe storage and transport of radioactive materials.
2. Labelling and Signage: Clearly indicating radiation hazards and safety protocols in the laboratory.

Regulatory Compliance and Training:

Above all safety measures, the workers and technicians need to be updated with the modern methods of safety and renewed regulatory protocols. This needs periodic training and hands on experience on the safety procedures and even rescue operations.

1. Safety Procedures and Training: Regular training programs for laboratory personnel on handling radioactive materials, emergency procedures, and safety protocols.

2. Compliance with Regulations: Adherence to local, national, and international regulations governing the handling, storage, and disposal of radioactive materials.

These radiation protection apparatus and safety measures are crucial to ensuring the safety of laboratory workers and minimizing the risks associated with working with ionizing radiation.

References:

1. International Commission on Radiological Protection (ICRP), https://www.icrp.org/
2. United states Nuclear regulatory commission (USNRC), Exposure (radiation) | NRC.gov
3. World Health Organisation Radiation and health (who.int)