Radioactive sources used in HO detector fabrication and the safety related issues

B.Satyanarayana,
Department of High Energy Physics,
Tata Institute of Fundamental Research,
Mumbai, INDIA, 400005

May 14, 2001

1 Units

Following are the definitions and conversions among the most commonly used units used to represent the radioactivity and and its dose etc.

1. Unit of activity = becquerel(Bq) or curie(Ci)

$$1\ Bq = 1\ Disintegration/Sec = \frac{1}{3.7 \times 10^{10}}\ Ci$$

2. Unit of absorbed dose = gray(Gy) or rad

$$1Gy = 1joule/Kg = 100rad = 6.24{\times}10^{12}Mev/Kg\ of\ deposited\ energy$$

3. Unit of equivalent dose (for biological damage) = Sievert = 100 Rem
REM stands for Roentgen Equivalent for Man.
Sv = Absorbed dose in grays for X and Gamma rays.

2 Types of radiation

There are two types of radiation - Ionizing and non-ionizing radiation. Ionizing radiation has enough energy to remove electrons from an electrically neutral atom. This is the type of radiation of most concern and what is usually referred to when one speaks of radiation.

Types of ionizing radiation include alpha particles, beta particles, gamma/X-rays, neutrons and muons.

Non-ionizing radiation such as microwaves, radio waves, ultraviolet and visible light does not have enough energy to remove an electron from an electrically neutral atom. Even though it is capable of causing biological damage, it is not a major radiological concern.

3 Radiation levels

We have always been exposed to radiation. We are exposed to it from sources in our environment and even from sources inside our bodies. In most of the world areas, the natural annual background whole-body equivalent dose is 40-400mR. These numbers vary by an order of magnitude between different places (for e.g. in the USA it is 360 mrem/year). Natural background radiation is by far the largest contributor to public radiation doses. Man made sources of radiation contribute the reminder of the annual average dose.

The main sources of natural background radiation are:

- Radon inside the buildings (196 mR/year),
- Terrestrial radiation or the radiation from the material in the earth's crust such as rocks and soil (28 mR/year),
- Internal radiation from materials present in our bodies such as potassium-40 (40 mR/year)
- Cosmic radiation or the radiation from the sun and outer space (28 mR/year)

and the man made sources include:

- Medical uses such as nuclear medicine (14 mR/year)

- Medical Diagnostic x-rays (40 mR/year)
- Consumer goods such as tobacco products (11 mR/year)
- Other sources like fallout from nuclear weapons testing (3 mR/year)

Lethal dose(resulting in 50% mortality in 30 days, assuming no medical treatment) is 250-300Rems.

Internationally recommended limit to exposure of radiation workers for whole-body dose is 2 Rems or 2000mR/year. This assumes 2000 working hours per year (50weeks X 5days X 8hours). Though some countries and institutes set their limit even lower (for example in CERN, the limit is 1500mR/year), in India, AERB recommends the international limit only.

4 Biological effects of radiation

Effects of radiation on biological systems depend on the total dose and the rate at which the dose is delivered.

Acute radiation dose refers to a large dose that is received over a short period of time such as radiation therapy for cancer treatment, where as a chronic dose is small amount of radiation received over long periods of time. Examples of chronic exposures are those from natural background radiation, routine medical exposures, and work-related or occupational exposures.

Biological effects from chronic exposures may be observed in the exposed individual or in the future children of the exposed individual. Genetic effects may appear in an exposed individual's children as a result of a dose to that person's reproductive cells prior to conception. Mutations in the chromosomes of the reproductive cells can be passed on to future generations.

A developing embryo/fetus is considered to be in the most radio sensitive stage of human development as the cells are rapidly dividing. Exposure of the embryo/fetus to radiation may increase the child's chances of impaired physical growth, slower mental development or childhood cancer. These risks could be virtually eliminated by special protective measures for pregnant radiation workers.

Occupational exposures may slightly increase the risk for the development of cancer and/or cataracts.

5 Our sources

We use Cs-137(for X-Y scanner) and Co-60(Wire source scanner) sources during HO detector fabrication work. Some information about these sources is as follows:

1. Cs-137: Emits gamma at 0.662 MeV. Low penetration. Half life is 30.2 years. Our source strength is 10mCi. For this source, the radiation at 1 m distance is about 3.3 mR/h(0.33R/h/Ci) and falls with the inverse square of the distance. While a shielding of 6.5mm lead around the source brings the radiation level to half, 22mm lead brings down the same by a factor of 10. The source holder that we had fabricated for X-Y scanner will have about 55mm lead in about all around the source.

2. Co-60: Emits two gammas at 1.173 MeV and 1.333 MeV. High penetration. Half life is 5.271 years. Our source was 3mCi in around 1997-98. Now must have decayed a bit. The radiation at 1 m distance is about 4 mR/h (1.32R/h/Ci). After this source wire is loaded into the scanner, the source tip is parked inside a lead cylinder when not in use. At this time, the radiation level on the surface of this cylinder is about 35 mR/h, which will drop down to 2.5mR/h at about 12cms away.

6 Survey meter

We have purchased a Pulsecho Systems made, DIGIRAD model radiation survey meter. This GM counter based meter, whose energy response is 100KeV to 1.3MeV can be used on Gamma and X-ray radiation. It is a 2-2000mR auto ranging instrument. It operates in slow(50/60 secs response time) or fast (10 secs response time, keep pressing ON button for this mode) modes. Apart from the visual display of the radiation level, audio alarms, whose number increases in higher radiation are also supported.

7 Safety issues

There are 3 basic principles of radiation protection used to maintain low levels of exposures: time, distance and shielding. Time - Reduce the amount of time spent near a source of radiation Distance - stay as far away from the source as possible while working Shielding - Place some type of shielding between you and the source.

We are maintaining one log book per source, which contains all information about its location, possible movements, purpose of the movement and people involved in the same etc. They are stored with sufficient amount of lead shielding.

The source holder for the X-Y scanner is expected to bring the radiation to below the safe levels. Further, when not in use, the holder will be parked at the home position, which will have a safe pad of lead to prevent radiation through its collimator.

We should follow the safety procedures specific to wire source as documented and/or told by Prof Virgil Barnes. One of the possible stages when a person can get exposed to maximum radiation is while loading the source wire into the driver. There after, since the source wire is garaged when not used, there is no possibility of radiation exposure. However, it is suggested that a area of about 2m all around the tray under test is cordoned off while the driver is being operated. Power to the source driver console should be switched off when the driver is not in use.

8 Acknowledgements

The author wish to thank Prof Virgil Barnes of Purdue University, USA, Dr V.G.R.Subramanian, BRIT, DAE and Mr Sunil Nair, Health Physics Division, BARC for the useful information provided by them.

9 Reference

1. Particle Physics Booklet, Particle Data Group, July 1998.