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Bulletin 272 Health & Safety

Radioactivity in schools - some misconceptions

Not everyone who uses radioactive sources in schools will have a physics background and some who do may still harbour misconceptions. Here are some that we have come across.

Misconception: If the corrected count rate measured from a source by a Geiger-Müller tube and counter is 10 counts per second, the source has an activity of 10 Bq

What would happen if you moved the source further away? The count rate would, of course decrease but the source can't be less radioactive and activity is a property of the source. Activity is measured in Becquerels (Bq) and 1 Bq means one nuclear disintegration per second. However, a Geiger-Müller tube window will only intercept some of the radiation emitted by a source. The further you are from the source, the less it will intercept. Think of it as being like looking at a light bulb. The closer to the bulb you are, the brighter the light seems, because your eyes are intercepting more light.

Some of the radiation emitted by the source, particularly for alpha radiation, may be absorbed by the air between the source and the Geiger-Müller tube or by the tube window itself and so not enter and be detected by the tube.

Additionally, some of the radiation that enters the tube will not be detected. Tubes may only be around 1% efficient for gamma radiation – most of the radiation passes through the tube without being detected. This is because detection relies on ionisation and gamma radiation is poor at causing ionisation. If you know the activity of your source, there's an interesting Advanced Higher project experiment to calculate detector efficiency. Please get in touch if you want to know more.

Therefore, the corrected count rate measured by a Geiger-Müller tube and counter is proportional to the actual activity of the source, dependent on a variety of factors. Although it does not give you the true activity of the source, as long as you vary only one of these factors at a time, for example introduce an absorber, it allows you to observe the effect of this.

Misconception: A leak test measures whether or not radiation is being emitted through a storage box

Most of the sources we use in schools are sealed. The definition of this is that radioactive material cannot get into the environment in normal use. The radioactive part of the source is usually in the form of a foil. The radioactive material is embedded in molten gold which then solidifies (think Maltesers in Malteser Rocky Road tray bakes). If the foil becomes damaged or deteriorates, radioactive material can be released. The leak test, described in Bulletin 263, involves swabbing the grill of a source, or its container, and using a detector to test for contamination. It has nothing to do with radiation being detected outwith a source's storage box. Any school following SSERC's guidance on storage of sources will be well within safety limits regarding radiation dose rates around the storage cabinet.

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Other topics

Misconception: School sources emit one kind of radiation

We tend to talk about alpha sources, beta sources and gamma sources. In reality, many radioactive materials emit more than one kind of radiation. For example, the radioactive cobalt used in school ‘gamma’ sources also emits beta radiation. The design is such that the beta radiation is absorbed by a piece of steel built into the source. Americium-241, which is the element commonly used to study alpha radiation, is also a gamma emitter. Since gamma radiation is more penetrating than alpha, it is impossible to engineer the source such that gamma radiation is absorbed but not alpha. The bulk of the detected radiation from the source is alpha, provided that the source is close to the detector. If the detector is more than a couple of centimetres from the source, the reading will still be above background but only gamma will be detected as the air will block all the alpha particles.

We heard a story about a student doing a crit lesson who was unaware of this. He set up his americium source and detector 10 cm apart and tried to show that alpha radiation was absorbed by a sheet of paper. Unfortunately, all the alpha radiation had already been absorbed by the air and the gamma radiation he was unknowingly detecting was singularly unimpressed by a paper absorber. Even more unfortunately, he remarked, in front of his tutor, that physicists had a saying, “When it doesn’t work, it’s down to friction.” He barely lived to tell the tale.

Misconception: Always use lead to shield against radiation

Lead is a good material to shield against gamma rays, though it does have to be a few centimetres thick to halve the dose you would get from a school gamma source. The trickster here is beta radiation. You can skip the next paragraph if you are not interested in the theory. Just accept that shielding beta sources with lead can result in the production of gamma rays. Perspex and aluminium are better beta shields.

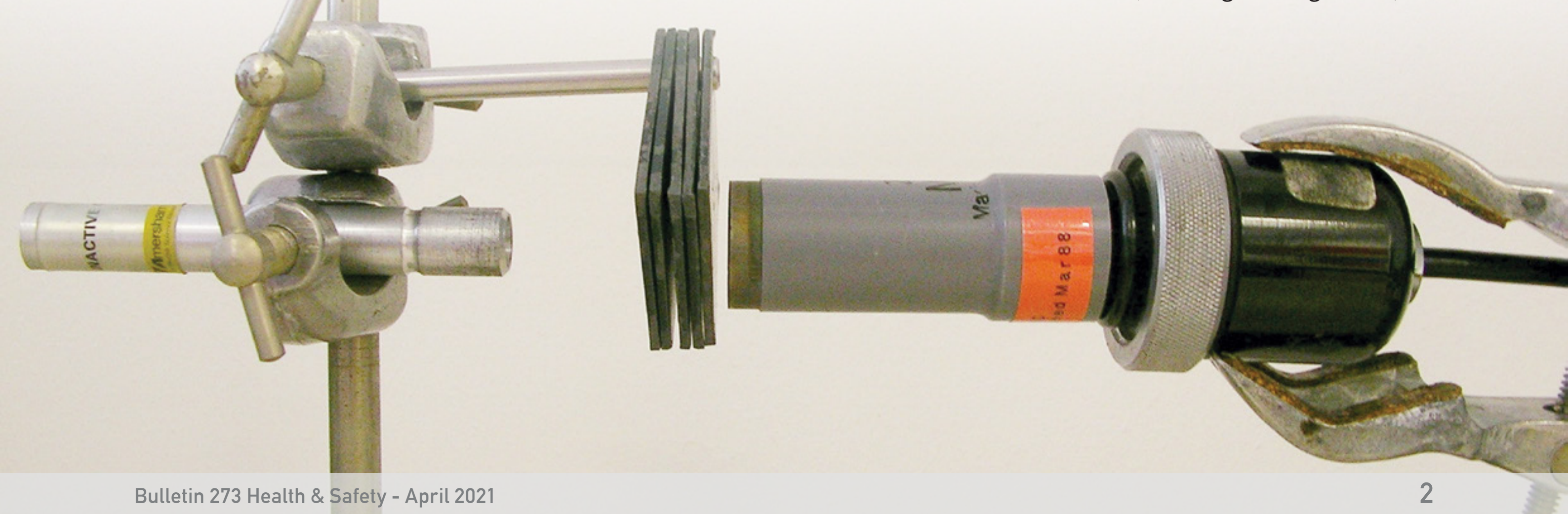
The reason is due to a phenomenon called Bremsstrahlung. This is a German word that means ‘braking radiation’. Beta radiation is made up of high speed electrons. A high speed electron approaching the large electron cloud of a lead atom will experience a repulsive force and slow down, i.e. it will lose kinetic energy. Where does its energy go? We know energy cannot be destroyed, only transformed to a different form. In this case, it is transformed to electromagnetic energy, namely gamma rays. Gamma rays are more penetrating than beta particles. Perspex is a polymer made of carbon, hydrogen and oxygen atoms. Like aluminium, these elements have low atomic numbers. This means that they have far fewer electrons orbiting their nuclei compared with lead. As a consequence, far less ‘braking’ takes place, resulting in very little gamma radiation.

Misconception: A protactinium generator is only radioactive when you shake it

As you may know, we are not great fans of protactinium generators. Whilst they are safe and effective when used according to SSERC guidelines, they have a relatively short recommended working life (RWL) and are expensive to dispose of. We also feel that it is hard for the pupils to understand what’s going on. Some teachers are not so sure either. Whilst a protactinium generator does have to be shaken before use, this is to ensure that the protactinium ends up close to the top of the container. The device is always radioactive and, being uranium-based, will not show any significant reduction in activity over its working life. The short RWL is due to the fact that aged generators can leak.

Misconception: If you put your hand in front of a radioactive source your hand will become radioactive until you clean off the radioactive particles emitted from the source

If you went to a tanning salon, the ultraviolet radiation from the tubes could give you a tan or, if you stayed under the lamp too long, could damage your skin. However, exposure to a tanning lamp would not make you personally emit ultraviolet radiation. The radiation comes from the tubes in the lamp and stops as soon as you switch the lamp off. Similarly, a radioactive source emits radiation that could also, in a large enough dose,



cause harm. The radiation comes from the radioactive material in the source and although you cannot switch off the radioactive material, once the source is shielded or removed from your location you are no longer exposed to the radiation. Just like with the tanning lamp putting your hand in front of a radioactive source does not make you emit radiation and does not contaminate you with anything that makes you do so. We would of course stress that you should never direct a radioactive source at yourself or anyone else within close range because of the unnecessary dose this would result in, however if this were to unintentionally happen you will not have contaminated yourself and SSERC can be contacted if you are concerned about the level of dose you have received.

We have already talked about sealed sources. We do very little work with unsealed sources in schools so the chances of getting material on your skin that emits radiation are very small.

We think that we know where this misconception comes from. Radiation may be emitted in the form of alpha particles or beta particles from some radioactive sources. Alpha and beta particles don't **emit** radiation, they **are** the radiation. However, news reporters often talk about a 'radioactive particle' being found on a beach and here they do mean a small piece of material that emits radiation. We wish they would just say 'a small piece of radioactive material was found on a beach' but they don't.

Whilst all of the above are unarguably misconceptions, we would like to tackle another two areas where it is our opinion, rather than scientific fact, that misconceptions exist.

Working with radioactive sources is very expensive

Individual radioactive sources are expensive. Of that there is no doubt. However, most sources will last for years. There are still sources bought in the 1970s that continue to give good service in schools. If you average the cost of a source over its lifetime, costs do not look so bad.

The paperwork etc. involved in using radioactive sources in schools is time-consuming

Once you have your radioactive sources and have adapted SSERC's generic risk assessments and contingency plans, this is what you will have to do:

- Every month (apart from the summer holidays), check stock against an inventory.
- Every time that you use a source, record this in a log book.
- Leak test each source every two years (or annually for older sources – see guidance). Record the result. A leak test takes about 15 minutes per source, most of which is spent watching a timer.

Dismissing any task as trivial in terms of the time it takes is insulting to busy school staff. We do believe that the gains from experiencing practical work with radioactive sources justify the time spent on the above tasks. For guidance on working with radioactive materials in schools, please log in to our website and visit the ionising radiation pages of our health and safety section [1]. <<

Reference

[1] https://www.sserc.org.uk/health-safety/physics-health-safety/ionising-radiation/

Home page for an art lover

There are significant hazards associated with some activities in Art and Design. SSERC welcomes health and safety enquiries from Art and Design practitioners.

Indeed much of our existing advice is appropriate to the subject. We have a number of relevant risk assessments in our Whole School and Technology sections and many of the chemicals used are in our Hazardous Chemicals pages.

What we have lacked is a web resource that makes this guidance easily accessible to teaching and support staff in Art and Design. We are delighted to report that SSERC is currently working with a representative from the National Society for Education in Art and Design to remedy this. Look out for updates in future bulletins and on our website news section. <<

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