3M Transcript for the following interview: Episode 81 – Ionising Radiation

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Welcome to the 3M Science of Safety podcast presented by 3M Australia and New Zealand Personal Safety Division. This is the podcast that is curious about the signs and systems of all things work, health and safety, that keep workers safe and protect their health. I am Mark Reggers, an occupational hygienist, who likes to ask the questions Why, How, and Please Explain. Whether you are a safety professional, occupational hygienist, or someone with any level of WHS responsibility in the workplace, maybe you are a user of safety equipment or maybe you are a bit of a safety nerd who finds this stuff really interesting, then this is the podcast for you.

(R) Today, we're talking all about ionising radiation with Robert Blackley. Welcome, Robert.

(B) Thanks for having me.

(R) Now, can you please introduce yourself? Where are you from and what do you do and why might you be the best person to talk about ionising radiation?

(B) Sure. My name's Robert Blackley. I work at ANSTO, which is the Australian Nuclear Science and Technology Organisation, and I work as a senior health physicist. So, I manage radiation protection consultancy, radiation safety training and calibrations group at ANSTO. I've been there for over 19 years now, a couple

of different roles, but still all in radiation protection. I've been pretty lucky in my job in terms of I get to travel to lots of different places, see lots of different industries and even overseas sometimes, helping all different parts of industry with a variety of their radiation protection needs. So, it just means I get to go and see some really nice places and enjoy those, but other times it means I end up literally in the middle of nowhere in a swamp somewhere or something like that or out on an oil and gas platform in the middle of the sea. So, it certainly makes day-to-day work interesting.

(R) It very much sounds like the life of an occupational hygienist. You don't know where you're going to be, but it all adds up to experience and fun. Now, we just did last week an episode about ANSTO, so for those that are interested about who ANSTO are and what they do, and there's quite a bit there, do go back and listen to the previous episode we just did with Carmen. So, yeah, make sure you don't miss that one. So, we are talking about ionising radiation, but to get back to basics, what is radiation and are there different types of radiation?

(B) Yeah, well, Australians are actually exposed to radiation from a variety of natural and also artificial sources every day of their lives. Radiation is basically energy travelling in the form of waves or particles. If the energy's high enough, then it has the capacity to ionise things, which means basically knocking electrons off an atom that it runs into, and then …

(R) And that's not a good thing, I take it.

(B) Well, it depends on what level it does that. So, it's okay in small amounts but not good in high amounts. And so, that's ionising radiation. If the energy isn't high enough, then it's what we call non-ionising radiation and what happens is it just has … it doesn't have enough energy to knock electrons off other atoms, but it does have enough energy to vibrate those particular atoms.

(R) So, ultraviolet light. That'd be a form of radiation, and that's what you mean, so that's ionising versus non-ionising?

(B) Kind of. So, ultraviolet light is actually one of those tricky ones where it actually falls a little bit into both, depending on what the energy of the ultraviolet is. But an example of non-iodising radiation would be your microwave oven. So, you put your food in there, and it actually heats it up by shaking those molecules and those atoms, because it doesn't have energy to ionise things. In terms of ionising radiation, then you'd be looking at examples like when you go to the hospital and get your arm x-rayed because you've broken your arm, those x-rays are actually ionising radiation.

(R) So, you talk about natural sources. The sun, UV. Are there other types of natural sources that you're referring to?

(B) Yeah, there is. There's lots of different types of natural sources, so they're often referred to as NORM, naturally occurring radioactive material. And so, that can be from outer space. There's lots of radiation flowing around out there. And also, the ground underneath our feet because there's a number of radioactive isotypes that exist in the ground themselves. There's stuff in the air. There's stuff in the water, so it's everywhere around us as part of our everyday lives.

(R) Because when I think about the word 'radiation', radioactive usually follows pretty close after that. So, what's the difference between something that is radiation versus something that is radioactive?

(B) So, we're going to have to jump into a little bit of science here. I hope that's okay.

(R) This is called the Science of Safety podcast, so more than okay. Please continue.

(B) All right. Well, if you remember at school, if you think about what an atom might look like, then you've got in the middle, in the nucleus, you've got your protons and your neutrons, and going around the outside you've got your electrons. Now, what you actually have, whether it's carbon or nitrogen or oxygen or gold or silver or any of those things, that's based on how many protons there are in that

nucleus of the atom. What you can do though is you can start chucking extra neutrons in or taking neutrons away from that nucleus, and what you end up with is just a slightly different version of the same thing. So, if you take gold as an example, then you can have slightly different versions of gold based on how many neutrons there are in the middle.

(R) And the properties change when you're playing around with these neutrons?

(B) Yeah, sometimes what can happen is you can chuck extra ones in or take them away and the atom goes, "Yeah, that's okay. I'm happy with how that all works. I don't mind the arrangement in the middle of myself." And so, what you have there is a stable isotope for that particular element.

(R) So, in balance would be a basic analogy? Everything's all hunky dory and we're evened out, so to speak?

(B) Yeah, that's right. It's just a slightly different version of the same thing. However, there are other times where you can start putting extra neutrons in or taking them away and the atom doesn't like that arrangement it's got in the middle because of the way the protons and the neutrons are all lined up, and so it's got too much energy in the middle of it. And so, it wants to get rid of that energy and it does that by giving off radiation. So, when that happens, you've got an unstable isotope, something that's radioactive.

(R) So, I remember hearing this analogy previously where something that is radioactive, it's like firing off bullets, sending energy out. Is that accurate?

(B) Yeah, it's like that, it's one way of thinking of it. The way that it gets rid of the extra energy is it can spit out a small bit of itself or a fairly big chunk of itself, or perhaps it can just give off energy. And so, that leads us to the different types of radiation that we've got, so things like beta radiation, alpha radiation, gamma radiation, those things. So, that's all based on how it gets rid of that energy. And what it's trying to do is make itself more stable and sometimes it'll give off that

energy and it'll be stable, and other times it might give off the radiation, and it'll be more stable but will still be a radioactive isotope, radio-nuclide.

(R) I think most people, when they hear the word 'radiation', they think of Chernobyl, maybe Fukushima, maybe Homer Simpson working at the nuclear power plant and thinking about worst case scenarios and emergencies, but radiation is used in a whole bunch of parts of our lives. So, what are some of these areas that people may not realise it's actually used to benefit society?

(B) Yeah, it's actually a funny one when you go out and people say, "What do you do?" and it's always Chernobyl or Homer Simpson or, "Do you glow in the dark?" So, it's interesting conversations when all of that happens. But you're right, radiation is used in a lot of different industries. I mean, you've got your x-rays in security as well as in medical treatments as well. They use radioisotope traces in doing a lot of environmental studies and research work. They use sealed sources in production industry and also in construction industry for quality control. They also use that in mining as well and sometimes, in some cases, that's what they're actually trying to mine, like in the case of a uranium. At ANSTO, we're actually pretty fortunate that we've got a lot of Australia's landmark infrastructure, which includes our OPAL research reactor, and that produces nuclear medicine for treating serious illnesses such as heart disease and cancer. I actually heard that one in two people in Australia benefit from nuclear medicines which is produced at ANSTO. So, lots of different things there. And as we said before, radiation is also naturally occurring in the environment around us, so in the ground underneath us and in the air, we breathe, in the water we drink and from outer space. So, the use of radioactive material is actually much more common than you think.

(R) So, we have also this electromagnetic spectrum that many of our listeners may be familiar with. Can you explain how that works with radiation and the different types of radiation?

(B) Yeah, certainly. So, on the electromagnet spectrum, you've got different frequencies. So, as you move up the frequency, you move from radio waves,

microwaves, infrared light, visible light, ultraviolet light and then all the way up into where your x-rays and your gamma rays are. So, in terms of ionising radiation, it's all the stuff at the high energy end of the spectrum.

(R) So, the shorter wave stuff? Is that another way to think about this spectrum?

(B) Yeah, so much shorter wavelength and it has that capacity to ionise things because of that higher energy levels.

(R) So, there's different types, so natural background radiation, alpha, beta, gamma. Can you explain some of the differences between some of these main types that people may have heard of, and you've already mentioned so far as well?

(B) Yeah, there's a couple of different ways of breaking it down. So, just thinking about natural background radiation and probably some of the main ones that our listeners may hear about is uranium and thorium and with those comes their decay chains. And then, there's other ones such as carbon-14 and tritium as well, which are naturally occurring. So, you might know carbon-14 from carbon dating. So, all of those things are your naturally occurring background radiation stuff. You mentioned before alpha, beta and gamma radiation, and when the isotope wants to get rid of that energy, as I said, it spits out a small bit of itself as a particle, or it can give off electromagnetic radiation. And depending on what it gives off, those different types of radiation have different properties. So, if I start thinking about radiation safety, which is the main part of my job, then it's depending on what it's giving off. You need to have different controls put in place to make sure that you're protecting yourself from those. So, some are very good at ionising whilst other ones such as gamma radiation are very good at penetrating for long distances. So, you're going to have different controls for the different types of radiation.

(R) That's where lead comes into it, like lead screening, because that's quite thick to stop the gamma. Have I got that correct there?

(B) Yeah, that's right. So, gamma radiation and x-rays, which are kinda similar, you'll often use shielding. Because they're very good at penetrating things, you'll use shielding like lead. So, that's when you go to the airport and they've got the x-ray machines. If you tried to pick up an x-ray machine and run away with it, you'd find it's very heavy because it's actually covered in lead, and that's just shielding. I did mention x-rays, and x-rays are a little bit different. So, they're again on the electromagnetic spectrum, but they're a little bit different where you don't have to have radioactive materials to produce x-rays. So, if you've got a power source, so something you plug into the wall, or a battery, then you've got a source of electrons. You accelerate them towards the target material and then when it has those interactions with the target material, it will actually produce this energy, this electromagnetic energy in the form of x-rays.

(R) And that causes those pictures that the doctors are looking at, essentially.

(B) Absolutely, yeah. So, the good thing about x-ray machines is you take away that power source, so you turn it off, and then there's no more radiation being produced. But it does need that power source to actually work. So, you don't actually have radioactive isotopes siting in there. You've just got a power source and a mechanism for making them. When we're talking about radiation safety, there's probably another key consideration that you've got to think about and that's whether it's something where you've got radioactive material that's all sealed up in something and that's what we call an external radiation hazard, where if you hang around it, in close proximity to it, then that radiation can run into your body and you'll receive a dose. I'll point out though that it doesn't actually make you radioactive or anything like that. So, for all the superhero fans out there, sorry, you don't actually turn radioactive, but it does - it can give you a dose just by ionising yourself. The other way you can be exposed is if you've actually got loose radioactive material, so contamination, similar to any other hazards that you've got out there, like chemicals or anything like that. If you've got loose material out there, then that has a chance to get inside you, and actually go through your body. So, that's what we call an internal radiation hazard.

(R) So, that's like Chernobyl. Do you use that as an example? That's all external stuff and if you breathe that in, then that will be internal, if you've got a radioactive bit of dust. Is that a way to differentiate that external-internal side of things?

(B) Yeah, so Chernobyl actually had both where the people who were close to the reactor, because it blew off all its shielding at the top. So, you saw in the mini-series, if you watched that, that people would look over the top and they'd actually get very high doses, exceptionally high doses of external radiation hazards. And then, wherever the wind blew, all the loose material went with the smoke as well and so, that's what the internal contamination hazard is, where you've got a chance of breathing that stuff in or it getting into your food, so you ingest it. So, all that stuff that ends up inside you. And the way that we protect ourselves in radiation protection for each of those is very different. So, for example, for the external radiation hazard, the three ways that we protect ourselves is we use time, and we use distance and we use shielding. So, less time, you get less dose. More distance, you get less dose. More shielding, you get less dose.

(R) It sounds very similar to a lot of I guess in occupational hygiene and safety controls and I was going to ask, it sounds very similar to the routes of entry considerations when thinking about an assessment or task or the worker interactions. It sounds very similar.

(B) Yeah, it actually is. So, a lot of people put radiation in a different field and make it special, but in terms of the controls and the way you manage those hazards, it's very similar to all those other things. So, the way that you look after internal radiation hazards, for example, so that loose contamination, that loose stuff that can get inside you, they're similar to other types of controls you'd have for other hazards, then you want to contain it if you can, or at least you want to isolate it from where people are. And worst case, if you actually have to work in those areas, then putting on things like PPE such as breathing protection to stop the stuff from actually getting inside you. So, it's still there as an internal radiation hazard, but if it's not inside you, then it's not doing the damage.

(R) So, we are a health and safety podcast. So, when should workplaces or workers be concerned that ionising radiation may be of risk to them?

(B) Well, there's lots of different guidance material out there in terms of how you need to manage these things. So, there are some fairly conservative dose limits that are in place and any industry that works with radiation has to make sure that they keep both staff below those levels and there's also lower levels for everyone else who doesn't actually work there, which we call members of the public. So, there's lower dose limits for those. So, they need to stay below those. There's also an added layer of conservatism where we're not just trying to make sure we stay below the limits but we're actually trying to optimise the process so that we minimise the dose as much as is reasonably achievable. So, lots of people think it needs to be zero, but that's actually not possible because you've got background radiation anyway. But it's all about managing that risk and minimising it where possible.

(R) Can you health monitor for radiation exposures, like you can for a lot of other contaminants and chemicals? We can see the effect on a worker's body or people. Is that similar for radiation exposures?

(B) At very high doses, you can see those effects on people. So again, going back to the Chernobyl mini-series, they portrayed that in a number of different ways. But that's at the extreme end of things and very different from anything you'd see in industry within Australia. So, the good thing I like about radiation is you can actually measure it directly, so there's lots of different instruments you can use, so stuff for airborne contamination or for the external dose rates. So, you've got instruments and you can get instantaneous readouts. So, you can get real-time readings on that stuff which I like, because it's a lot better than dealing with other things like heavy metals and all that stuff, which takes time to get those analysed.

(R) What unit of measure are you actually measuring radiation in? I'm assuming it's not milligrams per cubic metres or parts per million and parts per billion. What are you actually using, that's coming up on these direct reading instruments?

(B) So, in terms of measuring how much radiation is being given off by something, or how radioactive it is, the units we use for that are the becquerels, so that just says how radioactive it is, how many bits of radiation are being given off over a certain period of time. But in terms of the dose that's running into us, then the term we use is sievert. So, it doesn't matter how you're actually exposed, whether that's from an external radiation hazard or whether it's from breathing stuff in or ingesting it or injecting it or however it is, with the help of a bit of mathematics, then everything ends up as a dose and the units we use for that are the sieverts. So, a sievert's a big number, so we normally use a fraction of a sievert.

(R) So, you mentioned some controls before, and we talk about the hierarchy of controls quite regularly here, being a health and safety podcast, but what are some controls that ANSTO uses to protect workers, and talking from elimination down to maybe PPE scale of things?

(B) Yeah, so we do follow the hierarchy of controls very closely and it is important that we use stuff towards the top of that as opposed to the lower level stuff. And so, in the design of all of our facilities or any of the different uses we've got for radiation, or that involves radiation, then we make sure we put things in place towards the top. So, a lot of the key things, would be around engineering controls and trying to make sure we've got stuff contained or behind shielding or interlocked and all that stuff.

(R) That isolation stuff, all that important concepts, where possible.

(B) Yeah, that's right and there's obviously administrative controls such as procedures and training and things like that are key and are essential in all of that, but they're much more secondary compared to just trying to prevent people from being near the hazard in the first place.

(R) So, talking about PPE, can you get lead PPE suits? You spoke about lead being used as a shielding material. Does that work as PPE?

(B) Yes, you can actually get PPE that contains lead, so lead aprons are used a lot in the medical industry. One of the big problems with that is you can only carry so much shielding on you before you start introducing other hazards. So, it's only really effective for certain types of radiation, depending on how penetrating it is and depending how often you're getting exposed. So, often you'll see lead aprons in hospitals, things like that, for the people who are taking the x-rays of patients who have broken bones and everything, or they'll go and stand behind a wall. So, it is effective in that way but like I said, you can only have so much shielding you need to carry before you start breaking backs and things like that.

(R) And that goes down to risk assessment. It depends on the situation and what's happening there, but there are options out there if you are operating in that particular space. So, do your research and see what's going to work for you.

(B) Yeah, so what we try to do though is make sure we've actually got installed shielding and got the radiation behind it, and then people don't need to carry it around. It makes it a bit easier.

(R) And makes a whole lot of sense as well. So, we spoke with Carmen last time about ANSTO and the variety of different work that they actually do, but what does your day look like as a radiation protection officer?

(B) It's pretty varied. So, at ANSTO, our radiation protection advisors, they provide advice to the different facilities that we've got around the different sites about radiation hazards. They do calculations on potential exposures for the different tasks that people might be undertaking. They'll be talking about controls and making sure those controls are effective when they're implemented, to minimise people's exposures. They'll also go around with instruments, like you see in Hollywood, that go click-click, to actually do the compliance monitoring, and making sure that they're monitoring people's doses as well, to make sure that there well below the limits. So, my role's very similar except I do that sort of thing, but for other sites all around the country and overseas as well. So, it's good. It makes things nice and exciting, but regardless of where you do the role, it is actually one

of those jobs. If you want to work with radiation safety, then you need to have the technical skills, you need to have the technical experience. But one of the key things is actually having good communication skills and good interpersonal skills because you've got to be working with people, and to be effective you've got to make sure that you've got people on board to implement and use these things that you've got.

(R) Exactly the same in safety and health and occupational hygiene, is to be effective, you need to communicate to influence the change and inspire action, so to speak. I'd imagine in your role; you'd need a background in science and engineering maybe?

(B) Yeah, so most of the people who come through are science or engineering. In the medical sector, there is some specialised training that you need to do, so as part of the degree that you do to be a medical physicist or a radiologist or something like that; then there is specific training for that. Within Australia, radiation protection industry is not that large and so, a lot of organisations will have internal training programs. So, at ANSTO, we have an accreditation program that we have internally. We'll often also go to potentially overseas correspondence courses and things like that to upskill our people so that they're at a certain level. I will point out though that if you're going to be working with radiation, you need to have a licence, so that needs to be provided by the state or the commonwealth regulator, depending on which jurisdiction you're in. So, you can't just go and do things just for fun. You've actually got to be licensed and all of that, so they'll be checking what credentials you have in that space.

(R) Well, we've covered a lot today, but once again, we're on touching on some of the high-level concepts, and obviously, there's a lot more to do it if you do get into the depths of it. But as far as some key takeaway points that you want to leave with our listeners, what would they be?

(B) Probably the main ones would be that radiation is actually used in a very broad range of industries with lots of people receiving benefits from radiation, whether

it's due to medical treatments, efficiencies in production in different industries or having better security screening at borders and things like that. And also, that radiation hazards are similar in many ways to other types of occupational hazards around us, and so they can be safely used provided you've got the right controls in place.

(R) So, if people do want to get more information about radiation and ionising radiation and maybe get in contact with yourself at ANSTO, where would be a couple of places they could head online?

(B) Yeah, some of the best sources of information is from the national regulator, ARPANSA, ARPANSA stands for the Australian Radiation Protection and Nuclear Safety Agency. Their website, which is arpansa.gov.au, also the ANSTO website, ansto.gov.au or there are societies like the Australasian Radiation Protection Society or ARPS. So, if you just Google ARPS, they've got lots of information in there. And if you do want to get more training or anything like that, then ANSTO does provide radiation safety training, some of the best training in the country, I think.

(R) Thank you so much for coming today. I hope you've enjoyed yourself.

(B) I have. Thank you very much for having me.

(R) Well, thanks for listening everyone. You can get in contact with the show by sending an email to scienceofsafetyanz@mmm.com if you have any questions or topic suggestions or guests you think would be great to get into the studio. 3M can also help when it comes to PPE in your workplace. You can also visit our website, 3m.com.au/sospodcast for further resources on ionising radiation, as well as the transcript of the chat we've just had, as well as information on all of the other previous episodes. Be sure to subscribe, rate, review and share through Apple Podcasts, Spotify, Google Podcasts or wherever you get this podcast from. And as Harry Wong said, "It is not what is, but what is perceived that counts." Thanks for listening and have a safe day.