Radiation Basics Made Simple

Segment 3: Measuring Radiation

Now, when we work with radiation, there are different types of measurements that we can make. Let's say we have the radioactive source here. You should know that when we talk about the amount of radioactivity or levels of radiation, they don't necessarily correspond to the size, weight, or volume of the radioactive source. We could have a small amount of radioactive material that gives us a lot of radiation, or we could have a large bulk of radioactive material that gives us a little bit of radiation.

That's why it's important to make measurements, to know what we have and what we're dealing with. The three types of measurements that we can make is the amount of radioactivity, ambient radiation levels, and radiation dose. I'll tell you what that means.

Here's a jar of this – pretend this is a jar of radioactive sample. So, the first thing we want to know is, well, how much stuff is in here? How much radioactivity is in this sample? How many alpha particles, beta particles, or gamma rays are given off by this material? That's the amount of radioactivity. So that's one measurement.

Then we want to know, okay, we have this radioactivity here, radiation is coming out, what is the radiation levels here. That's the second type of measurement. Radiation levels, ambient radiation levels as a result of having an environment that has radioactive materials in it.

The third and last type of measurement is that, okay, what if I was standing here, how much of that radiation would be absorbed by my body? So, in other words, what would be the dose to my body and to me? That's the radiation dose. That's the third type of measurements that we can make.

So, we have this jar of radioactive material, and let's pretend its material that emits alpha particles only. As a review from a previous segment, if this jar contained radioactive material that only emitted alpha particles, what could we measure with the detector outside the glass? None. That's right because it would not penetrate the glass. If this was gamma-emitting we could, right? If it was gamma-emitting, we could have a detector here and we could measure it. But if it's alpha, then we're going to have to open the jar here and – of course if it was a bigger thing, we would have a probe, we could put it in close contact with it and measure the alpha particles.

But in terms of measuring the amount of radioactivity it's always best to collect a sample; that's the best way to analyze it. But even with portable instruments we could make an estimate of the amount of radioactivity.

To report the amount of radioactivity, the unit we use is Becquerel. Becquerel is the international unit of radioactivity, and it represents one radioactive decay per second; that's how it's based. We have an older unit of Curie, that many people in the United States still use, and the unit of Curie is based on the activity in one gram of radium. So, we relate radioactivity in any sample back to whatever the activity is in one gram of radium. They both measure the same thing, they're just on a different scale.

Becquerel, one disintegration per second is a very small unit, but a Curie is a larger unit. So, because it's so large, it's common to see not Curie but millicurie or microcurie or nanocurie. And Becquerel, because it's such a small unit, just one radioactivity per second, it's more common to see kilobecquerel and megabecquerel and gigabecquerel.

Now, to give you just a perspective of what these numbers could mean, what if I were to offer you something to eat, a snack. And I told you that this snack had 12 Becquerels of radioactivity in it. And what that means is that this particular snack emits 12 radiation particles – I'll be more specific, 11 beta particles and 1 gamma ray every second. So, you hold the snack, 11 beta particles and 1 gamma ray every second. Would you eat that? I bet you would. What I'm talking about is a banana. Remember we talked about Potassium 40 in banana? That's what it amounts to. An average sized banana would have 12 Becquerel of activity, more or less - some bananas are bigger than others. But that's 12 Becquerel of activity. And so, if you ingest that, it will continue to decay or go through the natural radioactive decay inside your body.

But you wouldn't worry about that. We eat this every day, some of us eat this every day. And if you had two bananas or three bananas and so forth, you don't worry about the amount of radioactivity in it. You worry about other things if you had so many bananas in one sitting. But you wouldn't worry about your radioactivity, because it's such a small amount for each of these 12 Becquerel.

So, another way to gauge the unit of Becquerel, remember we mentioned we have Potassium 40 in our bodies? Well, our bodies are different, you know. They come in different sizes; but take the average sized person. We measure the amount of Potassium 40 in thousands of Becquerel; thousands of radioactive decay per second inside our bodies, and that's every second that we live. And that's only from Potassium 40, we have carbon, too, remember, in our bodies.

So, we measure natural radioactivity in our bodies in units of thousands of Becquerel, because if you just – remember before, I showed you the banana you were hesitant about the banana, and that was only 12. So, one reason I presented you this example is that you're not going to remember Becquerel or Curie, and you're not supposed to, because it's not your job. So, if you ever encounter some measurement of radioactivity, some units, ask someone, because you're not required to know. Ask a radiation safety professional to explain that number to you and put it in perspective, because then you can gauge, and you can put it in perspective. Oh, okay, that's how much that is compared to something that's more familiar to you. So now this is one type of measurement.

Now we want to see if we have this radioactivity here, what would be the radiation levels over here? And again, any time we want to do that, we have to know what's the natural radiation levels in the environment, plus whatever is coming from that source. So that would be the ambient radiation levels.

The units we use to express that are gray per hour or Sieverts per hour, international units. And those are huge numbers, so again, it's more common to see nanogray per hour or microsieverts per hour. In the U.S., we use the units of Roentgen or rem per hour. And again, those are big numbers, so we use millirem per hour, or microroentgen per hour. Those are more common units.

And you notice we express them in terms of hour, so this would be, like, millisieverts per hour. And the way we use that information is that, okay, so radiation levels here, let's say would be 1 millisievert per hour. So, if I were to stand here for two hours, 2 times 1, I would get approximately 2 millisieverts of dose. So that would be the dose that I would get.

So, a common unit of radiation dose would be the dose that we would get – remember from our previous segment we were talking about millisieverts, getting 3 millisieverts from natural background radiation on average? So millisieverts is a common radiation unit we would see. Sieverts or millisieverts. And in the United States we use rem and millirem as a unit of dose. And the conversion is fairly simple, one Sievert equals 100 rem and 1 rem equals 10 millisieverts.

So, I said there are different types of measurements we can make. There are also different types of instruments we could use. So let me show you some of these instruments. This is the instrument – this is the pancake probe, portable instrument, and it is ideal for measuring or screening for contamination on surfaces, either on a person or an object. This is ideal for that purpose, and it's a very common instrument.

There's another instrument, portal monitor. They look like the metal detectors at the airport. You walk through them, and they're designed for screening large numbers of people for external contamination. They can walk through the portal monitor, and if they have any contamination on the outside of their bodies the alarm would go off. They're very sensitive and can detect gamma rays and also some forms of beta particles.

Another instrument is ionization chamber, and there are different models of this. The ones I have here are just the one particular model, but there are different brands and models of all of these instrumentation. Ionization chamber is a very good instrument to measure ambient radiation levels.

Geiger counters will give us an idea about whether the ambient radiation levels are high, low, and give us some measure. But to make a more accurate measurement, we would need to use an ionization chamber. And this instrument is particularly useful for first responders, it's an alarming dosimeter. These alarming dosimeters report radiation dose in real time.

So, it would allow the first responders to identify the way that they approach an unsafe area where the radiation levels may be high, or if they reach a pre-selected dose level So, they won't exceed their allowed dose. It's a very useful instrument. And radiation safety officers may use these to monitor a worker's dose. It's very useful for first responders.

Another instrument that's very useful for first responders is this one. This is called an isotope identifier. And again, there are different brands and models of these types of instruments. Remember, for these we can tell if it's alpha or beta, but we don't know what radionuclide.

If you have a gamma-emitting radionuclide in the environment at some kind of an incident, this instrument would allow identification of those radionuclides so we can tell it's cesium, or we can tell what type of radionuclide it is with this instrument. Again, that's valuable information to get in the field for responders.

There is also a specialized instrument to measure the amount of activity inside a person. So, when a person has been contaminated and has got internal contamination, and these specialized instruments are called whole body counters, and they measure the activity inside a person. Hospitals also have instrumentation that they routinely use to monitor the amount of radioactive materials that are given to the patients.

Of course we have laboratory equipment. These are very sensitive equipment, and we can measure the amount of radioactivity in the environmental samples, like in soil, water, or air samples. And we also use them to measure the amount of radioactivity in clinical samples. Urine, for example, that we collect from people. If someone is suspected of having some internal contamination, we can collect a urine sample and analyze it in a laboratory. These are very sensitive instruments and can measure very small amounts of radioactivity.

The last thing I want to leave you in this segment is that to get reliable and accurate measurements, we need to have both the right instrument and the right operator. The instrument is only as good as the person using it. So, it's important to provide hands-on training to anyone who's expected to use radiation detection equipment on the job or in response to an emergency.

And lastly, it's important to maintain radiation detection equipment to ensure that they're working properly.