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Detection Instrument Types and Selection Webinar Q&A

These are questions we did not get the opportunity to answer during the webinar. Please note, the answers below are based on our readings and experience and are not legal or medical advice. Where similar questions have come in, they have been grouped together.

Q: Can you please be sure to clarify the basics - when to use the pancake detector vs. scintillation detector, and Canadian Federal legislation.

A: The primary consideration is the type and energy range of radiation to be measured and what readings you need it to make, e.g. count rate, dose rate, or exposure. In addition, you need to determine whether it needs to be portable and if it needs to be mechanically rugged. Another consideration when choosing your instruments are the ease of use and servicing. Also, you need to think about whether there a risk it will be contaminated and if so, how easy is it to clean the instrument you are considering. Do not consider purchasing any instrument that cannot be calibrated, and research how reliable your instrument is known to be. As pointed out by Franz and Ian during the webinar, there are sometimes newer technologies out there which may be better suited to your needs than what has been around for a long time.

The CSNC's Radionuclide Information Booklet https://publications.gc.ca/collections/collection_2016/ccsn-cnsc/CC172-162-2016-eng.pdf has methods of detection for both dose rate and contamination for a number of commonly-used radioisotopes.

There is no regulation that speaks to exactly what instrument you need to purchase for which application. The Canadian Nuclear Safety Commission has the following resources on the broad topic of radiation detection:

- https://www.cnsc-ccsn.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc2-7-1/
- https://www.cnsc-ccsn.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc2-9-1-vol1-2/
- Section 2.10 of https://www.cnsc-ccsn.gc.ca/eng/nuclear-substances/licensing-class-ii-nuclear-facilities-and-prescribed-equipment/information-class-ii-licensed-facilities/radioisotope-safety-monitoring-contamination/
- https://www.cnsc-ccsn.gc.ca/eng/nuclear-substances/licensing-class-ii-nuclear-facilities-and-prescribed-equipment/information-class-ii-licensed-facilities/regulatory-expectations-calibration-survey-meters/
- https://www.cnsc-ccsn.gc.ca/eng/acts-and-regulations/consultation/comment/regdoc2-7-2-vol-i/
- Questions 12, 13 of https://www.cnsc-ccsn.gc.ca/eng/nuclear-substances/licensing-nuclear-substances-and-radiation-devices/faqs/

- Section 5 of https://www.cnsc-ccsn.gc.ca/eng/nuclear-substances/licensing-class-ii-nuclear-facilities-and-prescribed-equipment/information-class-ii-licensed-facilities/regulatory-expectations-calibration-survey-meters/

Some reference materials which may be helpful include:

- https://ncrponline.org/shop/reports/report-no-057-instrumentation-and-monitoring-methods-for-radiation-protection-1978/
- https://hps.org/ate_faq/devices/
- https://hps.org/ate_faq/radiationdetection/
- https://radiationsafety.ca/the-importance-of-calibrating-radiation-measurement-instruments/

Q: Is this technology just for detecting penetrating ionizing radiation? What are the sensitivity levels?

A: No. There are detection instruments designed to detect most charged particles as well. But the detectors must have a thin window to allow the particles to enter the detector. Some very low energy particles cannot be detected by survey meters and require other analysis like liquid scintillation counting. Sensitivity levels vary based on so many things (detector type, configuration and material type, the detector geometry compared to the source, the energy and type of the radiation being detected, etc.), that we really cannot discuss sensitivity.

Q: Which detection instruments would you say are best for outreach, for example when you've got some items like a banana or smoke detector, uranium glass, radium dial, etc., and would like to demonstrate the ability to quantify emissions in an engaging way?

A: An engaging way of visualizing radiation is to use a cloud chamber, but it only works if you can get the radiation into the chamber. If you search online, you can see examples.

In terms of selecting an instrument, please refer to the first answer in the Q&A document. For outreach, we suggest that you consider something that is easy to use and hard to break.

Q: What is the best way to sure the reliability of detectors offered by companies?

A: Ensuring can be calibrated and ensuring they are calibrated every 12 months will help give assurance that the readings are a reasonable reflection of what is being measured. Speaking with others in your industry is one way to see how they hold up in time.

Q: Is there any difference between parallel plate and plane parallel chamber?

A: Different manufacturers may have some differences, but they appear to be the same theory.

Q: At what time interval should radiation detection equipment be replaced?

A: There is no specific timeline. Regular calibration and/or source checking will allow evaluation of the detection equipment's function. When it stops functioning properly or cannot maintain consistent readings, then it should be replaced.

Q:

- During our inspection in 2023, we were cited for using a survey meter to look for contamination. They said that it couldn't be used instead of swipes because you need one with a certified minimal detectable activity. Could you give more information on this?

- I am always interested in any information you have regarding MDA, efficiency and any devices that are best suited for the shortest amount of counting time for surveys.
- What is the best method (set-up and source used) to evaluate the detector efficiency in nuclear medicine?

A: A contamination survey meter can give you information n bout the total activity that is present on a surface (assuming the survey meter can actually detect the radiation(s) emitted), but it gives no information about how mobile the contamination is (i.e., is it fixed contamination that is stuck to the surface or is it removable contamination that can get on hands and move around). Swipes are used to determine the mobile component of the surface contamination. Often licences will have allowable limits on both types of surface contamination or on removable and total contamination.

The type of surveys required would be part of your licence conditions around contamination levels. Please see Section 2.9 of https://www.cnsc-ccsn.gc.ca/eng/nuclear-substances/licensing-class-ii-nuclear-facilities-and-prescribed-equipment/information-class-ii-licensed-facilities/radioisotope-safety-monitoring-contamination/ on contamination monitoring programs and Section C.10 of https://www.cnsc-ccsn.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc2-7-1/#secC-10 for information about minimum detectable activity.

The CNSC had a webinar presentation on this topic; see the video link on this page, along with what appears to be answers to questions arising: https://www.cnsc.gc.ca/eng/resources/frequently-asked-questions/faq-contamination-monitoring/. A copy of the deck is found here: https://crpa-acrp.ca/wp-content/uploads/2024/05/Presentation-DNSR-Contamination-Monitoring-Licensee-Webinar-12-July-2023.pdf.

The CRPA has this as part of an on-demand PD session entitled *Radiation Detection Efficiency*. Please see partway down the page https://crpa-acrp.ca/resources/professional-development-sessions/ for price and a course outline. We have not attended the session, so cannot comment on the level of the material or quality of the presentation.

Here are a couple of articles available on the topic from the Health Physics Society; they are rather technical:
https://hps.org/publicinformation/ate/q10989/
https://hps.org/publicinformation/ate/q10110/

Q: In nuclear medicine, I am forever trying to decide which meter is better for detecting contamination...a GM counter or a Berthold.

A: Berthold is a manufacturer. They can make GM detectors and have other types of detectors as well. The type of instrument to use will depend on what you need to detect. It is entirely possible that you will need more than one type of instrument to detect contamination in your facility, as the types of radioisotopes used in your nuclear medicine procedures continue to expand. Please see the first Q&A on instrument selection as well as the next Q&A for more details on instrumentation in this type of facility.

Q:
- What instruments are recommended for nuclear medicine?
- In nuclear medicine, what criteria (and threshold) should you look for in a detector use for A) detect contamination B) quantify contamination?

- Which to use in medical setting such as isotopes in nuclear medicine (Lu-177, Radon, Iodine, Cs137, etc), versus nuclear plant.

A: Please refer to the first answer of the Q&A. Nuclear medicine is a broad field, so it is a process of determining needs and then finding a supplier that can provide an instrument that can meet those needs.

The CAMRT has a webinar available in conjunction with the CNSC which appears to address this question: https://camrt.my.site.com/CPBase__item?id=a10OK00000AZXOMYA5. We have not viewed the webinar, so cannot comment on the level of the material or quality of the presentation.

Q: Should we measure secondary radiation in fluoroscopy or conventional radiology in dose rate or accumulated dose? Which is the best method for surveys?

A: This depends on the purpose of taking the measurement. A dose rate will tell you what is happening in the moment, so that immediate action such as applying the radiation protection principles of time, distance, shielding can be taken to reduce dose should the rate be above a certain level. If dose rates are very low, getting an accurate measurement can be done by determining total dose over a longer period of time than a typical survey meter could manage. The best way to do the measurements is very dependent upon the situation.

Accumulated dose needs to be measured or estimated to compare worker dose to limits set according to an organizations ALARA policies and regulatory limits.

In terms of surveys, the requirements for survey vary by application. We had a webinar with Franz on February 17, 2023 on radiation surveys that may be of interest: https://radiationsafety.ca/services/webinars/#RSW11 or for certificate: https://onlinelearning.radiationsafety.ca/course/view.php?id=207.

Q: A radiation therapy department technologist is wearing a personal radiation dosimeter. It is located on one side of the body. What if radiation waves come from the other side and interact with the worker's body repeatedly. Will the

A: Unfortunately, the full question was cut off. Assuming it was related to a concern about the location of the dosimeter relative to the location of the radiation source, please note that dosimeters should be worn facing the source, as the body will act as shielding. While the CNSC does not regulate x-rays under 1 MeV, its REGDOC-2.7.2, Dosimetry, Volume 1: Ascertaining Occupational Dose may be of interest as a guideline to best practice. https://www.cnsc-ccsn.gc.ca/eng/acts-and-regulations/consultation/comment/regdoc2-7-2-vol-i/. It states, “Dosimeters should be secured to the body to prevent them from falling off during work activities, and should be facing outward, and not covered by other items or devices. They should be worn on the trunk of the body between the waist and shoulders at the location of the highest expected exposure (or placed as per the manufacturer’s specifications).”

Q: I have a question about filter using in some detecting instruments like RadEye B20/B20-ER in medical X-ray image. I would like to have more information on why without filter the RadEye B20/B20-ER models can not also be used for accurate dose rate surveys if used with correct energy compensated dose rate filter (17 keV– 3 MeV).

A: The question is unclear as it asks about not having the filter but then having the filter. We recommend speaking with the device manufacturer for the appropriate use of the equipment for specific applications.

Q: Are there any whole body monitors that can detect I-125?
A: I-125 decays with a very low emission rate of very low energy of gamma and x-ray photons (≤ 35 keV) in addition to electrons. The electrons will not leave the body to be detected. Most of the photon emissions from I-125 are not likely to leave deeper parts of the body and make it to a detector. It can be used for thyroid imaging as the thyroid is close to the body surface. So such a whole body monitor is not likely to be commercially viable.

Q:
- Which is the best type of instrument to measure pulsed radiation (from LINAC)?
- It would be good to explain why ionization chamber meters are most appropriate for very short (microsecond) pulsed radiation found around medical linear accelerators.
  Also, how could such pulsed high energy photon radiation result in false readings on a neutron scintillation detector?

A: We recommend speaking to several device manufacturers about the devices they have for various functions, as specific recommendations are beyond the scope of the general-purpose webinar.

Q:
- I would like to find out more about neutron detection within radiotherapy bunker mazes, and the challenges of measuring when you don't fully know the neutron spectrum.
- What are criteria for selecting instrument use for measuring scattered radiation in radiotherapy?

A: This is quite a technical topic. Please see the American Association of Physicists in Medicine Report 019: Neutron Measurements Around High-Energy X-Ray Radiotherapy Machines https://www.aapm.org/pubs/reports/detail.asp?docid=18. On the broader topic of neutrons in radiotheraphy, the following resources may be of interest:
- IAEA Safety Report Series 47 https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1223_web.pdf
- Neutron contamination in radiotherapy processes: a review study https://academic.oup.com/jrr/article/62/6/947/6359246

Q: I am working on dosimetry of cobalt 60 and Linac TrueBeam. Is this webinar a best option of getting details regarding radiation working areas.
A: Our webinars give general overviews of topics and refer out to references from reputable sources. Please see https://radiationsafety.ca/personnel-dosimetry-strategies-for-a-high-performing-radiation-protection-program/ and the reference section of https://radiationsafety.ca/wp-content/uploads/2021/03/PPE-and-Dosimetry.pdf for reference materials related to dosimetry.

Q: What is the expected response of a pressurized ion chamber to AmBe? I am referring to the gamma energy of 4.4MeV.
A: This would be dependent on too many factors to give a specific response. Such equipment should be able to detect this emission, but the efficiency will depend on many factors such as gas type, pressure, housing material, geometry, etc.

Q: What is the best detection instrument for leakages test and exposure dose rate to be used in rooms equipped with Chrysos Photon Assay unit?

A: Using https://www.researchgate.net/publication/335881236_PhotonAssay_-Efficient_Bulk_Gold_Analysis_in_the_Modern_World_Paper_II as a reference, the energy level of the x-rays being produced by this linear accelerator are 8.5 MeV. At these energies, not only do you need to be concerned for leakage x-ray radiation, but also from nuclear processes including pair production and photoneutron activation. In Canada, this application requires a Class II licence from the Canadian Nuclear Safety Commission. Please see the CNSC materials for Class II nuclear facilities: https://www.cnsc-ccsn.gc.ca/eng/nuclear-substances/licensing-class-ii-nuclear-facilities-and-prescribed-equipment/information-class-ii-licensed-facilities/.

Please refer to the answer to the first question in this document. In terms of this assay unit, remember that the denser the detection material, the better it will be for detecting x-rays. Neutron detection required a completely different detection mechanism. You may be able to get an instrument with different probes that will be able to measure everything required, or you may need to purchase separate instruments.

Q:
- Looking for recommendations for NORM monitoring (Pb210), radon gas for gas workers for both occupational exposure and environmental assessment.
- Want to know what sort of monitoring is required by law and what equipment is required for handling NORM (i.e. natural uranium) in mineral exploration if possible.

A: Resources on this topic include
- The Canadian Guidelines for the Management of NORM Volumes I & III
  https://publications.gc.ca/site/eng/9.698696/publication.html
  https://publications.gc.ca/site/eng/9.893894/publication.html
- https://www.iaea.org/publications/15085/management-of-naturally-occurring-radioactive-material-norm-in-industry
- Our NORM awareness webinar from May 27, 2021
  https://radiationsafety.ca/services/webinars/#Web14
- Our jurisdictional webinar from June 27, 2024:
  https://radiationsafety.ca/services/webinars/#RSW22

Q I also want to know where to refer the absolute abundance of 238U, 232Th and 40K.
A The details of naturally occurring radioactive material are beyond the scope of this webinar.

Q: I would like to run a survey on the residual radioactive materials in the crude oil. Would you mind to suggest which suitable & affordable detectors to archive creditable reading, and what you advise on using Radiacode 102 or 103 for this purpose.
A: The IOGP has recommendations for detection for the oil and gas industry in https://www.iogp.org/bookstore/product/412/, available free for download.

Q: I would also like you to talk about radon detectors after there is little information about radon detention in homes and in uranium and coal mines.
A: Please refer to https://carst.ca/, https://c-nrpp.ca/, and https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/radon/resources.html.

Q: I am a research scholar working on radioactivity analysis in water samples. I want to know if I can use NaI(Tl) scintillation detector for analysis after evaporating water and keep that container in detector?
A: This will depend on a lot of factors including the type of radioactive emissions from the materials that are being analyzed (e.g., alpha emitters, beta-emitters, gamma-emitters, etc.). For example, if the materials only emit alphas or betas, it is unlikely they will get through the metal casing around a sodium-iodide detector, to be able to be detected. It also depends on the concentration of the water and how much radioactivity ends up being deposited after evaporation. Please refer to the above questions on instrument selection and Minimum Detectable Activity.

Q: What is the appropriate type for measuring background radiation in the environment?
A: This depends on what you are trying to measure (for example, measuring background dose rates or measuring the concentration of radioactive material in a soil sample). There are so many variations of things to be measured in the environment. Please refer to the first question on instrument selection.

Q: I wonder if all diamonds detectors don't need bias?
A: If you are referring to x-ray scanners used to detect ingested diamonds, that would be x-ray generating equipment rather than the equipment being discussed, which is for detecting radiation. X-ray generating equipment does require bias/voltage to accelerate the electrons in order to generate x-ray photons.

Q: What is the best tool to use for detecting cosmic radiation? Especially when it comes to providing solutions for satellite shielding.
A: Please refer to the first question on instrument selection.

Q Can you provide a rough idea of what a basic GM costs (Canada)?
A Instrument pricing is going to depend on the type of detector you need as GM detectors come in a variety of formats. Also, with the changes in Canadian currency vs other currencies, pricing is not static. We recommend that you contact a supplier to get a current pricing on the detector type you are interested in.

Q Is possible to measure bq/cm^2 with pipe detector.
A Theoretically, it is possible to calibrate a detector to measure surface contamination on the interior of a pipe and determine the efficiency. With that efficiency one could program an instrument to provide a reading in Bq/cm^2. However, it is technically challenging – please see the next answer about calibration of a pipe detector.

Q How we do calibration for surface contamination typically example of pipes
A Calibration should be done in the same geometry that an instrument is to be used. For example, to calibrate a contamination meter that is used for detecting contamination on a flat surface, a source that is in a planar geometry of the size of the detector would be suitable. Calibration for a probe to be inserted in a pipe is much more complex, and beyond the general information that can be provided in a webinar such as this.

Q Can I use NaI (Tl) detector for analysis of radioactivity in water?
A Scintillation detectors are very versatile. You would need to find a manufacturer who has one available for this purpose and have it calibrated correctly, depending on the type of radiation you expect to find, as water will shield all or a portion of the radiation.

Q Could you kindly elaborate on how the calibration of the CZT detector is performed?
A This is a very specific and detailed question. Our webinars give general overviews of topics, and this question is beyond the general answers that we can provide for the webinar. The Canadian Nuclear Safety Commission's Regulatory Expectations for Calibration of Survey Meters can be found here: https://www.cnsc-ccsn.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-6-1-v2/#app-z.

Q Is lead shielding necessary for CZT based gamma spectroscopy measurements?
A This depends on your process and what level of radioactivity you need to detect. If you are trying to detect very low levels of radiation, then background radiation may interfere and shielding may be required. If you are analyzing high activity samples, shielding out background radiation may not be required.

Q Kindly share on institutions that offer masters and Phd programs in this field of detection and instrumentation.

A The Canadian Radiation Protection Association (CRPA) maintains a list of radiation protection programs and courses in Canada: https://crpa-acrp.ca/resources/radiation-protection-programs-in-canada/. It is not specific to detection and instrumentation, but it is a starting point to find an appropriate program.

Q Could you please elaborate how to find out operating voltage, window level setting, and baseline setting for the single channel analyzer?
Also, kindly provide the calibration procedures that should be followed for the same.
A This is a very specific and detailed question. Our webinars give general overviews of topics, and this question is beyond the general answers that we can provide for the webinar. The Canadian Nuclear Safety Commission's Regulatory Expectations for Calibration of Survey Meters can be found here: https://www.cnsc-ccsn.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-6-1-v2/#app-z.