Radiation Safety Institute of Canada
Institut de radioprotection du Canada

Lunch, Learn, & Dance
Wellness Webinars

March 11, 2021

# PPE and Dosimetry

Followed by Araguacu Latin Dance Co.

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# Webinar Functionality

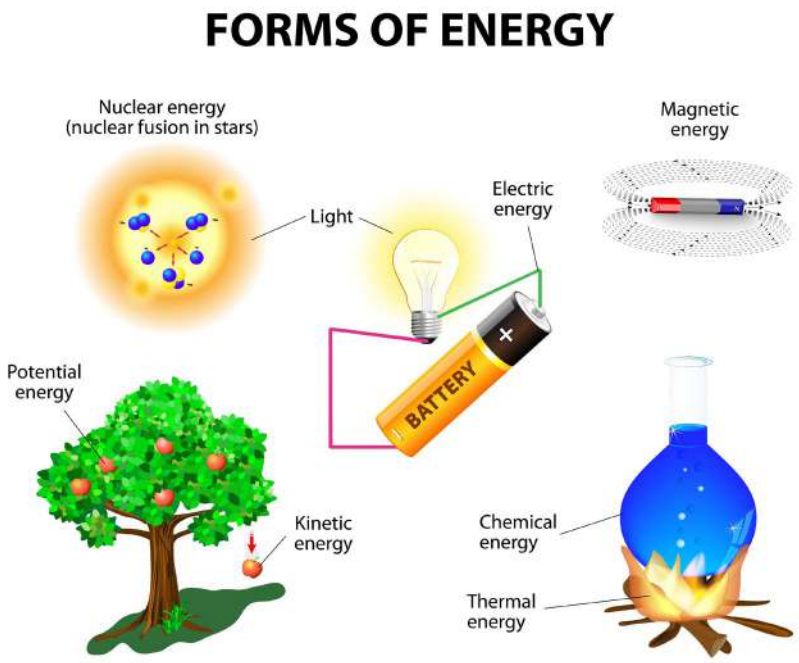
- Audio and video
  - Will be from the presenters only
  - Use computer or telephone (call in)
  - Computer seems to give the best sound quality
- Use the “Chat” feature to enter comments
- Use the “Questions” feature to ask questions
- Posted on webinar page
  - Video, Q&A answers, copy of the slides
- Follow up email will be sent
  - Topics covered, time of attendance
- It may be possible to change your Zoom view if the controls are hiding the closed captioning.

# Outline

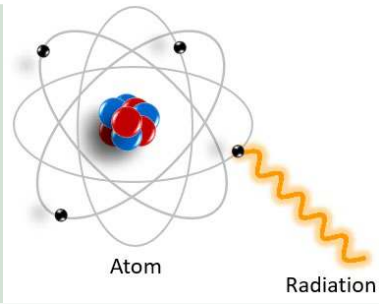
- What is Radiation?
- Ionizing vs. Non-ionizing
- Particle vs. Electromagnetic
- Aspects of a Radiation Protection Program
- Regulation
- Internal vs. External Exposures
- PPE Types
- Dosimeters
- PPE and Dosimetry by Radiation Type
- How to find out more

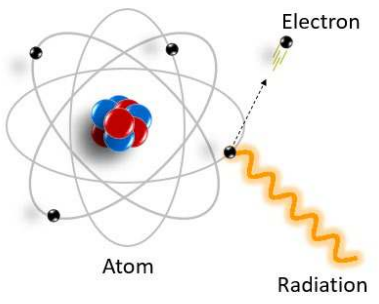
# What is Radiation?

- Matter
  - Mass
  - Volume
- Energy
  - Ability to make changes in matter
- Radiation
  - Energy moving out from a source
  - Material particles
  - Electromagnetic
    - Electromagnetic waves
    - photos



# Ionizing vs. Non-Ionizing




## Non-Ionizing

- Will not remove electrons from orbit
- Heating
- Photochemical effects
- Electromagnetic radiation
  - Radio – mid UV

## Ionizing

- Electrons can be removed from orbit
- Stochastic
- Deterministic/tissue
- Electromagnetic radiation
  - Mid UV – ɣ/x-ray
- Particles (α, β, neutron)

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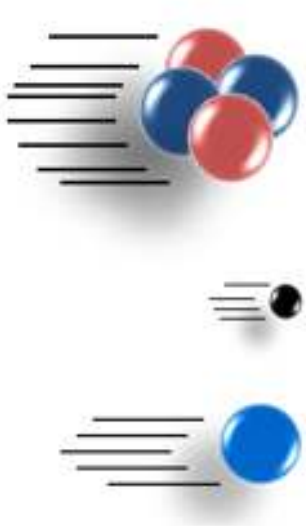
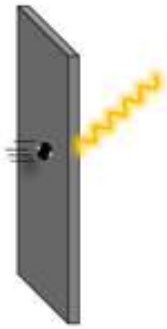
# Particle vs. Electromagnetic

## Particles




- Ejected by radioisotopes
- α, β charged
- Neutron neutral
- All ionizing

## Electromagnetic


- Electromagnetic waves/photons
- Photon energy related to wavelength
- UVB and above ionizing
- X-ray produced by machines, in gamma range

# Regulation


## CNSC Mandate

| Regulate use of | To Protect | To Implement | To Disseminate |
|---|---|---|---|
| • Nuclear energy<br>• Nuclear materials<br>• Prescribed equipment<br>• Prescribed information | • Health<br>• Safety<br>• Security<br>• Environment | • International commitments<br>• Peaceful use<br>• Nuclear energy | • Scientific, technical, and regulatory information<br>• To public |

# Regulation

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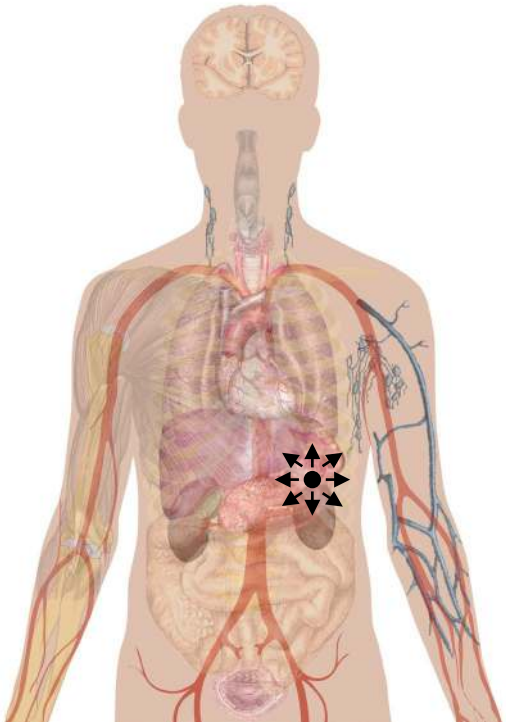
| Province or Territory | Acts and Regulations Addressing Radiation Safety |
|---|---|
| Alberta | Radiation Protection Act , Radiation Protection Regulations |
| British Columbia | Workers Compensation Act, Occupational Health and Safety Regulation |
| Manitoba | The Radiation Protection Act and Regulations |
| New Brunswick | Radiation listed as a health hazard in general terms in Public Health Act. No specific act or regulations. |
| Newfoundland and Labrador | Radiation Health and Safety Act and Regulations |
| Northwest Territories | Safety Act, Occupational Health & Safety regulations, Part 23 |
| Nova Scotia | Medical Imaging and Radiation Therapy Professionals Act mentions radiation safety, but no regulations regarding specifics to date |
| Nunavut | Safety Act, Occupational Health & Safety regulations, Part 23 |
| Ontario | Occupation Health and Safety Act, Regulation 861 and the Healing Arts Radiation Protection Act, Regulation 543 |
| Prince Edward Island | Occupational Health and Safety Act General Regulations for non-ionizing radiation; otherwise, no regulations |
| Quebec | Occupational Health and Safety Act and Regulations has basic expectations for dosimetry and protection as a contaminant |
| Saskatchewan | The Saskatchewan Employment Act Part V, The Radiation Health and Safety Regulations, Occupational Health and Safety Regulations, Health Hazard Regulations |
| Yukon | Yukon Occupational Health and Safety Act, Radiation Protection Regulations |

# Aspects of a Radiation Protection Program

- Doses ALARA
- Management control
- Personnel qualification and training
- Control of occupational and public exposure
- Planning for unusual situations

# Internal vs. External Exposure

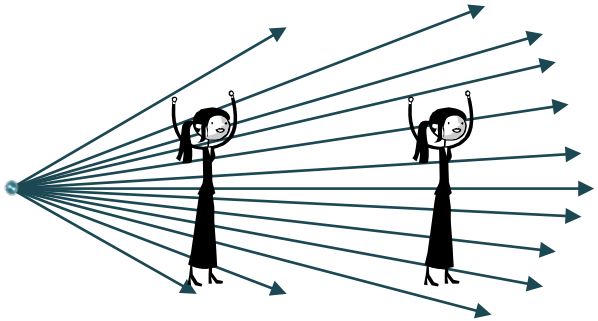


Mikael Häggström, Public domain, via Wikimedia Commons

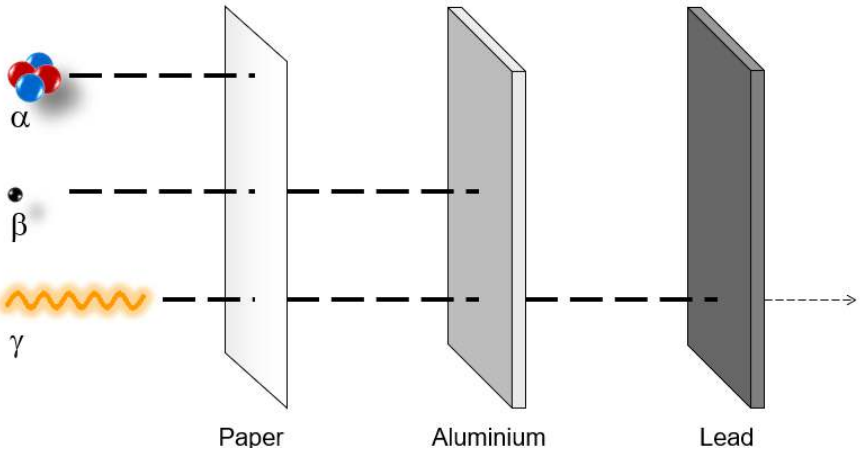
# Radiation Protection Principles

External radiation exposure can be decreased by:

- Time
- Distance
- Shielding

# Shielding




# Personal Protective Equipment

A –thyroid protection collar;

B – outside personal dosimeter (in the pocket);

C – protective eyeglasses;

D – radiation panoramic full-face mask for face shielding (preferred to eyeglasses);

E – protective one-piece apron;

F – additional protection for the gonads.

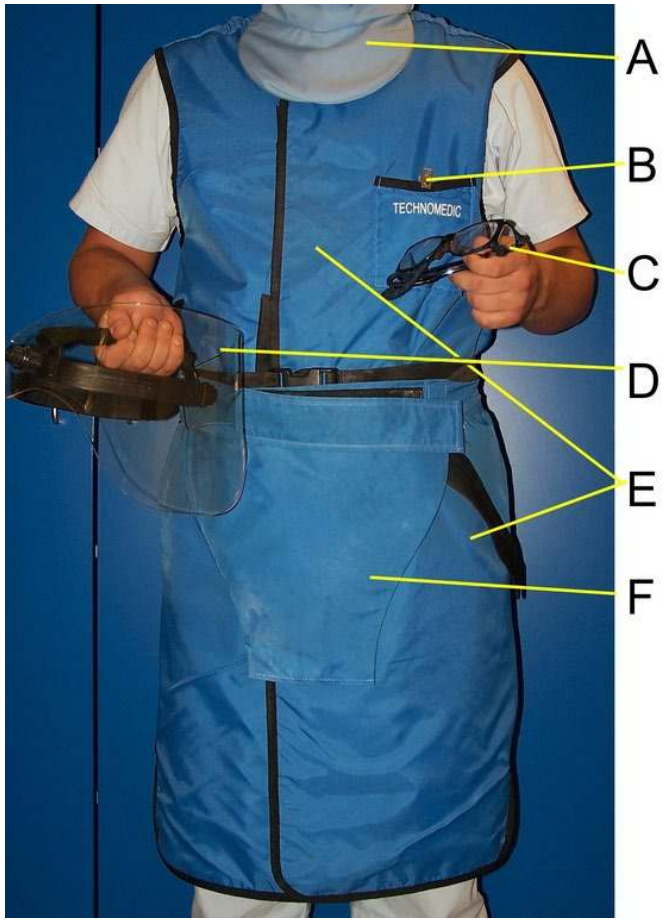



Image from Caluk, J. (2013) doi:10.5772/54033

# Personal Protective Equipment

# Care and Use of PPE

- Check for damage
  - Record/report
- Annual screening of lead PPE
- Proper fit
- Storage
  - Hung properly
  - Cool, dry
  - Eye shields in cases
- Clean as directed
- Follow disposal guidelines
- Check service life

# Radiation Dose

- Energy given to the body by radiation per unit mass
- Measure in Gray (Gy)

**Absorbed Dose**

**Equivalent Dose**

- Absorbed dose that also takes the type of radiation into account.
- Measure in Sieverts (Sv)

- Equivalent dose that also looks at the sensitivity of specific tissues to radiation.
- Measure in Sieverts (Sv)

**Effective Dose**

# Dosimetry

- Ionizing radiation
  - Cannot detect with our senses
  - Effects can occur years later
- Different types
  - Type of radiation
  - Location
- Internal or external

# Effective Dose Limits

| Person | Period | CNSC Effective Dose Limit | Ontario Effective Dose Limit |
|---|---|---|---|
| Nuclear Energy Worker / X-Ray Worker | 1-yr dosimetry period | 50 mSv | 50 mSv |
| | 5-yr dosimetry period | 100 mSv | n/a |
| Pregnant NEW / X-Ray Worker | Balance of the pregnancy | 4 mSv | 5 mSv |
| A person who is not a designated worker | 1 calendar year | 1 mSv | 5 mSv |

ALARA: As Low As Reasonably Achievable

# External Dosimetry

- Source external to the body
- Radiation can penetrate skin
  - Beta
  - Ionizing electromagnetic
  - Neutron

# Dosimeters


- Used to measure ionizing radiation dose
- Passive or active
- Sample collection (indirect) or personal

# Dosimeters


- Different strengths and weaknesses
  - Energy and angle dependence
  - Type of radiation
  - Fading
  - Response to dose
  - Minimum dose measured
  - Single or multiple use
  - Dose saved or time or not
  - Ease of wear and durability

# TLD

- Contains a chip
- Radiation causes electron release
- Electrons trapped in doping centers in excited state
- Chip heated in a reader
- Trapped electrons return to ground state
- Visible light emitted and detected
- Light curve analyzed to determine dose
- Come in badges, bracelets, rings (extremity)

# TLD

- TLD systems require calibration to be accurate
- Signal fade
- Linear over a wide range
- Can be reused
- Can only be read once
- Can be read on site

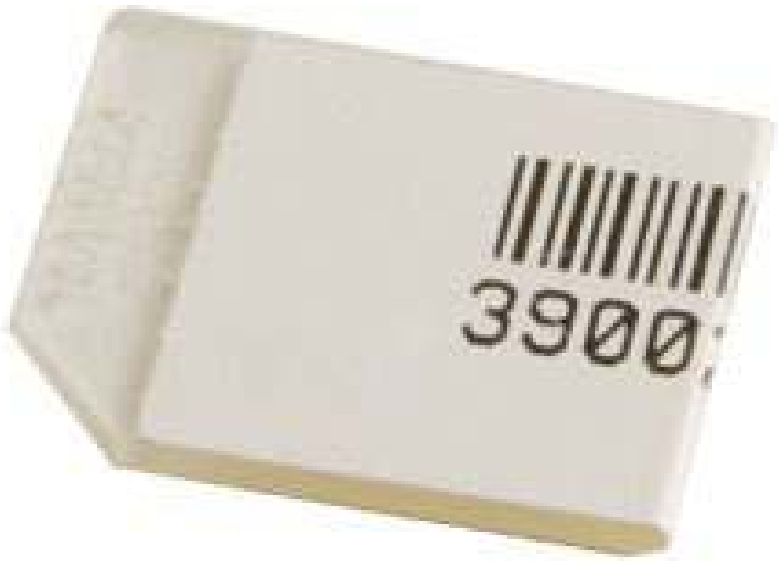
# OSLD


- Newer technology
- Works similarly to TLD
- Light is used to stimulate the trapped electrons
- Not affected by typical temperature variations
- More sensitive
- Can be reread
  - Can be stored for several years
- Can be reused
- More expensive
- Can be read on site

# DRD

- Real-time measurement
  - Diode
  - Geiger-Mueller
- Not typically official dose
- Alarms

# Solid-State Nuclear Track




- Neutrons
  - Interact with matter differently
  - Interact more with elements with light nuclei
- Solid-state nuclear track
  - CR-39 plastic
  - Interaction produces charged particles
  - Tracks made visible by chemical etching
  - Tracks imaged
  - Number of tracks related to dose
- Large angular dependence
- Not sensitive to low doses

# Portable Neutron Survey

- Area monitor
- Contains material which interacts with neutrons
- Personal dose is calculated rather than read

# Dosimeter Placement

- Badge dosimeter should be worn **underneath** the apron/PPE
- Ring or bracelet dosimeters can keep track of dose to the hands
- Eye dose measured using a dosimeter on the collar above the apron/PPE


# Dosimeter Best Practice

- Have a different dosimeter for each work location
  - In case of an unusual exposure
  - Each dosimeter reported to employee.
- Do not expose dosimeters to extreme conditions
- Store as directed
  - away from radiation sources
- Do NOT share dosimeters
  - Extras should be available

# Internal Dosimetry

- Whole/partial body counters
  - Gamma
- Body excretions
  - Activity concentration
- Activity in the air
  - Personal or fixed

Picture from National Archives at College Park, Public domain, via Wikimedia Commons

# Personal Alpha Track

- Uranium produces radon
- Radon and progeny are carcinogenic
- 2nd leading cause of lung cancer after smoking
- PAD
  - Film shows tracks
  - Tracks correlate with dose
  - Actively draw in air
  - Charged after use

# Internal Dosimetry

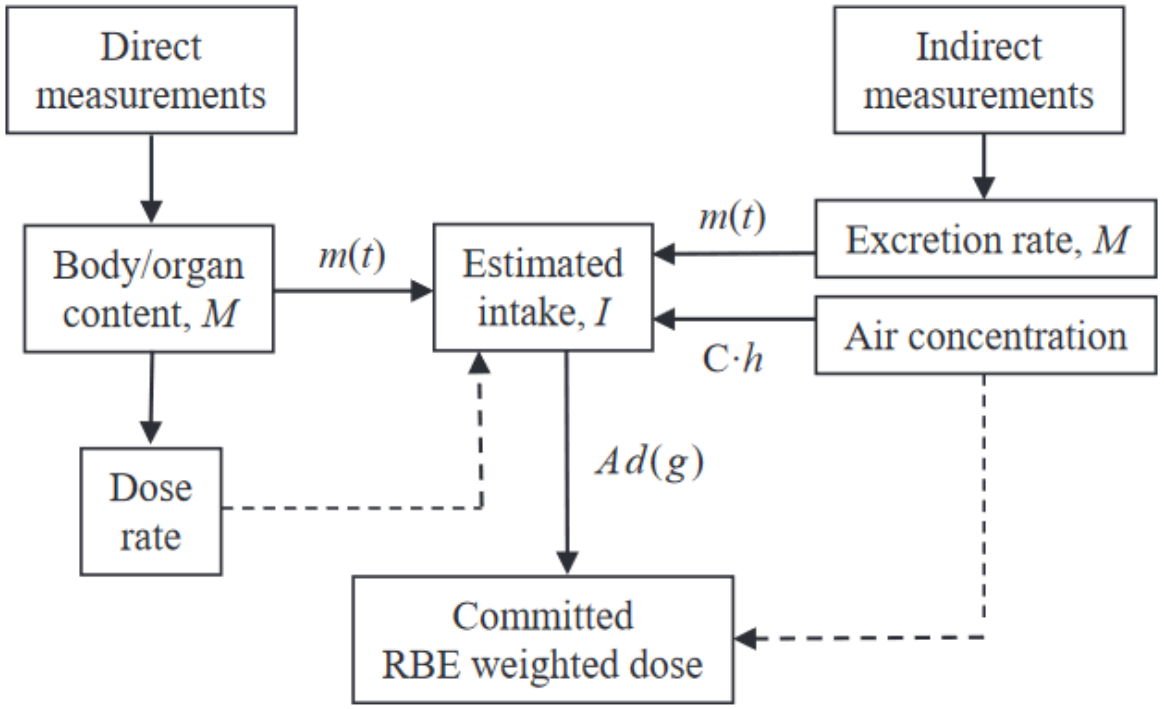



*FIG. 5. General scheme for the assessment of internal doses from monitoring measurements in emergencies.*

Image from IAEA Safety Standards Series No GSG-7

# Licensed Dosimetry Providers


- CNSC licensed service providers report dose to the National Dose Registry (NDR)
  - National Dosimetry Services, Heath Canada
  - Landauer
  - Mirion Technologies
- The National Dose Registry keeps a record of individual cumulative dose over multiple licensed service providers and multiple employers

# Alpha (α)

## PPE

- Ejected α particles will not penetrate dead layer of skin
- PPE blocks routes of entry
- Radioisotopes can contaminate PPE

## Dosimetry

- Personal Alpha Dosimeters
- Internal Dosimetry Measures

# Beta (β)

## PPE

- Ejected β particles can penetrate skin
- β can be shielded with plastic or aluminum
- Use of more dense materials can produce x-rays
- PPE for shielding and/or block routes of entry
- Radioisotopes can contaminate PPE

## Dosimetry

- TLD
- OSLD

# Neutron

## PPE

- Not a common type of radiation
- Portable sources have heavy shielding
- Engineering controls used in facilities
- Materials can become radioactive
- PPE as shielding and to prevent internal exposure for unsealed sources
- May need to shield for secondary radiation
- Low atomic weight-rich materials, textile composites

## Dosimetry

- Solid-state nuclear track
- Portable Neutron Survey

# Gamma

## PPE

- Provide protection from beam or from contamination from unsealed sources
- External shielding has high atomic number, such as lead

## Dosimetry

- TLD
- OSLD

## PPE

- X-ray are solely external
- High atomic number, such as lead

## Dosimetry

- TLD
- OSLD

## PPE

- Welding masks
- Clothing with SPF
- Sunscreens with SPF
- Glass/plastic

## Dosimetry

- Provincially regulated
- Available, but may not be mandated

## PPE

- Danger of burns, generated airborne, or fire
- Eye protection
- Protective clothing
- Air filtration

## Dosimetry

- Non-Ionizing
- Not Applicable

# Infrared

## PPE

- Danger from heat
- Flame resistant/retardant

## Dosimetry

- Non-Ionizing
- Not Applicable

# Takeaway Points

- PPE and dosimetry
  - Specific to the type of radiation
  - Specific to the situation
  - Part of a complete radiation protection program
- Procedures developed
  - Not arbitrary
  - For protection
- If unsure, ask

# How to Find Out More

- Radiation Safety Officer
- X-ray Safety Officer
- Health and Safety Committee
- CANLII
- References
- RSIC

# Radiation Safety Institute of Canada

- The Radiation Safety Institute of Canada is an independent, not-for-profit organization specializing in radiation safety.

- For further information on all types of radiation contact us at:

1-800-263-5803

info@radiationsafety.ca

www.radiationsafety.ca

# References/Resources


- Canadian Nuclear Safety Commission. (2018). *Proper Care and Use of Personal Dosimeters* [Poster]. Ottawa, ON: Author. Retrieved March 10, 2021, from https://nuclearsafety.gc.ca/pubs_catalogue/uploads/proper-care-personal-dosimeters-eng.pdf
- *Introduction to Dosimetry* [February 2012]. Ottawa, ON: Canadian Nuclear Safety Commission. Retrieved March 10, 2021, from https://nuclearsafety.gc.ca/pubs_catalogue/uploads/INFO-0827-Introduction-to-Dosimetry-e.pdf
- Izewska, J., & Rajan, I. (2005). Chapter 03 - Radiation Dosimeters. In 1241530410 920899393 E. B. Podgorsak (Ed.), *Radiation Oncology Physics: A Handbook for Teachers and Students*. Vienna, Austria: International Atomic Energy Agency. Retrieved March 10, 2021, from https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1196_web.pdf
- *Occupational Radiation Protection: General Safety Guide* (IAEA Safety Standards Series No. GSG-7) [October 2018]. Vienna: International Atomic Energy Agency. Retrieved March 10, 2021, from https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf
- *Personal Protective Equipment* (Practical Radiation Technical Manual 5) [April 2004]. Vienna: International Atomic Energy Agency. Retrieved March 10, 2021, from https://www-pub.iaea.org/MTCD/Publications/PDF/PRTM-5_web.pdf