



NMTCB RADIATION SAFETY CERTIFICATION EXAMINATION CONTENT OUTLINE

I. Content Pertaining to a RAM License: **(Expertise Area)**

A. Radiation physics and instrumentation

1. Basic radiation physics

- atomic structure
- definitions – radiation, radioactivity, half life
- modes of radioactive decay
- units and quantities of radioactivity
- decay calculations
- interactions of radiation with matter

2. Radiation detection and measurement

- detector types and uses (survey meters, dose calibrator, well counters, probes, gamma camera, PET Scanner)
- Detector / Instrument Selection
 - Detection efficiency
 - Energy Response
- statistics of counting
- detector use, calibration, quality control requirements and regulations

3. Production of Radionuclides

- reactors (basic principles and radionuclides)
- accelerators (basic principles and radionuclides)
- generators (column breakthrough limits, shielding, proper disposal)
 - $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ generator (LEU & HEU)
 - $^{82}\text{Sr}/^{82}\text{Rb}$ generator
 - $^{68}\text{Ge}/^{68}\text{Ga}$ generator
 - Others

4. Production of x-rays

B. Radiation dosimetry

1. Units of radiation exposure and dose – US and SI (definitions and conversions)
2. Personal monitoring devices
3. Bioassays

4. Area monitoring – room surveys
5. Effluent Monitoring
 - Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage
6. Sealed source monitoring
7. Basic concept of MIRD

C. Radiation protection and ALARA

1. Time, distance and shielding
2. Regulations – personnel and the general public
3. Dose and exposure Limits
 - Radiation workers
 - Pregnant radiation workers
 - The public
4. Personnel monitoring and records
 - Periodic review and annual reports
 - Employer responsibilities
 - Action limits and notifications level
 - Lead apron inspection and inventory
 - Dosimeter badge types (assigned badge position, electronic dosimeters, EDE1, EDE2, Webster, etc)
 - SDE, DDE, LDE, TEDE, Extremities
5. Restricted and unrestricted areas (definitions and sign posting)
6. Work place rules – best practices
7. ALARA philosophy
8. Patient radiation safety & instructions
 - Factors affecting patient dose
 - Pregnancy and breast feeding
 - Patient release rule and underlying theory

D. Mathematics pertaining to the use and measurement of radioactivity

1. Decay equation & tables
2. Counter efficiency / cpm to dpm
3. Exposure calculations based on time, distance and shielding
 - Time
 - Distance – inverse square law
 - HVL definition, concept and calculation
4. Effective Half Life
5. Dose calibrator tests
 - Accuracy Test (percentage error calculations)

- Geometry
- Constancy
- Linearity
- Measurement of betas

Energy resolution calculation and window setting

- E. Radiation biology
- F. Security and control of radioactive materials
 - 1. Room security and access
 - 2. Signs & Sign Posting
 - 3. Proper storage and shielding
 - 4. Inventory and record keeping
 - 5. Security of a “spill area”
- G. Shipping & receiving of radioactive materials (*air and ground*)
 - 1. Related radiation surveys and records
 - 2. Regulations
 - 3. Package labeling
 - 4. Internal Transport of Radiation within the facility
- H. Disposal of byproduct material (and all required records)
 - 1. General trash
 - 2. Sewer
 - 3. Biohazard trash
 - 4. Decay in storage
 - 5. Return to the manufacturer
 - 6. Shipment for offsite disposal
- I. Administrative controls to avoid a medical event
- J. Emergency procedures
 - 1. Major and minor spill – definitions and procedures
 - 2. Lost or stolen radioactive source
 - 3. Medical event – definitions and procedures
 - 4. Radio-iodine therapy patient (or other therapy patient) requiring emergency care
 - 5. Death of therapy patient (soon after therapy)
 - 6. Community radiation emergency response.
- K. Regulations & resources
 - 1. License requirements, applications and amendments
 - Facility design shielding requirements
 - Broad scope / limited scope
 - 2. Agreement and non-agreement states
 - 3. Authorized user, training / experience requirements
 - 4. NRC Regulations:

- NRC Title **10CFR19** Notices, Instructions and Reports to Workers)
- NRC Title **10CFR20** (Standards for Protection Against Radiation)
- NRC Title **10CFR35** (Medical Use of Byproduct Material)
- NRC Title **10CFR71** (Transportation of Radioactive Materials)

5. Department of Transportation Regulations

- Title 49CFR170 (Hazardous Materials)
- Training requirements for medical licenses
- White I, Yellow II, Yellow III, UN2910, UN2908, TI
- Exempt quantities and limited quantities

6. Other agencies

- Environmental Protection Agency (EPA)
- FDA CDRH

L. Radionuclide therapy best practices

1. Radio-iodine therapy

- Handling of doses
- Patients receiving less than 33 mCi
 - Inpatients – instructions for patients and nursing staff
 - Outpatients – instructions for patients and family members
- Patients receiving more than 33 mCi
 - Regulatory requirements for hospitalization and release from the hospital
 - Room preparation and cleanup for hospitalized patients
 - Inpatients – instructions for patients and nursing staff
 - Outpatients – instructions for patients and family members
- Storage and disposal of radio-iodine waste

2. Emergency care of radio-iodine therapy patients

3. Other radionuclide therapy (with P-32, Sr-89, Sm153, Ra-223, Lu-177)

4. Brachytherapy

M. Reference Documents: NUREG 1556 – Volume 9 and 10 CFR Part 37

II. Content Pertaining to CT: **(Expertise Area)**

A. CT Basics and Physics

1. Production of x-rays

2. X-ray detection

3. Shielding of poly-energetic beams

4. Scan Mode

- Helical
- Axial

5. MDCT/Single slice/CBCT

6. AEC Tube current modulation
 7. CT scatter iso-dose map application
 8. Reconstruction methods- filter back projection, iterative
- B. CT Dose Metrics
1. CTDI
 2. DLP
 3. Effective Dose
 4. SSDE Size Specific Dose Estimate
- C. CTDI Diagnostic Reference Levels
1. ACR values
 - Adult
 - Pediatric
 2. NCRP Report 172
 3. CRCPD NEXT Data
 4. CTDI Phantom size
- D. Dose optimization
- Protocol review
 - With or without contrast use
- E. Radiation Dose Management
1. Equipment Factors
 - kVp
 - mA
 - Fixed mAs
 - Tube current modulated mAs
 - Rotation time
 - Slice thickness
 - Pitch
 - Beam collimation
 - Resolution settings
 - Scan lengths
 - Bolus tracking
 - Delayed scans
 - Repeat scans
 2. Patient Factors
 - Body Habitus
 - Centering
 - Motion
 - General patient positioning
 - Increased attenuation
 3. Other Factors
 - Patient Shielding

- Holding patients
- Facility Shielding
- PPE for staff
- CT Fluoro

F. Deterministic vs. Stochastic Effects

G. High Radiation Dose CT Settings

- CT Brain Perfusion, CT Fluoro, Bolus tracking

III. Content Pertaining to X-ray & Fluoroscopy (Competence but not expertise)

A. X-ray and Fluoroscopy Physics

1. Production of X-rays
2. Detection of X-rays
3. Fluoroscopy Units
 - Fixed
 - C-Arm, Cone beam CT with fluoro, Mini
 - Bi-Plane

B. Fluoroscopy Dose Metric

1. Fluoroscopy time
2. Air kerma at the reference point ($K_{a,r}$)
3. Dose Area Product (P_{KA})
4. Peak skin dose ($D_{skin,max}$)

C. Patient risk factors for hypersensitivity to radiation exposure

D. High dose fluoroscopically guided intervention

- Interventional Radiology
- Cardiac Catheterization Lab
- Operating Room

E. Radiation Dose Management

1. ALARA
 - Time
 - Distance
 - Shielding
 - Types
 - Patient
 - Staff
 - Equipment
 - Thickness
 - Storage
 - Inspections
 - ALARA action levels

- Room Shielding
- Reporting requirements

2. Equipment Factors

- kVp
- mA
- Time
- Field size
- Quality control frequency
- Equipment Geometry
 - X-ray tube position
 - Image receptor
 - Table height
- Grids
- Magnification
- Collimation
- Filtration
 - inherent vs. added
- last Image Hold
- Pulse fluoroscopy
- Cine Mode
 - fluoroscopy frames rates
- Low versus normal detail mode
- Beam angle

3. Patient Factors

- Body habitus
- Scatter
- Entrance versus exit exposure ratios
- Dose notifications levels
 - Fluoroscopy time
 - Air kerma at the reference point ($K_{a,r}$)
 - DAP (P_{KA})

4. Staff Factors

- Position, training, apparel, PPE

F. Deterministic Exposure Levels

- Substantial radiation dose level (SRDL) and time to onset
 - Erythema
 - Early transient
 - Main erythema
 - Late erythema
 - Epilation
 - Dermal Atrophy
 - Dermal Necrosis
 - Secondary Ulceration
- Patient follow up after a Substantial radiation dose level (SRDL)

IV. Content Pertaining to MRI Safety: (Competence, but not expertise)

- A. Magnetic field units of measure
 - Gauss
 - Tesla

- B. Magnet types in MRI
 - Superconducting, Permanent, Resistive
 - Magnetic Susceptibility (Diamagnetic, Paramagnetic, Superparamagnetic, Ferromagnetic)

- C. Magnetic Fields
 - Static magnetic fields
 - Static magnetic field issues: Site Access Restriction Zoning
 - Gradient magnetic fields
 - Slew Rate
 - Spatial Gradient
 - Active vs. Passive Shielding
 - Fringe Field (Importance of 5 Gauss line)

- D. MRI Safety
 - Ferromagnetic objects/detectors
 - Codes in a MRI environment
 - Emergency responders (fire, police)
 - Define Zones I, II, III, & IV.
 - Personnel training levels
 - Screening (Patient, Staff, Equipment)
 - Appropriate MRI labeling (MR safe vs. MR conditional vs. MR unsafe)
 - MRI Quenching
 - Hazards associated with liquid Helium
 - Thermal Hazards
 - Fire Hazards
 - Asphyxiation Hazards
 - Hazards associated with strong radio frequency fields
 - (SAR)
 - Burns caused by Loops
 - Operating modes for MR systems
 - Sequences looping
 - Padding
 - Coils
 - Acoustic noise
 - Explosive decompression

- E. Contrast Agent Safety

V. Optimizing Radiation Exposure / Other Topics

- A. Appropriateness Criteria
- B. Image Wisely
- C. Image Gently
- D. Protocols
- E. Considerations for pregnant and/or pediatric patient
 - Alternative exams
 - Benefit vs. risk
- F. Regulations around Brachytherapy
 - HDR, LDR, permanent
- G. Microspheres
- H. Mammography
- I. DEXA / Bone density
- J. Research with Radioactive Materials
- K. Radioactive Seed Localization
- L. Linac – linear accelerator
- M. Blood irradiator

Related Guidelines & References:

- AAHP/HPS [Qualifications for Health Care Facility Radiation Safety Officer](#) (Jan 2003)
- National Council on Radiation Protection and Measurements (NCRP) - [Publications](#)
- ACR – [Disaster Preparedness for Radiology Professionals](#)
- NRC: [10 CFR Part 35](#), "Medical Use Licenses"
- AAPM Report No. 124 - [A Guide for Establishing a Credentialing and Privileging Program for Users of Fluoroscopic Equipment in Healthcare Organizations \(2012\)](#)
- AAPM Report No. 160 - [Radiation Safety Officer Qualifications for Medical Facilities: Report of Task Group 160](#);
- AAPM Report No. 204- [Size-Specific Dose Estimates \(SSDE\) in Pediatric and Adult Body CT Examinations](#)
- ACR-SPR [Practice Parameter For Imaging Pregnant or Potentially Pregnant Adolescent and Women with Ionizing Radiation](#)
- ACR [Guidance Document on MR Safety Practices](#); 2013. Journal of Magnetic Resonance Imaging 37:501–530 (2013) Authors: E. Kanal, AJ Barkovich, C Bell et al.
- [Image Gently® - The Alliance for Radiation Safety in Pediatric Imaging](#)
- [Image Wisely® - Radiation Safety in Adult Medical Imaging](#)