MEDICAL RADIATION SAFETY OFFICER’S REVIEW
2017 AAPM SPRING CLINICAL MEETING

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I Have No Disclosures
Radioactive Materials License:
- NRC or Agreement State
- Broad Scope & Medical Component
- Limited License
- Regulations - Basis
- Nuclear Regulatory Commission (NRC) Code of Federal Regulations
  - 10 CFR 19: Notices Instructions
  - 10 CFR 20: Standards For Radiation Protection
  - 10 CFR 35: Medical Use of Byproduct Material
  - 10 CFR 37: Physical Protection of category 1 & 2 Quantities of RAM
  - 10 CFR 71: Packaging and Transportation of Radioactive Material
  - 10 CFR 150.20: Reciprocity: Recognition of Agreement State Licenses
- Radiation Safety Committee
  - Meeting Frequency F(x) Radioactive Materials License
  - Topics
Supporting Documentation

- **Regulatory Guides**
  - *Volume 9, Rev. 2*, Program-Specific Guidance About Medical Use Licenses
  - *Volume 9, Rev. 3*, Program-Specific Guidance About Medical Use Licenses (Out For Comment)
  - *Volume 11*, Program-Specific Guidance About Licenses of Broad Scope
    - **RG 8.9** - Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program
    - **RG 8.13** - Instruction Concerning Prenatal Radiation Exposure
    - **RG 8.20** - Applications for Bioassay for I-125 and -131
    - **RG 8.29** - Instruction Concerning Risks from Occupational Radiation Exposure
  - **RG 8.35** - Planned Special Exposures
  - **RG 8.36** - Radiation Dose to the Embryo/Fetus
Supporting Documentation

- **Regulatory Guides**
  - *Volume 9, Rev. 2*, Program-Specific Guidance About Medical Use Licenses
  - *Volume 9, Rev. 3*, Program-Specific Guidance About Medical Use Licenses (Out For Comment)
  - *Volume 11*, Program-Specific Guidance About Licenses of Broad Scope
  - Other Supporting Documents/Resources
  - Complying with 10 CFR 35.400(a), 35.500(a), and 35.600(a) requirements for licensees to only use sources and devices "as approved in the Sealed Sources and Devices Registry" and "Sealed Source and Device Registry: Supplement for 10 CFR Part 35 Uses."

- *High Dose-Rate Remote Afterloader Brachytherapy Devices Approved for Patient Treatment Using Sources Exceeding 10 Curies* - provides a list of high dose-rate remote Afterloader brachytherapy devices that are FDA-approved for patient treatment using sources exceeding 10 Curies.
Supporting Documentation


- **Part 37 rule/Security order comparison** (Enclosure 2 to SECY-11-070)
Radioactive Material - Unsealed Sources
- Nuclear Medicine
  - Diagnostic
    - Radionuclides
    - Clinical Procedures
  - Therapeutic
    - Radionuclides
    - Clinical Procedures

Radioactive Material – Sealed Sources
- Nuclear Medicine
  - References Sources
    - Flood Source
    - Dose Calibrator Sources
    - Anatomical Marking Source
    - Check Sources
  - Irradiators
    - Blood
    - Research

Sources of Exposure – Medical Setting
RAM NRC/Agreement States
Common Radiopharmaceuticals

- **99mTc**: MDP, HDP, Sulfur Colloid, Ceretec, Myoview, Cardiolite, Neurolite, MAA, Choletec, DTPA, DMSA, MAG3, Fanolesomab, & WBC
- **201Tl**: Chloride
- **123 & 131I**: IodomethylNorcholesterol, Tositumomab, MIBG, OIH, & NA I
- **111In**: Pentriotide & WBC
- **67Ga**: Citrate
- **14C**:
- **18F**: FDG
- **82Rb**: Chloride

<table>
<thead>
<tr>
<th>Name &amp; Radiation</th>
<th>Half Life ( (T_{1/2}) )</th>
<th>Energy (kEv)</th>
<th>Medical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>99mTc - γ</strong></td>
<td>6.04 hr.</td>
<td>140</td>
<td>Many</td>
</tr>
<tr>
<td><strong>210Tl - γ</strong></td>
<td>73.0 hr.</td>
<td>69-83 Hg X-rays</td>
<td>Myocardial Perfusion</td>
</tr>
<tr>
<td><strong>123I - γ</strong></td>
<td>13.1 hr.</td>
<td>159</td>
<td>Thyroid Uptake &amp; Scan</td>
</tr>
<tr>
<td><strong>131I - γ</strong></td>
<td>8.1 d</td>
<td>364</td>
<td>Thyroid</td>
</tr>
<tr>
<td><strong>111In - γ</strong></td>
<td>2.8 d</td>
<td>173, 247</td>
<td>Tag Wbc’s &amp; others</td>
</tr>
<tr>
<td><strong>67Ga - γ</strong></td>
<td>78.3 h</td>
<td>93, 184, &amp; 300</td>
<td>Infection, Tumor etc.</td>
</tr>
<tr>
<td><strong>14C - β-</strong></td>
<td>5730 y</td>
<td>156.5</td>
<td>H Pylori</td>
</tr>
<tr>
<td><strong>18F - β+</strong></td>
<td>110 m</td>
<td>511</td>
<td>Tumor, brain, &amp; cardiac</td>
</tr>
<tr>
<td><strong>82Rb - β+</strong></td>
<td>1.3 m</td>
<td>511</td>
<td>Cardiac</td>
</tr>
</tbody>
</table>
Common \( R_x \) Radiopharmaceuticals

- \(^{131}\text{I}\): Sodium Iodine
- \(^{223}\text{Ra}\): Xofigo
- \(^{32}\text{P}\): Sodium Phosphate or Polycythemia Vera
- \(^{89}\text{Sr}\): Chloride
- \(^{90}\text{Sr}\): Zevalin
- \(^{153}\text{Sm}\): EDTMP
- \(^{90}\text{Y}\): Sirspheres Theraspheres

<table>
<thead>
<tr>
<th>Name &amp; Radiation</th>
<th>Half Life ( (T_{1/2}) )</th>
<th>Energy ( (\text{kEv}) )</th>
<th>Medical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{131}\text{I} - \gamma ) &amp; ( (\beta-) )</td>
<td>8.1 d</td>
<td>364 (606)</td>
<td>Thyroid</td>
</tr>
<tr>
<td>(^{222}\text{Ra} - \alpha)</td>
<td>11.4 d</td>
<td>5606</td>
<td>Prostate</td>
</tr>
<tr>
<td>(^{32}\text{P} - \beta-)</td>
<td>14.3 d</td>
<td>1710</td>
<td>RBC Poly Phosphate - METS</td>
</tr>
<tr>
<td>(^{89}\text{Sr} - \beta-)</td>
<td>50.5 d</td>
<td>1463</td>
<td>Bone Pain &amp; Mets</td>
</tr>
<tr>
<td>(^{90}\text{Sr} - \beta-)</td>
<td>28.6 y</td>
<td>546</td>
<td>MoAb RIT</td>
</tr>
<tr>
<td>(^{153}\text{Sm} - \beta-, (\gamma))</td>
<td>46.7 h</td>
<td>632, 702, 805 (103)</td>
<td>Bone Pain &amp; Mets</td>
</tr>
<tr>
<td>(^{90}\text{Y} - \beta-)</td>
<td>64 h</td>
<td>2284</td>
<td>MoAb RIT</td>
</tr>
</tbody>
</table>

Nuclear Medicine – Therapy
Common \(R_x\) Radionuclides

- \(^{60}\text{Co}\): Gamma Knife
- \(^{137}\text{Cs}\): GYN Implants; C&T
- \(^{192}\text{Ir}\): HDR & Mammosite
- \(^{125}\text{I}\): Eye Plaque
- \(^{103}\text{Pd}\): Prostate
- \(^{90}\text{Y}\): Sirspheres & Theraspheres

<table>
<thead>
<tr>
<th>Name &amp; Use</th>
<th>Half Life ((T_{1/2})) &amp; Energy ((\text{mEv}))</th>
<th>Exposure Rate Constant ((\Gamma)) Rcm(^2)/mCi-hr</th>
<th>Half Value Layer ((\text{Pb mm}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{60}\text{Co})</td>
<td>5.26 y 1.17 &amp; 1.33</td>
<td>13.07</td>
<td>11</td>
</tr>
<tr>
<td>(^{137}\text{Cs})</td>
<td>30.0 y 0.662</td>
<td>3.26</td>
<td>5.5</td>
</tr>
<tr>
<td>(^{192}\text{Ir})</td>
<td>73.8 d 0.380 Ave.</td>
<td>4.69</td>
<td>2.5</td>
</tr>
<tr>
<td>(^{125}\text{I})</td>
<td>60 d 0.028 Ave.</td>
<td>1.46</td>
<td>0.025</td>
</tr>
<tr>
<td>(^{103}\text{Pd})</td>
<td>17 d 0.021 Ave.</td>
<td>1.48</td>
<td>0.008</td>
</tr>
<tr>
<td>(^{90}\text{Y}-\beta-)</td>
<td>64 h</td>
<td>2284</td>
<td>MoAb RIT</td>
</tr>
</tbody>
</table>

Radiation Therapy – Brachytherapy
<table>
<thead>
<tr>
<th>Name</th>
<th>Half Life (T₁/₂) &amp; Energy (MeV)</th>
<th>Calibration Use</th>
<th>Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{60}\text{Co}$</td>
<td>5.26 y 1.17 &amp; 1.33</td>
<td>NM Dose Calibrator &amp; Therapy Chambers</td>
<td>Vial or Chamber</td>
</tr>
<tr>
<td>$^{137}\text{Cs}$</td>
<td>30.0 y 0.662</td>
<td>NM Dose Calibrator, Well Counters, Survey Meters, &amp; Therapy Chambers</td>
<td>Vial, Rod, Survey Meter, &amp; Button Check Source</td>
</tr>
<tr>
<td>$^{57}\text{Co}$</td>
<td>270.1 d 0.122</td>
<td>Dose Calibrator, Well Counters, &amp; Gamma Camera</td>
<td>Vial, Rod, Flood, or button Check Source</td>
</tr>
<tr>
<td>$^{133}\text{Ba}$</td>
<td>10.54 y 0.358</td>
<td>Dose Calibrator, Thyroid Uptake Probes, &amp; Well Counters</td>
<td>Vial, or Rod Check Source</td>
</tr>
<tr>
<td>$^{129}\text{I}$</td>
<td>59.4 d 0.028</td>
<td>Well Counter, Uptake Probe, Ionization Chambers</td>
<td>Rod, Chamber Source</td>
</tr>
</tbody>
</table>

**Nuclear Medicine & Radiation Therapy Calibration Sources**
Nuclear Medicine Calibration Sources
Clinical Procedures
- Stereotactic
- Radiosurgery (SRS)

Radionuclides
- Clinical Procedures
- Radiation Oncology – Unsealed Sources

Brachytherapy: Prostate Seed & Clinical HDR Applicators
Sources of Exposure – Medical Setting

- Radiation Oncology – Sealed Sources
  - Brachytherapy Sources
    - Low Dose Brachytherapy (LDR)
      - Manual Brachytherapy
      - Radionuclides
      - Clinical Procedures
    - High Dose Brachytherapy (HDR)
      - High Dose Remote After loaders
      - Radionuclides
      - Clinical Procedures
      - Gamma Knife
      - Radionuclide

Clinical Procedures

- Stereotactic Radiosurgery (SRS)
- Radionuclides
- Clinical Procedures
- Radiation Oncology – Unsealed Sources
- Radionuclides
- Clinical Procedures

Brachytherapy – Clinical Applicators
The objective of 10 CFR Part 37 is to provide reasonable assurance of preventing the theft or diversion of Category 1 and Category 2 quantities of radioactive materials.

The new 10 CFR Part 37 was effective on May 20, 2013, and NRC licensees were to comply with the requirements by March 19, 2014. The NRC confirmed the Agreement States' adoption of adequate and compatible 10 CFR Part 37 requirements by the March 19, 2016, deadline.

Academic and Research Licensees
Medical Licensees
<table>
<thead>
<tr>
<th>Radioactive material</th>
<th>Category 1 (TBq)</th>
<th>Category 1 (Ci)</th>
<th>Category 2 (TBq)</th>
<th>Category 2 (Ci)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-60</td>
<td>30</td>
<td>810</td>
<td>0.3</td>
<td>8.10</td>
</tr>
<tr>
<td>Cesium-137</td>
<td>100</td>
<td>2,700</td>
<td>1</td>
<td>27.0</td>
</tr>
<tr>
<td>Iridium-192</td>
<td>80</td>
<td>2,160</td>
<td>0.8</td>
<td>21.6</td>
</tr>
</tbody>
</table>
• Low Dose Rate Brachytherapy
• High Dose Rate Brachytherapy
• Gamma Knife
• Radionuclide Therapy
  ▫ 131-I Thyroid
  ▫ 131-I Bexar
  ▫ 90-Y SirSphere & Theraspheres
  ▫ 153-Sm, 89-Sr,
  ▫ 223-Ra

Rx Sealed & Unsealed Sources
RESEARCH IRRADIATOR

BLOOD IRRADIATOR

Sources Of Medical Exposure
RADIOGRAPHIC
FLUOROSCOPIC
DIGITAL ROOM

BONE DENSITY

Radiology Devices
DIGITAL MAMMO

STEREOTACTIC MAMMOGRAPHY

Radiology Devices
- Stereotactic
- Tomosynthesis
- Film/Screen
- Faxitron

Mammography
LINEAR ACCELERATOR

CT SIM

Radiation Oncology
Radiographic
- Fixed Devices
- Bone Mineral
- Mobile Devices

Fluoroscopic
- Diagnostic
- Cardiology
- Interventional
- Surgery
- Endoscopy
- Pulmonary
- Pain Management

X-Ray Devices
Mobile Fluoroscopic Devices
- C-arms
- O-arms

CT Scanning
- Axial
- Helical
- Dual Source
- PET/CT
- SPECT/CT

X-Ray Devices
Dental
- Intraoral
- Extraoral
- Panoramic
- Cephalometric
- Digital Radiography & Cone Beam (CB)
- Charge Couple Devices (CCD)
- Photostimulable Storage Phosphors Receptor

X-Ray Devices
Diagnostic Review Work Stations
Sources Of Medical Exposure Non Ionizing
Site Planning
- Diagnostic Radiology
- Radiographic
- Fluoroscopic
- Cath/EP & Interventional
- CT
- SPECT/CT & PET/CT
- Mammography
Site Planning NCRP Report 147

- Bone Density
- Dental
- Pain Management
- Surgery Centers

Diagnostic Shielding Design
Diagnostic Radiology
- Radiographic/Fluoroscopic
- Cath/EP & Interventional
- CT
- SPECT/CT & PET/CT
- Mammography
- Bone Density
- Dental
- Pain Clinics
- Surgery

Radiation Protection Surveys
Therapeutic Shielding Design; NCRP Report 151

- External Beam
  - Low Energy Accelerators
  - High Energy Accelerators
- Total Body Irradiation (TBI)
- Stereotactic Radiosurgery (SRS)
- Intensity Modulated Radiation Therapy (IMRT)
- Stereotactic Radiotherapy (SRT)
- Neutron Shielding, Skyshine, Intraoperative
  - Surgery Procedures
- Nuclear Medicine
- Diagnostic Radiology
- Radiation Oncology
- Non Ionizing Radiation

Radiation Protection In Medicine
Patient Safety

- Review IR, Cath Lab, EP & Diagnostic Procedures – Patient Exposure – Air Kerma
- Patient Dose Estimates
  - Fetal Dose Calculations
  - (Great Resource)
- Nuclear Medicine
- Diagnostic Radiology
- Operating Suites
- Lab
- Research Labs
- Radiation Oncology
- Pulmonary, Pain
- Endoscopy

Occupational Monitoring
- **Nuclear Medicine**
  - Adult Patient
  - Pediatric Patient
  - Pregnant & or Breast Feeding Patient

**Limiting Patient Exposure**
- **Diagnostic Radiology**
  - Adult Patient
  - Pediatric Patient
  - Pregnant & or Breast Feeding Patient

- **Radiation Oncology**
  - Adult Patient
  - Pediatric Patient
  - Pregnant

*Limiting Patient Exposure*
Key Areas:
- Aprons & Protective Devices – Inventory & Tracking
- Dose Monitoring & Dose Metrics
  - Dose Alerts – CT
- XR-29 Compliance & CT
- Other Tidbits
  - CR – DR Conversion & CMS Payments
Thank You

- Think Spring