Regulatory Guidelines and Computational Methods for Safe Release of Radioactive Patients

II. Brachytherapy

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Disclosures

• None
Talk Objectives

• Describe General Sealed Source Brachytherapy Applications
• Summarize NRC Rulings
• Describe Release Methods for LDR sources

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Talk Objectives

• Describe General Sealed Source Brachytherapy Applications
• Summarize NRC Rulings
• Describe Release Methods for LDR sources
Introduction

Brachy: short

Brachytherapy: Therapy at a short distance

Brachytherapy refers to radiation therapy that involves the application of radioactive material directly into or immediately adjacent to the tumor.

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Brachytherapy Treatments

• Low Dose Rate vs. High Dose Rate

• Techniques
  – Intracavitary
  – Interstitial
  – Intraluminal
  – Surface (topical)

• Definitive vs. Boost
  – Example of definitive treatment - prostate implant
  – Example of boost treatment - cervical implant

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Dose Rate in Brachytherapy

• Low Dose Rate (LDR):
  – Range of 0.4 to 2.0 Gy/hr (per ICRU #38)
  – Time to deliver prescription is days

• High Dose Rate (HDR)
  – Dose rate > 12 Gy/hr (per ICRU #38)
  – Time to deliver prescription is minutes

• Note: Medium Dose Rate (MDR)
  – Dose rate between LDR and HDR
  – Not as common in the USA

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From Multiple Sources/Manual Loading to a Single Source/Afterloading

Ra-226 Tubes → Cs-137 Tubes/Manual Loading → Cs-137 Pellet LDR → Ir-192 PDR/HDR

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Manual LDR Sources (MDACC)

- Cesium Pellet
- Cesium Walstram
- Cesium Tube Source
- Iridium Wire
- Gold (Au) Seeds
- Iodine Seeds

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Selectron LDR Afterloaders

- $^{137}$Cs Pellets sorted magnetically
- Active pellets stored in radiation protection safe
- Program active and inactive pellets in each channel
- Programmed pellets, in intermediate safe
- Compressed air transfer of pellets

MD Anderson, Houston, Tx

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Radium Tubes Sources to Cesium Selectron Pellets in the Tandem

25.0 mm = Ra-226 tube source with 3mm spacer

22.0 mm = Ra-226 tube

2.5 mm

Center of 1st tube source

Note: each pellet has a nominal activity of 5 mgRaeq.

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HDR/PDR Remote Afterloader

HDR: 10 Ci
PDR: 1-2 Ci

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High-Energy Brachytherapy Sources-examples

Figure 1. Schematic drawing of the Nucletron ‘Classic’ \( ^{192} \)Ir HDR brachytherapy source.

Figure 2. Schematic drawing of the Nucletron ‘V2’ \( ^{192} \)Ir HDR brachytherapy source.
Low-Energy Brachytherapy Sources- examples

- Amersham Health model 6702 source
- NASI model MED3631-A/M or MED3633 source
- Bebig model 25.506 source
- Best Pd
- Imagyn model IS-12501 source
- Mentor Prostatseed
- IsoRay model CS-1 Rev2
- Theragenics model 200 source
- Draximage LS-1
- Amersham 6733

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From MJ Rivard
### Most Common Radionuclides in Brachytherapy (LDR/HDR)

<table>
<thead>
<tr>
<th>Isotope</th>
<th>( T_{1/2} ) (y)</th>
<th>( E_{\text{avg}} ) (KeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{226}\text{Ra})</td>
<td>1,622</td>
<td>830</td>
</tr>
<tr>
<td>(^{60}\text{Co})</td>
<td>5.26</td>
<td>1,250</td>
</tr>
<tr>
<td>(^{137}\text{Cs})</td>
<td>30</td>
<td>662</td>
</tr>
<tr>
<td>(^{192}\text{Ir})</td>
<td>74.1</td>
<td>380</td>
</tr>
<tr>
<td>(^{198}\text{Au})</td>
<td>2.7</td>
<td>410</td>
</tr>
<tr>
<td>(^{131}\text{Cs})</td>
<td>~10</td>
<td>29</td>
</tr>
<tr>
<td>(^{125}\text{I})</td>
<td>~60</td>
<td>28</td>
</tr>
<tr>
<td>(^{103}\text{Pd})</td>
<td>~17</td>
<td>22</td>
</tr>
</tbody>
</table>

Low E (<50 keV)

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ICBT- Gynecology

- Intracavitary: Places radioactive sources within a body cavity (cervical cancer)
- LDR (temporary, 48hrs) or HDR (temporary, minutes)
**Characteristics of Cervical Cancer Treatment**

Total doses to reference points (LDR+EBRT)) - MDACC

<table>
<thead>
<tr>
<th>Reference point</th>
<th>Dose ± S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point A</td>
<td>87 ± 8 Gy</td>
</tr>
<tr>
<td>Bladder</td>
<td>70 ± 9 Gy</td>
</tr>
<tr>
<td>Rectum</td>
<td>70 ± 8 Gy</td>
</tr>
<tr>
<td>Vaginal surface</td>
<td>125 ± 15 Gy</td>
</tr>
</tbody>
</table>

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**Intraluminal**

- Intraluminal: Places the source of radiation within body “tubes” such as esophagus, trachea, bronchus and rectum.
- Temporary (HDR, minutes)

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Surface (Topical)

- Places the radioactive sources on top of the area to be treated (choroidal melanoma)
- Temporary: ~72hrs (LDR)

A custom-made radiation plaque. On the left is the inside of a plaque with the radiation seeds. On the right is the gold coating on the outside of the plaque.
Interstitial Examples

- **Interstitial**
  - Temporary
    - Sarcoma - muscle
      - Iridium seeds or wire, LDR
    - GI - rectum
      - Iridium seeds or wire, LDR
    - H&N - BOT, FOM nasal septum
      - Iridium seed or wire, LDR
  - Prostate
    - Iridium, HDR
Interstitial Examples

• Interstitial
  – Permanent

  • GU - prostate (I-125, Pd-103, Cs-131)
  • GYN - pelvic side wall (Au-198)
  • GI - rectum (Au-198)
Trans Rectal Ultrasound (TRUS) for Prostate Implants

- 1990’s - Advancements of the Ultrasound Guided Transperineal Brachytherapy Procedure

- Advancements made with the TRUS
  - pre-operatively plans the placement and number of seeds
  - Calculate 3-D radiation dose distribution for prostate, rectum, urethra, and bladder
  - adjust variables for dose escalation and normal tissue sparing
Prostate Implant OR Procedure
# Prostate Implant Typical LDR Prescriptions

<table>
<thead>
<tr>
<th>Source</th>
<th>$T_{1/2}$ (days)</th>
<th>Energy (median, KeV)</th>
<th>90% Dose delivered (days)</th>
<th>Monotherapy (Gy)</th>
<th>Boost (Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-125</td>
<td>~60</td>
<td>~28</td>
<td>204</td>
<td>145</td>
<td>100-110</td>
</tr>
<tr>
<td>Pd-103</td>
<td>~17</td>
<td>~22</td>
<td>58</td>
<td>120 or 125</td>
<td>90-100</td>
</tr>
<tr>
<td>Cs-131</td>
<td>~10</td>
<td>~30</td>
<td>33</td>
<td>115</td>
<td>85</td>
</tr>
</tbody>
</table>

AAPM Task Group 43

TG-43 Updates

Update of AAPM Task Group No. 43 Report: A revised AAPM protocol for brachytherapy dose calculations

Medical Physics, Vol. 31, No. 3, March 2004

Recommendations of the American Association of Physicists in Medicine regarding the Impact of Implementing the 2004 Task Group 43 Report on Dose Specification for $^{103}$Pd and $^{125}$I Interstitial Brachytherapy

Medical Physics, Vol. 32, No. 5, May 2005

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\[ \dot{D}(r, \theta) = S_K \cdot \Lambda \cdot \frac{G_L(r, \theta)}{G_L(r_0, \theta_0)} \cdot g_L(r) \cdot F(r, \theta) \]
Source Strength (Activity)

- 1 Ci (curie): $3.7 \times 10^{10}$ disintegration/sec
- 1 Bq (becquerel): 1 disintegration/sec
- 1 Ci = 37 GBq

mg-Ra-eq is the mass of radium required to produce the same exposure rate at 1cm from the substitute source

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Source Strength (Air Kerma)

- Product of air kerma rate times distance squared, usually 1 m, to point of specification.
- $S_k = (dK(r)/dt)*r^2$, units are in $\text{U}$
  - $1\text{U} = 1 \mu\text{Gy} \cdot \text{m}^2/\text{hr}$ or $1 \text{cGy} \cdot \text{cm}^2/\text{hr}$
- AAPM TG-43 protocol specifies air kerma strength on perpendicular bisector of source at 1cm

$$S_K = \dot{K}_\delta(d)d^2$$

*Updated – 5 keV cutoff

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TG 43-updated Dose Rate Constants

\[ \dot{D}(r, \theta) = S_K \cdot \Lambda \cdot \frac{G_L(r, \theta)}{G_L(r_0, \theta_0)} \cdot g_L(r) \cdot F(r, \theta) \]

**TABLE I.** NIST standard WAFAC calibration dates for air kerma strength for each manufacturer, and dose rate constant values. Note that for a given source type, the % change in \( \Lambda \) from the 1999 value is not necessarily equal to the average % change in air-kerma strength due the 1999 NIST WAFAC anomaly because some of the \( \Lambda \) values were calculated based on air-kerma strength measurements of a single seed.

<table>
<thead>
<tr>
<th>Manufacturer and source type</th>
<th>NIST date used by ADCL and NIST as standard</th>
<th>( \text{CON/} \Lambda ) [cGy-h(^{-1}).U(^{-1})]</th>
<th>% difference in ( \Lambda ) from 1999 value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amersham 6702</td>
<td>(^{125}\text{I}) April 15, 1998</td>
<td>1.036</td>
<td>N/A</td>
</tr>
<tr>
<td>Amersham 6711</td>
<td>(^{125}\text{I}) April 15, 1998</td>
<td>0.965</td>
<td>N/A</td>
</tr>
<tr>
<td>Best Industries 2301</td>
<td>(^{125}\text{I}) August 18, 2000</td>
<td>1.018</td>
<td>+3.3%</td>
</tr>
<tr>
<td>NASI MED3631-A/M</td>
<td>(^{125}\text{I}) June 30, 2001</td>
<td>1.036</td>
<td>+1.0%</td>
</tr>
<tr>
<td>Bebig/Theragenics 125 S06</td>
<td>(^{125}\text{I}) January 27, 2001</td>
<td>1.012</td>
<td>+2.2%</td>
</tr>
<tr>
<td>Imagyn IS-12501</td>
<td>(^{125}\text{I}) October 21, 2000</td>
<td>0.940</td>
<td>+3.5%</td>
</tr>
<tr>
<td>Theragenics 200</td>
<td>(^{103}\text{Pd}) July 8, 2000</td>
<td>0.686</td>
<td>+4.0%</td>
</tr>
<tr>
<td>NASI MED3633</td>
<td>(^{103}\text{Pd}) April 23, 2001</td>
<td>0.688</td>
<td>+4.3%</td>
</tr>
</tbody>
</table>
Talk Objectives

• Describe General Sealed Source Brachytherapy Applications

• **Summarize NRC Rulings**

• Describe Release Methods for LDR sources

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PART 35—MEDICAL USE OF BYPRODUCT MATERIAL

Subpart A—General Information
35.1 Purpose and scope.
35.2 Definitions.
35.3 Maintenance of records.
35.4 Provisions for the protection of human research subjects.
35.5 FDA, other Federal, and State requirements.
35.6 Information collection requirements: OMB approval.
35.7 Implementation.
35.8 License required.
35.9 Application for license, amendment, or renewal.
35.10 License amendments.
35.11 Exemptions regarding Type A specific licenses of broad
35.12 License issuance.
35.13 Specific exemptions.
Subpart B—General Administrative Requirements
35.24 Authority and responsibilities for the radiation protect
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35.27 Supervision.

Subpart C—General Technical Requirements
35.60 Possession, use, and calibration of instruments used to measure the activity of unsealed byproduct material.
35.61 Calibration of survey instruments.
35.63 Determination of dosages of unsealed byproduct material for medical use.
35.65 Authorization for calibration, transmission, and reference sources.
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35.69 Labeling of vials and syringes.
35.70 Surveys of ambient radiation exposure rate.
35.75 Release of individuals containing unsealed byproduct material or implants containing byproduct material.
35.80 Provision of mobile medical service.
35.92 Decay-in-storage.
§ 35.75 Release of individuals containing unsealed byproduct material or implants containing byproduct material.

(a) A licensee may authorize the release from its control of any individual who has been administered unsealed byproduct material or implants containing byproduct material if the total effective dose equivalent to any other individual from exposure to the released individual is not likely to exceed 5 mSv (0.5 rem).\(^1\)

(b) A licensee shall provide the released individual, or the individual’s parent or guardian, with instructions, including written instructions, on actions recommended to maintain doses to other individuals as low as is reasonably achievable if the total effective dose equivalent to any other individual is likely to exceed 1 mSv (0.1 rem). If the total effective dose equivalent to a nursing infant or child could exceed 1 mSv (0.1 rem) assuming there were no interruption of breast-feeding, the instructions must also include—

1. Guidance on the interruption or discontinuation of breast-feeding; and
2. Information on the potential consequences, if any, of failure to follow the guidance.

(c) A licensee shall maintain a record of the basis for authorizing the release of an individual in accordance with § 35.2075(a).

(d) The licensee shall maintain a record of instructions provided to a breast-feeding female in accordance with § 35.2075(b).


\(^1\) The current revision of NUREG–1550, Vol. 9, “Consolidated Guidance About Materials Licenses: Program-Specific Guidance About Medical Licenses” describes methods for calculating doses to other individuals and contains tables of activities not likely to cause doses exceeding 5 mSv (0.5 rem).
10 CFR 35.75

“Release of individuals containing unsealed byproduct material or implants containing byproduct material”

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10 CFR 35.75
Release Dose Limit

➤ A licensee may authorize the release from its control of any individual who has been administered unsealed byproduct material or implants containing byproduct material if the total effective dose equivalent (TEDE) to any other individual from exposure to the released individual is not likely to exceed 5 mSv (500 mrem).*

*NUREG–1556, Vol. 9, "Consolidated Guidance About Materials Licenses: Program-Specific Guidance About Medical Licenses"
10 CFR 35.75
Written Instructions for Release

- A licensee shall provide the released individual, or the individual's parent or guardian, with instructions:

  including written instructions, on actions recommended to maintain doses to other individuals as low as is reasonably achievable if the TEDE to any other individual is likely to exceed 1 mSv (100 mrem).
10 CFR 35.75

Nursing Infant or Child Ruling

If TEDE to a nursing infant or child could exceed 1 mSv (100 mrem) assuming there were no interruption of breast-feeding, the instructions must also include:

(1) Guidance on the interruption or discontinuation of breast-feeding; and

(2) Information on the potential consequences, if any, of failure to follow the guidance.

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A licensee shall maintain a record of the basis for authorizing the release of an individual in accordance with § 35.2075(a).

The licensee shall maintain a record of instructions provided to a breast-feeding female in accordance with § 35.2075(b).
Talk Objectives

• Describe General Sealed Source Brachytherapy Applications
• Summarize NRC Rulings
• Describe Release Methods for LDR sources for permanent implants (prostate)
Calculation of release limits following implant brachytherapy

Consolidated Guidance About Materials Licenses

Program-Specific Guidance About Medical Use Licenses

Final Report

Date Completed: January 2008
Date Published: January 2008

Prepared by
D. B. Howe, M. Beardsley, S. R. Bakhsh

Office of Federal and State Materials and Environmental Management Programs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
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APPENDIX U

Model Procedure for Release of Patients or Human Research Subjects Administered Radioactive Materials

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The activity at which patients could be released was calculated by using, as a starting point, the method discussed in the National Council on Radiation Protection and Measurements (NCRP) Report No. 37, “Precautions in the Management of Patients Who Have Received Therapeutic Amounts of Radionuclides.” This report uses the following equation to calculate the exposure until time $t$ at a distance $r$ from the patient:

Equation U.1:

$$D(t) = \frac{34.6 \Gamma Q_0 T_p (1 - e^{-0.693t/T_p})}{r^2}$$

where:

- $D(t)$ = Accumulated exposure at time $t$, in roentgens
- $34.6$ = Conversion factor of 24 hrs/day times the total integration of decay (1.44)
- $\Gamma$ = Specific gamma ray constant for a point source, R/mCi-hr at 1 cm (1.44)
- $Q_0$ = Initial activity of the point source in millicuries, at the time of the release
- $T_p$ = Physical half-life in days
- $r$ = Distance from the point source to the point of interest, in centimeters
- $t$ = Exposure time in days.

*The dose to an individual likely to receive the highest dose from exposure to the patient is taken to be the dose to total decay $\Rightarrow (1-e^{-0.693t/T_p})$ is set equal to 1.

*It is assumed that 1 R is equal to 10 mSv (1 rem).
Implants with radionuclides with a physical half-life greater than 1 day: Use Equation U.2

\[ D(\infty) = \frac{34.6 \Gamma Q_0 T_p (0.25)}{(100 \text{ cm})^2} \]

Eq. (U2)

It is assumed that the individual likely to receive the highest dose from exposure to the patient would receive a dose of 25% of the dose to total decay (0.25 in Equation U.2), at a distance of 1 meter.*

*Selection of 25% of the dose to total decay at 1 meter for estimating the dose is based on measurements discussed in the supporting regulatory analysis that indicate the dose calculated using an occupancy factor, \( E \), of 25% at 1 meter is conservative in most normal situations.
### Supplement A

#### Table U.5  Half-Lives and Exposure Rate Constants of Radionuclides Used in Medicine

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Physical Half-Life (days)</th>
<th>Exposure Rate Constant(^2) (R/mC·h at 1 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag-111</td>
<td>7.45</td>
<td>0.15</td>
</tr>
<tr>
<td>Au-198</td>
<td>2.696</td>
<td>2.3</td>
</tr>
<tr>
<td>Cr-51</td>
<td>27.704</td>
<td>0.16</td>
</tr>
<tr>
<td>Cu-64</td>
<td>0.529</td>
<td>1.2</td>
</tr>
<tr>
<td>Cu-67</td>
<td>2.578</td>
<td>0.58</td>
</tr>
<tr>
<td>Ga-67</td>
<td>3.261</td>
<td>0.753</td>
</tr>
<tr>
<td>I-123</td>
<td>0.55</td>
<td>1.61</td>
</tr>
<tr>
<td>I-125</td>
<td>60.14</td>
<td>1.42</td>
</tr>
<tr>
<td>I-125 implant(^1)</td>
<td>60.14</td>
<td>1.114</td>
</tr>
<tr>
<td>I-131</td>
<td>8.04</td>
<td>2.2</td>
</tr>
<tr>
<td>In-111</td>
<td>2.83</td>
<td>3.21</td>
</tr>
<tr>
<td>Ir-192 implant(^1)</td>
<td>74.02</td>
<td>4.594</td>
</tr>
<tr>
<td>P-32</td>
<td>14.29</td>
<td>N/A(^2)</td>
</tr>
<tr>
<td>Pd-103 implant(^1)</td>
<td>16.96</td>
<td>0.865</td>
</tr>
<tr>
<td>Re-186</td>
<td>3.777</td>
<td>0.2</td>
</tr>
<tr>
<td>Re-188</td>
<td>0.708</td>
<td>0.26</td>
</tr>
<tr>
<td>Se-47</td>
<td>3.351</td>
<td>0.56</td>
</tr>
<tr>
<td>Se-75</td>
<td>119.8</td>
<td>2</td>
</tr>
<tr>
<td>Sn-117m</td>
<td>13.61</td>
<td>1.48</td>
</tr>
<tr>
<td>Sr-89</td>
<td>50.5</td>
<td>N/A(^2)</td>
</tr>
<tr>
<td>Tc-99m</td>
<td>0.251</td>
<td>0.756</td>
</tr>
<tr>
<td>Tl-201</td>
<td>3.044</td>
<td>0.447</td>
</tr>
<tr>
<td>Yb-169</td>
<td>32.01</td>
<td>1.83</td>
</tr>
<tr>
<td>Yb-169</td>
<td>32.01</td>
<td>1.83</td>
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</tbody>
</table>

Footnotes for Table U.5


\(^2\) Values for the exposure rate constant for Au-198, Cr-51, Cu-64, I-131, Se-47, and Se-75 were taken from the Radiological Health Handbook, U.S. Department of Health, Education, and Welfare, p. 115, 1975. For Cr-57, I-125, In-111, Re-186, and Re-188, the values for the exposure rate constant were taken from D. E. Barber, J. W. Bunn, and C. B. Menold, “Radiation Safety Issues Related to Radiolabeled Antibodies,” NUREG/CR-4444, U.S. NRC, Washington, DC, 1991. For Ag-111, Gd-153, Sn-117m, Tc-99m, Tl-201, and Yb-169, the exposure rate constants were calculated because the published values for these radionuclides were an approximation, presented as a range, or varied from one reference to another. Details of the calculation of the exposure rate constants are shown in Table A.2 of Appendix A to NUREG-1492, “Regulatory Analysis on Criteria for the Release of Patients Administered Radioactive Material,” U.S. NRC, February 1997.

\(^3\) R. Nath, A. S. Meigooni, and J. A. Miel, “Dosimetry on Transverse Axes of 192Ir Intraluminal Brachytherapy Sources,” Medical Physics, Volume 17, Number 6, November December 1990. The exposure rate constant given is a measured value averaged for several source models and takes into account the attenuation of gamma rays within the implant capsule itself.

\(^4\) A. S. Meigooni, S. Sabnis, R. Nath, “Dosimetry of Palladium-103 Brachytherapy Sources for Permanent Implants,” Endocurietherapy: Hyperthermia Oncology, Volume 6, April 1990. The exposure rate constant given is an “apparent” value (i.e., with respect to an apparent source activity) and takes into account the attenuation of gamma rays within the implant capsule itself.
- For brachy implants use max dose rate method to release
- Assumed physical half life only
- Occupancy factor of 0.25 at 1 meter for physical half-lives greater than 1 day
- No shielding by tissue assumed
Cs-131: $T_{1/2} = 9.7 \text{ days}, E = 0.25$

\[ D(\infty) = 0.5\text{rem}(5\text{mSv}): X_{1m} = \frac{D(\infty)}{34.6 \times 9.7 \text{days} \times 0.25} \]

\[ = 6 \text{mrem/hr} (0.06 \text{mSv/hr}) \]

Where,

\[ X_{1m} = \Gamma Q \frac{1\text{cm}}{100\text{cm}}^2 \]
Release Criteria for Brachytherapy

- Release of patients based on measured dose rate
- 10 CFR 35.75(c) requires a record because the release is based on considering shielding by tissue
- Use dose rate limits in Table U2 to determine when instructions must be given.
Note: NRC does not intend to enforce patient compliance with the instructions nor is it the licensee’s responsibility to do so.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>COLUMN 1 Activity Above Which Instructions Are Required</th>
<th>COLUMN 2 Dose Rate at 1 Meter Above Which Instructions Are Required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(GBq)</td>
<td>(mCi)</td>
</tr>
<tr>
<td>I-125</td>
<td>0.05</td>
<td>1</td>
</tr>
<tr>
<td>I-125 implant</td>
<td>0.074</td>
<td>2</td>
</tr>
<tr>
<td>I-131</td>
<td>0.24</td>
<td>7</td>
</tr>
<tr>
<td>In-111</td>
<td>0.47</td>
<td>13</td>
</tr>
<tr>
<td>Ir-192 implant</td>
<td>0.011</td>
<td>0.3</td>
</tr>
<tr>
<td>P-32</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Pd-103 implant</td>
<td>0.3</td>
<td>8</td>
</tr>
<tr>
<td>Re-186</td>
<td>5.7</td>
<td>150</td>
</tr>
<tr>
<td>Re-188</td>
<td>5.8</td>
<td>160</td>
</tr>
<tr>
<td>Sc-47</td>
<td>2.3</td>
<td>62</td>
</tr>
<tr>
<td>Se-75</td>
<td>0.018</td>
<td>0.5</td>
</tr>
<tr>
<td>Sn-153</td>
<td>5.2</td>
<td>140</td>
</tr>
<tr>
<td>Sn-117m</td>
<td>0.21</td>
<td>6</td>
</tr>
<tr>
<td>Sr-89</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Tc-99m</td>
<td>5.6</td>
<td>150</td>
</tr>
<tr>
<td>TI-201</td>
<td>3.1</td>
<td>85</td>
</tr>
<tr>
<td>Y-90</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Yb-169</td>
<td>0.073</td>
<td>2</td>
</tr>
</tbody>
</table>

Footnotes for Table U.2

* The activity values were computed based on 1 millisievert (0.1 rem) total effective dose equivalent.

** Activity and dose rate limits are not applicable in this case because of the minimal exposures to members of the public resulting from activities normally administered for diagnostic or therapeutic purposes.

Notes: The values for activity were calculated using Equations U.2 or U.3 and the physical half-life. The values given in SI units (megabecquerel values) were using conversion factors.

In general, values are rounded to two significant figures; however, values less than 0.07 gigabecquerel (10 millirem) or 0.1 millisievert (10 millirem) per hour are rounded to one significant figure. Details of the calculations are provided in NUREG-1492.

Agreement State regulations may vary. Agreement State licensees should check their State regulations before using these values.
Content of Instructions

• Be specific to the type of treatment given—such as permanent implants

• Include the name of a knowledgeable contact person.

A small radioactive source has been placed (implanted) inside your body. The source is actually many small metallic pellets or seeds, which are each about 1/3 to 1/4 of an inch long, similar in size and shape to a grain of rice. To minimize exposure to radiation to others from the source inside your body, you should do the following for ______ days.

- Stay at a distance of ______ feet from ______.
- Maintain separate sleeping arrangements.
- Minimize time with children and pregnant women.
- Do not hold or cuddle children.
- Avoid public transportation.
- Examine any bandages or linens that come into contact with the implant site for any pellets or seeds that may have come out of the implant site.
- If you find a seed or pellet that falls out:
  — Do not handle it with your fingers. Use something like a spoon or tweezers to place it in a jar or other container that you can close with a lid.
  — Place the container with the seed or pellet in a location away from people.
  — Notify ___________________________ at telephone number ________________.

F. Mourtada, Ph.D.
Records of Release

• For Immediate Release of a Patient Based on Measured Dose Rate:
  – The results of the measurement, the specific survey instrument used, and the name of the individual performing the survey.

F. Mourtada, Ph.D.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients, including patients who are breastfeeding an infant or child</td>
<td>Administered activity</td>
<td>Administered activity ≤ Column 1 of Table U.1</td>
<td>Yes – if administered activity &gt; Column 1 of Table U.2</td>
<td>No</td>
</tr>
<tr>
<td>Retained activity</td>
<td>Retained activity ≤ Column 1 of Table U.1</td>
<td>Yes – if retained activity &gt; Column 1 of Table U.2</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Measured dose rate</td>
<td>Measured dose rate ≤ Column 2 of Table U.1</td>
<td>Yes – if dose rate &gt; Column 2 of Table U.2</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Patient-specific calculations</td>
<td>Calculated dose ≤ 5 mSv (0.5 rem)</td>
<td>Yes – if calculated dose &gt; 1 mSv (0.1 rem)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Patients who are breastfeeding an infant or child</td>
<td>All the above bases for release</td>
<td>Additional instructions required if:</td>
<td>Records that instructions were provided are required if:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Administered activity &gt; Column 1 of Table U.3 or Licensee calculated dose from breastfeeding &gt; 1 mSv (0.1 rem) to the infant or child</td>
<td>Administered activity &gt; Column 2 of Table U.3 or Licensee calculated dose from continued breastfeeding &gt; 5 mSv (0.5 rem) to the infant or child</td>
<td></td>
</tr>
</tbody>
</table>
• NUREG1556 is overly conservative in its assumption in the case of the common LDR sources ($^{131}$Cs, $^{125}$I, and $^{103}$Pd).

• The low mean energies cause the measured exposure rate (R/hr) to greatly exceed the “actual” effective dose equivalent rate (Sv/hr) due to tissue shielding of exposed individual.

• The effective dose equivalent rate may also be reduced by self-shielding by the patients themselves.
PATIENT RELEASE CRITERIA FOR LOW DOSE RATE BRACHYTHERAPY IMPLANTS

Dale E. Boyce* and Michael A. Sheetz†

• I-125 mesh implant along chest wall special case could exceed limits in NUREG 1556 Table U1
• Section U1.3 of NUREG 1556 permits patient-specific dose calculations
• See details in paper
Remember

• Determination of release rests with the authorized user physician.
• Communicating the radiation safety dose reduction instructions to the patient rests with the authorized user physician.
• Records of the basis for authorizing patient release shall be maintained for a minimum of 3 years.
• Records that dose reduction and/or breast-feeding discontinuation instructions were provided where applicable shall also be maintained.

F. Mourtada, Ph.D.