Without Adequate Planning, Whatever Can Go Wrong Just May Go Wrong

Irradiator Resourcing Overexposure Event:

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I. Irradiator

- **Gammacell 220 research irradiator**
- Atomic Energy of Canada, Ltd. / MDS Nordion
- Design in use since 1969 w/ excellent history
- Current SS&D # NR-8135-D-804-S
- Category I, floor model irradiator
- 64 inches (1.6 m) high
- Non-movable annular source geometry
- Vertically movable sample chamber
- Located in dedicated, shielded room

II. Source Rods (Pencils)

- Maximum activity 26,400 Ci (976.8 TBq) Co-60 per SS&D
- Up to 48 individual sources arranged in circle
- Double SS encapsulated, up to 3500 Ci (129.5 TBq) each
- **Sources being loaded 1210 Ci (44.77 TBq) each**
- Adding 12 sources to original 12
- Source capsule length ~8 inches (20 cm)
- Two 3.25 inch (8.28 cm) segments w/ central inert spacer
- Dose rate at 2 inches (5 cm) = 2.7 to 3.4 E5 rad/hr (2.7 to 3.4 E3 Gy/hr)
- Dsoe rate at 12 inches (30 cm) = 1.4 to 1.5 E4 rad/hr (1.4 to 1.5 E2 Gy/hr)
- **Dose at 39.4 inches (100 cm) = 1.5E3 rad/hr (15 Gy/hr)**

III. Parties Involved

- **New Jersey licensee** possessed irradiator
- **Pennsylvania licensee** filed for reciprocity in NJ to perform routine irradiator resourcing
  - RSO (operator 1) plus one resourcing assistant (operator 2)
  - Had already paid $3600 reciprocity fee for year
  - Minimal experience performing resourcing
- **California licensee** working under PA license
  - One source handler (operator 3), one resourcing assistant (operator 4), one observer w/Teletector (operator 5)
  - More experience performing resourcing
  - Designed & built source transfer shield
  - **Source transfer shield design not reviewed by regulatory agency**
  - Developed resourcing procedure

IV. Transfer Process

- Prepare Gammacell 220 for resourcing
- Position transportation cask with new sources
- Prepare platform near level of top of Gammacell and transport cask for personnel performing resourcing
- Setup transfer shield to unload sources from transportation cask and load into Gammacell 220
- **With transfer shield positioned over transport cask, insert handheld vacuum transfer tool through transfer shield into transport cask to engage source**
- **Retract transfer tool with source by hand into transfer shield and shield bottom of transfer shield**
- Move transfer shield over Gammacell 220 and reverse process, releasing source in Gammacell 220 by turning off vacuum pump

V. Radiation Safety Preplanning Issues

- **To tell if source rod attached to vacuum tool:**
  - **Hear change in vacuum pump sound**
  - **Observe survey meter strapped to transfer cask**
  - **Marking on transfer tool by bottoming out transfer tool in transfer shield after closing shield drawer**
- Handheld survey meter use by RSO (operator 1)
- For this resourcing only, an observer (operator 5) was assigned to provide backup monitoring with a Teletector
- No discussion of what to do if a source became unshielded
- No discussion of who was in charge of resourcing operational aspects
- RSO assumed in charge of radiological safety, but no direction during event

VI. What Happened - Initially

- **Initial confusion on which operator would operate resourcing tool**
  - Resourcing tool not initially inserted through transfer shield into transportation cask by resourcing operator 3
  - Vacuum pump apparently turned on after resourcing tool fully inserted and resting on top of source rod
  - No one acknowledged turning on vacuum pump
  - Audible indication of source rod engagement not heard
- **Decision made to retract resourcing tool to troubleshoot without taking adequate time to discuss ramifications**
- Operator 5 put down Teletector to get boroscope

VII. What Happened – Source Exposed

- No increase noted on strapped radiation survey meter
  - Strapping rendered instrument inoperable
- No physical verification that source rod wasn't engaged
- RSO was not monitoring with hand-held survey meter
- **Vacuum tool with source attached retracted fully from transfer shield**
- Radiation pagers alarmed and visual confirmation that the source rod was out of the transfer shield unshielded
- **No one suggested evacuating room to discuss how to proceed**
- Instead, ad hoc reactions to re-insert the source rod into the transfer shield by operators 3 and 4

VIII. What Happened – Re-Insert Source

- Unsuccessful attempt by operator 3 to reinsert vacuum tool and source)
- Partially successful attempt by operator 4 (1/2 shielded)
- **Non-fixed 4-inch (10.2 cm) high by 3.5-inch (8.9 cm) diameter tungsten shield on top of transfer shield shifted position and wasn't aligned with transfer shield hole**
- Vacuum tool broke near source during attempts to insert
- Operator 4 attempted to align tungsten shield by hand
- **Source rod was lying at angle from vertical and hung up on unrecognized small lip on bottom of hole in tungsten shield**
- Operator 3 got 16-inch tongs from operator 2 and attempted to move source vertical so it would fall into transfer cask
- **After several attempts at aligning tungsten plug and manipulating source rod, the source rod fell into the transfer shield**

IX. Dosimetry Worn & Initial Doses

- Three workers overexposed (Operators 1, 3 & 4 > 5 rem (0.05Sv) WB)
- All 3 wore electronic dosimeters (1&4 chest, 3 belt)
- **ED doses (rem or cSv) : 1 = 8.5; 2 = 3.3; 3 = 7.7; 4 = 8.1; 5 = 1.5**
- All 3 wore WB TLDs at chest
- **TLD doses (rem or cSv): 1 = 11.4; 2 = 3.6; 3 = 17.52; 4 = 17.2; 5 = 1.7**
- Operators 3 and 4 wore ring TLDs
- **Ring TLD doses (rem or cSv): 3 = 101.3; 4 = 61.5 (regulatory limit 50 rem or cSv)**
- Differences between WB TLDs and EDs disturbing
- **EDs had maximum dose rate lock in feature (999/300 rem or cSv/hr)**

X. WB Dose Reconstruction Methodology

- WB TLDs may not have been representative of WB
- Therefore calculated WB doses
- Broke down actions for operators 3 and 4 into 5 parts for WB dose calculations based on re-enactments
- Full source exposed in steps 1-3, and ½ source exposed in steps 4-5
- **Calculated doses using MicroShield to TLD locations, front of head/lens of eye, gonads, above elbows, and above knees for:**
  - Extraction of source to unshielded position
  - Operator 3 attempts to re-insert source
  - Operator 4 attempts to re-insert source
  - Operator 4 aligns the tungsten shield plug
  - Operator 3 moves the source into vertical position

XI. Dose Reconstruction Results

- Calculated doses to TLD location for operators 3 & 4 were approximately 56% of TLD doses
  - Therefore either operators 3 & 4 spent more time than estimated 25 seconds from re-enactments
  - Or, operators were closer to source than measured during re-enactments
  - Since distances were measured, it appears more likely that the stay times were underestimated
  - Or, a combination of the two
- Increased MicroShield calculated doses to other parts of WB by ratio of TLD doses to MicroShield calculated dose to TLD location
- **Maximum calculated WB doses: operator 3 was 19 rem (0.19 Sv) just above elbows; operator 4 was 29 rem (0.29 Sv) just above knees**
- **Lens of eye doses: operator 3 was 19 rem (cSv); operator 4 was 27 rem (cSv)**

XII. Extremity Dose Reconstruction

- Based on re-enactments, ring TLD dose for operator 3 was representative of maximum extremity dose
- But, TLD dose was not representative for operator 4
- During attempts to align tungsten shield, operator 4's index finger was closer to source than ring finger
- Since fingers were only inches from exposed ½ source, difference was significant
- Assumed ring TLD dose was from this operation, with exception of WB dose
- **MS Calculated index finger dose of 204 rem or (2.04 Sv) was about 2x TLD dose**

Conclusion:
Inadequate preplanning resulted in inadequate communications, radiation survey failures, inadequate routine procedures, lack of emergency procedures, and inadequate engineering controls resulting in overexposures to three individuals and unnecessary exposures to four others.

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