U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Incident Involving a Density Gauge VARSKIN Technical Meeting

Vered Anzenberg Shaffer, Ph.D.
Office of Nuclear Regulatory Research
Peter Lee, Ph.D. and Ryan Craffey, MRHP
Region III Inspectors
October 30, 2018

RAMP Meeting
Ottawa, Canada

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overview

- The Incident – setting the scene and scenario
- VARSKIN calculations
- Regulatory considerations

Image from: https://www.researchgate.net/figure/Troxler-Model-3430-Nuclear-Gauge_fig1_237406397

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Density Gauges

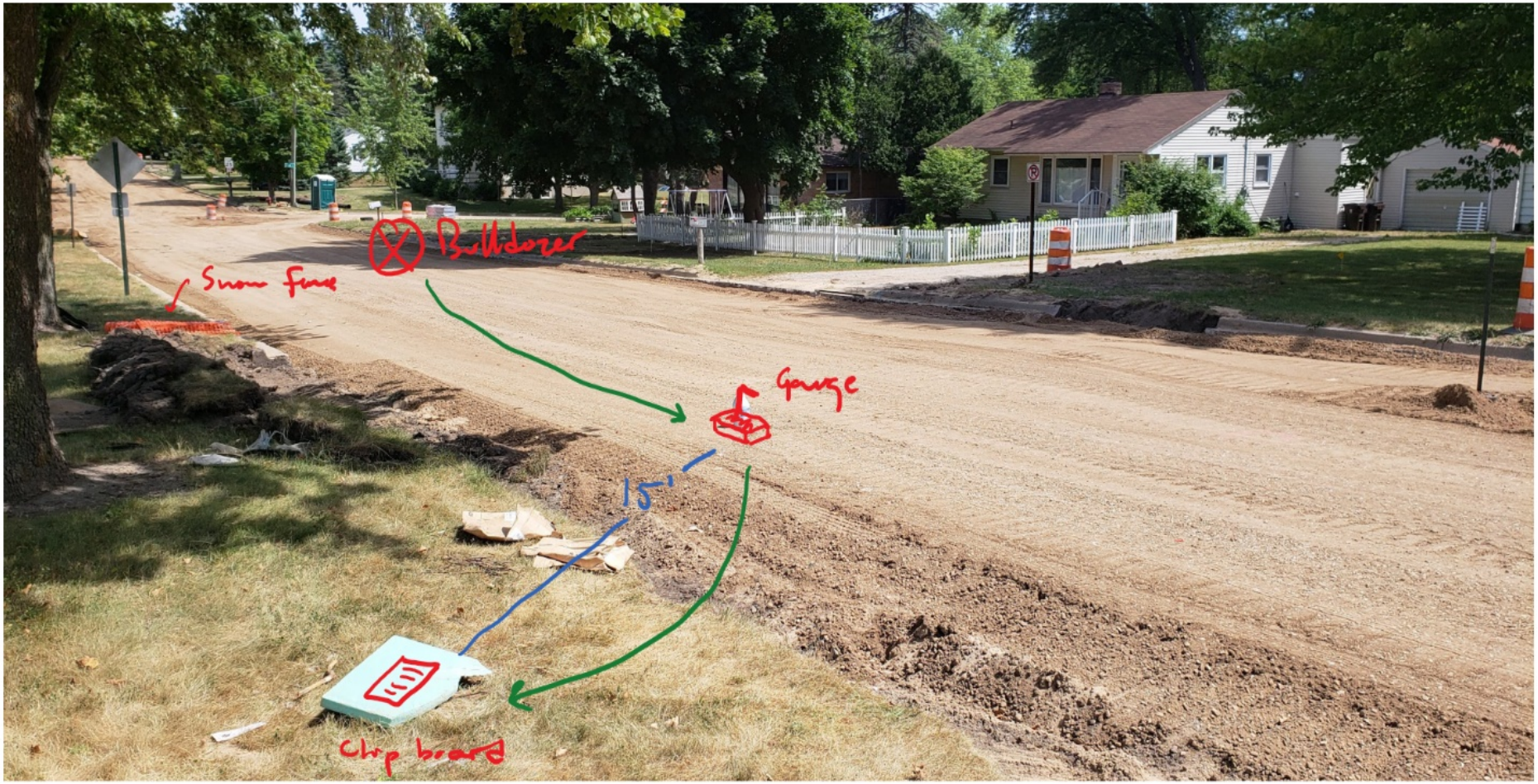
- Used in civil construction and the petroleum industry
- Used to measure soil or asphalt density and moisture content
- Regulatory requirement: authorized user must take an 8 hour course on the use of the gauge and basic radiation protection principles; on the field training is expected

Photo: U.S. Department of Defense Current https://commons.wikimedia.org/w/index.php?curid=51081027

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Setting the scene…

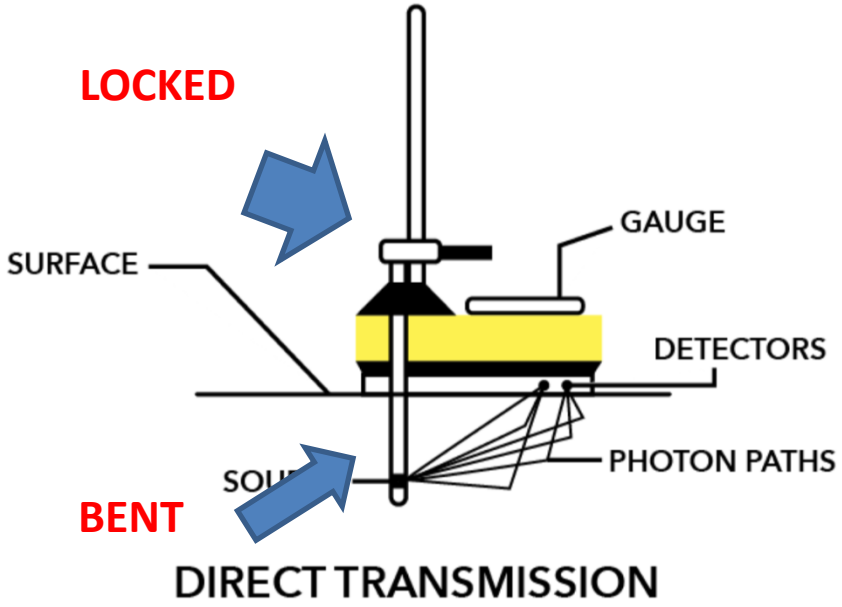
- Construction company out paving roads
- Authorized to use density gauge to make sure the road is properly constructed;
  - That day they were checking the sub base of the road to ensure the density is sufficient for weight of vehicles
  - Basically sand and gravel
- At the job location is the authorized user with a Troxler 3430 gauge
  - AmBe: 44mCi
  - Cs: 4.6 mCi


Bulldozer
Snow fence
Gauge
15'
Chip board

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

The current situation:



*not actual site picture

Photo: http://edtech.engineering.utoronto.ca/files/nuclear-densometer

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

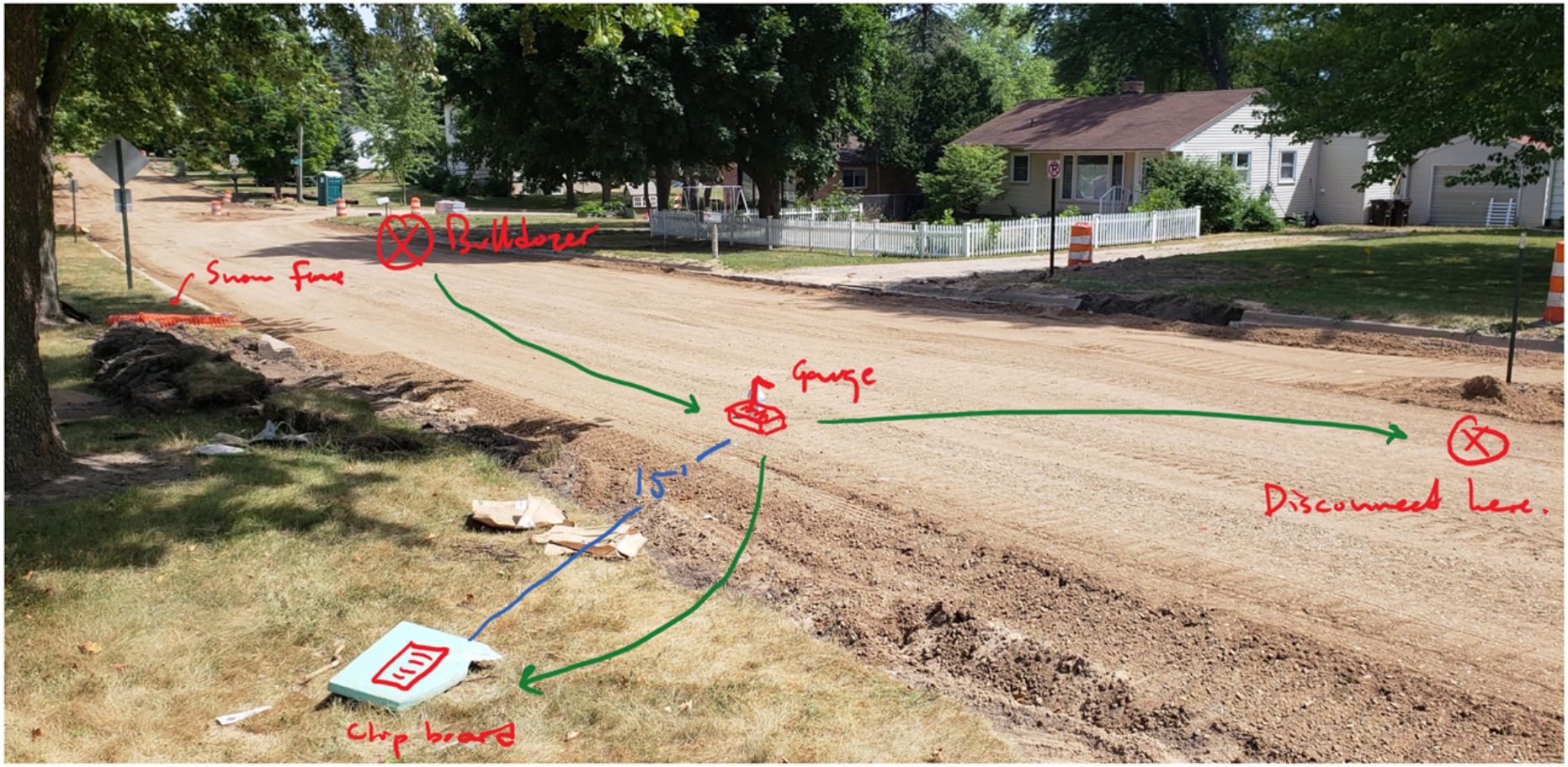
So far….

- The gauge was damaged around 6:00 PM
- By visual inspection the authorized user did not see anything that would be evaluated as source leakage
- The rod is bent and in the sand
- The trigger/locking mechanism is damaged
- Per regulations the area was roped off
- Regulations state that a licensee must have access to a survey meter
- Corporate Radiation Safety Officer was notified. Another licensee staff was at HQ and brought the Geiger counter (TroxAlert meter) and emergency procedures
- Surveyed the area and no contamination on the dozer or surrounding area
- AmBe source is intact and the Cs source is still attached
- So far…things are ok….it's 7:30 PM

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

And then….

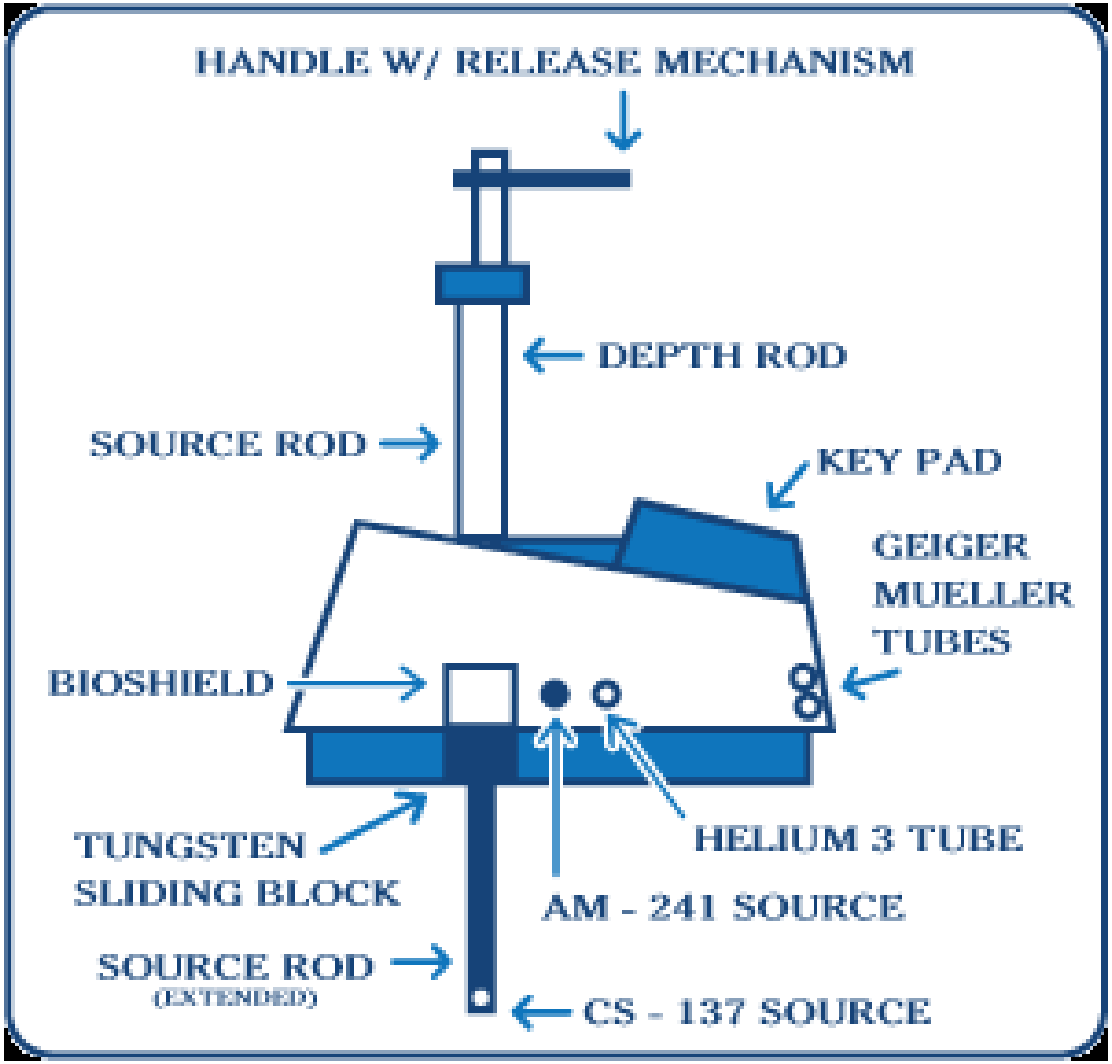
Licensee then decides that the ONLY way they can transport the gauge back to the office is by getting the lock mechanism to release, get the rod back in place, and the gauge back into the approved transportation container

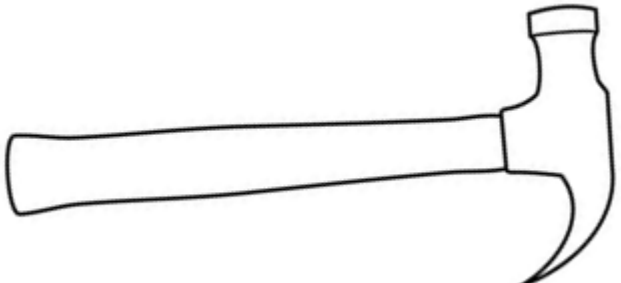

Bulldozer
Snow fence
Gauge
15'
Disconnect here.
Chip board

8 inches

Source

Tried getting the heavy machinery around to straighten the rod as well…





Hit the end of the rod where the source is encapsulated twice

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- The source rolls off
- The authorized user picks up the source with his bare hand
- Place the source on top of a truck, places some copper wire on top for shielding, and walks away – 15 ft
- It is now close to 10 PM and the 3 individuals at the site call the emergency number at the NRC
- The NRC tells them to place the source in a box of sand or gravel for shielding and to transport it back to their HQ
- Authorized user then picks up the source again with his bare hand and places it into the box with sand
- Did surveys before leaving and did not find any contamination


TROXLER
3430
MOISTURE - DENSITY GAUGE

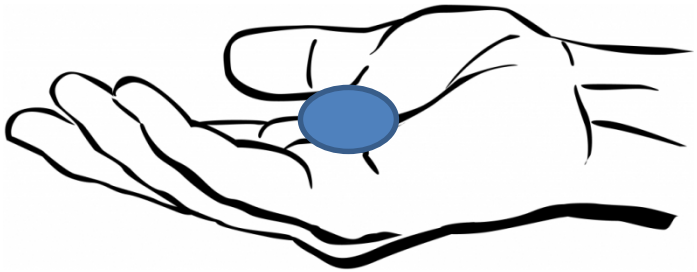
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Individual Occupational Exposures

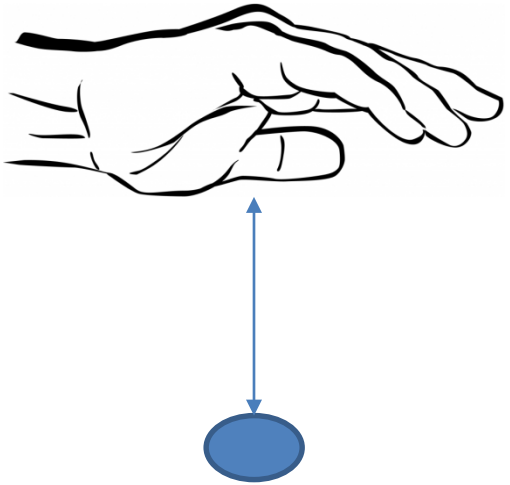
- Assuming it contained 8 mCi of Cs-137 when manufactured, the activity was approximately 4.6 mCi on date of the incident (07/16/18)
- Authorized user acknowledged handling this source capsule on two occasions, for up to 20 seconds in total
- Corporate individual acknowledged holding the source rod of the Troxler gauge (with the source still attached) at a distance of 8 inches from the source for up to 2 minutes
- Side note: leak tests on the source came back negative

VARSKIN Calculations

We will start with the most conservative approach – using a point source and ignoring the rod shielding.
If the dose calculated is nearing regulatory limits, then we will use more realistic geometries.



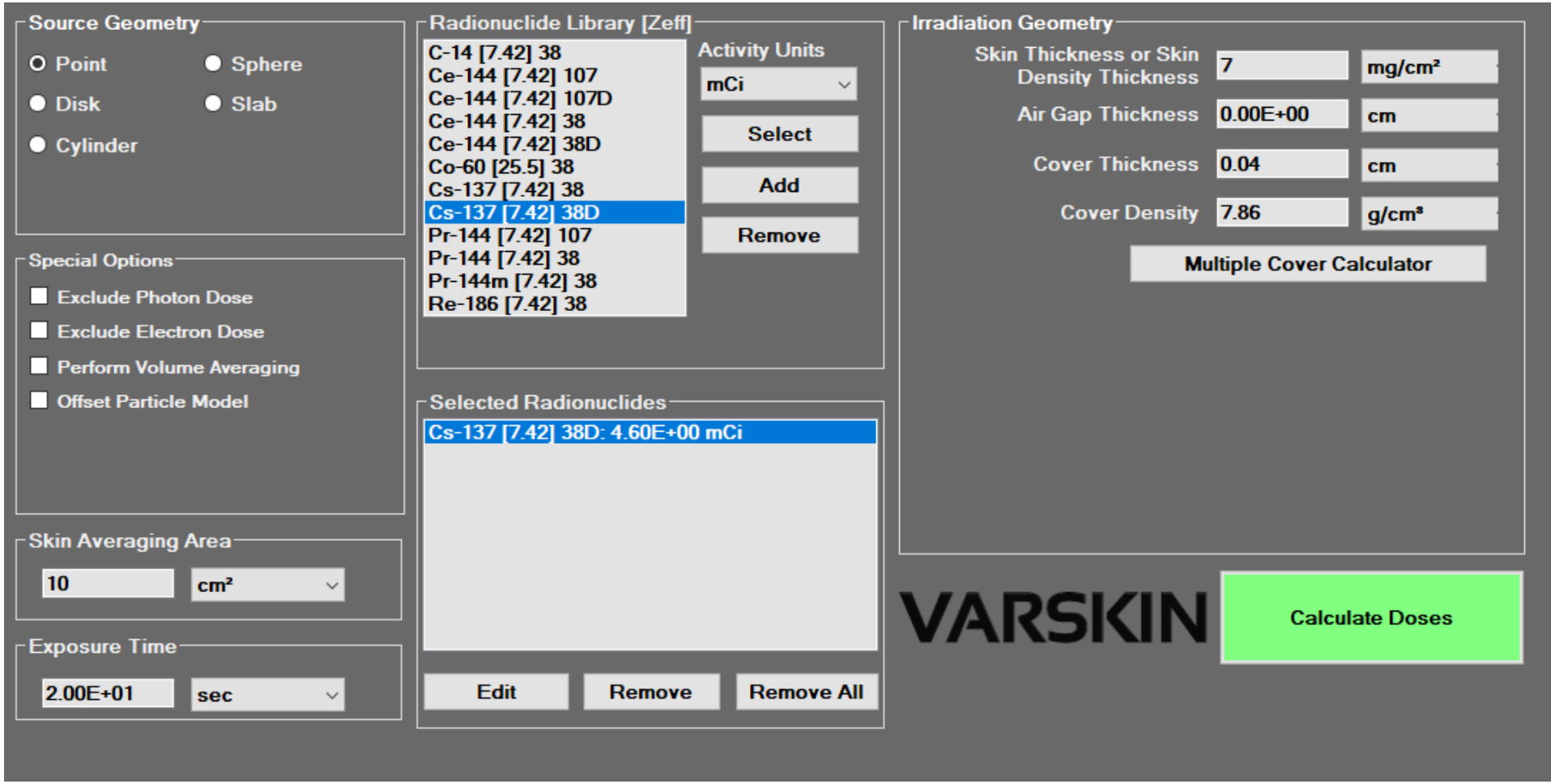
Time – 20 seconds
Area – 10 cm^2
Air gap – 0 cm

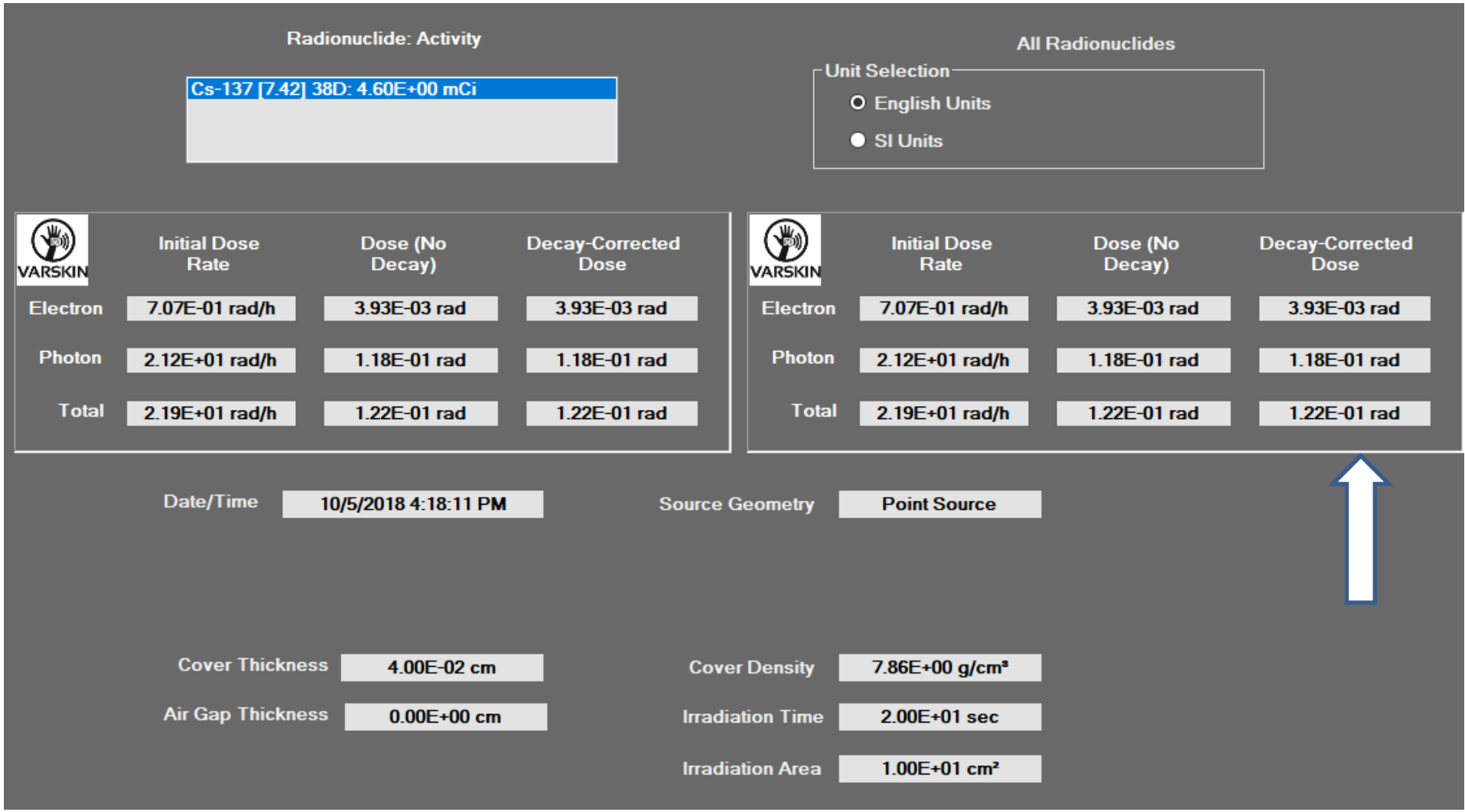


Time – 2 minutes
Area – 10 cm^2
Air gap – 20 cm (approx. 8 in)

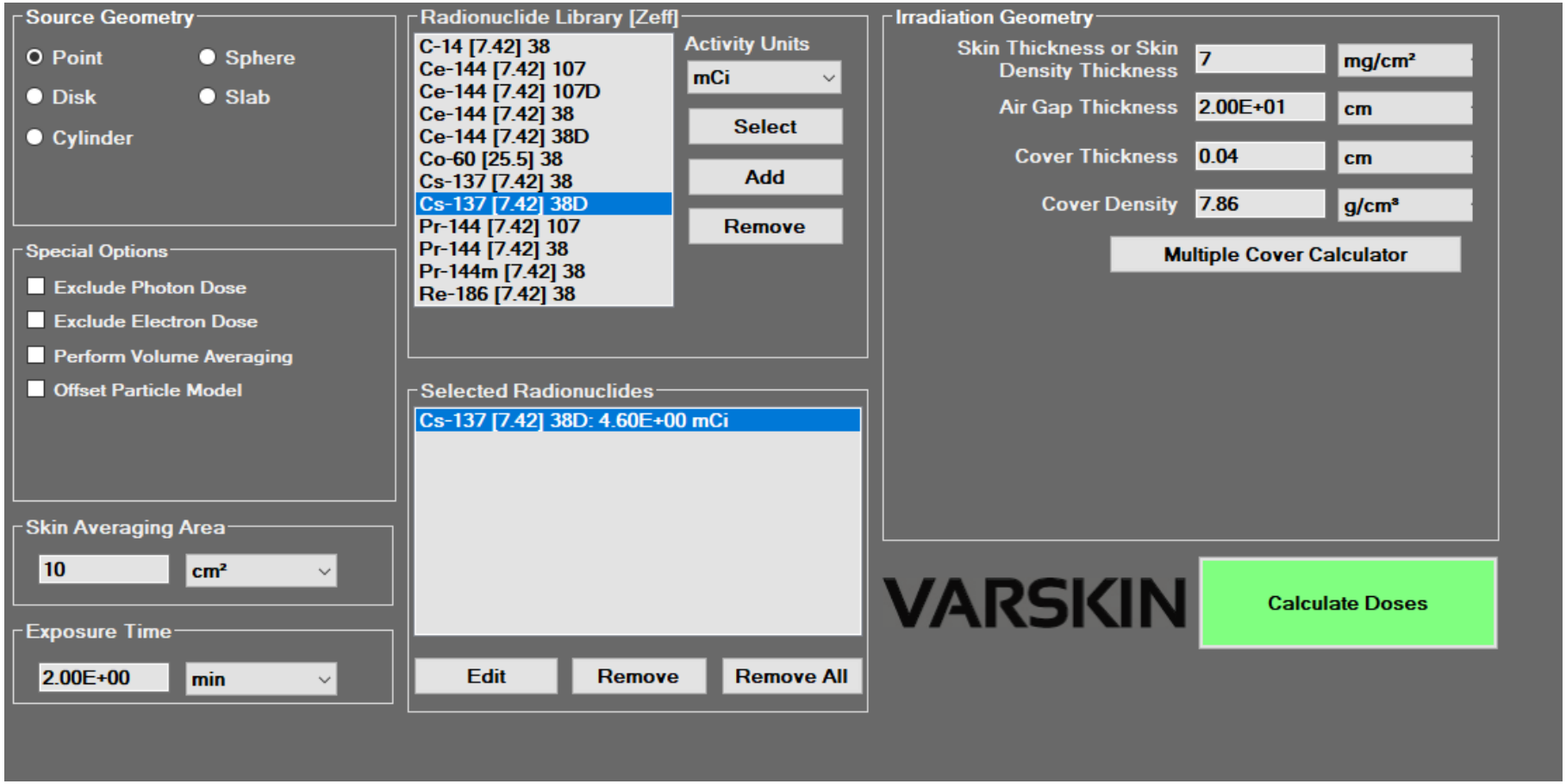
Point source: 4.6 mCi of Cs-137
Source is encased in small cover – Iron 0.4 mm thickness

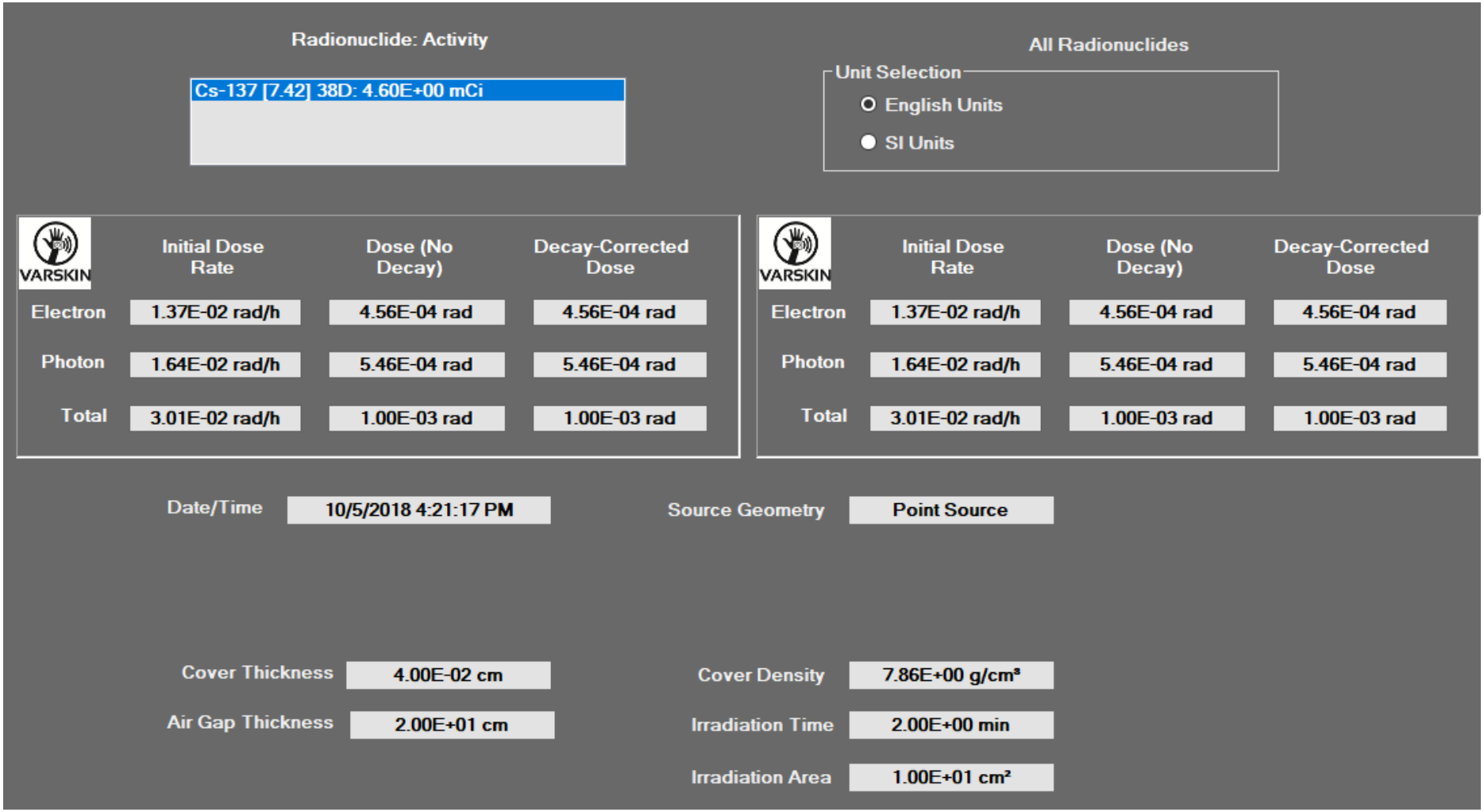
Holding Source in Hand




Radionuclide: Activity
Cs-137 [7.42] 38D: 4.60E+00 mCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
7.07E-01 rad/h
3.93E-03 rad
3.93E-03 rad
Photon
2.12E+01 rad/h
1.18E-01 rad
1.18E-01 rad
Total
2.19E+01 rad/h
1.22E-01 rad
1.22E-01 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron
7.07E-01 rad/h
3.93E-03 rad
3.93E-03 rad
Photon
2.12E+01 rad/h
1.18E-01 rad
1.18E-01 rad
Total
2.19E+01 rad/h
1.22E-01 rad
1.22E-01 rad
Date/Time
10/5/2018 4:18:11 PM
Source Geometry
Point Source
Cover Thickness
4.00E-02 cm
Air Gap Thickness
0.00E+00 cm
Cover Density
7.86E+00 g/cm³
Irradiation Time
2.00E+01 sec
Irradiation Area
1.00E+01 cm²

Individual Holding the Rod




Radionuclide: Activity
Cs-137 [7.42] 38D: 4.60E+00 mCi
All Radionuclides
Unit Selection
English Units
SI Units
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.37E-02 rad/h 4.56E-04 rad 4.56E-04 rad
Photon 1.64E-02 rad/h 5.46E-04 rad 5.46E-04 rad
Total 3.01E-02 rad/h 1.00E-03 rad 1.00E-03 rad
VARSKIN
Initial Dose Rate
Dose (No Decay)
Decay-Corrected Dose
Electron 1.37E-02 rad/h 4.56E-04 rad 4.56E-04 rad
Photon 1.64E-02 rad/h 5.46E-04 rad 5.46E-04 rad
Total 3.01E-02 rad/h 1.00E-03 rad 1.00E-03 rad
Date/Time 10/5/2018 4:21:17 PM
Source Geometry Point Source
Cover Thickness 4.00E-02 cm
Air Gap Thickness 2.00E+01 cm
Cover Density 7.86E+00 g/cm³
Irradiation Time 2.00E+00 min
Irradiation Area 1.00E+01 cm²

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Calculated Doses

- Authorized user handling this source capsule: **122 mrem**
- Corporate individual acknowledged holding the source rod of the Troxler gauge (with the source still attached): **1 mrem**
- NRC limit to the skin: 50 rem

NRC License Conditions

14. Sealed sources containing licensed material shall not be opened or sources removed from source holders by the licensee, except as specifically authorized.

18. Any cleaning, maintenance, or repair of the gauge(s) that requires detaching the source or source rod from the gauge shall be performed only by the manufacturer or by other persons specifically licensed by the U.S. Nuclear Regulatory Commission or an Agreement State to perform such services.

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety Culture

- The U.S. Nuclear Regulatory Commission (NRC) defines nuclear safety culture as the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment.
- Licensee was so concerned about adhering to US Department of Transportation rules for transporting the gauge in a DOT-approved container that they ended up making poor choices in the radiation protection area
- Panic, late hour, desire to go home, lack of clarity in their emergency procedures… perhaps these also contributed to the poor decision-making