ConRAD (Software Application User Guide):

https://www.proprofskb.com/blog/user-manual-for-software/

User Guide Instructions

Outline: Fill in at the end. Essentially a how to use the user manual.

Getting Started: T

Installation Guide: Add when more information is known about flet and executables.

Features and Functionality: Json file of isotopes (name file). No parameters can't be 0 at the moment, subject to change based on alpha equation.

Trouble Shooting: If app freezes. If added wrong isotope to .json file open file a delete the added information (add photos and instructions on how to do this). Add more as more testing is done.

Additional Resources:

Analytical Assumptions: (Grace section)

In order to create the equations used for dose rate of alpha, beta, and gamma radiation sources, the following analytical assumptions were made. The same equation was used to determine gamma and beta radiation, therefore the same assumptions were made. There is a sperate equation and assumptions for alpha sources.

For gamma and beta sources, we assume:

- The radioactive isotope is a point source.
- Surface area of the detector is factored into counts per second value from the detector.
- The μ in the absorption coefficient (μ_m/ρ_m) is valid to use in the Beer-Lambert Law for gamma and beta radiation.
- That Ionactive is a reliable source with accurate information, especially the page "Formula for calculating dose rates from gamma emitting radioactive materials," Mark Ramsay (2024).

For alpha sources, we assume:

- Using only very low energy alpha particles (non-relativistic)
- Using the Continuous Slowing-Down Approximation (CSDA):

    - Assuming continuous energy loss
    - Neglecting stochastic variations between different particles of the same energy
    - Neglecting angular deflection of the particles
    - The rate of energy loss at every point along the track is assumed to be equal to the total stopping power
- Assumed even distribution of particles throughout source which also spread out evenly

Plus, assumptions of the stopping equation include [4]:

- "for maximum energy transfer, the collision is head on.
- mass of α - particle is much greater than mass of electron.
- the velocity of electron in its orbit is much smaller than the velocity of heavy ion.
- the energy loss may be consider classically, because if Pi × b >> hbar this domain is classical physics domain. but Pi× b ≈ hbar uncertainty principle comes in to play. For such cases the formula has to be modified.
- the binding energy of electron in side the atom is very low as compared to the energy of incoming particle so that the electron can be treated as free.
- energy loss per collision of incoming particle is so small that its velocity after the collision may be taken the same."

Isotope assumptions (Paige):

ConRAD has the capacity to use any radioactive isotope from the periodic table of elements as well as allowing the user to enter their own isotope information. This information provides the energy emissions at the source to be used in the calculation equations. While there are many available options for the emissions of these radionuclides, the most commonly used and extensive is the Radionuclide and Radiation Protection Data Handbook 2002 (REFERENCE 6), colloquially known as the Delacroix tables. This set of data tables provides the top three highest emissions, of each radiation type, of every radionuclide and the probability of these emissions. All data is collected through experimental data and in reference to an isotope activity of 1 MBq

ENTER ANY MORE DELACROIX ASSUMPTIONS

The data from the Radiouclide and Radiation Protection Data Handbook 2002 was transformed into dictionary to be used in the ConRAD software with the following assumptions:

- Provide an average energy for gamma and beta emissions and an array of the top three energies of alpha emissions.
- If there is only one energy at an 100% emission rate. The energy stated is the energy.
- If there is only one energy at a <100% emission rate. The energy stated is the energy as any counts we are getting are of that energy.

- If there is only one energy at a >100% emission rate. The energy stated is the energy as any counts we are getting are of that energy.
- If there are two or more energies and a total emission probability of 100%. Calculated as average energy using the following equation:

$$(e_1 \cdot p_1) + (e_2 + p_2) + (e_1 + p_2)$$

- If there are two or more energies and the total emission probability is not equal to 100%. Average energy is calculated using the following:

$$\frac{(e_1 \cdot p_1) + (e_2 \cdot p_2) + (e_3 + p_3)}{p_1 + p_2 + p_3}$$

- If there are 'Electrons' included. These are included with the beta emissions.
- If there are beta and electrons within the table. Only the beta emissions are considered as the electron emissions should be negligible in comparison.
- Alpha emissions are stated as an array with the following layout: [e_1, p_1, e_2, p_2, e_3, p_3]. This is because each initial alpha energy will have a different stopping distance.
- Always rounded values up, even if a value of 10.1 rounds to 11.
- Some sources in the Delacroix have a '% omitted'. These values have been ignored.
- If the emission is stated to be <1%. Assumed to be 1% emission probability.

References:

1. Gamma/beta assumptions: https://ionactive.co.uk/resource-hub/guidance/formula-for-calculating-dose-rates-from-gamma-emitting-radioactive-materials
2. CSDA alpha assumptions 1: https://physics.nist.gov/PhysRefData/Star/Text/appendix.html
3. CSDA alpha assumptions 2: https://ecss.nl/item/?glossary_id=44
4. Alpha stopping power assumptions: https://etd.aau.edu.et/server/api/core/bitstreams/6c122e08-068c-475e-9399-e4ad032563fd/content
5. Main alpha equation source: https://www.sciencedirect.com/science/article/pii/S2352179120300107
6. Delacroix Tables: https://www.hep.ucl.ac.uk/~saakyan/phas0052/Radionuclide_Data_Handbook.pdf