Calculation of Dose received from Spill Incident on 3/28/24

Scenario: Employee spilled material at ~ 11 AM on 3/28/24. Material spilled was C-14 labeled 1,3-dichloropropene. Employee remained in area after the incident to wipe up the spilled liquid and place it in a waste container in a lab fume hood in the lab. Personal contamination was identified on the employee's shoes, but not other clothing or skin.

Known:

- A nasal swab was conducted shortly after the incident (within 1 hour) that did not show any detectable activity.
- A bioassay was conducted on 3/29/24 at 11 AM to assess potential exposure. This was not a full 24-hour urine sample, but just a sample collected at this time. This bioassay resulted in a C-14 concentration of 408 dpm/ml in the urine. This urine sample consisted of 76 ml of sample.
- A second bioassay was conducted on 4/1/24 at 11 AM. Again, this was a spot sample and not a 24-hour cumulative sample. This sample was non-detectable at 0 dpm/ml.
- Vapor pressure of 1,3-dichloropropene is 23 – 34 mmHg, so inhalation exposure is possible during the incident (Wikipedia, 2024).
- Biological half-life of 1,3-dichloropropene is 5.5 hours (Stott and Kastl, 1986)

Calculation: Based on the rapid decrease of the C-14 in the urine bioassay, it was clear that using the IRFs from NUREG CR-4884 for carbon dioxide was not appropriate for the 1,3-dichloropropene exposure. Based on these results, a literature search was conducted to determine the biological half-life of 1,3-dichloropropene in the body, and how it would be eliminated from the body.

Stott and Kastl (1986) indicates that dichloropropene is primarily eliminated in the urine, and that the biological half-life of 1,3-dichloropropene in rats is 5.5 hours (Stott and Kastl, 1986). It also indicates that 50-80% of the intake will be excreted via the urine. These values will be used to calculate a compound-specific IRF to convert the urine bioassay results into a total intake from the incident.

Based on a biological half-life of 5.5 hours, a calculation was performed to determine the fraction of the intake that would be present in a urine sample collected 23 hours after the exposure. It was presumed that this urine sample contained 4 hours of urine produced from 20-24 hours after exposure (roughly 7 am to 11 am) using the formula:

Concentration in the body at any given time, t:

$$A_{body}(t) = A_i * \exp((-\ln(2)*t/T_{1/2bio})$$

Where,

$A_{body}(t)$ = Activity in the body at time t

A_i = Activity in the body initially

t = time (hours)

$T_{1/2bio}$ = Biological half-life (5.5 hours)

For a urine sample collected at 11 am on the day after the spill (24 hours after spill occurred), it is assumed that the activity collected was the urine built up from when the worker woke up (~7 am) until 11 am.

Fraction of the intake in this sample:

$$A_{urine24} = (A_{body}(20)-A_{body}(24))*f$$

Where,

$A_{urine24}$ = Activity in the urine sample collected at 24 hours after the incident

f = fraction of compound that is excreted in the urine (50%)

Abody(20) = activity in the body at 20 hours post-incident

= Ai * exp ((-ln(2) * 20 hours)/5.5 hours)
= Ai * 0.0805

Abody(24) = activity in the body at 24 hours post-incident

= Ai * exp ((-ln(2) * 24 hours)/5.5 hours)
= Ai * 0.0486

The difference between the amount of 1,3-dichloropropene in the body at 20 hours and the amount of 1,3-dichloroproprene in the body at 24 hours will equal the amount of 1,3-dichloropropene that that eliminated from the body during these 4 hours. 50% of the amount of 1,3-dichloroproene that was eliminated from the body will be found in the urine. This allows a calculation of the fraction of the total intake that will be found in a urine sample that was collected 24 hours after the exposure event and contained the urine produced between 20 and 24 hours after exposure.

From this formula, it can be concluded that

$A_{urine24} = (0.0805\ A_i - 0.0319\ A_i)\ *0.5$

$A_{urine24} = A_i*0.016$

Radiological decay will not be significant for C-14 over this time period. This calculation indicated that 1.6% of the intake will be present in the urine sample collected 24 hours after the incident, which is an appropriate value to use for the IRF for this compound.

The total intake from the incident will equal:

$Intake = C_{bio} * V_{bio} / IRF / 2.2 \times 10^6$

Where,

C_{bio} = Concentration of C-14 in the bioassay sample (dpm/ml)
V_{bio} = Volume of the bioassay sample (mL)
IRF = Intake Retention Fraction (1.6%)
2.2×10^6 = conversion factor dpm-to-uCi

Intake = 408 dpm/ml * 76 ml / 0.016 / 2.2 x 10^6 (dpm-to-uCi)

Intake = 0.88 uCi

Dose = Intake / ALI * 5000 mrem

Dose = 0.88 uCi / 2000 uCi * 5000 mrem

Dose = 2.2 mrem

References

W.T. Stott, P.E. Kastl. 1986. Inhalation pharmacokinetics of technical grade 1,3-dichloropropene in rats. Toxicology and Applied Pharmacology, Volume 85, Issue 3. Pages 332-341.

Wikipedia. 2024-04-26. 1,3-Dichloropropene. https://en.wikipedia.org/wiki/1,3-Dichloropropene .