

Occupational Safety & Environmental Health
Radiation Safety Service
1239 Kipke Drive 1010
[764-4420]

CARBON - 14
[C-14]

PHYSICAL DATA

Beta Energy:	156.4 keV (maximum) 49.5 keV (average)(100%)
Physical Half-Life:	5730 years
Biological Half-Life:	10 days (Whole Body)
Effective Half-Life:	10 days (Bound / Whole Body)
Effective Half-Life:	40 days (Unbound / Bone)
Specific Activity:	4460 millicuries / gram
Maximum Beta Range in Air:	25.400 cm = 10.0 inches
Maximum Beta Range in Water / Tissue: *	0.030 cm = 0.012 inches
Maximum Range in Plexiglas / Lucite / Plastic:	0.025 cm = 0.010 inches

* [Fraction of C-14 beta particles transmitted through dead layer of skin (0.007 cm) = 17%]

RADIOLOGICAL DATA

- Critical Organ: Fat Tissue
- Routes of Intake: Ingestion, Inhalation, Puncture, Wound, Skin Contamination (Absorption)
- External exposure (deep dose) from weak C-14 beta particles is not a radiological concern.
- Internal exposure & contamination are primary radiological concerns.

Committed Dose Equivalent (CDE): 2.08 mrem / uCi
(Fat Tissue) (ingestion / inhalation / puncture)

Committed Effective Dose Equivalent (CEDE): 2.50 mrem / uCi (ingestion)

Annual Limit on Intake (ALI): 2 mCi (ingestion: labeled organic comp'd)
2000 mCi (inhalation: carbon monoxide)
200 mCi (inhalation: carbon dioxide)

* [1.0 ALI = 2 mCi (ingested C-14 organic comp'd) = 5,000 mrem CEDE]

- Skin Contamination Dose Rate: 1055 mrem/hour per 1.0 uCi/cm² (without air reflection)
* (Localized Basal Cell Dose at 7 mg/cm² or 0.007 cm depth in tissue)
- Immersion in C-14 Contaminated Air = 2.183E7 millirem/year per uCi/cm³ at 70 um depth of tissue and 4.07E6 millirem/year per uCi/cm³ value averaged over dermis.

SHIELDING: none required (≤ 3 mm plexiglass)

SURVEY INSTRUMENTATION:

- Can detect C-14 using a survey meter equipped with a G-M pancake / frisker (15.5 cm² surface area); however, the survey meter probe **must** be at a very close range (≤ 1 inch).
- G-M survey meters have very low counting efficiency for C-14 (3%).
- Liquid scintillation counter (indirect counting) should be used to detect removable C-14 contamination on smears, swipes, swabs, etc.

PERSONAL RADIATION MONITORING DOSIMETERS (Whole Body Badge or Finger Tabs): Not Needed (beta energy too weak).

Half-Value Layer (Water): 0.005 cm = 0.05 mm
 Tenth-Value Layer (Water): 0.017 cm = 0.17 mm

Dose Rate from a 1.0 millicurie isotropic point source of C-14:

<u>DISTANCE</u>	<u>RAD/HOUR</u>
1.0 cm	1241.4
2.0 cm	250.4
15.2 cm	0.126
20.0 cm	0.0046

REGULATORY COMPLIANCE INFORMATION (10 CFR 20 / Appendix B)

- Derived Air Concentration (DAC):
 (Occupational) 1.0E-6 uCi/cc (labeled compound)
 9.0E-5 uCi/cc (carbon dioxide)
 7.0E-4 uCi/cc (carbon monoxide)
- Airborne Effluent Release Limit:
 3.0E-9 uCi/cc (labeled comp'd)
 3.0E-7 uCi/cc (carbon dioxide)
 2.0E-6 uCi/cc (carbon monoxide)

* Applicable to the assessment & control of public doses (10 CFR 20.1302). If this concentration was inhaled or ingested continuously over 1-year would produce a TEDE of 50 millirem.

- Urinalysis: Not required; however, may be requested by RSS personnel after a C-14 radioactive spill or suspected intake.
- Unrestricted Area Removable Contamination Limit: 1,000 dpm / 100 cm²
- Posting Areas or Rooms [10 CFR 20.1902(e)]: > 10,000 uCi
- Container Labeling Quantity [10 CFR 20.1905]: > 1,000 uCi

- Exempt Quantity [10 CFR 30.18]: 100 uCi
- Limited Quantity [DOT Limits / C-14 Liquids]: \leq 5.41 mCi
- Type A Quantity [DOT Limits / C-14 Liquids]: * $>$ 5.41 mCi
* [Requires Certified Type A Transport Container]
- Reportable Quantity ("RQ" / 49 CFR 172.101) 10 Ci
* [Indicate "RQ" on transfer / shipping papers & package labels]

GENERAL RADIOLOGICAL SAFETY INFORMATION

- Inherent Volatility (STP): Not Significant
- Possibility of organic C-14 compounds being absorbed through gloves.
- Care should be taken NOT to generate CO₂ gas that could be inhaled.
- Skin contamination, ingestion, inhalation, and puncture are primary concerns (potential internal doses).
- **Always** wear a lab coat and disposable gloves when working with C-14.
- Slowly monitor your hands, shoes, clothing and work area using a G-M survey meter for gross C-14 contamination (3% counting efficiency).
- Monitor for surface contamination by smearing, swabbing, swiping, or wipe testing where used and counting in a liquid scintillation counter.
- Typical liquid scintillation counter counting efficiency for C-14 (full window / maximum) ~ 95%.
- The concentration of carbon in adipose tissue, including the yellow marrow, is about 3-times the average whole body concentration. No other organ or tissue of the body concentrates stable carbon to any significant extent.
- The fractional absorption of dietary carbon (uptake to blood) is usually in excess of 0.90.
- ¹⁴C-thymidine are specifically incorporated into the DNA of dividing cells and tissues are irradiated much more uniformly from ¹⁴C incorporated into DNA than they are from ³H incorporated into DNA.
- There are three main classes of carbon compounds which may be inhaled: organic compounds, gases (CO or CO₂), and aerosols of carbon containing compounds such as carbonates and carbides.

Organic Compounds - most organic compounds are NOT very volatile under normal circumstances and the probability of these being inhaled as vapors is therefore small. In circumstances where such substances are inhaled it would be prudent to assume that once they enter the respiratory system they are instantaneously and completely translocated to the systemic circulation without changing their chemical form.

Gases - the inhalation of CO and its retention in body tissues has been studied extensively. Since gas has a relatively low solubility in tissue water, doses due to absorbed gas in tissues are insignificant in comparison with doses due to the retention of CO bound to hemoglobin. CO₂ in the blood exists mainly as a bicarbonate.

Carbonates & Carbides - It is assumed that inhaled or ingested C-14 labeled compounds are instantaneously and uniformly distributed throughout all organs & tissues of the body where they are retained with a biological half-life of 40 days.