RP GN008 – SAFE WORKING WITH FLUORINE-18

VERSION CONTROL	
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Date of Creation:	September 2011
Date of Revision and Initials of Reviewer:	N/A
Date of next review (if required):	December 2023
Document Reference Number:	HS / RP / GN008.1

Risk

Fluorine-18 is a positron emitter. This means it emits positively charged beta particles – positrons – as a result of the atomic nucleus rearranging itself and losing energy. The positrons emitted have a maximum energy of 630 keV. There is also a small amount of electron capture, but this does not significantly affect radiological protection issues. Each positron is subsequently eliminated by interaction with a negatively charged beta particle, resulting in the production of two gamma rays, each of 0.511 MeV energy. It is these penetrating gamma rays that present the risk in handling F-18, and the external radiation risk can predominate. However the half-life of F-18 is short, only about 1.8h, and its daughter is stable.

Fluorine-18 will present a risk if it gains entry to the body. It can be inhaled, ingested and absorbed (and injected). It is a gas in the elemental form at room temperature, but is normally used in an aqueously soluble compound. Its biological half-life varies according to the compound to which it is attached and the organ. In the case of 2-fluoro-2-deoxy-D-glucose (FDG) values range from 8 minutes to infinity (ICRP 53 "Radiation Dose to Patients from Radiopharmaceuticals", Annals of the ICRP Vol. 18/1-4).

Special Considerations

- High-density shielding material should be used when storing F-18, but during the handling of the material substantial shielding is often impractical, and protection against external radiation must be predominantly by time and distance.
- Doses to the hand and fingers could be high when injecting F-18. A tungsten syringe shield provides useful shielding in this case, but the benefit of its use should be balanced against the potential of causing spillage and a longer handling time.
- The short half-life of this isotope means that radiation levels reduce quickly.

Monitoring

- Since the predominant radiation emitted by F-18 is gamma, field contamination monitors should use sensitive gamma detectors. Contamination therefore should normally be monitored by scintillation detectors, such as the Mini Instruments type 44A, or proportional counters like the Berthold LB124. These will give high readings next to any source of F-18, which could mask any readings from contamination. Sources must therefore be removed or shielded whilst monitoring for surface contamination. Further information is available in Guidance Note GN003 and from the Radiation Protection Unit.

- Dose rate monitoring can be undertaken by any energy-compensated geiger-müller tube, as well as proportional and ion chamber detectors.
- Conventional personal dosemeters are suitable for the external radiation from F-18.
- The need for any personal monitoring is reported in the relevant Proposed Scheme of Work form.
- Biological monitoring need only be considered after a suspected or known uptake. Such measurements would have to be undertaken by an outside competent laboratory after consultation with the RPU.

Physical Data and properties

Decay Data	
Half life ($t_{½}$)	1.83 hours
Decay constant (λ)	0.3788 h^{-1}
Daughter product	Stable (oxygen-18)

Emissions	Max. Energy	Abundance
Positron emission	634 keV	97%
X-ray emission	minor	
Gamma emission	511 keV	194%
Dose rate from a point source of 1 MBq at 1m distance	0.2 µSv/h	

Transmission through materials [a]	1 cm thick	10 cm thick	HVL	TVL
Lead	~ 0.27	~ 2.4 x 10^{-6}	6 mm	17 mm
Steel	~ 0.52	~ 1.5 x 10^{-3}	27 mm	64 mm
Concrete	~ 0.81	~ 0.13	~ 34 mm	~ 113 mm

Biological Data	All Compounds
Annual Limit of Intake by inhalation [b]	220 MBq
Annual Limit of Intake by ingestion [b]	410 MBq

Typical Contamination Readings [c]	Mini 44A	Berthold LB124
Background count rate (cps)	~ 8	~ 7
Count rate above background for spot activity of 1 Bq (cps)	~ 0.3 [d]	-
Count rate above background for a large area activity of 1 Bq cm^{-2} (cps)	~ 4 [d]	~ 25

Decay Table							
Hours	**% Remaining Activity**	**Hours**	**% Remaining Activity**	**Hours**	**% Remaining Activity**	**Hours**	**% Remaining Activity**
-4	455	4	22.0	12	1.06	20	0.051
-3	311	5	15.0	13	0.727	21	0.035
-2	213	6	10.3	14	0.498	22	0.024
-1	146	7	7.05	15	0.341	23	0.016
0	100	8	4.83	16	0.233	24	0.011
1	68.5	9	3.31	17	0.160		
2	46.9	10	2.26	18	0.109		
3	32.1	11	1.55	19	0.075		

NOTES:

a) HVL – Half-value Layer – is the thickness of a material that will reduce the dose rate to half of its original value. TVL – Tenth-value Layer – is the thickness that will reduce it by a factor of ten. The HVL and TVL values for lead and steel are from a standard reference; the values reported for steel are actually those for iron. The remaining values are calculated using reference mass attenuation coefficients for 500 keV photons. The values reported for concrete are for a density of 2.3 t m^{-3}.

b) The Annual Limit of Intake represents the activity that, if taken into the body, would lead to a committed effective dose equal to the occupational annual dose limit for the whole body for classified workers of 20 mSv. This value would have to be reduced if there is any other source of occupational exposure. Where there are inhalation values for different particle sizes, the most restrictive is quoted here.

c) At a probe-to-source distance of 10 mm.

d) Data are not readily available for this instrument. The value provided is an approximate estimate based on data for Ba133, which has a similar gamma energy and abundance.

For advice on any of the above topics please contact the Radiation Protection Unit, radiation@ed.ac.uk.