RP GN005 – SAFE WORKING WITH TECHNETIUM-99m

VERSION CONTROL	
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Risk

Technetium-99m is what is known as a metastable state nuclide. This means that it contains more energy in the atomic nucleus than the normal state. The excess energy is lost by the emission of photons, i.e. gamma rays. The "decay" of the nuclide does not then involve any nuclear transformation, and is known as "isomeric transition". Its daughter is the radioactive isotope Tc-99. For all intents and purposes, the emission can be regarded as monoenergetic gamma radiation, at 141 keV energy. Since no particulate radiation is emitted, the external dose rates from Tc-99m are low, although its gamma ray is penetrating. The daughter Tc-99 is a beta emitter, but has such a long half-life (210,000 years) that it only grows into the material very slowly, and there is little actually present during the expected period of use of the Tc-99m.

Technetium-99m will present a risk if it gains entry to the body. It can be inhaled, ingested and absorbed (and injected), and the risk varies according to the chemical form. It has a short radiological half life, but its biological half-life varies widely according to the compound to which it is attached. Values range from 8 minutes to 7 days (ICRP 53 "Radiation Dose to Patients from Radiopharmaceuticals", Annals of the ICRP Vol. 18/1-4). In the case of intravenously injected pertechnetate, the nuclide concentrates in the thyroid, GI tract and liver (ICRP 30 "Limits for Intakes of Radionuclides by Workers", Annals of the ICRP Vol. 4/3-4).

Special Considerations

- High-density shielding material should be used for the storage of Tc-99m, 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 Tc-99m. 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.
- Normal x-ray lead aprons only provide a small amount of shielding; a 0.35 mm Pb apron would reduce the radiation level by about 50%. Lead aprons should not be worn if they compromise the efficacy of clothing worn to protect against contamination.

Monitoring

- Since only gamma radiation is emitted by Tc-99m, field contamination monitors have to have sensitive gamma detectors. Contamination therefore has normally to be monitored by scintillation detectors, such as the Mini 44A and 44B. These will give high readings next to any source of Tc-99m, 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.
- Conventional personal dosemeters are suitable for the external radiation from Tc-99m.
- 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 ($t_{½}$)	6.0 hours
Decay constant (λ)	0.1155 h^{-1}
Daughter product	Radioactive (Technetium-99)

Emissions	**Max. Energy**	**Abundance**
Electron emission	-	None
X-ray emission	-	None
Gamma emission	141 keV	90%
Dose rate from a point source of 1 GBq at 1m distance	23 μSv/h	

Transmission through materials [a]	**1 mm thick**	**10 mm thick**	**HVL**	**TVL**
Lead	~ 0.1	~ 1.2 x 10^{-10}	0.3 mm	1 mm
Steel	~ 0.8	~ 0.2	4.5 mm	15 mm
Concrete		~ 0.7	~ 20 mm	~ 70 mm

Biological Data	**All unspecified compounds**	**Halides & Nitrates**	**Oxides & Hydroxides**
Annual Limit of Intake by inhalation [b]	1 GBq	690 MBq	690 MBq
	All Compounds		
Annual Limit of Intake by ingestion [b]	910 MBq		

Typical Dose Rate Readings [c]	**Mini E**	**Mini EP15**
Background count rate (cps)	1	1
Count rate above background equivalent to a dose rate of 1 μGy h^{-1} (cps)	4	12
Typical Contamination Readings [d]	**Mini 44A & B**	**Berthold LB1210D**
Background count rate (cps)	~ 8	~ 8

Decay Table

Hours	% Remaining Activity	Hours	% Remaining Activity	Hours	% Remaining Activity	Hours	% Remaining Activity
-24	1,580	9	35.5	39	1.12	69	0.035
-21	1,120	12	25.1	42	0.798	72	0.025
-18	792	15	17.8	45	0.565	75	0.017
-15	561	18	12.6	48	0.400	78	0.012
-12	397	21	8.94	51	0.283	81	0.009
-9	281	24	6.32	54	0.200	84	0.006
-6	199	27	4.48	57	0.142	87	0.004
-3	141	30	3.17	60	0.100	90	0.003
3	70.8	33	2.24	63	0.071	93	0.002
6	50.1	36	1.59	66	0.050	96	0.001

Count rate above background for spot activity of 1 Bq (cps)	0.12	-
Count rate above background for a large area activity of 1 Bq cm^{-2} (cps)	1.5	4

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 of a material that will reduce it by a factor of ten. These values are calculated, using reference attenutation coefficient data for 150 keV photons. The values for steel are actually those for iron. The values 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) Dose-rate readings should be undertaken with an instrument scaled in dose-rate units and using a compensated GM detector or ion chamber. The values in the table are for instruments that could be used as a backup if a dose-rate meter is not available.

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

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