RP GN006 – SAFE WORKING WITH PHOSPHORUS-32

VERSION CONTROL	
Document Author:	Colin Farmery
Date of Creation:	September 2011
Date of Revision and Initials of Reviewer:	June 2015 (CF)
Date of next review (if required):	December 2023
Document Reference Number:	HS / RP / GN006.2

Risk

Phosphorus-32 decays by emitting high-energy beta particles. The maximum beta energy is 1.7 MeV. Because of this high energy, the beta particles can travel some distance through air, so there is a potential external radiation risk to anyone in the same room when the radionuclide is being used. The highest dose rates, however, are found close to the source, particularly high activity sources in small handling containers such as Eppendorf tubes. The greatest risk in handling such sources is to the fingers and to the eyes. In addition, because of its high beta energies, there is the possibility of the presence of significant amounts of bremsstrahlung. The amount will be critical upon the type of material in which the beta radiation is being absorbed.

Phosphorus-32 will present a risk if it gains entry to the body. It can be inhaled, ingested and absorbed, and the risk varies according to the chemical form, although volatile forms of phosphorus are unusual in research laboratories. A large percentage of any ingested phosphorus is deposited in bone. The isotope has a relatively short radiological half-life, but is only slowly eliminated from the body, its biological half-life varying from a few days (soft tissue) to infinity (bone). The bone and lungs are considered to be the critical organs.

Special Considerations

- To reduce the risk of exposure to external radiation, full use should be made of perspex shields, containers and handling devices. In particular, small volume, high activity solutions in Eppendorf and similar tubes should be handled with forceps or in a perspex shield. Full use should be made of perspex screens when handling stocks and other active sources and waste material should be kept in a suitably shielded container or storage area. A technique for opening and dispensing stock vials is outlined in the Handbook for Laboratory Workers ("Radiation Protection: *A Handbook for Laboratory Workers",* T. J. Moseley ed., Association of University Radiation Protection Officers, 4th edition, 2007).
- To reduce the risk of the generation of bremsstrahlung, shielding material must be of a low density and/or low atomic number. Perspex is normally sufficient.

- If P-32 is being used in a gaseous, vapour or aerosol form, or there is a risk of the generation of such, the URPA must be consulted before starting work.

Monitoring

- Due to the high energy of the beta radiation, conventional contamination monitors with end-window Geiger Müller detectors will easily detect small quantities of this isotope. Examples are the Mini E, EL and EP15. These will give high readings next to any source of P-32, which could mask any readings from contamination. Sources must therefore be removed or shielded whilst monitoring for surface contamination. Further information is available in Code of Practice CoP003 and from the Radiation Protection Unit.
- Whole-body personal dosemeters might need to be worn if high activities of P-32 are handled. In addition, because of the higher risk to the hands and fingers, extremity thermoluminescent dosemeters might be appropriate.
- Biological monitoring can be carried out by monitoring the concentration in the urine. The presence of P-32 indicates that there has been an uptake, and the actual concentration can be used to estimate an approximate committed effective dose. In certain circumstances whole body counting is also an appropriate method to detect/assess the quantity of P-32 deposited on bone. Such measurements must be undertaken by an outside competent laboratory after consultation with the Radiation Protection Unit.
- The need for personal monitoring is reported in the relevant Proposed Scheme of Work form.

Physical Data and properties

Decay Data	
Half life ($t_{½}$)	14.3 days
Decay constant (λ)	0.048 d^{-1}
Daughter product	Stable (Sulphur-32)

Emissions	Max. Energy	Av. Energy	Abundance
Beta emission	1710 keV	700 keV	100%
Gamma emission	None [a]		
Dose rate from a point source of 1 MBq at 1m distance	~ 10 µSv/h		

Transmission through materials	Air	Plastic	Water	Glass
Maximum range of beta	6 m	6.3 mm	8 mm	3.4 mm

Biological Data	All unspecified compounds
Annual Limit of Intake by inhalation [b]	6.3 MBq
Annual Limit of Intake by ingestion [b]	8.3 MBq
Critical organs	Lungs / Bone

Typical Dose Rate and Contamination Readings [c,d]	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)	~ 2	~ 7
Count rate above background for spot activity of 1 Bq (cps)	~ 0.2	~ 0.3
Count rate above background for a large area activity of 1 Bq cm^{-2}	~ 1.7	~ 4

NOTES:

a) This excludes any possible bremsstrahlung.
b) The Annual Limit of Intake (ALI) represents the activity which, 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 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 with an 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. The value quoted is for beta radiation only.
d) Contamination readings are quoted for a probe to source distance of 10 - 20 mm.

Decay Table

Days	% Remaining Activity	Days	% Remaining Activity	Days	% Remaining Activity	Days	% Remaining Activity
-7	140	3	86	13	55	23	33
-6	134	4	82	14	51	24	31
-5	127	5	78	15	48	25	30
-4	121	6	75	16	46	26	28
-3	116	7	71	17	44	27	27
-2	110	8	68	18	42	28	26
-1	105	9	65	19	40	29	24
0	100	10	62	20	38	30	23
1	95	11	59	21	36	31	22
2	91	12	56	22	34		

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