RP GN004: Safe working with Chromium-51

VERSION CONTROL	
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Date of Creation:	July 2009
Date of Revision and Initials of Reviewer:	N/A
Date of next review (if required):	December 2023
Document Reference Number:	HS / RP / GN004.1

Risk

Chromium-51 is an electron-capture nuclide. This means that the unstable atom decays by the capture of an orbital electron by the nucleus, allowing the formation of a stable product nucleus. The only external emission from the electron capture mode is caused by the excess energy of the electrons being lost as x rays and ejected electrons. In the case of Cr-51 there is a 20% probability of decay per transformation resulting in a very low energy x ray, and 67% probability resulting in an even lower energy electron. However, it also emits a medium energy gamma ray at ~ 10% probability per transformation, and it is this gamma ray that contributes most of the exposure (see table overleaf). External exposure to chromium-51 is therefore a relatively low risk, although the radiation concerned is penetrating.

Chromium-51 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. It has a relatively short radiological half life, but is only slowly eliminated from the body, its biological half-life being 616 days. The lower large intestine is the critical organ for the intake of soluble compounds and the ingestion of insoluble compounds. The lung is the critical organ for the inhalation of insoluble compounds.

Special Considerations

- High-density shielding material should be used for the storage of Cr-51, but shielding is unlikely to be necessary for the quantities being handled during tracer work.
- If Cr-51 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 both the low energy and the low percentage emission from Cr-51, field contamination monitors have to have sensitive gamma detectors. Contamination therefore has normally to be monitored by scintillation detectors, such as the Mini 42B and 44B. These will give high readings next to any source of Cr-51, 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 URPA.

- Conventional personal dosemeters will pick up the external radiation from Cr-51, although they are unlikely to be needed for the small activities used in tracer work.
- Biological monitoring can be carried out by monitoring the concentration in the urine. The presence of Cr-51 indicates that there has been an uptake, and the actual concentration can be used to estimate an approximate committed effective dose. Whole body counting is also an appropriate method. Such measurements must be undertaken by an outside competent laboratory after consultation with the URPA.
- The need for personal monitoring is reported in the relevant Proposed Scheme of Work form.

Physical Data and properties

Decay Data				
Half life ($t_{1/2}$)	**27.7 days**			
Decay constant (λ)	**0.025 d^{-1}**			
Daughter product	**Stable (Vanadium-51)**			
Emissions	**Max. Energy**		**Abundance**	
Electron emission	4 keV		**67%**	
X-ray emission	5 keV		**20%**	
Gamma emission	320 keV		**10%**	
Dose rate from a point source of 1 GBq at 1m distance	5 μSv/h			
Transmission through materials (1)	**10 mm thick**	**100 mm thick**	**HVL**	**TVL**
Lead	~0.03	$<10^{-5}$	2mm	**7mm**
Steel	~0.7	~0.04	21mm	**50mm**
Concrete	~0.8	~0.08	~28mm	**~93mm**

Biological Data	**All unspecified compounds**	**Halides and Nitrates**	**Oxides and Hydroxides**
Annual Limit of Intake by inhalation (2)	667 MBq	588 MBq	**556 MBq**

Biological Data	**Hexavalent compounds**	**Trivalent compounds**
Annual Limit of Intake by inhalation (2)	526 MBq	**541 MBq**
Critical organ	lungs/lower large intestine	**lungs/lower large intestine**
Typical Dose Rate Readings (3)	**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)	2.2	**6**
Typical Contamination Readings (4)	**Mini 42B**	**Mini 44B**
Background count rate (cps)	2	**6**
Count rate above background for spot activity of 1 Bq (cps)	0.011	**0.041**
Count rate above background for a large area activity of 1Bq cm^{-2}	**NA**	**0.5**

Notes:

1. 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 10mm and 100mm values for lead and steel are derived from the reported HVL value. All values for concrete are derived from linear absorption coefficient data and based on a density of 2.3 t m^{-3}.

2. 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.
3. 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.
4. At a probe to source distance of 10 -20 mm

Decay Table

Days	% Remaining Activity	Days	% Remaining Activity	Days	% Remaining Activity	Days	% Remaining Activity
-9	125	17	65	44	33	71	**17**
-6	116	20	61	47	31	74	**16**
-3	108	23	56	50	29	77	**15**
-1	103	26	52	53	27	80	**14**
2	95	29	48	56	25	83	**13**
5	88	32	45	59	23	86	**12**
8	82	35	42	62	21	89	**11**
11	76	38	39	65	20	92	**10**
14	**70**	**41**	**36**	**68**	**18**	**95**	**9**

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