Doses to the embryo/foetus from intakes of radionuclides by the mother and the impact on unsealed source work by female laboratory workers.

Recent studies [1,2] have indicated that in some circumstances when working with unsealed sources the foetus can receive a higher dose than the mother following an intake of radionuclide. Dose factors for different mechanisms of uptake have been calculated for a wide range of artificial and naturally occurring radionuclides. With many radionuclides the difference in uptake is not significant, or, in the case of the actinides greatly less, but with radionuclides used in the biomedical sciences there is a preferential uptake and this is most significant with the bone building elements of phosphorous and calcium.

In AURPO Guidance Notes to IRR99 Appendix 3 Model A[3], maximum working quantities for a Supervised Area, equivalent to an internal dose constraint of 0.2mSv, for different grades of laboratory and different types of work were derived from an NRPB model[4]. For non-volatile work these equated to 120 ALIs in a Grade 'C' laboratory and 1200 ALIs in a Grade 'B' laboratory.

Working to an internal dose constraint of 0.2mSv in Model A allows an increased dose factor of 5 for the foetus without breaching the 1mSv dose constraint of IRR99 Reg 8(5). This will accommodate all radionuclides except the phosphorous and calcium radionulides. The highest increased dose factors associated with these radionuclides are given in Table 1 below:-

Table1 - Foetal dose factors associated with intakes of radionuclide by the mother

Radionuclide	Pathway	Increased dose factor
P-32	inhalation	x 17 at 35 weeks x 13 during term of pregnancy
P-32	ingestion	x 14 at 35 weeks x 10 during term of pregnancy
P-33	inhalation	x 23 at 25 weeks x 19 during term of pregnancy
P-33	ingestion	x 25 at 25 weeks x 20 during term of pregnancy
Ca-45	ingestion	x 16 at 25 weeks x 11 during term of pregnancy
Ca-47	ingestion	x 6.3 at 35 weeks x 4.8 during term of pregnancy

If one took the highest factor from the above table (25 for P-33 with the intake at 25 weeks) and used it for all the phosphorous and calcium radionuclides, one would need to work to a dose constraint from the internal hazard to the mother of 0.04mSv in order to comfortably meet the constraint to the foetus of 1mSv. In our model, for work with non-volatile radionuclides, this would mean working to a limit of 24 ALIs in a Grade 'C' laboratory and 240 ALIs in a Grade 'B' laboratory. This is still a considerable amount of activity and for penetrating radiations control of the external hazard may still be the overriding factor. Therefor it should still be possible to choose a maximum working level for a supervised area that will satisfy the dose constraint for the foetus whilst not discriminating against women workers.

Table 2 gives the activities associated with various multiples of the ALI for commonly used radionuclides.

Table 2 - ALIs/Activities for the Common Radionuclides

Radionuclide	1 ALI	24 ALI	120 ALI	240 ALI	1200 ALI
H-3 (water)	1.1 GBq	26 GBq	132 GBq	264 GBq	1320 GBq
H-3 (OBT)	470 MBq	11 GBq	56 GBq	113 GBq	560 GBq
C-14	34 MBq	816 MBq	4 GBq	8.2 GBq	40 GBq
S-35	15 MBq	360 MBq	1.8 GBq	3.6 GBq	18 GBq
P-32	6.2 MBq	149 MBq	744 MBq	1.5 GBq	7.4 GBq
P-33	14 MBq	336 MBq	1.7 GBq	3.4 GBq	17 GBq
Ca-45	7.4 MBq	178 MBq	888 MBq	1.8 GBq	8.9 GBq
Ca-47	9.5 MBq	228 MBq	1.1 GBq	2.3 GBq	11 GBq
Cr-51	530 MBq	13 GBq	64 GBq	127 GBq	640 GBq
Fe-55	22 MBq	528 MBq	2.6 GBq	5.3 GBq	26 GBq
Rb-86	7.1 MBq	170 MBq	852 MBq	1.7 GBq	8.5 GBq
I-125	1.3 MBq	31 MBq	156 MBq	312 MBq	1.6 GBq

The ALIs (Annual limits of intake) in the above table are based on the most restrictive pathway.

Because of the external hazard from P-32 and Rb-86 the 24 ALI level for work in a Grade 'C' Supervised Area is still on the high side and we currently work to half these levels at Sheffield University. The risk from the internal hazard therefor becomes very low and it is acceptable for female workers to carry out work at this level without apprehension about the potential dose to the foetus.

In the event of a major incident, where activities approaching the maximum permitted levels are spilt, an internal dose assessment should be made for all female workers involved. Only after the results of the assessment have been evaluated and found to be satisfactory should any pregnant workers be allowed to resume their work. (NB It should be noted that the model used in determining the maximum working levels assumes that there is one major spillage per year and that this accounts for the bulk of the potential dose received by the worker.)

T.J.Moseley, University of Sheffield

References

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4. NRPB-M443 Categorisation and Designation of Working Areas in which Unsealed Radioactive Materials are used. Hudson AP, Shaw J, Dec 1993