Review of BAT at University of Sheffield - 2011

Introduction

The use of Best Achievable Techniques (BAT) in relation to the accumulation and disposal of radioactive wastes is a requirement of all Environment Agency (EA) permits that relate to radioactive waste. BAT has replaced BPM (Best Practicable Means) and BPEO (Best Practicable Environmental Option). As BPEO only ever affected the nuclear sector, for the non-nuclear sector BAT has just replaced and is equivalent to BPM.

We are required to use BAT to:-

- justify the use of radioactive materials
- minimise activity and volume of radioactive waste generated
- dispose of radioactive waste so as to minimise the impact on the environment and the public.

All facilities used for the disposal and storage of radioactive waste should be maintained in good repair. This will relate to LEV, drainage systems and solid waste storage facilities. We are also required to routinely check effectiveness of procedures, systems and facilities in meeting the requirements of BAT. Staff should be adequately trained to meet the requirements of BAT and appropriate records must be kept to demonstrate compliance.

Scope

This BAT review relates to work with radioactive materials at all University of Sheffield sites covered by the following waste authorisations:

1) BU7073, 13/06/03, University Buildings, Western Bank

2) BL2068, 17/07/01, University of Sheffield Medical School, Royal Hallamshire Hospital

Justification

BAT starts with a justification for the use of radioactive material and an assessment of the type, volume/quantity, and activity of radioactive waste that is likely to be produced.

We have covered this requirement by our revised work certificate application form, which was introduced in Oct 2002 (http://cms.shef.ac.uk/safety/ir/localrules/registration.html). This requires the user to make a justification statement and also asks for an estimation of the various waste streams, potential activities to be used in the experimental work and the frequency of these activities. Areas where work is to be carried out are inspected by Safety Services.

Environmental Impact Assessments have been reviewed and are appended to this document. They show that all predicted doses to members of the public are well below 10uSv/y. They give justification to our disposal policies, in particular, that aqueous wastes should be disposed of without delay.

Disposal Strategies

Gaseous disposals are kept to a minimum with gases trapped and recycled where reasonably practicable.

Solids are stored for decay, when appropriate, to minimise disposal costs and environmental impact.

Aqueous wastes are disposed of without delay to minimise the risk and impact of accidental spillages. This is justified because of the limited aqueous disposals and the correspondingly low environmental impact.

Operational Procedures

The ultimate responsibility for all operational procedures lies with the Vice-Chancellor of the University. The competent person for management of radioactive waste procedures and compliance with the conditions of Permits under Environmental Permitting Regulations 2010 (*authorisation issued under the Radioactive Substances Act 1993 now come under EPR2010*) is the RPA Mr T.J.Moseley. He is assisted by a technician (Dr Chris Bull) who is responsible for the day-to-day running of the waste stores and decay store, collection of radioactive wastes (solid and scintillant wastes), sorting, storing and onward transfer of wastes to SRCL (formerly White Rose Environmental). In departments it is the responsibility of the DRPS to organise waste removal (solids and scintillant waste) to the waste stores and if necessary delegate this responsibility to a suitably trained technician.

In departments- radioactive waste should be segregated from non-radioactive waste and the radioactive waste should not be stored for more than one month in the laboratory. It should be stored in lidded containers that are appropriately shielded and labelled. Long-lived radionuclides (H-3, C-14, Ni-63) should be kept separate from short-lived radionuclides and scintillant waste should also be stored separately in lidded plastic tubs. At the end of each month, after monthly usage records have been collated, waste should be bagged up and labelled with details of radionuclides, activities and a reference date for the waste. The waste should then be deposited in the appropriate waste store and logged in the waste deposit book.

In the waste stores - separate areas are labelled for waste to be deposited by departments. At least once/month the waste is checked, sorted and logged onto computer by Safety Services staff. It is then given a unique bag reference number, segregated according to half-life, and put into 240L containers ready for transfer to the decay store in the Husband Building.

Procedures for the collection and transfer of waste to the Husband Building and subsequent transfer to an Authorised Contractor are documented in the 'Quality Assurance Programme for the Transport of Radioactive Waste' held in room A1, Safety Services, 40 Victoria St.

Storage in the decay store is for up to 6 months in accordance with the Western Bank Certificate of Authorisation - BU7073 dated 13/06/2003. The timing of this accumulation period is from when the waste is first deposited in any of the Western Bank waste stores. Permitted storage time at RHH is 3 months. All short-lived radionuclides are stored until the activity is insignificant (<0.1MBq/bag) or the 6 months storage time has been reached, whichever occurs first. All long-lived radionuclides are disposed of at the earliest opportunity. We normally have a collection by SRCL once every 3 months when an economic load of 4-6 x 820L wheelie bins should have been accumulated. (NB 8 m^3 is our maximum permitted storage volume.)

Monitoring of the waste for external dose-rates is performed prior to any transport movement and recorded on consignment certificates. (In most cases dose-rates are less than 5uSv/h and waste is transported as excepted packages.) Monitoring of the waste stores is undertaken periodically after the store has been emptied of waste.

We also have procedures for registration of workers and new projects, inspection of facilities, designation of laboratories, monitoring etc - see

http://www.shef.ac.uk/safety/ir/localrules/index.html)

Facilities for Waste Disposal

BAT requires facilities to be well maintained with documented reports of inspections and remedial actions taken.

All fume-cupboards are checked on an annual basis as part of LEV maintenance programme. Gaseous disposals are very limited and subject to assessment by the RPA before approval, to ensure FC is adequate and discharge points acceptable.

Drainage systems in laboratories are checked on an annual basis and all discharge points and drains are marked. Sinks must have small U bends or P traps to be approved for low-level disposals. High-level disposals to be down a sluice or sink whose drain connects directly to a main drain.

Waste stores for accumulation of radioactive solid waste are checked on a monthly basis when the waste is logged in by Safety Services. Stores to be kept clean and tidy by Safety Services staff. The concrete floors and 15cms up the walls of these stores have been sealed with epoxy resin. It has been decided that further sealing of walls and ceilings can not be justified under BAT as the risk of spillages in the store leading to significant doses is very low. (Only solid wastes and small volumes of scintillant wastes in mini-vials are stored in good packaging.)

All areas where work with radioactive materials takes place are subject to annual inspection. A written report is made of this inspection and any deficiencies in laboratory conditions are highlighted for remedial action to be taken. DRPSs are requested to report back when items have been addressed. Records of inspections are kept in Departmental Files in Safety Office.

Staff Training

BAT and its requirements should be covered in the training of staff.

All new radiation workers receive introductory training and this emphasises the need for justification and optimisation, only using radioactive materials if they are the best option and then using the minimum quantities and the radionuclides with the minimum radiotoxicity. Information is also given on waste segregation and packaging procedures. This generic information is then followed up in departments with more specific information relating to the individuals work in the department.

Summary

Current procedures are considered adequate and in keeping with BAT.

Documents Appended:

Annex 1: Assessment of Disposal of Aqueous Wastes from University of Sheffield
Annex 2: Assessment of Disposal of Gaseous Wastes from University of Sheffield
Annex 3: Assessment of likely impact of fire or accidental release in waste stores

T.J.Moseley RPA 26/01/2011

Annex 1: Assessment of Disposal of Aqueous Wastes from University of Sheffield

1. Western Bank Authorisation (BU7073) Aqueous Disposal Limits

Tritium: 20 GBq/month
Low energy betas: 2 GBq/month
Others: 2 GBq/month

For the purposes of this assessment it will be assumed that tritium disposals are split 50/50 as HTO and OBT.
The low energy betas used in the assessment will be C-14 (1 GBq) and S-35 (1 GBq). The other weak beta emitter disposed of on a regular basis is P-33 but this generally has a lower impact than the two radionuclides chosen.
The others will be split into P-32 (1 GBq) and I-125 (1 GBq). The bulk of our discharges come from P-32 but in theory more could come from I-125 and as this has a much higher impact it has been chosen for use in this cautious assessment. There has been no use of I-131 for many years in the University.

Assessment
HPA-RPD Radiological Assessments for Small Users (NRPB-W63) has been used to obtain the following data. The assumptions used in producing the tables in Appendix C can be taken as broadly applicable to the situation in Sheffield - assumes discharges into a medium sized river from a medium sized sewage works. The typical monthly discharge rates for individual radionuclides (Given in Table C5) can be matched exactly with our own discharge authorisation. A summary of potential doses to critical groups can then be extracted from Tables C7 - C11 and are reproduced in the Table below.

Radionuclide	Monthly discharge	Dose to sewer maintenance workers (Sv/y)	Dose to sewage workers (Sv/y)	Fish eaters 2kg/y (Sv/y)	Farmers from sewage sludge 8kg/m^2 (Sv/y)
Tritium (HTO)	10 GBq	9.2E-12	2.6E-11	1.0E-11	8.9E-9
Tritium (OBT)	10 GBq	2.1E-11	4.0E-10	-	-
C-14	1 GBq	3.1E-11	1.3E-11	1.6E-7	1.5E-6
S-35	1 GBq	4.0E-11	8.8E-11	9.7E-9	2.4E-6
P-32	1 GBq	1.2E-10	5.0E-10	4.4E-6	3.3E-6
I-125	1 GBq	9.3E-8	3.4E-7	1.8E-8	4.5E-7
Total in uSv/y		0.09 uSv/y	0.34 uSv/y	4.6 uSv/y	7.7 uSv/y

NB have not used irrigation of crops by river water as a potential route as assumed most irrigation east of Sheffield will be by abstraction from boreholes. Also have not used drinking water assessment as abstraction is also from boreholes. In any case outcomes would have been fractions of a uSv as there are no discharges of I-131.

Summary

It can be seen from the above table that even using the cautious assumptions in the NRPB model maximum potential dose to critical group is <10uSv/y and no further detailed assessment is warranted. Doses to sewage workers are dominated by iodine discharges and I-131 in particular hence the low outcomes here. It is unlikely that fish eaters from catches in the R.Don are a significant critical group but here P-32 is the most significant discharge. It is not known how much sewage sludge is spread on the fields but using the model this produces the critical group of farmers eating their own produce (7.7uSv/y). These findings will be used as a screening tool for assessments for other authorisations.

It should be noted that our actual discharges are only a fraction of the permitted levels and the potential dose to the critical group based on these would come out at <1uSv/y.

2011 review of above.

Usage has continued to decline particularly of radioiodines (none in 2010). P-32 is main radionuclide of significance used. Average monthly discharges of P-32 and S-35 are:- 25MBq and 37MBq respectively, well below authorisation limits. Outcomes for critical groups are therefore well under 1uSv/y.

2. Medical School RHH Authorisation (BL2068) Aqueous Disposal Limits

Tritium & C-14:	0.6 GBq/month
I-125:	0.3 GBq/month
Others:	1.6 GBq/month

Assessment

Tritium and C-14 are a fraction of the levels used in the Western Bank Assessment and the I-125 is a third of the level used. If the others were assumed to be 1GBq of P-32 and 0.6GBq of S-35 per month, then, using the table in the Western Bank assessment, the critical groups would be fish eaters from the R.Don at approx 4.4uSv/y and farmers spreading sewage sludge at 4.8uSv/y.

2011 Review of above.

Usage has continued to decline with average monthly disposals of only 1.5MBq (I-125); 1.5MBq (S-35) and 212MBq (P-32). P-32 is main radionuclide of significance but outcomes for critical groups are still well under 1uSv/y.

T.J.Moseley Jan 2011

NB

NRPB-W63 was published in June 2004 and is the replacement document for NRPB-M744 written by Ciaran McDonnell.

Annex 2: Assessment of Disposal of Gaseous Wastes from University of Sheffield

1. Western Bank Authorisation (BU7073) Gaseous Disposal Limits

Tritium:	2000 GBq/year	Daily limit of 20 GBq
C-14:	1 GBq/year	Daily limit of 50 MBq
Others:	0.2 GBq/year	Daily limit of 5 MBq

The high disposal figure for tritium was in relation to work with tritium gas, which is 10,000 times less toxic than HTO. In this assessment the model used uses the data for HTO.
The others will be assumed to be all I-125 which is the most radiotoxic radionuclide used.

Assessment
HPA-RPD Radiological Assessments for Small Users (NRPB-W63) has been used to obtain the following data. The assumptions used in producing the tables in Appendix D have been taken as broadly applicable to the situation in Sheffield. The expected doses from Table D7 have been adjusted in proportion to our authorisation limits and a summary of potential doses to the general public in the vicinity of University Premises Western Bank is given in the Table below:-

Radionuclide	Annual discharge	% of model	Total effective dose Sv/y (inc. inhalation, all foods, cloud gamma & beta dose to skin)
Tritium (HTO)	2000 GBq	200%	2.2E-7
C-14 *	1 GBq	1%	1.3E-8
Others (I-125)	0.2 GBq	20%	7.2E-8
Total in uSv/y			0.3 uSv/y

* Highest dose coefficient used for C-14

Summary
It can be seen from the above table that even using the cautious assumptions in the NRPB model and the highest dose coefficients for tritium and C-14 potential doses to the public are insignificant and do not warrant further investigation.

2011 Review of above
Usage and discharges have fallen dramatically in recent years with high level tritium work in abeyance. Potential outcomes are therefore currently much lower than the low levels stated above.

2. Medical School RHH Authorisation (BL2068) Gaseous Disposal Limits

Any: 0.4 GBq/year Daily limit of 20MBq

Assessment
Assume all gaseous releases are I-125. 0.4 GBq is 40% of figure used in model and therefore equates to a total effective dose to a member of the public of <0.15 uSv/y and is insignificant.

2011 Review of above
I-125 usage has continued to decline – no recorded gaseous discharges in 2010.

T.J.Moseley Jan 2011

NB NRPB-W63 publication is the replacement document for NRPB-M744 written by Ciaran McDonnell.

Annex 3: Assessment of likely impact of fire or accidental release in waste stores

WB1 – Firth Court Garage Radioactive Waste Store

Waste is accumulated here from MBB, BMS and APS. Maximum transfer from here to decay store in 2006 was 93.2MBq (6/6/06) (*max 2010 was 43MBq*). Of this 3.4MBq was H-3, 9MBq was C-14, 60MBq was S-35 and 21MBq was P-32. For the purposes of this assessment it will be assumed that at least twice this amount could be in this store at any one time. The following figures will therefore be used in the assessment for this store:-

- H-3 10MBq
- C-14 20MBq
- S-35 120MBq
- P-32 50MBq

We will assume that a fire engulfs the whole store and that all the radioactivity is released into the atmosphere in a few hours. In such a situation the only people in close proximity to the store are likely to be firefighters with breathing apparatus. NRPB W63 section 6.2 on short releases to atmosphere looks at this scenario and considers a member of the public observing the fire from 100m downwind throughout the duration of the release. Reference values for such a release are given in Table E2 and are reproduced in the table below together with extrapolated values for our store.

Rad	Ref Activity	Inhalation Dose (Sv)	Gamma dose(Sv)	Beta Dose(Sv)	Total Dose(Sv)	fraction for our store	Our Total (Sv)
H-3	100 GBq	4.2E-07	0	0	4.2E-07	0.0001	4.2E-11
C-14	10 GBq	1.4E-08	0	0	1.4E-08	0.002	2.4E-11
S-35	1 GBq	3.2E-07	0	2.8E-09	3.2E-07	0.12	3.8E-08
P-32	1 GBq	1.8E-07	0	4.0E-08	2.2E-07	0.05	1.1E-08
						TOTAL	**0.05uSv**

Another scenario[1] could be based on observed data from accidental releases when the maximum intake of workers has been found to be of the order of 10^{-6} of the activity of the radioactive material present. If this figure was to be used in relation to a potential release from the waste store the following outcome would occur.

Rad	Intake (Bq)	Dose coefficient (Sv/Bq)	Dose (Sv)
H-3	10	1.8 x E-11	1.8 x E-10
C-14	20	6.5 x E-12	1.3 x E-10
S-35	120	1.3 x E-09	1.56 x E-07
P-32	50	3.2 x E-09	1.6 x E-07
		TOTAL	**0.3uSv**

In both scenarios it can be seen that the outcomes are not significant. (*2011 review – no significant change except for a decline in quantities stored*.)

[1] Health Physics Vol39 p992-1000, Brodsky, Resuspension Factors and Probabilities of Intake of Material in Process

WB3 – Husband Building Decay Store

Material here is collected from all the waste stores and accumulated for decay and onward shipment to SRCL. Waste is taken from Royal Hallamshire Hospital, Childrens Hospital , Northern General Hospital, Chemistry and Western Bank store. It will be assumed that the maximum activity in the store will be in accordance with Authorisation BU7073 and be no greater than the following:-

- H-3 500 MBq
- C-14 100 MBq
- S-35 400 MBq
- P-32 200 MBq
- Cr-51 200 MBq
- I-125 200 MBq

In reality the **annual** transfer of waste to the store: from RHH in 2010 was <4MBq of I-125 and <100MBq of Cr-51; from CH was <400 MBq of H-3; from NGH 6MBq of H-3 and <6 MBq of I-125. Transfers from Chemistry were minimal and the maximum monthly transfer from Western Bank was 43 MBq (as indicated above). The maximum at transfer to SRCL was 168 MBq of H-3 and 51 MBq of others.

Again using the NRPB model as indicated previously the following outcomes can be deduced.

Rad	Ref Activity	Inhalation Dose (Sv)	Gamma dose(Sv)	Beta Dose(Sv)	Total Dose(Sv)	fraction for our store	Our Total (Sv)
H-3	100 GBq	4.2E-07	0	0	4.2E-07	0.005	2.1E-09
C-14	10 GBq	1.4E-08	0	0	1.4E-08	0.01	1.4E-10
S-35	1 GBq	3.2E-07	0	2.8E-09	3.2E-07	0.4	1.3E-07
P-32	1 GBq	1.8E-07	0	4.0E-08	2.2E-07	0.2	4.4E-08
Cr-51	1 GBq	8.6E-09	1.3E-09	0	9.9E-09	0.2	2.0E-09
I-125	1 GBq	1.2E-06	1.7E-09	0	1.2E-06	0.2	6.0E-07
						TOTAL	**0.8uSv**

And using the accidental release scenario using the factor 10^{-6} we get the following.

Rad	Intake (Bq)	Dose coefficient (Sv/Bq)	Dose (Sv)
H-3	500	1.8 x E-11	9.0 x E-09
C-14	100	6.5 x E-12	6.5 x E-10
S-35	400	1.3 x E-09	5.2 x E-07
P-32	200	3.2 x E-09	6.4 x E-07
Cr-51	200	3.6 x E-11	7.2 x E-09
I-125	200	7.3 x E-09	1.5 x E-06
		TOTAL	**2.68uSv**

Again in both scenarios it can be seen that the outcomes are not significant and this study previously last reviewed in 2007 is still valid today in 2011.

T.J.Moseley January 2011