RADIATION SAFETY SUMMARY SHEET

RADIONUCLIDE INFORMATION

TRITIUM **^{3}H** **PHYSICAL DATA**	**DOSIMETRY**
Physical Half-Life: 12.35 Years Maximum Beta Energy: 0.019 MeV (100%) Maximum Range of Beta in Air: about 4.7 mm (0.19 inch) Detector to use**: Liquid scintillation counter only**.	Millicurie quantities of ^{3}H do not present an external exposure hazard because the low energy betas emitted cannot penetrate the dead layer of skin. The critical organ for tritium uptake is the whole body water. Tritiated water is eliminated with a ten-day biological half-life. Increasing water intake may increase eliminations rates. **No external dosimetry is required.**

CARBON-14 **^{14}C** **PHYSICAL DATA**	**DOSIMETRY**
Physical Half-Life: 5730 Years Maximum Beta energy: 0.156 MeV (100%) Maximum range of Beta in Air: About 22cm (8.6 inches) Detector to use**:** Pancake G-M or Liquid scintillation counter.	Millicurie quantities of ^{14}C do not present a significant external exposure hazard because the low energy betas emitted barely penetrate the outer dead skin layer. The critical organ for uptake of many ^{14}C labeled compounds is the fat. Most ^{14}C labeled compounds are rapidly metabolized and the radionuclide is exhaled as $^{14}CO_2$. Some compounds and their metabolites are eliminated via the urine. Biological half-lives vary from a few minutes to 35 days – ten days being a conservative value for most compounds. **No external dosimetry is required.**

PHOSPHORUS-32 **^{32}P** **PHYSICAL DATA**	**DOSIMETRY**
Physical Half-Life: 14.29 Days Maximum Beta Energy: 1.71 Me V (100%) Maximum range of Beta in Air: about 6m (20 feet) Maximum Range if Beta in Water: about 8mm (0.3 inch) Detector to use: Pancake G-M or Liquid scintillation counter	The high-energy beta emissions can present a substantial skin dose hazard depending on activity, frequency and duration of use. The bone is the critical organ for uptake of transportable compounds of ^{32}P. Phosphorus metabolism is complex: 30% is rapidly eliminated from the body, 40% possesses a 19 day biological half-life, and the remaining 30% is reduced by radioactive decay. The lung and large intestine are the critical organs for inhalation and ingestion, respectively, of non-transportable ^{32}P compounds. **Ring badges are required for personnel handling ^{32}P**.

SULFUR– 35 **^{35}S** **PHYSICAL DATA**	**DOSIMETRY**
Physical Half-Life: 87.4 Days Maximum Beta energy: 0.167 MeV (100%) Maximum Range of Beta in Air: about 24 cm (9.6 inches) Detector to use: Pancake G-M or Liquid scintillation counter.	Millicurie quantities of ^{35}S do not present a significant external exposure hazard since the low energy emissions barely penetrate the outer dead layer of skin. The critical organ for ^{35}S is the whole body. The elimination rate of ^{35}S depends on the chemical form. Most ^{35}S labeled compounds are eliminated via the urine. ^{35}S methionine used for metabolic labeling is volatile. Vials should be opened in an operating fume hood. Activated charcoal should be placed in incubators to reduce contamination. **No external dosimetry is required.**

PHOSPHORUS– 33 **^{33}P** **PHYSICAL DATA**	**DOSIMETRY**
Physical Half-life: 25.2 Days Maximum Beta energy: 0.249 MeV (100%) Maximum Range of Beta in Air: about 50 cm (19.7 inches) Detector to use: pancake G-M	Millicurie quantities of ^{33}P do not present a significant external exposure hazard because the low energy betas emitted barely penetrate gloves and the outer skin layer. The bone is the critical organ for intake of transportable compounds of ^{33}P. Phosphorus metabolism is complex: 30% is rapidly eliminated from the body, 40% possesses a 19 day biological half-life, and the remaining 30% is reduced by radioactive decay. The lung and lower large intestine are the critical organs for inhalation and ingestion, respectively, of non-transportable ^{33}P compounds. **No external dosimetry is required.**

RADIATION INSTRUMENTATION

GM	LSC
^{14}C, ^{33}P, ^{32}P, ^{35}S	^{3}H, ^{14}C, ^{33}P, ^{32}P, ^{35}S

GM = Geiger Mueller or Beta Probe   LSC = Liquid Scintillation Counter

Survey meter information

A survey instrument consists of a meter and a detector. The **meter** contains the operational switches and the readout display. It is calibrated electronically. Meters may be compatible with different types of detectors.

The **detector** is usually a handheld probe that actually detects the radiation emitted from radioactive material. Some detectors are built into the meter itself, usually located on the bottom of the unit. It is important that you know what type of radiation you want to detect (i.e., gamma or beta). The calibration label on the side of the meter will help. Detectors and meters are calibrated together. Changing the detector to a different meter may affect the efficiency of the detector.
The detector is calibrated by exposing it to a radioactive source. The calibration label lists the detector's efficiency for measuring that radionuclide.

Make sure you use the correct detector for the radionuclide(s) you're working with in your lab.

GM detectors are used to detect beta radiation. (See Radionuclide information, above)
NaI detectors are used to detect gamma radiation (these detectors are not currently in use at PSU).

For purposes of calibration, radionuclides with similar energies have similar detection efficiencies, as seen on calibration stickers and documentation:

^{32}Si decays to ^{32}P
^{14}C and ^{35}S energies are interchangeable
^{99}Tc betas approximate ^{33}P betas
^{210}Bi betas approximate ^{32}P betas

Tips for using your survey meter

Use the detector for the appropriate radionuclide. Make sure the meter and detector were calibrated together (see calibration label and explanatory notes above).

Before use, check the battery and also hold the detector to a source (your lab's radioactive waste is one option) to be sure it detects the radionuclide(s) of interest.

Note: If you cover the face of the detector with plastic wrap or parafilm to protect it from contamination, you will reduce the detection efficiency. Do not wrap the detector when surveying for C-14 or S-35 contamination. Detection efficiency will be drastically reduced.

Survey slowly, moving the detector 1-2 inches/second, about ¼ to ½ inches from the surface of the area being surveyed. Do not expose meter or detector to sharp objects or liquids.

Do not leave red cap on detector when surveying for beta emitters. The cap will shield the detector. Be careful not to cover the little air hole on the red cap when replacing it over the detector face. The pressure may cause the thin membrane over the detector to burst.

All survey instruments must be annually.

CALCULATIONS

To determine activity remaining after a period of time:

$$A=A_o e^{-\lambda t}$$

A_o = Activity of sample at some original time
A = Activity remaining after a time interval, t
λ = Decay constant for the particular radioactive element (= $0.693/T_{1/2}$)
e = Base of natural logarithms (2.718…)
t = Elapsed time
$T_{1/2}$= Half-life of a particular radioactive element

Example of determining radioactive decay for a given isotope:
32P has a half-life of 14.29 days
The elapsed time is 30 days
The original activity was 100 μCi

λ = (0.693 / 14.29 days) = 0.0485 **(Note: t and $T_{1/2}$ must be in the same units. i.e.: days, months, years)**

0.0485 x 30 days =1.456 change to –1.456 (the negative indicates a decreasing function)

$e^{-1.456} = .233$

0.233 x 100 μCi = 23.3 μCi left after 30 days.

To determine activity from LSC count:

1. cpm / efficiency = dpm
2. dpm / 2.22 x 10^6 dpm/μCi = μCi
3. Example: If there is 966,022 cpm indicated in the ^3H channel on the LSC printout, calculate the actual activity for the location wiped (assume ^3H efficiency is 50%):

   966,022 cpm / 0.5 =1,932,044 dpm

   1,932,044 dpm / 2.22 x 10^6 dpm/μCi = 0.87 μCi

NOTE: remember to ALWAYS calculate MDA_{dpm} for the monthly wipe tests and compare this number to the highest count level seen on the LSC printout.

To determine MDA_{dpm} for Monthly wipe tests:

MDA in dpm = 2.71 + 4.65 √ (bkgd) / (eff.)

NOTE: If any of the wipes are 2X the MDA_{dpm} the area that was wiped is contaminated and must be cleaned and re-wiped until all areas are below the MDA_{dpm}. Documentation must be kept.

To determine activity from instrument count:

1. cpm / efficiency = dpm

2. dpm / 2.22 x 10^6 dpm/μCi = μCi
3. Example: If there is 10,000 cpm indicated on a GM instrument in a laboratory where ^{32}P contamination is detected and the ^{32}P efficiency indicated on the instrument calibration label is 28.5%, calculate the activity:

   10,000 cpm/0.285 = 35,087.8 dpm

   35,087.8 dpm/2.22 x 10^6 dpm/μCi = 0.0158 μCi

Note: The detector must be held at approximately ½ inch from the contaminated surface to correctly determine the activity. All survey instruments calibrated by the RSO have efficiencies determined with the detector at ½ inch from the source of radiation.

<u>To determine drain disposal activity:</u>

1. cpm / efficiency = dpm
2. (dpm / volume of aliquot (ml)) x total volume in the container (ml) = total dpm
3. total dpm/2.22 x 10^6 dpm/μCi = μCi

Example 1: If the counts on an LSC of a 10μl aliquot are 700 cpm in the ^{32}P channel (assume 100% efficiency) and the total volume of the waste container is 2 liters. How much can be dumped?

24,654 cpm / 1 = 24,654 dpm

(24,654 dpm / 0.01ml) x 2000 ml = 4,930,800,000 dpm

4,930,800,000 dpm / 2.22 x 10^6 dpm/μCi = 2,221.08 □ Ci

500 □ Ci / 2221.08 μCi = 0.225

0.225 x 2,000 ml = 450 ml (this is assuming that there have been no other drain disposals for the month and that 500μCi is the limit for ^{32}P.)

Example 2: If the counts on an LSC of a 1ml aliquot are 20,000 cpm in the ^{35}S channel (assume 80% efficiency) and the total volume of the waste container is 1250 ml. How much activity is in the waste container?

20,000 cpm / 0.8 = 25,000 dpm

(25,000 dpm / 1 ml) x 1250 ml = 31,250,000 dpm

31,250,000 dpm / 2.22 x 10^6 dpm/μCi = 14.08 μCi

<u>PSU DRAIN DISPOSAL LIMITS (Effective 4/1/2012)</u>

Based on each licensee/month

^{3}H 1 mCi

^{14}C 1 mCi

All other radionuclides combined 1 mCi

RADIOACTIVE WASTE DISPOSAL

LSC Waste

Biodegradable: RSO pickup or drain dispose (Remember to document waste disposal)

NEVER ABSORB LSC OR PUT IN DRY WASTE. To drain dispose biodegradable LSC, use copious amounts of water, before, during and after disposal. Vials must be triple rinsed (until no white residue remains) before disposing vials into non-radioactive waste.

Dry Waste

Sharps must be in puncture resistant containers.
No freestanding liquid.
No lead.
>90-day half-life: can combine radionuclides (^{3}H, ^{14}C) together.

Waste pickups will be by appointment.
Only properly documented and packaged waste will be accepted.

<90-day half-life: can decay in lab or have RSO pickup.

- RSO pick up: All waste must have radioactive labels removed/defaced
  All radionuclides must be segregated for RSO pick up
  Other rules as for longer half-life radionuclides apply as above.
- Decay in lab: See above rules for RSO pick up
  Waste must be held a minimum of 10 half-lives
  Survey waste with appropriate instrument (see Radiation Instrumentation section) and verify at or below background.
  Once waste has been decayed, only clear bags can be used for disposal to the regular trash. **No yellow bags.**
  Documentation is required for all decayed waste disposed to regular trash: name, disposal date, radionuclide, instrument used (serial #, cal date), bkgd counts and retain for records.

Liquid Waste

Drain dispose according to limits (must have all supporting data prior to disposal).
Decay in lab (store in secondary container).
Store for RSO pickup (^{32}P only).

WORKING IN THE LAB

Surveys and wipe tests

- Frequent surveys and wipe tests are necessary to locate contamination as easily and rapidly as possible. Surveys must be performed each time after using radioactive material, but no documentation is required for these surveys.
- Wipe tests and/or meter surveys are required every month when radioactive materials are used. Wipe test results must be recorded in MDA (minimum detectable activity) in dpm (see above for calculations).
- Documented surveys are not required for periods of non-use greater than one month since the last documented survey. Periods of non-use must be documented in the survey records.

Contamination Control

Areas where radioactivity is to be used MUST be covered with absorbent paper and labeled. Bench tops can be labeled and covered permanently or temporarily while radioactive materials are in use. However, once radioactive

work has ceased in these areas, surveys must be performed to verify no radioactive materials are present.
All items that are used with radioactivity must be labeled with "Caution-radioactive material" tape.
Items that are used with radioactivity MUST be checked with appropriate survey instrument before removal from work area

RADIOACTIVE SPILLS

If a spill occurs:

1. Stop the spill
2. Warn others
3. Isolate the area
4. Minimize contamination and radiation exposure
5. Secure/redirect ventilation
6. Clean up:
    a. Contact the RSO
    b. Absorb the spill using paper towels.
    c. Survey the area with an appropriate survey instrument to find the extent of the contamination.
    d. Place a labeled disposal bag close to the work area.
    e. Clean the area working from the outside in to prevent the spread of contamination. Use the survey instrument often.
    f. Wipe the area and use LSC data to determine if removable contamination has been eliminated.
    g. If the survey instrument still detects radiation but all removable contamination in eliminated, then cover the area with appropriate shielding material, label the area with the date, radionuclide and cpm. If it is a short half-life radionuclide, the cover material can be removed when meter levels are at background.
    h. Document the incident and file with supporting LSC data and a floor plan showing the area in which the contamination occurred.
    i. If the event requires further assistance for cleanup and evaluation, contact the RSO.

DECONTAMINATION PROCEDURE FOR HANDS AND CLOTHES

1. If hands are contaminated, wash with soap and water. Then verify with survey meter that they are clean or free of contamination. Do NOT scrub or use anything abrasive which may cause the contamination to further penetrate the dead layer of the skin making it harder to remove.
2. If clothes or shoes are contaminated, remove immediately and place in a bag to give to the RSO. If the suspected radionuclide has a half-life less than 90 days, the RSO will decay the material and return it.

<u>IMMEDIATE CLINICAL EFFECTS OF AN ACUTE RADIATION DOSE TO HUMANS</u>

RANGE	SUBCLINICAL RANGE	THERAPEUTIC RANGE 100-1000 rem			LETHAL RANGE Over 1000 rem	
	0-100 rem	100-200 rem	200-600 rem	600-1000 rem	1000-5000 rem	Over 5000 rem
INCIDENCE OF VOMITING	NONE	100 rem: 5% 200 rem: 50%	300 rem: 100%	100%	100%	100%
DELAY TIME	---------	3 hours	2 hours	1 hour	30 minutes	
LEADING ORGAN	NONE	Bone Marrow			Gastrointestinal Tract	Central Nervous System
CHARACTERISTIC SIGNS	NONE	Moderate Leukopenia	Severe Leukopenia, Hemorrhaging, Infection, Purpura, Epilation Above 300 rem		Diarrhea, Fever, Electrolyte Loss	Convulsions, Tremor, Ataxia
THERAPY	Reassurance	Blood Surveillance	Blood Transfusion, Antibiotics	Possible Marrow Transplant	Maintain Electrolytes	Sedatives
PROGNOSIS	Excellent	Excellent	Good	Guarded	Hopeless	
INCIDENCE OF DEATH	NONE	NONE	0 to 80%	80 to 90%	90 to 100%	

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