

Western Michigan University Radiation Safety

Instrumentation and Dosimetry Program

Purpose

- A. To provide the means of monitoring exposure and exposure rates to ensure exposure at or from Western Michigan University is As Low As Reasonably Achievable (ALARA).
- B. To ensure instruments used to assess the radiological conditions are reliable, quality controlled, and available to maintain exposure ALARA and protect the public.

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I. Responsibilities

A. Executive Manager

1. Support the RSO and AUs in complying with the requirements of this program.

B. Radiation Safety Officer (RSO)

1. Calibrate or send the instruments for calibration.
2. Investigate the instrument's use for those instruments that fail the 'As Found' Data check during calibration.
3. Review the Dose reports.
4. Co-ordinate the Quarterly exchange of personal monitoring devices.
5. Order and distribute personal monitoring devices.
6. Generate and send Individual Dose history as required or requested.
7. Maintain the records and documentation required by this program.

C. All

1. Use the instruments in accordance with procedures and practices.
2. Wear personal monitoring devices as prescribed.
3. Notify the RSO of any problems with the instruments or dosimetry.

II. Definitions

'As Found' Data	The readings taken when the instrument is exposed to a known dose rate prior to calibration adjustments.
Calibration	The determination of variation or accuracy from a standard of a measuring instrument to ascertain necessary correction factors.
ccpm	An acronym for corrected counts per minute. It is derived by subtracting the background reading from the sample or survey reading when determining loose or fixed contamination levels.
Conversion rule	Mathematical formula based on calibration data that converts the instrument readings from cpm to dose rate readings in mR/hr.
Declared pregnant women	A woman that has voluntarily informed the RSO, in writing, of her pregnancy and estimated date of conception.
Dose	A general term that refers to absorbed energy or equivalent.
Exposure	The act of being exposed to ionizing radiation or radioactive material.
Extremities	The parts of the arms from the elbow to the fingertips and the legs from the knees to the toes.
Multi-purpose instruments	These instruments are built with a meter face that can be read in cpm or mR/hr. The multi-purpose instruments are calibrated in the count rate mode (cpm) on the x 0.1 scale and in the dose rate mode (mR/Hr) for the other scales.
Occupational exposure	Exposure received in the course of employment in which duties involve exposure to ionizing radiation.

Personal monitoring device	A device designed to be worn or carried by the individual for estimating exposure received.
Pre-operational checks	A series of instrument checks that verify that the instrument can reproduce accurate results from use to use.
REM	The unit of measure of the equivalent absorbed dose in a human. REM = Rad x Quality Factor
Whole Body	For the purposes of external exposure determinations, include the head, trunk, gonads, legs above the knees, and arms above the elbows.

III. Requirements for Instrumentation

A. Multi-purpose instruments

1. The Ludlum Model 3 with a G-M detector.
 - a. Used in the areas with a need to monitor β - γ contamination and radiation levels.
 - b. The x 0.1 scale is calibrated in cpm mode for contamination monitoring.
 - c. Ranges - 0 - 420 cpm and 0 - 200 mR/hr
 - d. Conversion rule 100 cpm = 1000 dpm
2. The Ludlum Model 14 C with a G-M detector.
 - a. Used in the areas with a need to monitor β - γ contamination and radiation levels.
 - b. The x 0.1 scale is calibrated in cpm mode for contamination monitoring.
 - c. The x 1000 scale uses an internal probe.
 - d. Ranges - 0 - 660 cpm and 0 - 2000 mR/hr
 - e. Conversion rule 100 cpm = 1000 dpm

B. Single-purpose instruments

1. The Ludlum Model 14 B with a G-M detector.
 - a. Used in the areas with a need to monitor β - γ radiation levels.
 - b. Range - 0 – 2000 mR/hr
2. The Ludlum Model 12 with a proportional detector.
 - a. Used in areas to monitor neutron radiation levels.
 - b. Range - 0 – 500,000 cpm
 - c. Conversion rule 75 cpm = 1 mREM/hr
3. The Ludlum Model 21 with a ZnS(Ag) probe.
 - a. Used to count wipes for α contamination.
 - b. Range - 0 – 1,000,000 cpm
4. Packard 2600 TR Scintillation Counter
 - a. Used to count prepared samples for β - γ contamination.
 - b. Provides direct dpm results.
 - c. Processes low energy β at a minimum 60% efficiency, such as H-3 β .

C. Calibration [10CFR20.15001 / 333.5036 / NUREG 1556 Vol 11]

1. Calibrations will be conducted by, either
 - a. A vendor licensed by the Nuclear Regulatory Commission, or

b. Internal procedures reflective of and containing the requirements of the model instrument calibration program specified in Appendix O to NUREG-1556, Vol. 11, "Program - Specific Guidance about Licenses of Broad Scope."

2. Calibration Frequency

- a. Annually.
- b. Prior to initial use.
- c. Post maintenance evolutions that may affect the calibration.
- d. As requested by the RSO to verify proper operation.

3. Calibration failure of 'As found' data

a. Investigate the use of the instrument.
b. Conduct additional surveys, if possible and necessary, to verify previous instrument readings.

c. Document the results of the investigation.

4. Calibration documentation, records, and applicable conversion charts for each instrument in accordance with the Administration Program procedures.

5. The RSO will maintain a list of all instruments and their calibration due dates as a second check to ensure an uncalibrated instrument is not used.

D. Pre-operational checks

1. Pre-operation checks provide the means to verify the instrument can reproduce accurate results from use to use.

2. Prior to use all instruments are source checked or verified to have been source checked in accordance with their use procedures.

3. The pre-operational checks include:

a. A Calibration verification to ensure the instrument has been and is currently calibrated.

b. A battery/power check to ensure the instrument will have adequate voltage supplied to the detector and meter to reproduce readings.

c. A source check to verify the instrument will give consistent readings to the same source from use to use and person to person.

4. Failure of pre-operational checks.

- a. The instrument is removed from service.
- b. The instrument is sent for recalibration.
- c. The RSO will investigate the use of the instrument.

1. If the instrument 'As found' data is within the acceptable ranges, close out the investigation.

2. If the instrument 'As found' data is outside the acceptable ranges, the investigation will be completed under the calibration section.

IV. Requirements for Dosimetry

A. Personal monitoring devices shall be issued to: [10CFR20.1502 / 333.5064, 5294, 5317, 5348, and 8333]

1. Individuals expected to receive occupational exposure at levels > 10 mREM/month.
2. Individuals working with millicurie (mCi) quantities of η , β , γ , or X-Ray emitters.

3. Radiation Workers involved with radioactive material or radiation producing machines, who request to be monitored due to personal concerns.

B. Western Michigan University will use a certified supplier to provide dosimetry services, such as: **[10CFR20.1501 / 333.5063]**

1. Calibration of dosimetry,
2. Routine and investigational readings,
3. Reports of individual exposure.

C. Devices worn for establishing record dose will be processed, read, and reported:

1. Quarterly **[License]**
2. As requested by the RSO

D. Table of Dose Limits **[10CFR20.1201, 1207, 1208, 1301, and 1502 / R333.5057, 5058, 5059, and 5060]**

	Federal and State Adult	Federal and State Minor (≤ 18 yrs)	Declared Pregnant Woman	Public	WMU Level 1 [License]	WMU Level 2 [License]
Whole Body	5 REM/yr	0.5 REM/yr	0.5 REM/gestation	0.1 REM/yr	0.1 REM/qtr	0.2 REM/qtr
Lens of the Eye	15 REM/yr	1.5 REM/yr	15 REM/yr	N/A	0.5 REM/qtr	1 REM/qtr
Skin & Extremities	50 REM/yr	5 REM/yr	50 REM/yr	N/A	1 REM/qtr	2 REM/qtr

NOTE: For individuals exceeding WMU Levels, follow the Emergency Plan for an overexposure.

E. To keep radiation exposure ALARA, the following actions will be taken: **[10CFR20.1101]**

1. Work that is expected to result in exposure to an individual greater than Level 1:
 - a. Reviewed by the RSO and AU for ALARA considerations.
 - b. Document the review and any adaptations as a result of the review.
 - c. Consider an increase in surveillance of the job by the AU or RSO.
2. Unplanned exposure to an individual exceeding Level 1 limits:
 - a. Will be investigated by the RSO to determine the cause AND why the exposure was not reviewed and planned.
 - b. The RSO and AU will develop and implement a plan to prevent recurrence.
3. Unplanned exposure to an individual exceeding Level 2 limits.
 - a. The RSO will restrict the individual from further exposure until the investigation is completed.
 - b. Will be investigated by the RSO to determine the cause AND why the exposure was not reviewed and planned.
 - c. The RSO and AU will develop and implement a plan to prevent recurrence.

4. All AUs and Radiation Workers should routinely evaluate their practices and protocols for ALARA considerations. Suggestions, ideas, or implemented changes that result or may result in the reduction of exposure should be discussed with the RSO for presentation to other users.

F. The quarterly dosimetry change out.

1. Dosimeters will be collected at the end of each quarter; Jan, Apr, Jul, Oct.
2. A new dosimeter will be given ONLY when the previous dosimeter has been returned.
3. Dosimeters can be obtained from the RSO or a prearranged Department Representative.
4. The RSO will send expired devices to the vendor for processing.
5. The RSO will review the vendor reports, make necessary notifications, update the individual records, and maintain the files in accordance with the Administrative Controls Program.

G. Records and Reports

1. NRC Form 4
2. NRC Form 5
3. Quarterly Exposure Report
4. Overexposure Reports - Documented via an Incident Report.

V. Final Conditions

A. Exposure is being monitored in accordance with the rules and regulations governing the use of radiation and radiation producing machines.

B. Instruments are calibrated and operational.

C. All records are maintained in accordance with the Administrative Controls Program.

Appendix A Ludlum Model 3

I. The following steps will be performed by all users:

A. Perform the pre-operational checks:

NOTE: If the instrument is out of calibration or fails the second attempt of any check, remove the instrument from service and notify the RSO.

1. Verify the instrument has a valid calibration and sticker.
 - a. If the instrument is out of calibration, remove the instrument from service and notify the RSO.
2. Perform an instrument battery check.
 - a. Turn the range selector switch to BATT.
 - b. Observe the meter deflection.
 - c. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Turn the instrument off.
 - b. Locate and remove the battery compartment cover.
 - c. Open the cover.
 - d. Remove and properly dispose of the batteries.
 - e. Inspect the battery compartment for damage or battery acid; Stop and notify the RSO if damage or acid is noted.
 - f. Place new batteries in the compartment.
 - g. Close the cover.
 - h. Repeat the instrument battery check.
3. Perform an instrument source check.
 - a. Turn the range selector switch to the range necessary to obtain the expected source check band.
 - b. Place or verify the audible response is on.
 - c. Open the check source cover.
 - d. Place the detector probe over the check source.
 - e. Observe the needle deflection until it stabilizes for 15 seconds.
 - f. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the acceptance band, the check is Sat and the instrument is ready for use.
 2. Outside of the test band, the check is Unsat.
 - a. Reposition the probe over the source.
 - b. Repeat the instrument source check.

NOTE: The instrument can be used for both contamination and radiation surveys. The lowest range (x 0.1) is calibrated in the counts per minute (cpm) mode and the remaining scales in the dose rate (mR/hr) mode.

B. Operation of the instrument.

1. Fixed contamination (frisking) monitoring.

a. Set the meter to the x 0.1 scale for readings in cpm and turn on the audible response, if the meter has one.

b. Determine the background levels.

NOTE: The probe should be held within 1/4 to 1/2 inch of the surface being monitored. Contact with the surface being monitored should be minimized to prevent the spread of contamination. However, it has been demonstrated that occasional contact will not contaminate the probe or another area.

c. Slowly (1" - 2" per second) move across the surface.

d. Listen to the audible response of the meter

e. If the frequency of the audible response quickens:

1. Stop.

2. Monitor the meter reading until it stabilizes for 15 seconds.

f. Record the reading, if necessary.

2. Loose contamination (wipes) monitoring.

a. Set the meter to the x 0.1 scale for readings in cpm and turn on the audible response.

NOTE: If the background level is > 200 cpm, relocate to an area of lower background.

NOTE: If the activity requires use of a scale > x 0.1, record the reading in mR/hr/100 cm². Background, if it was < 200 cpm, will be negligible.

b. Determine the background levels in cpm.

c. Place the wipe ¼ - ½ inch from the probe face.

d. Note the meter reading after it has stabilized for 15 seconds.

e. Determine the activity of the wipe in dpm.

$$\text{dpm} = (\text{Meter Reading (cpm)} - \text{Background reading (cpm)}) \times 10$$

f. Record the activity in dpm of the wipe.

3. Radiation (dose rate) level monitoring.

a. Set the meter to the highest scale that corresponds to the expected dose rate and turn on the audible response, if the meter has one.

b. General Area Radiation Survey

1. Hold the probe about waist high and ≥ 30 cm from an object.

2. Slowly move about the area.

3. Listen to the audible response of the meter

4. If the frequency of the audible response quickens

a. Stop.

b. Monitor the meter reading until it stabilizes for 15 seconds.

c. Record the reading, if necessary.

5. Continue the process until a representative survey of the condition of the room has been obtained.

6. Record the General Area readings.
- c. Contact Radiation Survey
 1. Hold the probe $\frac{1}{4}$ - $\frac{1}{2}$ inch from the surface.
 2. Slowly (1" - 2" per second) move across the surface.
 3. Listen to the audible response of the meter
 4. If the frequency of the audible response quickens:
 - a. Stop.
 - b. Monitor the meter reading until it stabilizes for 15 seconds.
 - c. Record the reading, if necessary.
 5. Continue the process until a representative survey of the condition of the room has been obtained.
 6. Record the contact readings.

Appendix B Ludlum Model 14 C

I. The following steps will be performed by all users:

A. Perform the pre-operational checks:

NOTE: If the instrument is out of calibration or fails the second attempt of any check, remove the instrument from service and notify the RSO.

1. Verify the instrument has a valid calibration and sticker.
 - a. If the instrument is out of calibration, remove the instrument from service and notify the RSO.
2. Perform an instrument battery check.
 - a. Turn the range selector switch to a low multiplier.
 - b. Depress the battery check button
 - c. Observe the meter deflection.
 - d. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Turn the instrument off.
 - b. Locate and remove the battery compartment cover.
 - c. Open the cover.
 - d. Remove and properly dispose of the batteries.
 - e. Inspect the battery compartment for damage or battery acid; Stop and notify the RSO if damage or acid is noted.
 - f. Place new batteries in the compartment.
 - g. Close the cover.
 - h. Repeat the instrument battery check.
3. Perform an instrument source check.
 - a. Turn the range selector switch to the range necessary to obtain the expected source check band.
 - b. Place or verify the audible response is on.
 - c. Open the check source cover.
 - d. Place the detector probe over the check source.
 - e. Observe the needle deflection until it stabilizes for 15 seconds.
 - f. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Reposition the probe over the source.
 - b. Repeat the instrument source check.

NOTE: The instrument can be used for both contamination and radiation surveys. The lowest range (x 0.1) is calibrated in the counts per minute (cpm) mode and the remaining scales in the dose rate (mR/hr) mode.

B. Operation of the instrument.

1. Fixed contamination (frisking) monitoring.

a. Set the meter to the x 0.1 scale for readings in cpm and turn on the audible response, if the meter has one.

b. Determine the background levels.

NOTE: The probe should be held within 1/4 to 1/2 inch of the surface being monitored. Contact with the surface being monitored should be minimized to prevent the spread of contamination. However, it has been demonstrated that occasional contact will not contaminate the probe or another area.

c. Slowly (1" - 2" per second) move across the surface.

d. Listen to the audible response of the meter

e. If the frequency of the audible response quickens:

1. Stop.

2. Monitor the meter reading until it stabilizes for 15 seconds.

f. Record the reading, if necessary.

2. Loose contamination (wipes) monitoring.

a. Set the meter to the x 0.1 scale for readings in cpm and turn on the audible response.

NOTE: If the background level is > 200 cpm, relocate to an area of lower background.

NOTE: If the activity requires use of a scale > x 0.1, record the reading in mR/hr/100 cm². Background, if it was < 200 cpm, will be negligible.

b. Determine the background levels in cpm.

c. Place the wipe ¼ - ½ inch from the probe face.

d. Note the meter reading after it has stabilized for 15 seconds.

e. Determine the activity of the wipe in dpm.

$$\text{dpm} = (\text{Meter Reading (cpm)} - \text{Background reading (cpm)}) \times 10$$

f. Record the activity in dpm of the wipe.

3. Radiation (dose rate) level monitoring.

a. Set the meter to the highest scale that corresponds to the expected dose rate and turn on the audible response, if the meter has one.

b. General Area Radiation Survey

1. Hold the probe about waist high and ≥ 30 cm from an object.

2. Slowly move about the area.

3. Listen to the audible response of the meter

4. If the frequency of the audible response quickens

a. Stop.

b. Monitor the meter reading until it stabilizes for 15 seconds.

c. Record the reading, if necessary.

5. Continue the process until a representative survey of the condition of the room has been obtained.

6. Record the General Area readings.

c. Contact Radiation Survey

1. Hold the probe $\frac{1}{4}$ - $\frac{1}{2}$ inch from the surface.

2. Slowly (1" - 2" per second) move across the surface.

3. Listen to the audible response of the meter

4. If the frequency of the audible response quickens:

a. Stop.

b. Monitor the meter reading until it stabilizes for 15 seconds.

c. Record the reading, if necessary.

5. Continue the process until a representative survey of the condition of the room has been obtained.

6. Record the contact readings.

Appendix C Ludlum Model 14 B

I. The following steps will be performed by all users:

A. Perform the pre-operational checks:

NOTE: If the instrument is out of calibration or fails the second attempt of any check, remove the instrument from service and notify the RSO.

1. Verify the instrument has a valid calibration and sticker.
 - a. If the instrument is out of calibration, remove the instrument from service and notify the RSO.
2. Perform an instrument battery check.
 - a. Turn the range selector switch to a low multiplier.
 - b. Depress the battery check button
 - c. Observe the meter deflection.
 - d. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Turn the instrument off.
 - b. Locate and remove the battery compartment cover.
 - c. Open the cover.
 - d. Remove and properly dispose of the batteries.
 - e. Inspect the battery compartment for damage or battery acid; Stop and notify the RSO if damage or acid is noted.
 - f. Place new batteries in the compartment.
 - g. Close the cover.
 - h. Repeat the instrument battery check.
3. Perform an instrument source check.
 - a. Turn the range selector switch to the range necessary to obtain the expected source check band.
 - b. Place or verify the audible response is on.
 - c. Open the check source cover.
 - d. Place the detector probe over the check source.
 - e. Observe the needle deflection until it stabilizes for 15 seconds.
 - f. R Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Reposition the probe over the source.
 - b. Repeat the instrument source check.

B. Operation of the instrument.

1. Radiation (dose rate) level monitoring.

a. Set the meter to the highest scale that corresponds to the expected dose rate and turn on the audible response, if the meter has one.

b. General Area Radiation Survey

1. Hold the probe about waist high and ≥ 30 cm from an object.
2. Slowly move about the area.
3. Listen to the audible response of the meter
4. If the frequency of the audible response quickens
 - a. Stop.
 - b. Monitor the meter reading until it stabilizes for 15 seconds.
 - c. Record the reading, if necessary.
5. Continue the process until a representative survey of the condition of the room has been obtained.

6. Record the General Area readings.

c. Contact Radiation Survey

1. Hold the probe $\frac{1}{4}$ - $\frac{1}{2}$ inch from the surface.
2. Slowly (1" - 2" per second) move across the surface.
3. Listen to the audible response of the meter
4. If the frequency of the audible response quickens:
 - a. Stop.
 - b. Monitor the meter reading until it stabilizes for 15 seconds.
 - c. Record the reading, if necessary.
5. Continue the process until a representative survey of the condition of the room has been obtained.

6. Record the contact readings.

Appendix D Ludlum Model 12 Neutron Monitor

I. The following steps will be performed by all users:

A. Perform the pre-operational checks:

NOTE:	If the instrument is out of calibration or fails the second attempt at its any check, remove the instrument from service and notify the RSO.
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1. Verify the instrument has a valid calibration and sticker.
 - a. If the instrument is out of calibration, remove the instrument from service and notify the RSO.
2. Perform an instrument battery check.
 - a. Turn the range selector switch to a low multiplier.
 - b. Depress the battery check button
 - c. Observe the meter deflection.
 - d. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Turn the instrument off.
 - b. Locate and remove the battery compartment cover.
 - c. Open the cover.
 - d. Remove and properly dispose of the batteries.
 - e. Inspect the battery compartment for damage or battery acid; Stop and notify the RSO if damage or acid is noted.
 - f. Place new batteries in the compartment.
 - g. Close the cover.
 - h. Repeat the instrument battery check.
3. Perform an instrument source check.
 - a. Turn the range selector switch to the range necessary to obtain the expected source check band.
 - b. Center the Troxler over the detector probe sphere.
 - c. Turn on the Troxler.
 - d. Open the Troxler source shield .
 - e. Observe the needle deflection until it stabilizes for 15 seconds.
 - f. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Reposition the Troxler over the detector probe sphere.
 - b. Repeat the instrument source check.

B. Operation of the instrument.

1. Radiation (dose rate) level monitoring.

a. Set the meter to the highest scale that corresponds to the expected dose and turn on the audible response, if the meter has one.

b. General Area Radiation Survey

1. Hold the probe about waist high and ≥ 30 cm from an object.
2. Slowly move about the area.
3. Monitor the response of the meter.
4. If the meter needle jumps or accelerates:
 - a. Stop.
 - b. Monitor the meter reading until it stabilizes for 15 seconds.
 - c. Record the reading, if necessary.
5. Continue the process until a representative survey of the condition of the room has been obtained.

6. Record the General Area readings.

c. Contact Radiation Survey

1. Hold the probe $\frac{1}{4}$ - $\frac{1}{2}$ inch from the surface.
2. Monitor the response of the meter.
3. If the meter needle jumps or accelerates:
 - a. Stop.
 - b. Monitor the meter reading until it stabilizes for 15 seconds.
 - c. Record the reading, if necessary.
4. Continue the process until a representative survey of the condition of the room has been obtained.
5. Record the contact readings.

Appendix E Ludlum Model 21 with a ZnS(Ag) Probe Alpha Counter

I. The following steps will be performed by all users:

A. Perform the pre-operational checks: for the meter operating in the count rate mode:

NOTE: If the instrument is out of calibration or fails the second attempt of any check, remove the instrument from service and notify the RSO.

1. Verify the instrument has a valid calibration and sticker.
 - a. If the instrument is out of calibration, remove the instrument from service and notify the RSO.
2. Ensure the instrument has power as indicated by the power light.
3. Perform an instrument source check.
 - a. Turn the range selector switch to the range necessary to obtain the expected source check band.
 - b. Place the check source under the detector probe.
 - c. Observe the needle deflection until it stabilizes for 1 minute.
 - d. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Reposition the probe over the source.
 - b. Repeat the instrument source check.

B. Operation of the instrument in the count rate mode for loose contamination (wipes) monitoring.

1. Set the meter to the appropriate scale for readings in cpm

NOTE: If the background level is > 200 cpm, relocate to an area of lower background.

2. Determine the background levels in cpm.
3. Place the wipe $\frac{1}{4}$ - $\frac{1}{2}$ inch from the probe face.
4. Note the meter reading after it has stabilized for 1 minute.
5. Determine the activity of the wipe in dpm.
$$\text{dpm} = (\text{Meter Reading (cpm)} - \text{Background reading (cpm)}) \times 30$$
6. Record the activity in dpm of the wipe.
7. Clean the area.
8. Dispose of samples.
 - a. < 20 dpm α in normal trash
 - b. \geq 20 dpm α in trash marked as radioactive.

C. Perform the pre-operational checks: for the meter operating with a scaler.

NOTE: If the instrument is out of calibration or fails the second attempt at its any check, remove the instrument from service and notify the RSO.

1. Verify the instrument has a valid calibration and sticker
2. Verify or connect the instrument to the scaler.
 - a. Attach the cable to the connector to the back of Model 21
 - b. Attach the other end on the cable to the scaler.
3. Ensure the instrument has power to it as indicated by the power light.
4. Perform an instrument source check.
 - a. Set the collection time for the background check, usually 10 minutes.
 - b. Place an empty tray or sample container beneath the probe.
 - c. Start the count collection.
 - d. Determine the count rate by dividing the number of counts by the count time.
 - e. Record the background level.
 - f. Place the check source under the detector probe.
 - g. Set the collection time for the sample count, usually 5 minutes.
 - h. Determine the count rate by dividing the number of counts by the count time.
 - i. Determine the check count rate by dividing the number of counts by the count time.
 - j. Subtract the background count rate from the check count rate.
$$\text{Source (cpm)} - \text{Bkg (cpm)} = \text{Check count rate (ccpm)}$$
 - k. Determine if satisfactory (Sat) or unsatisfactory (Unsat).
 1. Within the test range area, the check is Sat; proceed to instrument source check.
 2. Outside the test range area, the check is Unsat:
 - a. Reposition the probe over the source.
 - b. Repeat the instrument source check.

D. Operation of the instrument with a scaler.

1. Verify the instrument has had a background check completed with 24 hours.
2. Place the sample under the detector probe.
3. Set the collection time for the sample count, usually 5 minutes.
4. Determine the count rate by dividing the number of counts by the count time.
5. Subtract the background count rate from the sample count rate.
$$\text{Sample (cpm)} - \text{Bkg (cpm)} = \text{Sample count rate (ccpm)}$$
6. Determine the activity in dpm.
$$\text{dpm} = \text{Sample ccpm} \times \text{instrument efficiency from the calibration data}$$
7. Record the sample activity.
8. Clean the area.
9. Dispose of samples.
 - a. < 20 dpm α in normal trash
 - b. ≥ 20 dpm α in trash marked as radioactive.

Appendix D Packard Liquid Scintillation Counter

NOTE: The machine must be energized for a minimum of 24 hours prior to calibrating or using the instrument.

NOTE: Avoid touching the viewing surfaces of the vial with your hands/fingers. The oil residue may affect the results by absorbing or refracting the light pulses emitted in the sample.

I. The following steps will be performed by all users:

A. Perform the weekly pre-operational checks:

1. Record your name and the date in the Weekly Pre-operational Checks Log.

NOTE: If the instrument is out of calibration or fails the second attempt at its any check, remove the instrument from service and notify the RSO.

2. Perform the Instrument Performance Assessment (IPA).

- a. Obtain a large rack for the source vials.
- b. Insert the SNC flag into the rack.
- c. Place the Carbon - 14 (C-14) source vial into the 1st position.
- d. Place the Hydrogen - 3 (H-3) source vial into the 2nd position.
- e. Place the Background Standard vial into the 3rd position.
- f. Ensure the flag is extended.
- g. Place the rack into the counter with the flag on the left side of the track.

NOTE: [**] Indicates operator action to press the action key on the computer screen with the pointer.

- h. [] - to initiate the counting process.
- i. Review the computer printout when the machine completes the counting.
 1. System normalized.
 2. C14 IPA Data Processed and efficiency.
 3. H3 IPA Data Processed and efficiency.
 4. BKG IPA Data Processed.
- j. Record the results, including any abnormalities; Notify the RSO of any abnormalities noted on the printout.
- k. Compare the efficiency values with the acceptance criteria: C-14 acceptable efficiency $\geq 91\%$ and H-3 acceptable efficiency $\geq 60\%$
 1. If acceptable continue.
 2. If Unacceptable,
 - a. Mark the instrument 'Out of Specification - Do Not Use'
 - b. Notify the RSO
 - c. Continue through the remainder of the Weekly Quality Control checks.

- l. Return the standards to their storage place under the lid.
- m. Return the rack to its storage.

B. Determine Minimum Detectable Activity (MDA)

1. Verify that the weekly pre-operational checks have been completed or complete them in accordance with Section A. of this procedure.
2. Collect a 60 minute background.
3. Calculate the MDA.

NOTE: Efficiency is in cpm/dpm and is a conservative estimate based on H3 (.019 MeV) 60% eff and C14 (0.157 MeV) 96% any isotope with a higher β MeV output should be more efficient.

NOTE: Standard sample count time is one (1) minute.

$$\text{MDA (dpm)} = \frac{2.71 + (4.65 * \sqrt{\text{Bkg (cpm)} * \text{Bkgd count time (min)}})}{\text{Sample count time (min)} * \text{Detector Efficiency (0.9 cpm/dpm)}}$$

$$\text{MDA (uCi)} = \frac{\text{MDA (dpm)}}{2.22 \times 10^{-6} \text{ dpm/uCi}}$$

C. Operation

1. Verify that the weekly pre-operational checks have been completed or complete them in accordance with Section A. of this procedure.
2. Place the sample in the scintillation vial.
3. Add enough scintillation fluid to fill the sample vial three quarters full.
4. Cap the vial.
5. Obtain an appropriate size sample rack for the sample vials.
6. Choose the counting protocol flag.
7. Insert the flag into the rack.
8. Place the samples into the rack.
9. Ensure the flag is extended.
10. Place the rack into the counter with the flag on the left side of the rack.
11. Count the prepared samples in the Liquid Scintillation Counter.
 - a. [] - to initiate the counting process.
12. Record the activity of the samples from the computer printout.
13. Inform the RSO of any abnormalities with the counting system or results.

D. Clean the counting area.

1. Discard samples with an activity of < 1000 dpm/100 cm² as normal trash.
2. Discard samples with an activity of ≥ 1000 dpm/100 cm² as radioactive trash.