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GUIDELINE ON LEAK TESTS

This document has been prepared as a guide to assist with all requirements to check for all the radioactive leak test. Appropriate radiation monitoring equipment should be used to perform leak test measurements with relevant sensitivity to detect alpha and beta radiation or activity.

It is the responsibility of the authority holder, radiation protection officer and acting radiation protection officer to ensure that leak test of all radioactive material is performed per the leak test frequency requirements for each type of application.

Document History

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Glossary

Abbreviation/ Term	Meaning
AH	Authority Holder
RPO	Radiation Protection Officer
ARPO	Acting Radiation Protection Officer
SAHPRA	South Africa Health Products Regulatory Authority
TLD	Thermoluminescent Dosimeter
EPD	Electronic Personal Dosimeter

1. INTRODUCTION

Leak test is a form of non-destructive testing used to check for leakage of radioactive material. This test is performed by wiping the surface of the container of the radioactive material with an absorbent material (or smear sample), then after, the absorbent material is tested for activity or alpha and beta particles absorbed on the material. In this document the requirements for authority holders concerning the leak tests are explained broadly.

1.1 Purpose

The purpose of leak test is to detect radioactive contamination around the container of the source. Thus, this is done to ensure necessary precautions to be taken for the safe use and handling of such radioactive material.

1.2 Scope

The scope of this document is to deal with all the requirements needed to be met in all procedures which involves leak testing for radioactive contamination, the What, the Who and How of the leak test.

1.3 Background

A leak test (also known as a wipe tests or smear test) is a procedure which involves the following two steps: A piece of absorbent material (e.g., tissue paper) is used to wipe the surface of a gauge containing a sealed source. If radioactive material, e.g., (Cesium powder) is leaking from the source, some of the radioactive material will adhere to the tissue paper. The absorbent material (smear sample) is monitored with a contamination monitor to determine whether any radioactive material (contamination) is present. Measuring radiation levels (exposure rates) directly in the vicinity of a gauge with a radiation monitor is NOT a leak/wipe test. This is a different type of test which checks the integrity of the shielding container and confirms that levels of gamma radiation near the gauge are acceptable. It is not possible to detect contamination (and thus a leaking source) with a radiation monitor in this manner.

2. LEGAL PROVISION

The Regulations relating to Group IV Hazardous Substances, made in terms of section 29 of the Hazardous Substances Act 15 of 1973 and published under Government Notice R247 in Government Gazette 14596, dated 26 February 1993 (R247) require an Authority Holder when uses a Group IV hazardous substance in the course of his activities, monitor or cause to be monitored the radiation levels and contamination, as the case may be, at regular intervals as required by the particular activities in order to ensure that the applicable maximum dose limits are not exceeded.

3. REQUIREMENTS FOR AUTHORITY HOLDERS

3.1 What is a leak test?

A leak test (also known as a wipe tests or smear test) is a procedure which involves the following two steps:

- 3.1.1 A piece of absorbent material (e.g., tissue paper) is used to wipe the surface of a gauge containing a sealed source. If radioactive material, (e.g., Cesium powder) is leaking from the source, some of the radioactive material will adhere to the tissue paper.
- 3.1.2 The absorbent material (smear sample) is monitored with a contamination monitor to determine whether any radioactive material (contamination) is present. Thus, this is solely for measuring alpha and beta particles with a contamination monitor.
- 3.1.3 Measuring radiation levels (exposure rates) directly in the vicinity of a gauge with a radiation monitor (survey meter) is NOT a leak/ wipe test. This is a different type of test which checks the integrity of the shielding container and confirms that levels of gamma radiation near the gauge are acceptable. It is not possible to detect contamination (and thus a leaking source) with a radiation monitor in this manner that is meant to measure gamma radiation.

4. WHO MUST PERFORM THE LEAK TEST?

Wherever possible, leak tests should be carried out on a routine basis by the company responsible for servicing the gauge or any equipment with radiation sources. Where this is not feasible, however, the first step of the leak test, i.e., taking the smear sample, may be performed by the Authority Holder's (AH's), Radiation Protection Officer (RPO) or the Acting Radiation Protection Officer (ARPO), or by someone acting under their instruction.

If the AH has access to a suitable contamination monitor, the second step, i.e., the analysis of the smear, may also be performed and recorded by the holder himself.

Usually, however, the AH does not have a contamination monitor. In such cases, smear samples may be sent to the supplier of the gauge, or any other institution or company who has the necessary monitoring equipment to perform the leak test.

5. HOW MUST THE SMEAR SAMPLE BE SENT?

The smear samples should be sealed in a plastic bag, e.g., bank bags, and can be sent by road, rail or airfreight. Smear samples may NOT be sent by normal post. Freight packages need only be marked "radioactive" on the

inside, i.e., they should be marked in such a manner that a radiation warning sign is clearly visible upon opening the package. The consignment must be correctly identified in the transport documents and can be classed as "excepted radioactive material".

6. HOW MUST THE LEAK TEST BE CARRIED OUT?

The leak test should be performed with a piece of absorbent material, such as cotton wool, tissue, or filter paper. The material can be moistened slightly with water or alcohol, or it can be used dry.

The gauge must be turned off before the test is carried out, i.e., the source must be in the fully shielded position within the source container or housing.

Method: Gently wipe the external surface of the source container/housing, and along any joints or external movable parts, where it is more feasible that contamination might occur. Do NOT dismantle any part of the gauge or source container to do the leak test.

For certain types of gauges, e.g. some models of fill-level detector and thickness gauges more thorough internal leak test can be carried out by trained representatives of the supplier of the gauge during routine maintenance or servicing. These internal leak tests involve dismantling of the gauge and wiping the source directly and should thus NOT be carried out by the AHs themselves.

7. WHAT MUST BE DONE WITH LEAK TEST RESULTS?

The result of the leak test as recorded on the Leak Test Certificate should be safely filed and kept for inspection purposes.

If a source is found to be leaking, the Radionuclides Sub-Unit of Radiation Control must be notified immediately.

8. LEAK TEST FREQUENCIES

The holder of the authority must ensure that leak tests are performed as indicated in Table 1.

TABLE 1: LEAK TEST FREQUENCIES

TYPE OF APPLICATIONS	OTHER NAMES	LEAK TEST FREQUENCY
*Sealed sources used in any aspect of food processing must be leak tested annually		

*All radioactive sources, excluding Ra-226, not being used and only being stored must be leak-tested once every two years. Stored radioactive sources must be leak-tested before being put back into use again.

AFTERLOADING DEVICE	Annually
ALIGNMENT GAUGE	Every 24 months
ASH MONITOR	Every 24 months
ASPHALT GAUGE	Every 24 months
BELT MASS METER	CONVEYOR SCALE BELT WEIGHER Every 24 months
BETA LIGHTS	LUMINOUS MARKERS LIGHT SOURCES GUNSIGHTS LUMINOUS EXIT SIGN Leak tests not required

BOREHOLE LOGGIN	GEOGRAPHY LOGGING	Annually, unless source is permanently built-in, in which case 2 yearly tests will suffice
DENSITY GAUGE	DENSITY METER MASS FLOW METER	Every 24 months
DEWPOINT METER		Every 24 months
DUST MONITOR		Usually, every 24 months

ELECTRON CAPTURE DETECTOR	GASCHROMATOGRAPH	No leak tests required
INDUSTRIAL RADIOGRAPHY SOURCE	RADIOGRAPHY SOURCE	Every 6 months
IRRADIATOR	IRRADIATION FACILITY EXPERIMENTAL SOURCE	Every 6 months
LEVEL GAUGE	FILL LEVEL GAUGE LEVEL CONTROL	Every 24 months
MEASURING INSTRUMENT	PHOTOMETER/SPOTMETER URANIUM ORE ANALYSER TRANSFORMER RECTIFIER TUBE SPARK/FUSE GAP MEASURER BONE OR PROFILE SCANNER SULPHUR-IN-OIL ANALYSER	Leak tests must be carried out every 24 months if the source is permanently built into the gauge; else annually.
MOISTURE GAUGE		Gauges with a movable source rod must be tested annually. Others, with built-in source only, must be leak tested every 24 months
PORTABLE LEVEL GAUGE		Annually
PRE-IONISER SOURCE	PLASMA DISPLAY TUBE	Not required

REFERENCE SOURCE	SEALED SOURCE CALIBRATION SOURCE EDUCATIONAL SOURCE FLOOD SOURCE ANATOMIC MARKER	Annually. If sources are not in regular use (in storage) leak tests can be done every 24 months, and before bringing the source back into use.
SCINTILLATION COUNTER	LIQUID SCINTILLATION COUNTER	Source built into LSC's generally need not be leak tested. Loose calibration sources should be leak tested
SMOKE DETECTORS		Not required
SOIL GAUGE	HIDRODENSIMETER SOIL METER DENSITY/MOISTURE GAUGE	Those soil gauges which have a movable source rod (usually incorporating a Cs-137 source) must be leak tested annually. Others, with built-in source only, must be leak tested every 24 months
STATIC ELIMINATORS	ANTISTATIC STRIPS	Leak test not required
TELE THERAPY UNIT	CANCER THERAPY UNIT	Annually
THERAPY SOURCE	CA CERVIX APPLICATOR LINEAR SOURCE TRAIN RA-NEEDLES STRONTIUM EYE- APPLICATOR	Where appropriate, every 6 months. If sources are stored (not in use) leak tests must be done once a year and before bringing back into use
THICKNESS GAUGE	SUBSTANCE GAUGE PROFILE SCANNER BASIS WEIGHT METER	Every 24 months, unless the gauge incorporates a gaseous source (e.g., Kr-85, or H-3) in which case no leak test is

	MASS FLOW METER	required
TRACERS	TRACE SOURCES	Leak tests usually not required, unless tracers are sealed sources.
UNSEALED SOURCE	IN-VIVO/IN-VITRO/RIA	Not required
XRF ANALYSER	METAL ANALYSER MINERAL ANALYSER HILGER & WATTS ANALYSER TEXAS NUCLEAR ANALYSER	Every 24 months - leak tests must be carried out in accordance with the manufacturer's specifications

9. REQUIREMENTS FOR LEAK TESTING FACILITIES

9.1 General Requirements

- A. Sealed sources and detector cells shall be tested for leakage and/or contamination at interval as specified by the regulatory authority (see table 1).
- B. In the absence of a certificate from a supplier indicating that a leak test has been made within the time specified for that source (see table 1) prior to the transfer, a sealed source or detector cell received from another person shall not be used until tested.
- C. Each sealed source fabricated by the holder of the authority shall be inspected and tested for construction defects, leakage, and contamination prior to any use or transfer as a sealed source.
- D. Sealed sources need not be leak tested if:
 - (i) they contain only hydrogen-3; or
 - (ii) they contain only a radioactive gas; or
 - (iii) the half-life of the isotope is 30 days or less; or
 - (iv) they contain not more than 50 microcuries (1,85 MBq) of beta and/or gamma emitting material or not more than 5 microcuries (185 kBq) of alpha emitting material; or

- (v) they are not designed to emit alpha particles, are in storage, and not being used. However, when they are removed from storage for use or transferred to another person and have not been tested within the required leak test interval, they shall be tested before use or transfer. No sealed source or detector cell shall be stored for a period of more than 10 years without being tested for leakage and/or contamination.
- E. The leak testing equipment shall be capable of detecting the presence of 0,5 nanocurie (18,5 Bq) of radioactive material on the test sample and the calibration certificate of the equipment must be valid during the time the leak test is performed. If the test reveals the presence of 5 nanocurie (185 Bq) or more of removable contamination a report shall be filed with this Radiation Control and the source shall be removed immediately from service and decontaminated, repaired, or disposed of in accordance with regulations. The report shall be filed within 5 days of the date the leak test result is known. The report shall specify the source involved, the test results, and the corrective action taken.
- F. The holder of the authority is authorized to collect leak test samples for analysis. Tests for leakage and/or contamination shall be performed by persons specifically accredited by Radiation Control to perform such services.

9.2 Training for Individual Responsible for Leak Testing

- A. The following information should be provided about the individual(s) who will be responsible for leak testing:
 - (i) The person's name
 - (ii) The person's training
- B. Formal training should encompass the following topics:
 - The principles and practices of radiation protection
 - Radiation measurements, monitoring techniques and the use of instruments
 - Mathematics and calculations basic to the use and measurement of radioactivity
 - The biological effects of radiation
- C. A minimum of 40 hours of formal course work should be completed by such a person.

- D. On-the-job training should encompass hands-on training in leak testing the typical sources and devices specified in your application, including performing independent analysis of leak test samples.

9.3 Facilities and Equipment:

- A. Describe such items as:
- (i) Laboratory counting rooms and calibration source storage facilities
 - (ii) Receiving and handling areas where leak test samples are received from customers
 - (iii) Shielded areas, including auxiliary shielding (“L” blocks, etc.), where bare sources may be actually leak tested
 - (iv) Storage facilities for sealed sources or devices that may be received by you for leak testing in your facilities
 - (v) Special tools for handling bare sources or devices and for wiping sealed or devices
 - (vi) Provide Radiation Control with a certificate which certifies that the equipment has the required sensitivity (see section II.1 (E))

9.4 Radiation Safety Programme:

9.4.1 Personnel Monitoring Equipment

- All personnel should wear personnel monitoring devices such as Thermoluminescent Dosimeters (TLD's) or Electronic Personal Dosimeters (EPD's) when performing routine leak tests on uncontained/naked sealed sources in the low millicurie activity range and leak tests on multi-millicurie sources contained in devices.
- If personnel monitoring will not be used, provide a justification that clearly demonstrates it is unlikely that any individual will receive a radiation dose equal to or greater than that specified in the regulations for non-radiation workers (1 mSv a year).

9.4.2 Radiation Detection Instruments and Instruments Calibration

You should list the radiation instruments you will have available for use in performing the leak test services.

Your list should specify for each instrument:

- (a) the type of the instrument
- (b) the number of instrument available
- (c) the radiation detected
- (d) the sensitivity ranges
- (e) the specific use
- (f) when was the instrument calibrated
- (g) expiry date of the instrument
- (h) instrument serial number

The instrument listed should have sufficient sensitivity to accurately measure any radioactive contamination on leak test samples obtained from your customer's sources and devices.

9.4.2.1 Survey Meters

Survey meters must be calibrated at least once every 14 months and after any servicing of the instrument (other than a simple battery exchange). You have three options for calibration, as follows:

- (a) The instrument will be returned to the manufacturer for calibration,
- (b) If the survey instruments will be contracted out for calibration, state the name and address of the firm
- (c) If the instruments will be calibrated in-house, provide the following additional information:
 - (i) The name of the manufacturer and model number of each radiation source to be used,
 - (ii) The nuclide and quantity of radioactive material contained in each source,
 - (iii) The accuracy of each source and the traceability of the source to a primary radiation standard,
 - (iv) The step-by-step procedures, including associated radiation safety procedures you will

use in calibrating, and,

- (v) The name, experience, and training in instrument calibration of each individual who will perform the calibrations

9.4.2.2 Wipe Sample Counting Equipment

Quantitative measuring instruments used to perform analytic measurements on leak test samples should be calibrated before use with standard sources having an accuracy better than or equal to 5 % of the stated value. Standard sources should be traceable to a primary radiation standard such as those maintained by the National Bureau of Standards. You should supply the following information on the calibration of the listed instruments you will use to perform measurements on leak test samples:

- (a) List the standard sources to be used with each listed wipe-sample counting instrument by nuclide and quantity of radioactive material contained in each of the sources.
- (b) Provide a statement of the accuracy of each standard source (information usually available from the source manufacturer). At a minimum, you should state that the accuracy of the standard will be $\pm 5\%$ of the stated value and traceable to a primary radiation standard such as those maintained by the National Bureau of Standards.
- (c) Provide an example of a calculation for converting leak test sample counting results to becquerels or nanocuries.

9.4.2.3 Operating Procedures

The following elements should be included in your operating and emergency procedures, if applicable:

- (a) Instructions for performing the wipe tests, including materials to use and methods of handling samples to prevent or minimize exposure to personnel.
- (b) Surveys to be performed, such as those around the housing to be sure the device is in the “safe”, “store” or “off” position before wipe samples are taken from designated areas of the device.
- (c) Surveys to be performed on wipe-or leak test samples to check for gross contamination before

removal from the site.

- (d) Any specific instructions provided by source and device manufacturers on recommended methods and areas to be wiped.
- (e) Instructions on what to do in case of emergencies, for example, if sources or devices are found to be leaking or excessive radiation levels are found around devices. These instructions should include procedures for proper notification to customer personnel, means of preventing and controlling the spread of contamination, and means of obtaining professional assistance, if needed.

9.4.2.4 Commercial Leak Test Kits

If you plan to manufacture and distribute commercial leak test kits for your customer's use, provide samples of each type of kit you intend to distribute. Commercial leak test kits are designed to be used by your customers to wipe specific sources or to wipe sources in specific devices; the wipes are then returned to you for analysis. Each type of kit you wish to distribute should be identified by a separate model number and clearly labelled as to the type and strength of the source or device it is designed to test.

Each kit should contain all necessary components for use:

- (a) the swabs, wipes, absorbent-tipped sticks, etc., that are to be used to make the wipes on the specified sources or devices
- (b) instructions for safe use of the particular kit (including the type and strength of the source the kit is designed for), step-by-step procedures for making the wipes or smears, and procedures for returning the wipes to you for analysis
- (c) a label for the customer to fill out that identifies the customer's name, authority number, source or device (by manufacturer, model number, and activity) wiped, and the name of the individual who made the wipes.

You must have appropriate sample analysis equipment to properly evaluate the customer's wipes for each type of kit you wish to distribute.

9.4.2.5 Records

You should include copies or descriptions of the types of records you will maintain on leak test samples as part of the documentation of your radiation protection program.

These records should include:

- (a) Identification of each source or device (manufacturer, model number, serial number, isotope, quantity)
- (b) Identification of each customer (name, address, person to contact)
- (c) Radiation survey measurements, as appropriate
- (d) Date of test and date of next schedule test
- (e) Information on test methods used (e.g., type of wipe such as dry filter paper or wet cloth swipe and areas wiped)
- (f) Leak test results expressed in becquerels or nanocuries of alpha, beta, or gamma radiation for each area wiped, and identification of the individual who performed the test.

You should include a copy of the leak test certificate you will supply to customers.

10. LEAK TEST METHODS

This part is included for informative purpose and as guide to promote uniformity of practice to meet the objective of the standard.

10.1 General

Maintenance of its integrity after testing of the sealed source is the criterion for determining that a source meets the specifications of a particular class for a given test. In the case of any test that depends on the measurement of radioactive material associated with a test source as an indicator of source capsule integrity, a comparison of activity removed from the source before and after a performance test must be the criterion. The amount of activity removed from a source following a performance test, unless related to the removable activity on the source before the test, is not a measure of leakage from the test source interior or necessarily an indication of a breach in capsule integrity.

Several methods of leak testing (integrity testing) are acceptable to determine whether sealed sources meet or fails the specifications of a test. Not all the listed leak test methods are applicable to all sources. The test, or tests, most applicable to all particular source configurations should be chosen. In the case of

multiple encapsulations, different leak test methods may be appropriate for each encapsulation.

Leak Test Methods

A1. Screening measurements:

A screening measurement should be done to determine if any contamination is present. The swab should be counted for an optimised time to determine if the reading is out of the range $x \pm 2,58 b$, where x is the average background and b the standard deviation of the background reading. If the measurement lies within this range, there is a 99 % certainty that the reading is only background. If the value lies out of this range a quantitative analysis shall be done on the swab.

10.2 Acceptable Leak Test Methods

10.2.1 General

For the tests by radioactive means, it is assumed that the source has been cleaned and is free from radioactive surface contamination before the performance test is initiated.

10.2.2 Wipe (Smear) Test

Wipe all external surfaces of the sealed source thoroughly with a piece of filter paper or other suitable material of high wet strength and absorbent capacity, moistened with a solvent which will not attack the material of which the outer surfaces of the source are made and which, under conditions of this test, has been demonstrated to be effective in removing the radioactive substance involved. Measure the activity on the wiping material. If the activity is less than 5 nCi (185 Bq) the source is leak free.

10.2.3 Dry (Smear) Test

Wipe all external surface of the sealed source thoroughly with a piece of filter paper or other suitable material of high wet strength and absorbent capacity, moistened with a solvent which will not attack the material of which the outer surfaces of the source are made and which, under conditions of this test, has been demonstrated to be effective in removing the radioactive substance involved. Measure the activity on the wiping material. If the activity is less than 5 nCi (185 Bq), the source is considered to be leak free.

10.2.4 Immersion with Boiling Test

Immerse the sealed source in a solvent which will not attack the material of which the outer surfaces of the source are made and which, under the conditions of this test, has been demonstrated to be effective in

removing the radionuclide involved. Boil for 10 minutes, remove the source (retaining the solvent) and allow to cool, then rinse the source using fresh solvent. Repeat these operations twice, for a total of three tests, using the original solvent for the boiling. Measure the total activity in the solvent. If the activity is less than 5 nCi (185 Bq) the source is considered leak free.

10.2.5 Gaseous Emanation Test (for Radium-226 Sources)

Put the sealed source to be tested into an appropriate small gas-tight container together with activated carbon or two cotton filters and leave it there for 24 hours. Take out the source and shut the container again. Measure immediately the activity of the absorber. If the activity corresponds to less than 1 nCi (37 Bq) of Radon or daughter products, the source is considered leak free.

10.2.6 Kr-85 Test

Place the cleaned sealed source in a suitable pressure chamber. Evacuate the chamber and introduce a known amount of Kr-85. Pressurize the chamber with argon to a pressure of at least $0,4 \text{ MN/m}^2$ (60 lb/in^2) for at least 10 minutes. Vent the chamber and place the source in a clean test chamber. Purge the chamber with argon at atmospheric pressure and allow the system to stand for at least 5 minutes. Draw a fraction of the chamber atmosphere into an evacuated, calibrated Kr-85 counting chamber. Calculate the leak rate from the counting rate. If the leak rate is less than 1×10^{-8} standard cubic centimeter per second, the source is considered leak free.

11. REFERENCES

The following related documents are referenced:

- 11.1 South Africa. 1973. Hazardous Substances Act, No.15 of 1973. Pretoria: Government Printer.
- 11.2 South Africa. 1993. Regulations relating to Group IV Hazardous Substances. Published under Government Notice R247 in Government Gazette 14596 of 26 February 1993

12. VALIDITY

This guideline is valid for a period of 5 years from the effective date of revision and replaces the old guideline on Leak Tests, revised in January 2015. It will be reviewed on this timeframe or as and when required.