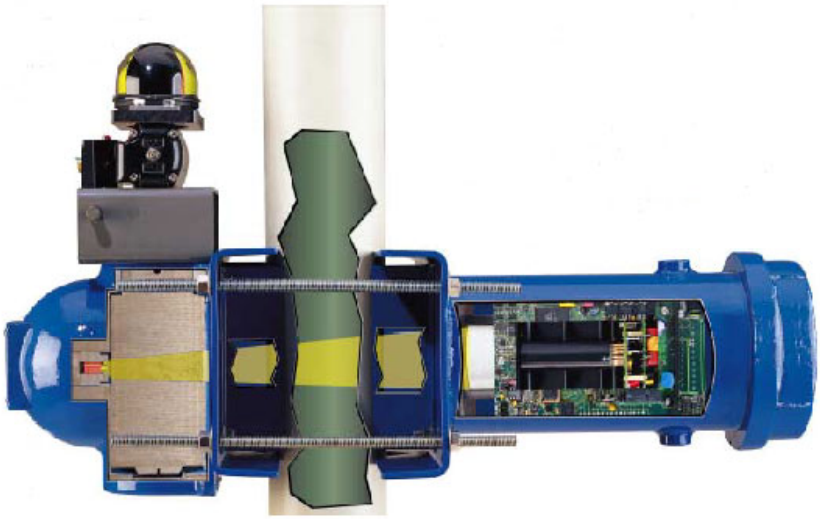
Government of **Western Australia**
RADIOLOGICAL COUNCIL

INDUSTRIAL COMPLIANCE TESTING

WORKBOOK 1
Fixed radiation gauges

2023



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PREFACE

The compliance testing program for industrial (fixed) radiation gauges was introduced on 1 July 2000 by the Radiological Council, the regulatory body established under the Radiation Safety Act 1975 of Western Australia.

This workbook provides the standard tests approved by the Radiological Council[1] for routine compliance testing of fixed gauges containing radioactive material. Variations to the recommended test methods may be used provided they are first approved by the Radiological Council. Documentation on any proposed alternative test method will need to be provided.

Persons performing these tests in Western Australia must hold a licence under the Radiation Safety Act for the purpose or be acting under the direction and immediate personal supervision[2] of a licensee.

The tests assess compliance with regulations under the Act and the relevant Codes of Practice.

The tests are largely concerned with radiation safety.

[1] Other regulators and professional groups who may wish to reproduce all or part of this workbook for use in their own testing programs should contact the Radiological Council for permission to do so.

[2] Immediate personal supervision requires the licensee to be present and directly observing the person concerned.

CONTENTS

1. INTRODUCTION

1.1 SCOPE AND APPLICATION

This workbook describes methods for standard compliance tests on fixed gauges that incorporate radioactive sources. It does **not** apply to gauges which use electrically generated x-rays.

The workbook does not necessarily cover all tests that may be part of a comprehensive quality assurance (QA) program but outlines those tests which relate to radiation safety standards.

Persons intending to use this workbook are to be familiar with the Industrial Compliance Testing *Program Requirements*[3] which is available on the Radiological Council website. It also includes information on the approvals required to perform the tests.

The required frequency of equipment testing as prescribed by the regulatory authority is every three years for gauges that are both in use or in storage. Testing is also required upon installation for any equipment that has been in storage or relocated, or after any service or repair which may affect the performance of the equipment.

Test equipment that may be required includes –

- Test sheets (see **Attachment 1**)
- Tape measure
- Radiation Survey Meter[4]

1.2 DEFINITIONS

Gauges Code

In this workbook, "Gauges Code" means the Australian *Code of Practice and Safety Guide for the Safe Use of Fixed Radiation Gauges (2007)*, Radiation Protection Series No. 13. Australian Radiation Protection and Nuclear Safety Agency.

Radiation Units

The following Système Internationale (SI) quantities are used in radiation measurement.

Exposure (C kg^{-1})

A measure of the ionisation produced in air by x and γ radiations. The quantity 'exposure' has limited use in relation to the biological effect of radiation.

Absorbed Dose (Gy)

Is the energy absorbed per unit mass in a nominated medium. Because the amount of energy deposited in a material from a radiation will depend on the material being irradiated, it is common for the medium to be stated, for example, in air, in soft tissue, etc.

[3] www.radiologicalcouncil.wa.gov.au/Registrations/Common-Requirements/Compliance-Testing

[4] All radiation measuring instruments must be calibrated at the frequency prescribed by the Radiological Council.

The unit of absorbed dose is the Gray (Gy), which is equal to the deposition of 1 joule of energy in a mass of 1 kg of the nominated material.

Equivalent Dose (Sv)

This quantity takes into consideration the type of radiation being measured. The unit of equivalent dose is the Sievert (Sv).

$$\text{Equivalent Dose (Sv)} = \Sigma \text{ (Absorbed Dose x } W_R)$$

where W_R is the Radiation Weighting Factor and Absorbed Dose refers to the average dose over a tissue or organ.

The Radiation Weighting Factor relates to the biological effects that result from the various types of radiation. For x and γ-rays, the weighting factor equals 1 and thus an absorbed dose of 1 Gray (Gy) of x or γ radiation gives an equivalent dose of 1 Sievert (Sv).

Effective Dose (Sv)

The quantity of effective dose is perhaps the most meaningful quantity to be used in radiation protection because it relates the equivalent dose to certain tissues or organs to a whole body dose of radiation.

$$\text{Effective Dose} = \Sigma \text{ (Equivalent Dose x } W_T)$$

where W_T is the Tissue Weighting Factor.

The following table compares SI and non-SI units.

Quantity	SI unit	Old unit	Conversion
Exposure	C kg^{-1}	Roentgen (R)	1 C kg^{-1} = 3876 R
Absorbed Dose	Gray (Gy)	rad (rad)	1 Gy = 100 rad
Equivalent Dose	Sievert (Sv)	rem (rem)	1 Sv = 100 rem
Effective Dose	Sievert (Sv)	rem (rem)	1 Sv = 100 rem

All radiation output measurements should be recorded as absorbed dose or dose rate in air. The unit for absorbed dose is the Gray (Gy). Commonly used sub-multiples of this are milliGray (mGy = 10^{-3} Gy) and microGray (μGy = 10^{-6} Gy). For x and γ radiation, an exposure of 1 R = 8.73 mGy in air and 1 mR = 8.73 μGy in air.

Permission

Before performing any of the tests in this workbook, ensure that all necessary approvals to operate the gauge have been obtained from –

- the regulatory authority (eg. by licensing)
- the equipment owner or Radiation Safety Officer (note that some tests may affect functions dependent on the gauge's operation).

The Registrant's Radiation Safety Officer must, in any case, be made aware of the planned tests.

Radiation Protection

Persons carrying out testing must take appropriate measures to protect themselves from the radiation hazard during all tests.

While not essential, persons carrying out the testing of some devices may wish to wear an approved personal monitoring device (TLD, OSL or suitable electronic dosemeter) to record their occupational radiation dose.

Recording Test Results

All compliance test measurements must be recorded on a standard test sheet. An example of a test sheet is provided in **Attachment 1**.

Any faults found during testing must be detailed on the test sheet, even if such faults are corrected before the completion of testing. Such faults may be common to the particular model of gauge, and failure to report them may put other users and nearby workers at risk.

2. REGISTRATION INFORMATION

Record on the test sheet the following registration information –

- registrant's name and address details;
- the name of the Radiation Safety Officer;
- the registration number;
- whether the registration conditions are accessible;
- the date of the audit.

Assessment and Evaluation

Where there is an existing registration, the information recorded is to be checked against the most recent registration certificate and any subsequent amendments that have been submitted to the Radiological Council.

Note any discrepancies in the accuracy of the details provided for the first three points and advise the Registrant or Radiation Safety Officer immediately; Section 38 of the Radiation Safety Act requires the registrant or the Radiation Safety Officer to provide notice of a change in circumstances of the information furnished to the Radiological Council. Discrepancies should still be recorded on the compliance testing worksheet.

3. RADIATION MANAGEMENT PLAN

Record on the test sheet whether the Radiation Management Plan incorporates the required details from the Gauges Code, including –

- work practices and clear working rules;
- roles and responsibilities;
- how to conduct radiation surveys and wipe tests;
- how to operate and lock source containers;
- how to prevent persons from gaining access to or entering the useful radiation beam;
- how to store and transport gauges within the premises and on public roads;
- the inspection frequency of source containers, calibration of survey meters, the presence of labels and warning notices;
- emergency procedures including the steps to be taken to bring an incident under control following theft or other unaccounted loss, fire, loss of shielding, a transport accident or suspected malfunction of the shutter mechanism;
- when and how the RSO must investigate an incident and to whom the RSO must issue a report;
- records and accountability.

Record on the test sheet whether the Radiation Management Plan –

- is made available to the staff;
- includes up to date emergency contact details;

Record on the test sheet the date the working rules and emergency procedures were last reviewed.

Assessment and Evaluation

The Radiation Management Plan must be developed, readily available, regularly reviewed and up to date. It must incorporate the subject matter required by Clause 2.2.1 and specified in Schedule A of the Gauges Code. Additional guidance is provided in Section 2 of the Safety Guide to the Gauges Code.

It is recommended that emergency procedures for fixed gauges also be incorporated in the site's emergency procedures manual.

Details of any incomplete content should be provided in the comments section of the test sheet.

4. COMPANY RECORDS

Record on the test sheet whether records showing the following details are available –

- source inventory, including –
  - the number and location of all gauges together with their identifying numbers;
  - the radionuclide(s) present in each gauge;
  - activities and dates of measurement of the radionuclide(s);
  - check the inventory of gauges and sources against the supplementary sheet included with the current registration certificate **and** subsequent approved amendments; note any discrepancies in the accuracy of registered assets;
- results of the annual wipe tests by a recognised[5] laboratory for ALL gauges on site;
- periodic radiation response check of the survey meter(s);
- results of annual audit;
- results of 12 monthly shutter operation test.

Assessment and Evaluation

Records should be kept by the owner and be available at the time of the audit.

Under the Conditions applied to registrations under Section 36 of the Radiation Safety Act, for the use of ^{137}Cs sources beyond the manufacturer's recommended working life, the source capsules must be examined and have their integrity confirmed 15 years from the date of manufacture. The overall life of source capsules containing ^{137}Cs is not to exceed 30 years.

*Gauge housings must be wipe tested **annually** and assessed by a recognised laboratory (note that the Conditions applied to registrations under Section 36 of the Radiation Safety Act overrides the frequency for wipe tests in Clause 2.2.3(i) of the Gauges Code).*

Gauges must be inspected every 12 months in accordance with Clauses 2.2.3(g) and C2.7 of the Gauges Code.

[5] Recognised means recognised in writing by the Radiological Council.

5. RADIATION STORE

Record on the test sheet whether –

- the store is reasonably able to withstand unauthorised entry and kept securely locked with the key being held by a responsible person;
- the site of the store allows it to be used as a thoroughfare;
- the store is inappropriately located with respect to the ALARA principle;
- all gauges kept in the store are locked in the 'off position';
- suitable notices are present with the wording 'CAUTION' and a radiation hazard symbol;
- the RSO contact details are present and current.
- the dose rate at any accessible point outside the store is less than 25 µSv/h;
- flammable, explosive or corrosive materials are segregated such that they are not co-located with radioactive material in the store.

Assessment and Evaluation

The store must comply with the requirements of Regulation 30 of the Radiation Safety (General) Regulations and with the Clause 2.2.17 and Schedule G of the Gauges Code. Additional guidance is provided in Section 5 of the Safety Guide to the Gauges Code.

Note

Flammable or explosive materials and photographic or x-ray film should not be co-located where radioactive materials are stored.

6. RADIATION SURVEY METERS

Record on the test sheet –

- whether suitable portable survey meters are available;
- whether the instrument is functional when checked with a source of ionising radiation;
- the manufacturer and model of the instrument;
- the date of last calibration;
- the organisation which calibrated the instrument
- if neutron sources are used on the site, whether a neutron survey monitor is available or if suitable information is used to estimate the neutron dose from gamma measurements.

Assessment and Evaluation

Users of in-stream analysis gauges are exempted from the requirement of having a survey meter capable of measuring the radiation dose rate. However, they must have available an instrument capable of indicating the presence of radiation, judged by having at least a 50% deflection on the most sensitive range for the type of radiation emerging from the in-stream analysis probe.

Survey meters must be suitable for the measurement of the applicable isotope energies in use, radiations emitted and expected dose rates, and are required to meet the criteria specified in Clause 4.2 and Schedule E of the Gauges Code.

7. GAUGE DETAILS

The information outlined in this Section requires the compliance tester to physically inspect each gauge.

7.1 CONTAINER AND SOURCE DETAILS

Take photographic evidence at the time of testing of the gauge label and warning signage. Retain as a record. If photographs cannot be taken (eg due to environment), note this on the test.

Record on the test sheet the following source and container details –

- location on premises;
- gauge container manufacturer;
- model of container;
- serial number of container;
- use of gauge, eg. level, density, etc;
- isotope(s) contained in the gauge;
- original activity of isotope(s) in MBq and date of activity (note that the isotope activity and date of measurement must be for the *original* date, not the date the gauge was refurbished or otherwise serviced, nor the date the source capsule was leak tested as part of extension to the manufacturers recommended working life where relevant);
- source serial number(s);
- whether an appropriate, legible label is displayed on the gauge housing indicating the source and container serial numbers, the isotope, activity and date the activity was measured, the maximum radiation level at 1 metre, and the name and address of supplier or manufacturer;
- whether the required gauge warning signs are attached in close proximity and are clean and legible;
- whether a bin/hopper warning sign is present if applicable;
- whether the gauge has been locked in the 'on' position.

Assessment and Evaluation

The source container must be a make and model approved for use in Western Australia by the Radiological Council.

Unless exempted by the Council, the radioactive substance used must comply with Clause 2.1.11 and Schedule B1 of the Gauges Code.

The source details must be durably marked on a label in accordance with the requirements of Schedule C of the Gauges Code.

The warning signs must be of appropriate form and size such that they are visible and legible, in accordance with Clause 2.2 of the Gauges Code. They must be attached as close as convenient to the radiation gauge.

Radiation Gauges should be designed such that they cannot be locked in the beam 'on' position, in accordance with Schedule C2.2 of the Gauges Code, unless prior approval has been given by the Radiological Council.

Additional guidance is provided in Annexes A, B and D of the Safety Guide to the Gauges Code.

7.2 RADIATION LEVELS

Purpose of Test

To determine the level of radiation leakage from the source housing and the potential dose to persons who may be in the vicinity.

Equipment Required

Tape measure
Survey Meter

Method

1. Measure the dose rate at 1 metre from the surface and at a number of different points around the gauge with the shutter closed (if fitted). Record the values on the test sheet diagram showing clearly where the test measurements were made.

2. Repeat the above but at a distance of 5 cm from the surface.

3. Repeat 1 and 2 above but with the shutter in the 'open' position.

4. Where any person is working, or may work, in close proximity to the gauge or the useful radiation beam, estimate their maximum likely radiation dose.

Assessment and Evaluation

Gauge Housing Leakage Limits

Clause C2.3 of the Gauges Code stipulates the following dose rate limits with the shutter or control mechanism in the 'off' position –

500 µSv/h at any point 5 cm from the external surface of the housing.
10 µSv/h at any point one 1 m from the surface of the housing.

Potential Exposure of Workers

Is any worker, in a normal situation[6], likely to be in a location where they may receive a radiation dose exceeding the following regulatory limits (Regulation 24 and Schedule I of the Radiation Safety (General) Regulations) –

(a) in any period of 5 years, an average effective dose of 1 milliSievert per year;

(b) in any period of 12 months, an effective dose of 5 milliSieverts; and

(c) in respect of an area which such persons might continuously occupy –

(i) an effective dose of 20 microSieverts in any 1 hour; and
(ii) an effective dose of 250 microSieverts in any period of 7 days.

[6] Normal situation means other than for work performed on or adjacent to the gauge for which the Radiation Safety Officer's approval has been obtained (ie the worker is subject to the public dose limits)

When dose rates in an area are high enough that a member of the public could receive a dose in excess of the above limits, additional measures are required to prevent public access to these higher dose rates, such as building enclosures around the gauges.

Public dose can be estimated in areas near the gauge by using radiation levels, determined during the surveys with the shutter open, and applying the "inverse square" law to evaluate the effect of distance on radiation levels and occupancy factors to account for the actual presence of members of the public.

If, after making a public dose estimate, the conditions used to make the evaluation change (e.g., changes to the location of gauges, changes to the type or frequency of gauge use, addition of gauges, changes to the occupancy of adjacent areas), then a new evaluation to ensure that the public dose limits are not exceeded must be undertaken and any necessary corrective action made.

7.3 SHUTTER OPERATION TEST

Purpose of Test

To determine the correct operation and labelling of the shutter mechanism (where fitted).

Equipment Required

Survey meter

Method

Operating the shutter mechanism may impact on the plant's operations. Approval to operate the shutter mechanism must be obtained from the owner or owner's representative.

For some gauges it may be difficult to detect a change in the survey meter's response as the shutter mechanism is actuated. In such situations it may be necessary to confirm the shutter's operation from the gauge's output meter alone. That meter may be sited at a location remote from the gauge itself and may require the assistance of a second person to confirm the meter's response by two-way radio. For example, when testing a density gauge, a significant increase in the specific gravity (SG) reading on the gauge meter is an indication that the shutter has closed.

For mechanically operated shutters –

1. Record on the test sheet the type of shutter or source control mechanism.
2. Avoiding the useful radiation beam, place the operating survey meter in a position near the port of the gauge.
3. Turn the shutter mechanism to the 'on' position while monitoring the response of the survey meter (and/or gauge meter).
4. Turn the shutter mechanism to the 'off' position while monitoring the response of the survey meter (and/or gauge meter).
5. Repeat steps 3-4 until 4 cycles have been performed.
6. Note on the test sheet any impedance to free movement of the shutter during operation of the shutter.
7. Record whether the shutter position indicators are legible.

For electronically operated shutters –

1. Perform steps 1 to 5 above. Associated plant equipment may also need to be operated.
2. For gauges installed on moving lines, note whether the shutter closes when the line is stopped.
3. Record whether the shutter position indicators are legible.

Assessment and Evaluation

The requirements for the shutter test are provided in Clauses 2.2.3 and Schedule C of the Gauges Code. The shutter mechanism must operate freely and without obstruction from corrosion or the build-up of foreign matter through the full movement between the 'open' and 'closed' positions. The 'open' and 'closed' position must be clearly identified.

Note

Determination of the shutter operation for level gauges should not require access to the bin, hopper or vessel. Means of testing the shutter operation should be performed by use of the detector. If after repeating steps 3 and 4 above several times there is no change in the detector's response a small activity 'test' source could be placed near the detector to determine whether the detector may be at fault.

7.4 CONTAINER CONDITION DETAILS

Purpose of Test

To determine the current condition of the source container.

Equipment Required

Survey meter

Method

Note the following –

1. the rigidity of the mounting and whether it is secure such that it does not allow for any part of the human body to access the primary radiation beam;

2. evidence of cracks or corrosion on the mounting points or bolts;

3. build-up of foreign matter on the container;

4. evidence of corrosion or damage to the container;

While noting the response of the survey meter, check the continuity of the shielding by moving the survey meter slowly across the surface of the gauge at a distance of approximately 10 cm.

Take photographic evidence to show the gauge condition. Additional photographs are to be taken to illustrate any flaws or abnormalities observed with the gauge during testing. Retain as a record. If photographs cannot be taken (eg due to environment), note this on the test.

Assessment and Evaluation

The condition of the gauge and the mounting hardware shall be such that it is undamaged and the gauge housing remains securely fastened to its supporting structure, with particular reference to the criteria specified in Clause C2.2.3 of the Gauges Code, with further guidance provided in Section 2.3 of the Safety Guide to the Gauges Code.

Any response on the survey meter suggesting a flaw in the shielding must be noted and the shielding further investigated by a person licensed to service radioactive devices.

RELATED PUBLICATIONS

1. Radiation Safety Act 1975 (as amended)

2. Radiation Safety (General) Regulations 1983 (as amended)

3. Radiation Safety (Transport of Radioactive Substances) Regulations 2002 (as amended)

4. 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication 103. International Commission on Radiological Protection, 2007.

5. Australian *Fundamentals for Protection Against Ionising Radiation (2014)*, Radiation Protection Series F-1, published by the Australian Radiation Protection and Nuclear Safety Agency.

6. Australian *Code for Radiation Protection in Planned Exposure Situations (2020)*, Radiation Protection Series C-1, published by the Australian Radiation Protection and Nuclear Safety Agency;

6. Australian *Code of Practice and Safety Guide for the Safe Use of Fixed Radiation Gauges (2007)*, Radiation Protection Series No. 13, published by the Australian Radiation Protection and Nuclear Safety Agency.

ATTACHMENT 1
TEST SHEET TEMPLATE

FIXED GAUGES TEST SHEET

Testers should complete all relevant sections and submit the completed form by email together with any attachments of other test results to the Radiological Council.

NOTE: Boxes should be completed with a ✓ for 'yes' and a × for 'no'.

Registration Information (Section 2)

Name:

Address:

Suburb/Town:

Postcode:

Phone number:

RSO Name:

Registration number: *RS* _____ / _____ _____

Registration conditions accessible? ☐

Date of test:

Radiation Management Plan (Section 3)

Incorporate recommended content ? ☐

Copy available to staff ? ☐

Include current emergency contact details ? ☐

Date last reviewed:

Company Records (Section 4)

Source inventory complete ? ☐

Annual wipe test results recorded ? ☐

Annual audit and shutter check recorded? ☐

Annual shutter check recorded ? ☐

Periodic survey meter check? ☐

Date of last recorded audit:

Radiation Store (Section 5)

Security adequate ? ☐

Store location satisfactory ? ☐

Gauges in store locked off ? ☐

Warning signs present and legible ? ☐

RSO contact details present and correct ? ☐

Dose rate outside store ≤ 25 μSv/h ? ☐

Dangerous goods segregated ? ☐

Radiation Survey Meters (Section 6)

Survey meter available and appropriate to site ? ☐

Functioning ? ☐

Manufacturer:

Model:

Date of last calibration:

Organisation calibrated by:

Notes

If any of the above areas are not in compliance, please record further information or recommendations in the Comments section

GAUGE DETAILS (Section 7)

Complete all of the details below for each gauge (copy this page if necessary)

Details	**Gauge**				
	1	***2***	***3***	***4***	***5***
Location of gauge on premises					
Manufacturer					
Model					
Serial number of container					
Use D density; L level; ISA in stream analysis; O other					
Isotope					
Original activity (MBq)					
Date of original activity					
Source serial number					
Gauge label present and legible ? *** Photo**					
Gauge warning sign present ? *** Photo**					
Bin/Hopper warning sign present ?					
Gauge locked in the 'on' position ?					
Shutter fitted ?					
Max. dose rate at 5cm (μSv/h), shutter off					
Max. dose rate at 1m (μSv/h), shutter off					
Shutter operating freely ?					
Shutter position indicators legible ?					
Gauge mounting rigid and secure ?					
Gauge housing and mounting clean and undamaged ? *** Photo**					

*** Take photographs where indicated and retain as record.**

Comments

Compliance Tester's Instrument Calibration

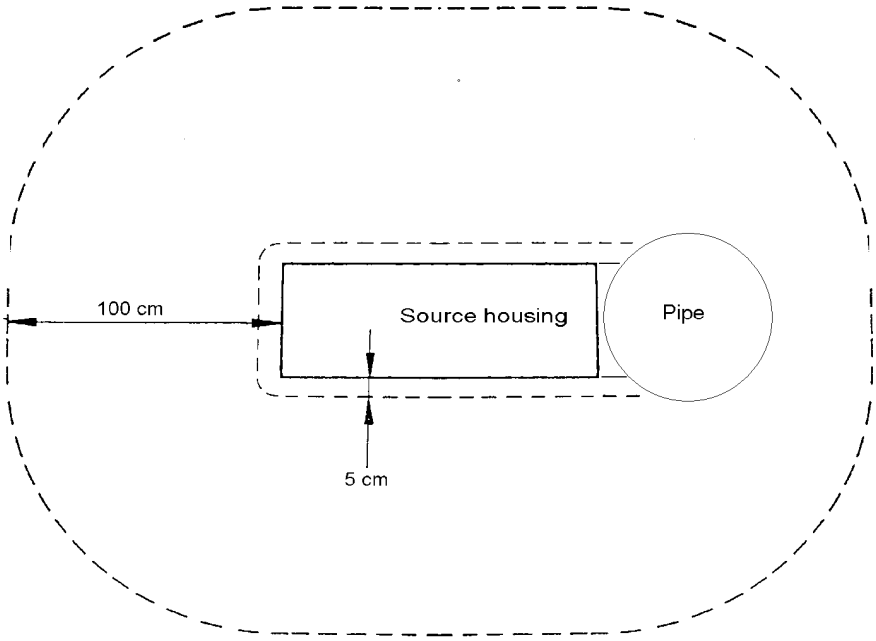
Instrument	***Serial No***	***Date***	***Organisation***

Compliance Tester (Print Name)

Compliance Tester (signature) ***Date***

DENSITY GAUGE LEAKAGE

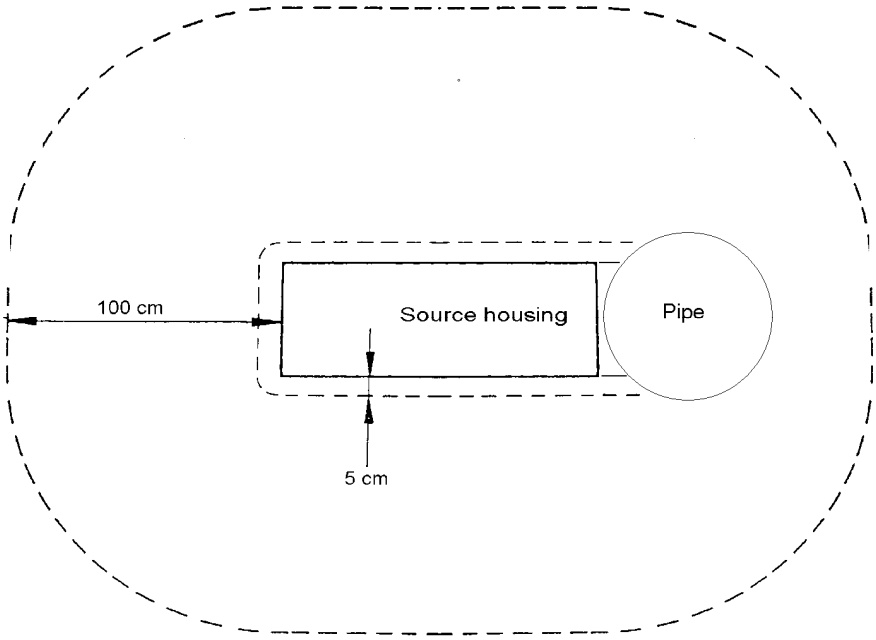
(Refer to Section 7.2)



Gauge serial number: ……

Maximum leakage at 5 cm: …… μSv/h with shutter 'off'

Maximum leakage at 1 m: …… μSv/h with shutter 'off'



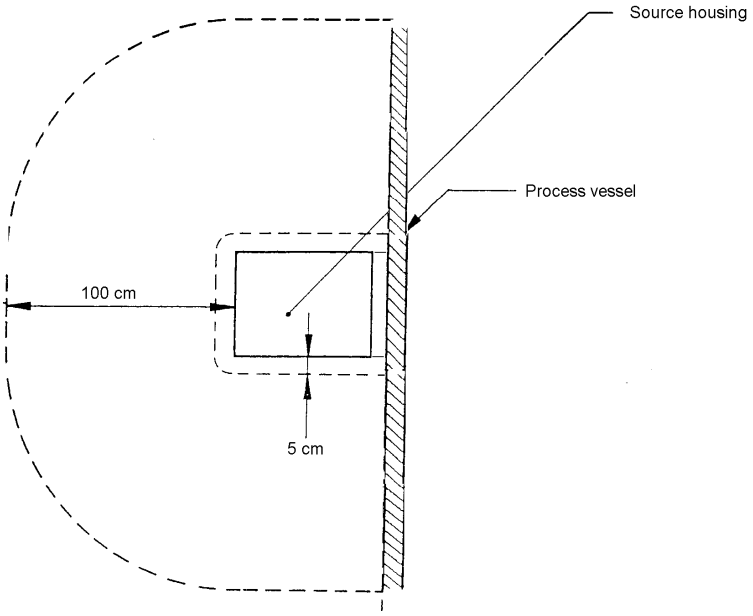
Gauge serial number: ……

Maximum leakage at 5 cm: …… μSv/h with shutter 'off'

Maximum leakage at 1 m: …… μSv/h with shutter 'off'

LEVEL GAUGE LEAKAGE

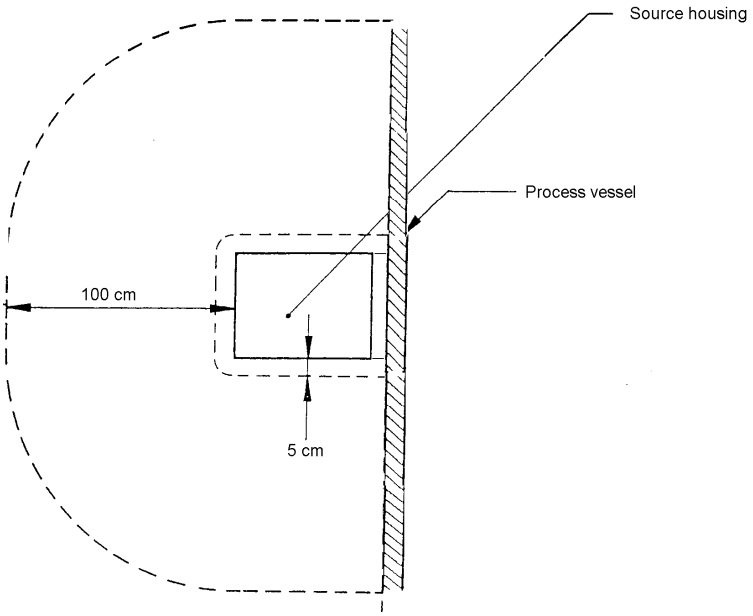
(Refer to Section 7.2)



Gauge serial number: ……

Maximum leakage at 5 cm: …… μSv/h with shutter 'off'

Maximum leakage at 1 m: …… μSv/h with shutter 'off'



Gauge serial number: ……

Maximum leakage at 5 cm: …… μSv/h with shutter 'off'

Maximum leakage at 1 m: …… μSv/h with shutter 'off'