

NRL GN15

GUIDANCE NOTES

Safe Practice for the Use of Nuclear Density Meters

National Radiation Laboratory
Ministry of Health
PO Box 25-099
Christchurch
NEW ZEALAND

June 2000
Revised July 2010

© 2000, National Radiation Laboratory
Ministry of Health

Published with the permission of the Director-General of Health

CONTENTS

	<i>Page</i>
INTRODUCTION	
LEGAL REQUIREMENTS AND RESPONSIBILITIES	1
Consents for import, export, sale and ownership	1
Licences to use radioactive material	2
Use by an unlicensed person	3
Responsibilities of the owner	3
Equipment registers and records of use	4
Radiation Safety Plan	5
SAFETY MANAGEMENT	6
Storage facilities	6
Responsibilities for storage	7
Labelling of the meter and its transport case	7
Accident prevention	8
Maintenance and wipe testing	8
Withdrawal from use	9
Decommissioning	10
Safety audits	11
OPERATOR SAFETY	12
Safety during normal use	12
Use by an unlicensed person	12
Personal monitoring	13
Radiation survey meters	13
ACCIDENTS, LOST SOURCES, AND EMERGENCIES	14
Accidents	14
Lost sources	15
Fire and civil defence emergencies	15
TRANSPORT	17
REFERENCES	18
APPENDIX UNITS OF MEASUREMENT	19
Units of radioactivity	19
Units of radiation dose	20
CROSS-REFERENCE INDEX	21

INTRODUCTION

These *Guidance notes* have been written to provide information for owners and users on the safe care and use of instruments containing radioactive materials used for the measurement of moisture content and/or density of materials. They give practical guidance on compliance with the requirements of radiation protection legislation and the *Code of safe practice for the use of nuclear density meters, NRL C15*.

Some of these instruments have been known as “soil moisture gauges” and others as “nuclear density meters” or just “NDMs”. For simplicity, these *Guidance notes* will follow industry terminology and use the term “nuclear density meter”. In the marginal notes, the abbreviation NDM will be used.

Some parts of these *Guidance notes* and of the *Code, NRL C15* are relevant for users of asphalt gauges containing radioactive sources. These are normally laboratory bench instruments, and are not portable field instruments. Nevertheless, the radioactive sources used are similar to those used for moisture measurement and the safety implications are similar.

The units of measurement of radioactivity and radiation dose are discussed in the Appendix.

LEGAL REQUIREMENTS AND RESPONSIBILITIES

The ownership and use of radioactive materials in New Zealand is controlled by the *Radiation Protection Act 1965*^[1] and the *Radiation Protection Regulations 1982*^[2]. Importing, exporting and selling is controlled through a consent process, and users must be licensed under the *Act*. The *regulations* contain more detailed general requirements for both owners and licensed users of radioactive material.

Both ownership and use of NDMs are controlled by law

The additional requirements specific to nuclear density meters are contained in the *Code of safe practice for the use of nuclear density meters, NRL C15*. Anyone licensed to use a nuclear density meter must comply with this *Code*.

NRL C15 must also be complied with

If these requirements are always fulfilled, every nuclear density meter will remain under the responsibility of an authorised person, from the time it is imported into New Zealand until it is exported or finally disposed of.

Consents for import, export, sale and ownership

Section 12 of the *Act* requires that no-one can sell, import, or export any radioactive material (including nuclear density meters) without having a consent to do so. An application must be made to NRL for a consent prior to any such transaction.

A consent from NRL is necessary

If a nuclear density meter is being imported by a NZ agent, then the agent must apply for a consent. If you are importing it directly, then you must apply for a consent.

Who needs the consent?

In terms of the *Act*, “sale” includes lending or hiring. Any owner must apply for a consent prior to hiring or lending nuclear density meters to other companies or individuals. Where a company has several branches, and circulates a nuclear density meter around them, but maintains responsibility for it as the owner, then this is not classed as “loan” and is not subject to consent.

“Selling” includes lending or hiring

If a nuclear density meter is owned by a syndicate of independent individuals or companies, then one must be nominated as the “owner” in terms of the legislation. In this case a consent is necessary before it is loaned to the other members.

One person or company must be named as the owner

How to get a consent form and fee information

Forms and fee information are available on our web site: <http://www.nrl.moh.govt.nz/regulatory/consent.asp>

In summary if you are:

- *importing a nuclear density meter directly from overseas you need to apply for a consent;*
- *buying a nuclear density meter from a NZ agent then it is up to the agent to arrange for a consent;*
- *selling, lending, or hiring out your nuclear density meter to another company you need to apply for a consent;*
- *transferring a nuclear density meter from one branch to another of the same company then a consent is not needed (but you should notify NRL of the change of location);*
- *exporting a nuclear density meter you need to apply for a consent.*

Licences to use radioactive material

A licence is necessary

Anyone using radioactive material for any purpose (including a nuclear density meter) must either hold a licence for that purpose under the *Act* or be acting under the supervision or instructions of a licensee (see Section 13 of the *Act*). All such licences require compliance with the *Code of safe practice, NRL C15*. Further specific conditions may be added in some cases.

Obtaining a licence information pack

A licence information pack, containing an application form for a licence to use a nuclear density meter and copies of the *Code of safe practice NRL C15*, these *Guidance notes*, the *Act*, and *regulations* can be obtained from NRL.

Training requirements

To be eligible for a licence an applicant must have received training approved by NRL in all aspects of the safe handling and management of nuclear density meters. The licence application form includes a request for evidence of this training. Licensees may also be required to demonstrate on-going competency at subsequent licence renewals.

What does the term “principal licensee” mean?

Where there is more than one licensee using the same nuclear density meter, then each has full responsibility for safety and compliance with all regulatory requirements while they are using the meter. However there are some aspects of safety management where it may be ambiguous which licensee is responsible (eg, maintenance of a log). In this case one licensee must be designated the “principal licensee” (see *regulation 9(3)*). Some of the requirements in the *Code* refer specifically to the principal licensee (see *NRL C15, Sections 1.3, 2.1, 2.2, 3.2.1, 3.10.1, 5.2.1*).

Licensees cannot reasonably maintain control of meters beyond a limited geographical area or in other branches of the owner's organisation, so there should be a principal licensee in each area or branch.

How many principal licensees should there be?

Use by an unlicensed person (NRL C15 Section 4.2)

A person who is not licensed may use a nuclear density meter *under the supervision or instructions* of a licensee. In order to ensure that it does not become too far removed from the control of a licensed person, there must be at least one licensee at each separate operational base or branch of a company that uses a nuclear density meter.

Use under supervision

It is up to the licensee who is supervising to ensure the unlicensed person is trained in all aspects of safety necessary for the degree of independence from supervision they will have. A person operating in the presence of the licensee will not need as much training as one who takes a meter away for a day to use in the absence of the licensee.

Training is required for unlicensed users

For short term absences (eg, annual leave) an unlicensed person may use a meter under the licensee's instructions as long as the licensee can be easily contacted.

Short term absence of the licensee

The important thing for the licensee to remember is that they still have full legal responsibility for the safety of the meter and they must have full confidence that the unlicensed person knows what to do in all circumstances.

But the licensee is still responsible

The unlicensed person must be given a set of written instructions detailing what should be done if anything goes wrong, and how to contact the licensee.

In case of emergency

Responsibilities of the owner

Regulation 9(1) requires the owner of a nuclear density meter to take all reasonable steps to ensure there is always a suitably licensed person to take care of safety. This applies whether the meter is actually being used or not. There must be someone on hand who is suitably trained to ensure the meter is safely stored when not used, that it is safely packaged and consigned when it is sent elsewhere, and that records are properly kept. There must be a licensee at each branch to look after the overall management of safety. When there is more than one licensee at a branch, then it is the responsibility of the owner to designate one as the principal licensee (see p. 2) to attend to these matters.

The owner must ensure there is a licensee

<i>Resignation or retirement of licensee</i>	In the event of resignation or retirement, then another appropriate person must be designated by the owner to apply for a licence, and there must be no interim period without a licensee.
<i>Storage without a licensee</i>	If for any unforeseen reason it has not been possible to assign a suitable licensee as required by <i>regulation 9(1)</i> then the owner must either store the meter to the satisfaction of the Director-General of Health or dispose of it in accordance with the <i>Regulations</i> . If stored, the storage facility must comply with Section 3.1 of the <i>Code</i> and the owner must notify NRL of all necessary details of the storage (see <i>regulation 9(4)</i>).
<i>In the case of bankruptcy, receivership or liquidation</i>	A particular difficulty can arise in the case of bankruptcy, receivership or liquidation, if a nuclear density meter is included in the assets taken over by the administrator. A change of ownership of this nature involves legal issues beyond the scope of these <i>Guidance notes</i> . However, the previous owner or the licensee must advise NRL of the situation, and advise the administrator of the owner's obligations under <i>regulation 9</i> . If the licensee is still employed then that person retains all the legal responsibilities (see <i>regulation 9(2)</i>).
<i>Owner's responsibilities to licensee</i>	Most of the owner's responsibilities are met once a licensee has been assigned. From then on most of the legal responsibility for compliance with the <i>regulations</i> and the <i>Code</i> lie with the licensee. However, the owner must provide facilities and equipment required for the safe use, storage, transportation, or disposal as requested by the licensee (see <i>regulation 9(1)</i>).

Equipment registers and records of use (NRL C15 Section 2)

<i>Importance of good record keeping</i>	There is a history of nuclear density meters being misplaced, with potential significant safety consequences. No other use of radioactive materials in New Zealand involves the movement of radioactive sources in portable instruments between jobs and between different responsible licensees on a comparable scale. It is therefore vital that complete and unambiguous records are kept of the whereabouts of every nuclear density meter.
<i>There is a legal requirement for records to be kept</i>	<i>Regulation 16(1)</i> requires that anyone who has control of any radioactive material, including a nuclear density meter, must keep a record of the quantity, nature, and location of them at all times.

Section 2 of the *Code* lists details of what must be recorded. A record keeping system only works if it is **always** followed. The *Code* makes it clear that every licensee using (or responsible for the use of) a nuclear density meter is also responsible for completing the records when it is used.

NRL C15 lists requirements

There are two types of record:

- A register that contains identification details of each nuclear density meter, and where it is usually stored (see Section 2.1 of the *Code*). This is like an asset register, and gives a single check list that can be used to verify that each meter is accounted for. Much of the information required for the register is usually supplied with a new meter, or can be obtained from the agent or manufacturer.
- A use log for each nuclear density meter (see Section 2.2 of the *Code*). This should enable anyone to pick a meter listed on the register, go to the corresponding log and find out where it has been used, who was responsible for it, and most importantly, where it is at the present time.

Equipment register

Use log

These registers and logs should be kept in a place where they are convenient to maintain, and will not be misplaced even if the meter is. The log should not be kept in the carry-case of the meter.

Where should records be kept?

If a company with several branches shares a single meter (or pool of meters), then each branch should have a log that records when each meter arrives at the branch and then logs all use until it leaves again.

Each branch should keep a log

A company hiring out nuclear density meters must maintain a register of all instruments that are available or out for hire. But a log of use must then be kept by the person assigned responsible at the firm to which the meter has been hired, while it is in their possession.

NDMs available for hire - registers and logs

In a similar way a firm that services meters on behalf of other owners must keep a record of the receipt and return of each meter they service.

Registers at firms that service meters

The true test of a record system is whether it is possible to follow an unbroken record trail for each meter of where it was and who was responsible for it from the time it was obtained up to its present location.

Radiation Safety Plan

It is a condition of the user's licence that a Radiation Safety Plan is issued and implemented.

Further guidance on the preparation of radiation safety plans is available in *NRL Matters No. 16*, Radiation Safety Plans, <http://www.nrl.moh.govt.nz/regulatory/nrlmatters16.pdf>

SAFETY MANAGEMENT

Storage facilities (NRL C15 Section 3.1)

<i>There are storage requirements</i>	Both the <i>regulations</i> and the <i>Code</i> contain strict rules for storage. This is because radioactive materials do not “switch off” when you stop using them. The storage facility must fulfill the requirements of Section 3.1 of the <i>Code</i> .
<i>It must be secure</i>	<p>In particular, it must be secure. Access must be controlled by the principal licensee so that no unauthorised person can come in and tamper with, move, or steal, the meter.</p> <p>Consideration should be given to installation of additional security measures such as intrusion alarms, security cameras or patrolled premises, etc.</p>
<i>It should be fire-resistant</i>	It must protect the radioactive sources from any potential damage that may affect the encapsulation or shielding. So it should be as fire-resistant as practical, and should not contain other dangerous materials.
<i>NDMs should be segregated from other dangerous goods</i>	<p>Good practice suggests that nuclear density meters should not be stored in the same area as any dangerous goods of the following classes as specified in <i>United Nations recommendations on the transport of dangerous goods (UNRTDG)</i>^[3]:</p> <ul style="list-style-type: none">1 explosive2.1 flammable gas3 flammable liquid4.1 flammable solid4.2 spontaneously combustible4.3 dangerous when wet5.2 organic peroxide8 corrosive
<i>Is the storage appropriate?</i>	Thus many typical industrial dangerous goods stores are inappropriate storage locations for nuclear density meters.
<i>Radiation shielding is necessary</i>	It must contain sufficient radiation shielding so that there will be no external radiation hazard to anyone outside. The exposure limit set in Section 3.1.3 of the <i>Code</i> will be achieved if the dose rate is less than 0.5 µSv/h at all accessible positions outside the store. This will be achieved with a typical nuclear density meter if it is stored in its transport case, 2 metres from any occupied position.
<i>Signage is required</i>	In addition to it being a labelled <i>Type A</i> package there must be a sign on the door indicating the presence of radioactive material inside (see Section 3.1.2 of the <i>Code</i>). This assists emergency services in the event of a call-out. If the meter is kept in a locked safe or cupboard, the sign can be on its door.

Responsibilities for storage (NRL C15 Section 3.2)

It has been stressed already that a major safety concern with nuclear density meters is from them going missing. The use of appropriate storage and the conscientious return of a meter into the correct storage facility are key safety factors. It is essential that everyone understands and meets their responsibilities.

Use an appropriate store and ensure the NDM is returned to it after use

In summary:

- *the principal licensee (or only licensee if there is only one) responsible for a nuclear density meter is responsible for ensuring that a suitable storage facility is provided that satisfies the requirements of Sections 3.1 and 3.2 of the Code;*
- *the owner is responsible for ensuring the facility meets the specifications designated by the principal licensee (see regulation 9);*
- *every licensee who uses (or is responsible for someone else using) a nuclear density meter is responsible for returning the meter to its proper storage facility.*

Labelling of the meter and its transport case (NRL C15 Section 3.3)

Section 3.3 of the *Code* requires three different types of labeling:

- There must be a label on the meter indicating that it contains radioactive material. This is required by the regulations, and the information that the label must give is quite specific (including the trefoil symbol, the words “radioactive material” and the nuclide, activity and activity date for each sealed source). The details required are normally provided by a manufacturer’s label, but if not, or if the manufacturer’s label is removed, then an equivalent alternative label must be provided.
- Both the meter and the transport case must be clearly marked with contact details. If the meter is misplaced, it can then be easily returned.
- The transport case must be labelled to satisfy the IAEA transport regulations^[4]. These apply whenever a nuclear density meter is transported by whatever means. (See the Transport section of these *Guidance notes*.)

Radiation label

Contact details label

Transport labelling

Metal labels are best The labels must be maintained in a clearly legible condition, and replaced if they are worn or defaced. This will be more easily achieved if the labels are made from a durable material eg, embossed metal labels.

Accident prevention (NRL C15 Section 3.4)

Sound procedures will minimise accidents Accidents in which nuclear density meters are run over, especially on construction sites, happen all too frequently, not only in New Zealand but worldwide. The circumstances are all different, but the cause is always the same: the driver of the vehicle did not know it was there. And once the meter is run over, not only is it put out of action, but there is the added inconvenience of having to treat the site of the accident as a potential radiation hazard area. It is important to have sound procedures to minimise the likelihood of accidents.

There are mandatory requirements Section 3.4 of the *Code* makes two commonsense procedures mandatory: the nuclear density meter must be made highly visible while it is being used (eg, by the use of brightly coloured or fluorescent cones, flashing lights, or by the operator wearing a high visibility vest) and it must never be left unattended.

Remove after use At the completion of the measurement remove the meter to a safe place, such as the user's vehicle (and not on the ground behind a parked roller!).

Keep other workers informed Other workers on the site, particularly drivers of construction machinery, must be informed about nuclear density meters and the problems they may present. The safety module of initiation briefings for new workers on construction sites should include a description of, and warnings about, these instruments.

Maintenance and wipe testing (NRL C15 Sections 3.5, 3.6 & 3.7)

Follow the instruction manual Maintenance should follow closely the instructions given in the manufacturer's instruction manual. (Insist on being provided with this when a nuclear density meter is bought, and keep it for future reference.) The manual will usually provide good advice on safe ways of doing things, and what extra equipment is needed.

Minor maintenance Maintenance that does not involve the sources (such as changing batteries, checking electrical circuitry, etc) must be done with the source locked in the "closed" position where this is appropriate. The meter should be handled for no longer than is necessary, but there are no other precautions required, **as long as no source is exposed.**

Any work involving inspecting, testing or cleaning the sources, or maintenance of the source movement mechanism, may only be done by a licensee (see Section 3.5 of the *Code*).

Maintenance of source movement mechanism

Regular inspections and source wipe tests are required by the *Code* to ensure the integrity of the encapsulation^[5] of the radioactive material. Note that the schedule in 3.6.1 of the *Code* is the minimum required. Additional inspections are required if there is any suspicion of damage to the encapsulation. If a nuclear density meter is subjected to particularly rugged or abrasive conditions, an inspection and wipe test may be justified at each regular maintenance. Any time the source housing is cleaned to remove a build-up of soil or dust it should be inspected and appraised to determine whether a wipe test is warranted.

Regular inspections and wipe tests are required

When doing an inspection and wipe test the following procedures should be followed:

- *always refer to the instruction manual. If you do not have one, and it is not possible to get one, then advice should be obtained from NRL about safe procedures for your type of meter;*
- *always inspect the source housings for any sign of damage before cleaning;*
- *look for any distortion from forcing the source, or abrasive wear, corrosion, etc;*
- *moisten a cotton bud and thoroughly wipe the source housings;*
- *without touching the cotton bud, either seal it in a plastic bag for sending to a suitable laboratory for counting, or hold it as close as possible (without touching) to a suitable radiation survey meter (see p. 13 for more information).*
- *enter in the records for that meter that an inspection and wipe have been done.*

Normally no radiation should be detected. Section 3.8.1 of the Code specifies a maximum activity that can be accepted, but if there is any detected at all NRL should be consulted.

Withdrawal from use (NRL C15 Section 3.8)

Once there is any indication that there is a problem with the source, the meter should be withdrawn from service. The two best indicators of source integrity are wipe tests and age.

If there is any problem with encapsulation the NDM should not be used

What is the upper limit for leakage?

If a wipe test of a radioactive source removes more than 0.2 kBq of radioactive material^[6] then the meter must be withdrawn from service and either disposed of or sent to an authorised service agent for replacement of the source.

Transport of a leaking source

Whenever a meter with a source known to be leaking is freighted anywhere it must be wrapped carefully in plastic before placement in the freight container, and a label attached indicating the leaking source.

Obsolete NDMs should be withdrawn from use

While the external encapsulation of a radioactive source may appear to be durable and in good condition after many years of use, there is no means of determining the condition of the internal radioactive material, particularly after it has been subjected to years of intense beta or alpha radiation. The material used for encapsulation of sources in nuclear density meters is known to lose its retention qualities with the passage of time. Most nuclear density meters are withdrawn from use because they are obsolete before about 20 years from the date of manufacture. However, NRL strongly recommends that all sources in nuclear density meters continuing in operation be withdrawn from use and disposed of before 30 years from manufacture.

Decommissioning

There are rules for decommissioning

Nuclear density meters may be decommissioned for any number of reasons. They may be obsolete, damaged and uneconomic to repair, or just surplus to requirements. Because of the radioactive sources in a meter, the owner is not at liberty to dispose of it at will or by just abandoning it.

If for any reason a nuclear density meter is no longer required, then the owner has four options:

It can be stored – with a licensee

- the meter can be held in storage under the control of a licensee. While this arrangement can continue indefinitely as long as there is a licensee responsible for it, there is a risk of the meter being “forgotten”. Therefore NRL strongly recommends that it is sold or disposed of;

It can be stored – without a licensee

- in the absence of a licensee, the owner must store the meter to the satisfaction of the Director-General of Health;

It can be sold

- the meter may be sold or exported (see p. 1);

It can be disposed of

- it may be disposed of as waste in an approved way (see Section 3.9.1 of the *Code*).

For further advice on how to dispose of a meter contact NRL. Remember that if it is transferred to anyone else either for use or disposal then the present owner must apply to NRL for a Consent to do so.

Contact NRL for more advice

Safety audits (NRL C15 Section 3.10)

Safety procedures only work if everyone follows them, and record systems only work if they are kept up to date. It does not take much of a gap in a set of records before the record system becomes dysfunctional, and before long nobody bothers to keep them. The reason for a safety audit is to make a routine check that everyone is following the rules.

Good record keeping and safety procedures are imperative

The safety audit should be assigned to an individual at each establishment who should systematically work through the records for each meter and verify compliance with the *Code*.

Who is responsible for the safety audit?

The easiest way to do this is to have a check list. Each meter should either be sighted in storage or verified as being with the person who has signed it out. All current entries in the use log must be verified as correct. The safety audit should also verify that placarding and documentation requirements are being complied with (see the Transport section of these *Guidance notes*).

What should the safety audit cover?

Anything found during the audit that is not satisfactory should be noted with details of remedial actions.

Note any remedial actions

The check list should be completed, signed, and filed so that when NRL does a compliance monitoring inspection there is evidence that the safety audits have been done.

File the check list

Section 3.10 of the *Code* requires the internal safety audit to be carried out at least annually. An audit once a year is satisfactory for an organisation with only one or two nuclear density meters which are always operated from and returned to the same base. But a firm with several meters, or meters frequently transported between branches, should conduct audits sufficiently often to reveal that a meter is missing before tracing it becomes too difficult. For such firms, monthly audits are recommended.

Audits must be performed regularly

OPERATOR SAFETY (NRL C15 SECTION 4)

Safety during normal use

Keep exposures as low as possible

The main safety concern with nuclear density meters is either loss of a meter or damage to the radioactive sources. However, even in routine normal use a meter is continuously emitting a small amount of radiation. This is not particularly hazardous, but the exposure to it can be minimized by taking a few commonsense precautions. (It is a requirement of *regulation 18* that exposure to radiation must always be the minimum practicable.) These rules should be followed:

Keep the source "closed" whenever possible

- If the meter is of the type that has a source on the end of a rod that extends into the medium being measured the source rod should always be locked in the "closed" or "off" position at any time other than during a measurement. The source is well shielded when it is either in the meter or in the ground. Even when moving the meter from one test hole to another nearby, withdraw the source into the meter before moving it.

Keep at a distance

- As far as practical keep everyone not involved in taking measurements at least 3 metres away from the meter. At this distance the radiation from the source, even unshielded, is negligible.

Use by an unlicensed person (NRL C15 Section 4.2)

Use under supervision or instructions of a licensee

The responsibilities of a licensee for anyone using a nuclear density meter under their supervision or instructions have already been covered (see p. 3).

Information must be given to an unlicensed user

If you are asked to use a nuclear density meter and you do not have a licence, then you should have the following information in writing: the name of the licensed person who is responsible for safety while you are using the meter and their contact details in case there is a problem of any sort, as well as procedures to follow in case of an emergency. Make sure that you understand what the radiation hazards are and how to use the meter safely.

Advice must be given directly by the licensee

Written instructions must be provided by the licensee. It is important that the safety message does not get "watered down" by being passed on from one unlicensed user to another.

Personal monitoring (NRL C15 Section 4.3)

Nuclear density meters are designed so that under normal use the amount of radiation emitted is very small. If the user is never exposed to the unshielded source (and this is what is intended to happen if the instrument is used correctly) there is insufficient radiation to warrant personal monitoring. This is why the *Code* does not make the wearing of a personal monitor mandatory unless the use involves extensive dealing with unshielded gamma sources (such as wipe-testing or servicing). If required personal monitoring services are available commercially.

Personal monitoring is not normally required

Radiation survey meters

A “thin window” Geiger Muller (GM) type radiation survey meter is capable of detecting alpha and beta radiation. An instrument of this type is therefore useful for screening wipe tests. It will not indicate the activity of the wipe, but a result which is at background level only is sufficient to show a clean test. Routine calibration should be carried out in accordance with the instruction manual provided.

What sort of radiation meter can be used?

A survey meter is also a useful teaching aid when instructing someone in the safe use of a nuclear density meter. It gives a clear indication of the difference in radiation dose rate when the source is exposed and unexposed, and how quickly the dose rate reduces with distance.

A radiation meter has other uses

Because the external radiation hazard is not large, and there are alternative methods of analysing wipe tests, the purchase of a survey meter, while recommended, is not mandatory. Contact NRL for advice on what type to get.

Purchasing a survey meter

ACCIDENTS, LOST SOURCES, AND EMERGENCIES

Accidents (NRL C15 Section 5.1)

There are a range of accident scenarios

Around the world one of the most common types of accidents involving radioactive sources has been the running over of nuclear density meters by heavy construction machinery. New Zealand is no exception. Nuclear density meters have also been damaged in transport accidents. For such a portable type of instrument, almost any conceivable accident scenario is possible. Usually the encapsulation of the radioactive sources remains intact after the accident and there is no spread of contamination. However, the consequences of a contamination incident totally justify the precautions specified in the *Code*.

Always assume that damage to the radioactive source encapsulation and possible leakage of radioactive material may have occurred after every accident which results in substantial mechanical damage to a nuclear density meter. As soon as possible a source inspection and wipe test must be carried out to confirm or rule out such damage. Use the following procedure:

Accident procedure

Note: Life saving actions or injured persons should always take precedence over the radiation hazard. NRL can be contacted at any time if there is any doubt as to how to respond to the incident (NRL Duty Officer 021393632).

- 1 *Establish a clear zone of about 3 m radius around the damaged meter.*
- 2 *The licensee responsible for the meter at the time should be called if not on site.*
- 3 *The licensee, or another person trained in these accident procedures, should inspect the meter to assess the degree of damage. An immediate wipe test should be carried out, and if a GM meter or similar instrument is available at the site, it should be immediately assessed. In the absence of a GM meter, the wipe should be sent for assessment as soon as possible.*
- 4 *Retract the source rod into its "closed" position if possible, if this was extended at the time of the accident.*
- 5 *Whether or not any release of radioactive material is indicated, the damaged instrument and any debris should be placed inside a large plastic bag and sealed with adhesive tape. In the absence of a plastic bag it should be placed on a sheet of plastic, wrapped in the plastic and sealed with adhesive tape. A warning label should be attached to the package. The external radiation dose received in the short time expected for the wrapping is of much less concern than the need to contain any radioactive contamination, no matter how unlikely its occurrence. If the source rod is jammed outside the shielding, it should be left as is within the wrapping, but care should be taken to minimise handling close to the source, and its position within the wrapping should be noted.*

- 6 *The wrapped instrument should then be transferred to a safe place.*
- 7 *NRL must be advised of the accident as soon as reasonably practicable, and the commercial agent should also be contacted for advice.*

Before further transport can be undertaken, the packaging should be re-evaluated and probably adapted to ensure compliance with transport requirements, particularly in relation to external radiation dose rates if the gamma source is initially unretracted.

Before moving the NDM again, check the packaging

In order to follow the recommendations above, the instrument's transport box should contain:

What items should be readily available?

- *cottonwool buds or swabs for wipe tests*
- *a large plastic bag*
- *a roll of adhesive tape*
- *a warning label*

Lost sources

The loss of any radioactive source can have serious consequences. Once it is lost it is no longer under the control of anyone responsible for its safety. Once equipment containing radioactive sources is dismantled it is not evident which parts are radioactive, and they may be scavenged unknowingly.

The consequences of losing an NDM can be serious

By following the requirements in the *Code* and the advice in these *Guidance notes* on security in storage and during transport and proper record keeping, the risk of loss will be minimised.

How to minimise the risk of loss

If a nuclear density meter is in any way lost from the control of the licensee responsible for it, the licensee must take immediate action to locate and recover it. NRL must be notified of the loss as soon as reasonably practicable and no later than 7 days of such an occurrence and of the actions taken. (This is a requirement of *regulation 11(2)*).

NRL must be notified

Fire and civil defence emergencies (NRL C15 Section 5.2)

Every owner should have a manual of procedures to be followed in the case of an emergency, including evacuation from buildings, dealing with medical emergencies, earthquakes, etc. This manual must have a section dealing with procedures covering emergencies involving nuclear density meters.

Every company's emergency handbook must have a section on NDMs

Responsibilities must be assigned

In each case the procedure must establish who is responsible for:

- the security of any meter (if the storage building has been damaged);
- the safety of any meter (if there may be damage to the meter itself).

This will usually be the licensee but procedures must cover any eventuality.

TRANSPORT

Further guidance on the requirements for transporting radioactive material is available at <http://www.nrl.moh.govt.nz/regulatory/transportofradioactivematerial.asp>

REFERENCES

- 1 *Radiation Protection Act 1965*. Govt. Print., Wellington.
- 2 *Radiation Protection Regulations 1982*. Govt. Print., Wellington.
- 3 *UN recommendations on the transport of dangerous goods (UNRTDG)* - 11th revised edition, 1999.
- 4 *IAEA regulations for the safe transport of radioactive material*. 2009 ed. Vienna: International Atomic Energy Agency. *TS-R-1*.
- 5 *Radiation protection - sealed radioactive sources - general requirements and classification*. Geneva: International Standards Organization. *ISO 2919:1999*.
- 6 *Radiation protection - sealed radioactive sources - leakage test methods*. Geneva: International Standards Organisation. *ISO 9978:1992*.
- 7 *IATA dangerous goods regulations*. 40th ed. Quebec: International Air Transport Association, 1999.
- 8 *Land Transport Rule: dangerous goods 1999*. Wellington: Land Transport Safety Authority, 1999.
- 9 *Transport of dangerous goods on land*. Wellington: Standards New Zealand. *NZS 5433:1999*.
- 10 *1990 recommendations of the International Commission on Radiological Protection*. Oxford: Pergamon Press, 1991. *ICRP publication 60*.

APPENDIX UNITS OF MEASUREMENT

Units of radioactivity

The atoms of materials that are radioactive are continually undergoing nuclear transformations that result in the emission of radiation (eg, gamma rays, alpha particles, beta particles, neutrons). The amount of radioactivity is specified in terms of how many nuclear transformations occur during a given time. This is called the activity.

The SI (the internationally accepted) unit of activity is the becquerel (Bq). A quantity of radioactive material that has an average rate of one transformation per second has an activity of 1 becquerel (1 Bq).

The becquerel is a very small amount of activity and most radioactive sources have activities where many millions or more transformations occur per second. Hence multiples of becquerels are commonly used in describing radioactive sources.

In the case of nuclear density meters and their safe use, the following multiples of becquerels are commonly used:

1 kilobecquerel (1 kBq)	=	1 thousand (1000 or 10^3) Bq
1 megabecquerel (1 MBq)	=	1 million (1 000 000 or 10^6) Bq
1 gigabecquerel (1 GBq)	=	1 thousand million (1 000 000 000 or 10^9) Bq

Many radioactive sources will have their activities stated in terms of an older unit called the curie (Ci). This is a relatively large unit and often its sub-multiples are used.

Both units are still in use, and this is likely to continue until the use of curies is completely phased out. Useful conversions are:

1 nCi	=	37 Bq	1 kBq	=	27 nCi
1 μ Ci	=	37 kBq	1 MBq	=	27 μ Ci
1 mCi	=	37 MBq	1 GBq	=	27 mCi
1 Ci	=	37 GBq			

Note 1: The activity of radioactive material will decrease over time due to the decay of the radioactive material.

Note 2: A statement of activity, in becquerels or curies, gives no indication of the physical size of the radioactive material.

Units of radiation dose

In radiation protection it is the risk of biological effects of the radiation that is of concern. These biological effects are related to the amount of energy absorbed from the radiation by the tissue, organ or body. The absorbed energy per mass of the tissue, organ or body, multiplied by a factor dependent on the type of radiation, is called the equivalent dose. The SI unit of equivalent dose is the sievert (Sv). One sievert is a large dose and more commonly equivalent doses are expressed in terms of the sub-multiples: millisieverts (mSv) and microsieverts (μ Sv).

There is an older unit for equivalent dose that is still sometimes used, called the rem. Conversion from rem to sieverts can be made using:

1 mrem	=	10 μ Sv
1 rem	=	10 mSv
10 rem	=	100 mSv
100 rem	=	1 Sv

Dose rate is measured in units of Sv/hour or mSv/hour, etc.

Radiation dosimetry is a complex subject and a comprehensive treatment of it is beyond the scope of these *Guidance notes*. Precise definitions and descriptions of the technical concepts can be found in *ICRP publication no. 60*^[10].

CROSS-REFERENCE INDEX

These *Guidance notes* give practical advice for compliance with radiation protection legislation and the relevant *Code*, *NRL C15*. The references to the legislation in this index are not always directly cited in this document or the *Code*, but do provide the regulatory authority for the *Code's* requirements and the *Guidance notes'* recommendations.

The references are from these *Guidance notes: safe practice for the use of nuclear density meters* to:

- *Code of safe practice for the use of nuclear density meters, NRL C15 (NRL, June 2000);*
- *Radiation Protection Regulations 1982;*
- *Radiation Protection Act 1965;*

Guidance notes	NRL C15	Regulations	Act
<i>Page No./Contents</i>	<i>Section</i>	<i>No.</i>	<i>Section</i>
LEGAL REQUIREMENTS AND RESPONSIBILITIES			
1 Consents for import, export, sale and ownership			12
2 Licences to use radioactive material			13
3 Use by an unlicensed person	4.2		13
3 Responsibilities of owner		9(1), 9(4)(C), 9(2)	
4 Equipment registers and records of use	2	16(1)	
5 Radiation Safety Plan			
SAFETY MANAGEMENT		9, 11	
6 Storage facilities	3.1	12, Second schedule	
7 Responsibilities for storage	3.2		
7 Labelling of the meter and its transport case	3.3	Second schedule	
8 Accident prevention	3.4		
8 Maintenance and wipe testing	3.5, 3.6, 3.7		
9 Withdrawal from use	3.8	13 (3)	
10 Decommissioning	3.9	14, 15	
11 Safety audits	3.10	12, 13, Second schedule	
OPERATOR SAFETY	4	11, 18	
12 Safety during normal use	4		
12 Use by an unlicensed person	4.2		13(1)
13 Personal monitoring	4.3	20	
13 Radiation survey meters		20	
ACCIDENTS, LOST SOURCES AND EMERGENCIES			
14 Accidents	5.1		
15 Lost sources		11(2)	
15 Fire and civil defence emergencies	5.2		
TRANSPORT	6	3	