GUIDANCE NOTES

Safe practice for the use of x-ray analytical equipment

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

August 2001

http://www.nrl.moh.govt.nz

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INTRODUCTION

These *Guidance notes* are advisory only and have been written to provide information for owners, licensees and users on the safety of x-ray analytical equipment used for study of crystal structures (diffraction equipment) and identification and quantification of elemental composition of materials (fluorescence equipment). They give practical guidance on compliance with the requirements of radiation protection legislation and the *Code of safe practice for the use of x-ray analytical equipment, NRL C17*. Compliance with the *Code* will ensure that radiation burns or other injuries cannot arise from use of this type of equipment.

Most x-ray analytical equipment uses x-ray tubes operated at voltages up to 100 kVp, but usually in the range 20-60 kVp. The radiation emitted from the tube consists of a continuous bremsstrahlung spectrum with superimposed lines of K_α and K_β radiation characteristic of the target element. Tube windows are usually of beryllium, with a thickness of the order of 1 mm, which is transparent to all but the softest radiation. Typically the dose rate in the primary beam close to the tube window is of the order of a few tens of gray per second, a very high dose rate.

In diffraction equipment, filters, collimators and other devices are often inserted in the beam close to the tube window. The effect of these is to reduce the dose rate at the specimen distance to about a few tens of gray per minute. Historically skin burns have occurred when fingers have been exposed to the very high dose rate primary beam.

Fluorescence spectrometers commonly use unfiltered radiation from a high atomic number target (eg, tungsten) and operate at comparatively high voltages. Moreover the specimen position is usually quite close to the tube window. Serious burns could therefore result if fingers were able to be inserted into the specimen chamber with x-rays being produced.

LEGAL REQUIREMENTS AND RESPONSIBILITIES

Both ownership and use of irradiating apparatus are controlled by law

The ownership and use of irradiating apparatus in New Zealand is controlled by the *Radiation Protection Act 1965*[1] and the *Radiation Protection Regulations 1982*[2]. Sales of equipment are controlled through a notification process, and users must be licensed under the *Act*. The *Regulations* contain more detailed general requirements for both owners and licensed users of irradiating apparatus.

NRL C17 must also be complied with

The additional requirements specific to x-ray analytical equipment are contained in the *Code of safe practice for the use of x-ray analytical equipment, NRL C17*. Anyone licensed to use x-ray analytical equipment must comply with this *Code*.

There are legal requirements for buyers and sellers

The *Radiation Protection Act 1965* places obligations on persons who sell, and in some cases on those who buy or own, irradiating apparatus.

Selling and buying x-ray equipment

"Selling" includes lending or hiring

The definition of "sell" given in Section 2 of the *Act* covers a wide range of actions that result in the transfer of responsibility from one person to another. For the purpose of establishing who has responsibility for irradiating apparatus, this means either:

- sale, by means of a financial transaction, or
- any hire, lease or loan, involving a signed contract.

It also includes disposal of old equipment

When new irradiating apparatus is bought to replace existing equipment, the old irradiating apparatus will either be rendered inoperative and disposed of directly, or will be removed for resale or later disposal. This removal for re-sale or disposal is itself a sale in terms of the *Act* and the National Radiation Laboratory (NRL) must be formally notified by the previous owner in the same way as for any other sale.

This wide definition of "sell" means that a person may sometimes be unaware that their actions are bringing them under the scope of the* Act *and its obligations.

If selling within NZ irradiating apparatus can only be sold to an appropriately licensed person

No person can sell irradiating apparatus to another person in New Zealand unless the prospective purchaser holds a current licence under the *Radiation Protection Act* that authorises the use of the particular type of irradiating apparatus being offered for sale.

If purchasing from overseas the buyer must have an appropriate licence

If buying irradiating apparatus directly from an overseas seller it is the purchaser's responsibility to ensure that a current licence under the *Radiation Protection Act* is held authorising the use of the particular type of irradiating apparatus being purchased.

Notification: responsibilities and procedure

NRL must be notified of any sale

NRL, under the delegated authority of the Director-General of Health, must be notified of any sale (see Section 14(2) of the *Act*).

Who is responsible for the notification?

- Where the seller is in New Zealand (this can be either the previous owner or the NZ agent of an overseas supplier) then the seller must make the notification.
- In cases where the seller is outside New Zealand, responsibility for notification of the purchase lies with the buyer.

How and when to notify NRL

Notification must take place on or before the date of the sale and must include the name and address of the buyer. It can be by letter, e-mail or fax and should be an automatic part of the sale procedure. To help facilitate the notification process NRL has developed a standard form. This form does not have to be used but it does provide a convenient means of enabling sellers to meet their obligations. A sample copy of the notification form is attached as Appendix 1 and further copies can be obtained from NRL or down-loaded from the NRL web site. NRL will formally acknowledge each notification, thereby confirming that statutory obligations have been met.

Why is there a need for these requirements?

Irradiating apparatus is capable of producing harmful radiation. The *Act* sets up a licensing system for controlling the use of irradiating apparatus. This control needs to be from "cradle to grave", and the requirements for selling ensure that equipment does not escape from regulatory control during movements from one owner to another.

NRL must be able to maintain an accurate register

In addition there must be control over the whereabouts of irradiating apparatus. As the national regulatory body, NRL must be able to maintain an accurate register of all irradiating apparatus, including make and model, location and who is responsible for it. Notification provides the mechanism for keeping this register current.

Where to obtain more information

More information on buying, selling and notifications can be found in *NRL matters no 8*, available from the web site or by contacting NRL.

These obligations apply to all sales irrespective of whether the irradiating apparatus is new or used. Failure to comply with these requirements is a breach of the* Act *and may be subject to such penalties as are prescribed in Section 26(2) of the* Act*.

Licences to use irradiating apparatus

A licence is necessary

Anyone using irradiating apparatus (including x-ray analytical equipment) for any purpose must either hold a licence for that purpose under the *Act* or be acting under the supervision or instructions of a licensee (see Section 15 of the *Act*).

Obtaining a licence information pack

A licence application pack, containing an application form for a licence to use x-ray analytical equipment and copies of the *Code of safe practice*, *Act*, *Regulations* and these *Guidance notes* can be obtained from NRL.

Training requirements and who can provide it

To be eligible for a licence an applicant must have received approved training including passing an examination in radiation safety. Training in the operation and safety requirements of the equipment may be given by the owning company or organisation, or by the equipment suppliers. The licence application form requires evidence of this training. Radiation safety training including knowledge of requirements of the *Code* is also required. An outline syllabus for such training is included as Appendix 4. Licensees may be required to demonstrate on-going competency at subsequent licence renewals.

Required qualifications and experience

Applicants for a licence for the purpose of x-ray analysis using diffraction equipment should hold an approved science or engineering degree or other qualification or have extensive practical experience in x-ray diffraction equipment operation. Applicants for a licence for the purpose of x-ray analysis using fluorescence equipment should have verifiable work experience in the area of application.

What does the term "principal licensee" mean?

Where there is more than one licensee responsible for the operation of the same equipment, or sets of equipment, then each has full responsibility for safety and compliance with all regulatory requirements when rostered for use. However there are some aspects of safety management where it may be ambiguous which licensee is responsible (eg, maintenance of records). In this case one licensee must be designated the "principal licensee". Some of the requirements in the *Code* refer specifically to the principal licensee (see *NRL C17*, Sections 1.3, 2.1.1, 2.1.3, 2.2.1, 2.3.1, 2.4.2, 3.1, 3.2, 4.1.1, 4.2.1, 5.1.1, 6.1, 6.2). More information on principal licensee responsibilities can be found in *NRL matters no 10* available from the web site or by contacting NRL.

There may need to be more than one principal licensee

Licensees cannot reasonably maintain control of x-ray analytical systems beyond a limited geographical area or in other sections of the owner's organisation, so there should be a principal licensee in each area or department (eg, of a university).

Licences must be renewed annually

Licences are renewable annually on the anniversary of the date of issue. Applications for renewal must be made at least 28 days before the date of expiry of the licence. A renewal application form will be provided by NRL in sufficient time to allow the form to be returned by the due date.

Use by an unlicensed person (*NRL C17 Section 4.2)*

Use under supervision or instructions

Section 15 of the *Act* allows a person who is not licensed to use an x-ray system *under the supervision or instructions* of a licensee. *Supervision* requires the physical presence of a licensee who oversees the work with radiation; only minimal levels of training are required for a supervised worker. Work under *instructions* does not require the presence of a licensee during the work period, but does require clear orders or guidelines, and an appropriate level of training, for the instructed worker.

There must be written instructions

For the licence purpose of "use of x-ray analytical equipment", operation under supervision would be expected to occur only during training. After training, staff other than licensees would operate according to instructions. Such staff must be given a set of written instructions which include actions to be taken in accidents and emergencies such as inadvertent exposure, or building evacuation, and how to contact the licensee.

Unlicensed users must be trained – but the licensee retains legal responsibility

It is up to the supervising licensee to ensure the unlicensed person is trained in all aspects of safety as required by the degree of independence from supervision they will have. The licensee retains full legal responsibility for the safety of the system and must have full confidence that the unlicensed person knows what to do in all circumstances.

Responsibilities of owners

The owner must ensure there is a licensee with a suitable level of authority

Regulation 9(1) requires the owner of x-ray analytical equipment to take all reasonable steps to ensure there is always a suitably licensed person to take care of safety. There must be a licensee in each department to look after the overall management of safety. When there is more than one licensee in a department, then it is the responsibility of the owner to designate one as the principal licensee to attend to these matters. Licensees should be in a position within the organisation where they have line management or other authority to implement radiation protection practices and ensure compliance with the *Code*, but also retain operational involvement with the x-ray analytical systems for which they are the licensee.

Absence, resignation or retirement of the licensee

In the event of the pending absence of the licensee, or his or her resignation or retirement, then another appropriate person must be designated by the owner to apply for a licence, so that in normal circumstances there is no period without a licensee.

Storage without a licensee

If, for any unforeseen reason, there is no licensee for the time being, for example, as a result of sudden death or resignation of the appointee, then as allowed under *regulation* 9(4), the owner may store the x-ray system (without using it). Storage without a licensee would be expected to meet the same requirements as those in Section 2.3.1 of the *Code* for storage with a licensee. Within a period of three months the owner would be expected either to have sold the x-ray equipment, rendered it permanently inoperative, or have assigned another licensee to take responsibility for it. The owner must notify NRL of the action taken (see *regulation* 9(4)).

Owner's responsibilities to licensee

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 *Regulations* and the *Code* lie with the licensee. However, the owner must ensure that equipment requested by licensees for safety is provided (see *regulation* 9(1)). More information on owners' responsibilities can be found in *NRL matters no 10*, available from the web site or by contacting NRL.

RADIATION SAFETY MANAGEMENT

Radiation safety plan (*NRL C17 Section 2.1*)

What is a radiation safety plan?

The radiation safety plan is a collection of documents that records who at the facility is authorised to use x-ray equipment, documents local safety rules, and maintains other records. The component records and documents of the plan may be dispersed in location, but if so, there should be a document which specifies the whereabouts of each component. Any audit of the facility for compliance with regulatory requirements will normally start with these documents to assess how all the requirements have been addressed, and that the written procedures are being followed.

What should it contain?

The content of the safety plan is prescribed in the *Code*. Sections are described briefly here, and examples are given in Appendix 3.

- *Details of radiation safety policy, responsibilities and authorisations*

  There must be a policy statement that demonstrates a commitment to ensuring the safe use of equipment. It must name who has responsibility as principal licensee, and must also list all other staff who are authorised by way of licensing or training to operate x-ray systems.

- *Radiation protection induction and training of staff*

  All staff, including licensees, must be familiar with the contents of the safety plan. The training necessary before an unlicensed person is authorised to work must be outlined, and it must be documented that this training has been given in each case.

- *A register of x-ray equipment*

  The register or record must contain identification details of each system (make, model, serial number) and where it is located.

- *Procedures for radiation safety audits*

  Records of initial and routine internal radiation safety audits must be maintained. Components of audits are described in more detail in the section on **Radiation safety audits** (p 7).

- *Maintenance and repair of equipment*

  This section must set out the timetable and other details for routine maintenance and other repairs of equipment that have implications for radiation safety (see also p 8).

- *Incident and accident investigation records*

  This should contain a record of any incident or accident as required by Section 6.1 of the *Code*. The purpose of any investigation is to modify procedures in order to minimise the recurrence of such events.

Local rules or written instructions required by the *Code* must be kept in the radiation safety plan, whether or not they are displayed and used elsewhere. The local rules must include specific instructions for unlicensed operators. There should also be a statement concerning who can make changes and how they are promulgated. Keeping a log of equipment use might form part of the local rules.

➢ *Written local rules for safe operation of x-ray systems*

The facility must have written procedures detailing actions in case of an emergency, such as fire or earthquake. These procedures need to cover actions required with respect to x-ray equipment.

➢ *Emergency procedures*

Maintenance of these records will both materially aid the quality management of radiation protection and safety within the organisation, and the conduct of compliance monitoring audits carried out by the National Radiation Laboratory.

Radiation safety audits (*NRL C17 Section 2.2*)

Frequency and scope of audit varies

Radiation safety audits are an in-house means of ensuring that the *Code* is being complied with at all times. The *Code* requires the internal radiation safety audit to be carried out at installation, and thereafter as specified in the manufacturer's manual or at least annually. The scope of the radiation safety audit will vary, depending on the reason for it being performed:

- if it is a new facility, the scope of the radiation safety audit is compliance with all aspects of the *Code*;
- if a new x-ray system is being installed in an existing facility, the radiation safety audit must ensure the x-ray equipment complies with the relevant parts of the *Code*, and must also ensure that the radiation safety plan is modified or amended to incorporate the change in x-ray equipment;
- if it is after major maintenance, the scope of the radiation safety audit can be limited to those areas of the *Code* that are relevant, but wider implications for the radiation safety plan need to be checked;
- if it is the routine annual radiation safety audit then again the scope is all of the *Code*.

Use a checklist

It is strongly recommended that a checklist be used to confirm compliance with the requirements of the *Code*. The checklist should be completed, signed, and filed so that when NRL does a radiation compliance monitoring inspection there is evidence that the safety audits have been done.

Note remedial actions

The radiation safety audit may be conducted as part of a wider audit of health and safety items within the organisation. Anything found during the audit that is not satisfactory should be noted with details of remedial actions.

Maintenance and servicing (*NRL C17 Section 2.4*)

Follow the instruction manual

Maintenance and servicing should follow closely the instructions given in the manufacturer's instruction manual. The manual will usually provide good advice on safe procedures, and what extra equipment is needed.

Who can undertake servicing?

Servicing of the x-ray generator or tube, or production of x-rays with any shielding removed, should be carried out only by a licensed person with appropriate training. Service personnel must be thoroughly familiar with the equipment and aware of the need to restore all safety features to a fully effective and operative state on completion of the work.

Ensure the service person has all relevant information

Before work commences the principal licensee has responsibility to ensure that the service person is informed of all matters relevant to radiation safety, such as an adequate description of faults or missing components.

Disposal of x-ray equipment

NRL must be notified

If x-ray analytical equipment is to be disposed of then the licensee responsible has the options of sale or write-off as scrap. If the equipment is sold in New Zealand it must be purchased by a holder of a licence issued under the *Act* for an appropriate purpose and the sale notified to NRL (see **Notification: responsibilities and procedure**, p 2). If the equipment is not sold it must be rendered permanently inoperable by, eg, breakage of the x-ray tube or destruction of the generator. Again NRL must be notified of the disposal.

FACILITY AND EQUIPMENT SAFETY (*NRL C17 Section 3*)

Equipment must be securely housed

X-ray analytical equipment must be housed in rooms which can be secured, with access controlled by the licensee so that no unauthorised person can tamper with the equipment. Alternatively, the equipment must be operable only by means of a key which is withdrawn when the equipment is not in use, or some other device which both prevents unauthorised use and also allows the machine to be switched off in case of emergency, quickly and easily. (See Section 3.1 of the *Code*).

Access should be restricted

If the use of the x-ray analytical equipment requires extended periods of continuous operation (eg, overnight or similar) then such an unattended unit should be housed in a locked room. Access to this room should be restricted to only those persons that are authorised to use x-ray analytical equipment. While the interlocks etc on the unit should turn the unit off in the event of unauthorised tampering, prevention of access provides an added layer of safety.

Accidental exposure of operators must not be possible

The equipment must be designed so that no exposure of operators to radiation beams can occur without very deliberate circumvention of interlocks, shielding and other safety devices. The dose rate limit for stray radiation emission from enclosed ancillary devices and x-ray tube must be complied with (see Section 3.2(d) of the *Code*). This can be verified by measurement. However, direct measurement is not required if the equipment as received and installed is accompanied by a test certificate indicating compliance with the requirement of 3.2(d) of the *Code*.

NRL must be advised of any intention to deviate from Code *requirements*

In the event that in order to carry out analytical measurements the requirements of the *Code* relating to enclosure of beams and interlocking of shielding devices are unable to be complied with, the principal licensee must submit to NRL a safety evaluation of procedures to be carried out and a copy of the proposed local operator rules for approval.

Labelling and warning signs

There must be warning lights

Warning lights readily visible to equipment operators must be illuminated whenever x-rays are being produced (see Section 3.2(f) and 3.2(g) of the *Code*).

And a radiation warning sign

Cautionary wording such as "CAUTION – X-RAYS", or a trefoil radiation warning symbol, the dimensions for which are given in Part 1 of the Second Schedule of the *Regulations*, must be affixed in a readily visible position to the exterior of the equipment (see Section 3.2(c) of the *Code*).

An identification label is required

The machine must be labelled. Section 3.2(b) of the *Code* requires labelling of the equipment with information which is sufficient to allow unequivocal identification of the system with the item in the licensee's register. If desired, the identification label may be incorporated with the warning symbol.

Metal labels are best

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

OCCUPATIONAL SAFETY (*NRL C17 Section 4*)

Safety during normal use

Stringent precautions will prevent injuries

Stringent precautions against exposure to primary radiation are required as such exposures have been the cause of almost all serious injuries to operators. Safety shutters at tube ports and conspicuous "X-rays on" warning signs or warning lights would have avoided most injuries from x-ray analytical equipment. The primary means of ensuring safe operation are therefore the requirement for in-built shutters, safety interlocks and beam enclosures which prevent inadvertent exposure, and written rules for equipment users.

There are dose limits

Dose limits for operators will very quickly be exceeded if exposures to primary beams occur. ICRP publication 60[3] dose limits for radiation personnel are as follows:

(a) An *effective dose* of 20 mSv per year averaged over any five year period and 50 mSv in any one year.

(b) An *equivalent dose* of 500 mSv to the skin (at the nominal depth of 7 $mg/cm^{2)}$ averaged over 1 cm^2, regardless of the total area exposed, in any one year.

(c) An *equivalent dose* of 150 mSv to the lens of either eye in any one year.

(d) An *equivalent dose* of 500 mSv to the hands and feet in any one year.

(e) For women who declare themselves pregnant, a dose of 2 mSv at the surface of the abdomen over the remainder of the pregnancy.

The limits which are particularly relevant to the use of x-ray analytical equipment are (b) and (c).

Personal monitoring

Personal monitoring is not normally required

X-ray analytical equipment commonly produces very narrow beams which are unlikely to be detected by a personal monitoring device worn at the waist or lapel. It is also difficult to meaningfully relate detection of some exposure on a personal dosimeter with an effective dose to a wearer. The emphasis is therefore on prevention rather than monitoring of exposures to small area high dose rate beams. The *Code* therefore does not require the wearing of a personal monitor. If wanted, personal monitoring services are available commercially.

Radiation survey meters

What sort of radiation meter can be used?

A thin window GM type radiation survey meter is capable of detecting both low energy x-ray and gamma radiation. An end window instrument of this type is useful for surveying for narrow beam leakage radiation around x-ray analytical equipment. The survey meter must be routinely calibrated and, in between calibrations, a check source needs to be used to verify that the meter is functioning correctly.

Other options

If exposure to primary beams is prevented the external radiation hazard is low, and the purchase of a survey meter is not mandatory for routine use. A directly measuring instrument or integrating dosemeter may be required for the initial radiation safety audit required in Section 2.2.1 of the *Code*, and if such dosemeters are not held by the licensee they may need to be available to the installation engineer or other person undertaking the survey. Contact NRL for further advice on dosemeter types.

PUBLIC SAFETY (*NRL C17 Section 5*)

Public access must be controlled

Public safety can be ensured by not allowing unauthorised access to areas where x-ray analytical equipment is located or used. This eliminates the possibility of such a person playing or tampering with the x-ray equipment causing it to produce x-rays in an unsafe manner.

INCIDENTS, ACCIDENTS AND EMERGENCIES (*NRL C17 Section 6*)

Incidents and accidents

Do not compromise radiation safety

An incident can be considered as an event which disrupts normal operation and may have radiation safety implications. An example for a diffraction unit would be a faulty spring on a port shutter. Operators must have training and instructions on methods of dealing with incidents in ways which do not compromise radiation safety.

Any accidental exposure must be investigated

If the requirements of the *Code* are met accidental exposures should not occur. However, if an exposure to primary beam radiation occurs or is suspected, the equipment should be turned off and the principal licensee notified. The principal licensee must investigate and report any overexposure event.

Incidents or accidents should be used to improve safety measures

In addition the principal licensee must determine whether there is a need to change work practices, local rules etc, in order to minimise the likelihood of a recurrence of the incident or accident.

Fire and civil defence emergencies

Every organisation's emergency handbook must have a section on x-ray analytical equipment

Every facility should have a manual of procedures to be followed in the case of an emergency, including evacuation from buildings, fires, earthquakes, etc. This must have a section dealing with procedures covering emergencies involving x-ray analytical equipment. However, if there is no general procedure manual, there must be specific written procedures in case of an emergency involving x-ray analytical equipment.

Responsibilities must be assigned

In each case the procedure must establish who is responsible for the shut-down, if necessary, and security of the x-ray equipment in the event of evacuation.

COMPLIANCE MONITORING AND ENFORCEMENT

NRL carries out audits of facilities

The National Radiation Laboratory, as New Zealand's regulatory authority under the *Radiation Protection Act 1965*, is empowered to carry out compliance monitoring audits of facilities where ionising radiation is used. These compliance monitoring audits occur at frequencies determined by the National Radiation Laboratory. Advance notification of an impending audit is normally given to the principal licensee of a facility where radiation is used.

Compliance with legislation and the Code *is required*

During the audit evidence will be looked for that the use of radiation at the facility is in compliance with the *Radiation Protection Act*, the *Radiation Protection Regulations* and the *Code NRL C17*.

The audit process

The audit commences with an entrance interview between the NRL representative and the principal licensee, plus any other person the principal licensee wishes to have present. The principal licensee would make available the facility's radiation protection documentation. This is reviewed by the National Radiation Laboratory representative, to check for compliance with the *Code*. In addition particular measurements or tests may be performed. Observation of the use of x-rays may also take place.

Items of non-compliance

The compliance monitoring audit concludes with an exit interview at which the results of the audit are presented and discussed. Any items of concern will be explained and for those items of actual non-compliance, corrective actions will be agreed upon, including a time-frame for compliance.

Corrective actions must be implemented

The compliance monitoring audit cycle for a given facility remains open in those cases where there is non-compliance until the principal licensee notifies the National Radiation Laboratory in writing that the agreed corrective actions have been implemented.

Further information on compliance monitoring can be found in* NRL matters no 10 *available from the web site or by contacting NRL.

REFERENCES

1 *Radiation Protection Act 1965*. Govt. Print, Wellington.

2 *Radiation Protection Regulations 1982*. Govt. Print, Wellington.

3 *1990 Recommendations of the International Commission on Radiological Protection.* Oxford: Pergamon Press, 1991. *ICRP publication 60*.

APPENDIX 1

Form for notification of sale of irradiating apparatus

(Note: this is also available on the NRL web site: www.nrl.moh.govt.nz).

NRL
National Radiation Laboratory

RADIATION PROTECTION ACT 1965

NOTIFICATION OF SALE OF IRRADIATING APPARATUS

Use one notification form per apparatus

Name and address of seller (trade name):

Seller's fax number:

Name and address of buyer (trade name):

Name of principal licensee responsible for safe care of equipment:

NRL licence number:

Purpose for which apparatus is (or was) used:
(eg, medical diagnostic, chiropractic, medical therapy, dental, veterinary, industrial, analytical, etc)

Equipment make:

Equipment model:

Enter the control panel* serial number:

Maximum operating rating: kV/MV: mA:

State the physical location the apparatus is to be installed or if a portable unit, the base location:
(eg, facility, street address, department, room, etc)

If apparatus is *second–hand*, state the physical location from where the apparatus was removed:
(eg, facility, street address, department, room, etc)

If apparatus is being *disposed* of, enter the process for rendering it inoperable and means of disposal:
(eg, x-ray tube punctured and placed in bin, etc)

Name and signature:

Date:

* If control panel identification plate is missing, enter 'missing' and record any other ID tracking number and corresponding component.

Please send to: National Radiation Laboratory
Attn: Licensing
PO Box 25-099
CHRISTCHURCH
Fax: (03) 353-5667

NRL acknowledgement of notification

Name and date:

V4.03

APPENDIX 2

Ionising Radiation Incident Report Form: Actual or potential exposure other than medical misadministration

(Note: this is also available on the NRL web site: www.nrl.moh.govt.nz)

NRL

National Radiation Laboratory

IONISING RADIATION INCIDENT REPORT FORM
ACTUAL OR POTENTIAL EXPOSURE OTHER THAN MEDICAL MISADMINISTRATION

EMPLOYER AND LICENSEE DETAILS

Employer's name:

Address:

Phone: Fax: E-mail:

Licensee's name: Licence no:

DETAILS OF INCIDENT (*if necessary use the rear of the report form*)

Date & time of incident: Date NRL notified:

Date form sent to NRL: Total number of pages:

Name(s) and designation(s) of persons involved:

Did anyone receive an extra radiation dose because of this incident?: No ☐ Yes ☐

Physical location of incident (*if different from above*):

Type(s) of radiation source(s) involved:

Assessment of radiation doses to persons involved (*include calculations*):

Description (*include diagrams where necessary*):

Actions taken immediately:

INCIDENT ASSESSMENT (*if necessary use the rear of the report form*)

Main cause(s) of the incident: (*tick whichever apply*)
Equipment failure ☐ Operator error ☐ Lack of training ☐
Inadequate safety procedures ☐ Other (specify) ☐

Could the incident have been more serious? No ☐ not much more ☐ much more ☐ very much more ☐

Main cause(s) for concern:

Could it occur again (*include any actions that have been taken to prevent a recurrence*)?

Is an internal investigation taking place ? yes ☐ no ☐ undecided ☐
(*a copy of any report should be forwarded to NRL*)

Name and signature of person completing form: _____

PLEASE SEND TO: National Radiation Laboratory
PO Box 25 099
Christchurch
New Zealand

Fax no. (64) (03) 366 1156
Phone no. (64) (03) 366 5059

APPENDIX 3
Components of an example *Radiation safety plan* (see also p 6 – 7)

The following pages give examples of some of the documentation in a *Radiation safety plan* for a facility where x-ray analytical equipment is used.

The *Code* requires the following documents to be included in a *Radiation safety plan*:

- Details of radiation safety policy, responsibilities and names of persons authorised to operate the x-ray equipment;
- Radiation protection induction and training requirements for staff, and associated records;
- Register of all x-ray analytical equipment at the facility;
- Procedures for radiation safety audits and associated records;
- Records of maintenance and repair work on x-ray analytical equipment;
- Incident and accident investigation records;
- Written local rules for the safe operation of x-ray analytical equipment;
- Emergency procedures.

It should be noted that the following are examples only and some of the "in-house" rules for the "School of Chemical Sciences" may not be appropriate or applicable in other facilities where x-ray analytical equipment is used.

Occasional editorial comments are given in parentheses, as here: <<editorial comment>>.

SAMPLE RADIATION SAFETY PLAN

SCHOOL OF CHEMICAL SCIENCES (SCS)
RADIATION SAFETY PLAN

X-ray analytical equipment

Radiation safety policy

SCS will ensure, as far as reasonably possible, the health and safety of its employees, contractors working on the premises, and members of the public who may be exposed to the hazards arising from the use of x-ray analytical equipment.

No member of SCS staff is permitted to use or operate x-ray analytical equipment unless he/she is so authorised in this *Radiation Safety Plan* and has signed the relevant entry to indicate familiarity with and acceptance of the requirements and procedures in this *Radiation Safety Plan*.

Responsibilities and authorisations

Principal licensee

Overall responsibility for ensuring this *Radiation Safety Plan* is implemented and reviewed lies with the principal licensee for SCS.

Name	***Licence number***	***Position title***	***Signature***
Dr L1	11011	HoD	

Licensed users

The following licensed persons are authorised to use x-ray analytical equipment at SCS and are responsible for complying with the procedures in this *Radiation Safety Plan*.

Name	***Licence number***	***Position title***	***Signature***
Dr L2	11012	Senior Lecturer	
Dr L3	11013	Senior Lecturer	
Dr L4	11014	Research Officer	

Persons authorised by the principal licensee to use x-ray analytical equipment under instructions

The following persons are authorised to use x-ray analytical equipment at SCS under the instructions of the principal licensee, and are responsible for complying with the procedures in this *Radiation Safety Plan*.

Name	***Position title***	***Date of initial authorisation***	***Signature***
Mr R1	PhD student	01/03/99	
Ms R2	PhD student	03/02/00	
Ms R3	MSc student	28/11/00	
Mr R4	MSc student	15/02/01	

Persons authorised by the principal licensee to use x-ray analytical equipment under supervision

Students from under-graduate classes are authorised to operate the x-ray analytical equipment only under the direct supervision of a licensee. The supervising licensee must ensure that all students have been briefed on the basic radiation protection requirements associated with the safe use of x-ray analytical equipment.

Induction and training procedures for staff and other users

<< Please note these are the "in-house" rules for induction and training. In addition to these there are licensing requirements of the Act to be met. For staff to be granted a licence to use x-ray analytical equipment they will need to satisfy the criteria set by the National Radiation Laboratory and discussed elsewhere in these Guidance Notes (page 3 and Appendix 4). The in-house course, RSC-03, may not be sufficient to satisfy all requirements for eligibility for a licence. Additional training external to RSC-03 is likely to be needed, especially with regard to NZ regulatory requirements. >>

- All academic staff who intend using x-ray analytical equipment must have attended the departmental radiation safety course for analytical x-ray equipment, *RSC-03*, before using the equipment. A copy of the course syllabus and the course handout is filed with this *Radiation Safety Plan*.
- On completion of *RSC-03*, academic staff will apply to the National Radiation Laboratory for a licence to use x-ray analytical equipment if they do not already hold a licence for that purpose.
- All other users, such as post-graduate students and research officers from other institutions, must have completed the departmental radiation safety course for analytical x-ray equipment, *RSC-03*, before being authorised by the principal licensee (Dr L1) to work under his instructions. The authorisation must be recorded in this *Radiation Safety Plan.*
- For an initial training period academic staff (who will become licensees) and other users (who will be authorised to act under instructions) may operate the x-ray analytical equipment under the supervision of, and in the presence of, a licensee.

X-ray equipment register

Equipment used for x-ray analysis at School of Chemical Sciences, University of Advanced Techniques, Cayley Street, Albany.

1.

Manufacturer and model:	***Philips PW 1725***
Serial no:	AB10089
Location:	Room 23
Purchased:	4 September 1989
Verified by:	Dr L1, principal licensee
Signed:	
Date:	24 March 2001

2.

Manufacturer and model:	***Siemens XRF 321***
Serial no:	CD 2345
Location:	Room 27
Purchased:	24 September 1998
Verified by:	Dr L1, principal licensee
Signed:	
Date:	24 March 2001

SCS Radiation safety audits

- An annual radiation safety audit will be performed by the U of AT Safety Officer, Mr SO, in conjunction with the principal licensee, Dr L1.
- The checklist template below will be used.
- Originals of audit forms are kept in file 37/38/39, Safety audits-School of Chemical Sciences-Radiation Protection, kept in the office of the University Safety Officer, Administration Building. Copies are filed here.

RADIATION SAFETY AUDIT CHECKLIST

Radiation Safety Plan	**Complies**	**Notes**
Authorisations valid: Licensees Users under instructions	 ✓ ✓	
Training records correct	✓	
X-ray register correct	✓	
Local rules for the safe use of x-ray analytical equipment are current	✓	
Incidents/Accidents records	✓	1
Emergency procedures in place	✓	
Philips PW 1725		
Access to Room 23 controlled	✓	
Dose rate < 25 µGy/hr @ 5 cm	✓	
Use log	✓	
Maintenance & Servicing	✓	2
Labelling	✓	
Radiation warning sign	✓	
Warning lights	✓	
Interlocks	Not tested	3
Siemens XRF 321		
Access to Room 27 controlled	✓	
Dose rate < 25 µGy/hr @ 5 cm	✓	
Use log	✓	
Maintenance & Servicing	✓	2
Labelling	✓	
Radiation warning sign	✓	
Warning lights	✓	
Interlocks	✓	
Signed by the principal licensee		
Date of audit	24/09/01	

Notes:

1. No incidents recorded.
2. Annual maintenance recorded in department's maintenance log.
3. Long term experiment in progress – critical alignment not disturbed.

SCS Maintenance and servicing records

- The original records are to be kept in the School's maintenance log kept by the maintenance workshop. Copies are filed here.

Maintenance record for Philips PW 1725, serial no AB10089

15/02/00: Cooling water flow micro-switch not operating.
Filter removed and cleaned.
Operation checked.
Minimum flow rate checked.

01/03/00: Annual maintenance check as per manual.

21/05/00: "HV ON" warning light on panel not operating.
Bulb replaced.

01/03/01: Annual maintenance check as per manual.

Maintenance record for Siemens XRF 321, serial no CD 2345

01/03/00: Annual maintenance check as per manual.

01/03/01: Annual maintenance check as per manual.

SCS X-ray incident and accident records

(See also file of OSH accident report forms kept in the office of the University Safety Officer, Administration Building.)

20/05/00: A student, believing an exposure had terminated on the PW 1725, removed the camera before switching off the x-ray beam. The camera interlock operated and closed the shutter, alerting the student when he noticed the tube head warning light go out. He then noted that he had been fooled because the "HV ON" warning light wasn't working. The workshop has been asked to check.

A supplementary instruction has been given to all users emphasising the need to check and observe **all** indicators of the status of the x-ray beam.

SCS Local rules for the safe use of x-rays

- The following requirements are a controlled document. The master copy is kept filed with this *Radiation Safety Plan*.
- Copies of these local rules are to be posted in Rooms 23 and 27.
- If any changes are required these must be made to the master copy, signed by the principal licensee, Dr L1, and copied to the other places where they are posted (Rooms 23 and 27) or filed.

1. All x-ray analytical equipment must be housed in rooms that are kept locked when not in use.
2. The keys for operating any x-ray analytical equipment are to be kept, when not in use, in the office of the principal licensee, Dr L1.
3. Any use of the x-ray analytical equipment must be in accordance with the authorisations given in this *Radiation Safety Plan*.

4. Members of the public and other visitors are not permitted in Rooms 23 and 27 unless specifically authorised by the principal licensee, Dr L1.
5. Any abnormality in the running of the x-ray generators must be reported immediately to the principal licensee, Dr L1.
6. In the event of any accident or emergency the principal licensee, Dr L1, must be contacted immediately. Ph Ext 3345; Home 456 7865; 021 785 453.

Specific rules for the operation of the Philips PW 1725

1. Operation of the Philips PW 1725 must follow the manufacturer's operating manual except where specifically authorised by the principal licensee, Dr L1.
2. All use of the PW 1725 must be recorded in its log book.
3. The Philips single crystal and powder cameras and diffractometer in the cupboard in Room 23 may be used on the PW 1725. Other equipment borrowed from elsewhere in the university is not to be used unless it has been approved by the principal licensee, Dr L1, after checking or modifying to ensure that no safety features are compromised.
4. Room 23 may be left unattended with the PW 1725 operating, provided the start up key is removed from the panel and the door is locked.

Specific rules for the operation of the Siemens XRF 321

1. Operation of the Siemens XRF 321 must follow the manufacturer's operating manual except where specifically authorised by the principal licensee, Dr L1.
2. All use of the XRF 321 shall be recorded in its log book.
3. Room 27 may be left unattended with the XRF 321 operating, provided the start up key is removed from the panel and the door is locked.

Emergency procedures – X-Ray Rooms

1. If there is an emergency requiring evacuation of the building while an x-ray generator is operating, the person operating the equipment must switch off the machine and turn off the main isolating switch for the room on the way out.
2. If an emergency occurs while x-ray equipment is operating unattended, do not enter the building to switch it off. Any emergency services personnel that are required to enter the building are to be advised that x-ray equipment may still be operating if the mains supply has not been turned off.

APPENDIX 4

SYLLABUS FOR RADIATION SAFETY COURSE FOR X-RAY ANALYSIS

Coverage of the following topics would be considered the minimum to achieve the requisite background knowledge in radiation protection for operating x-ray analytical equipment. Such a course would be expected to be a minimum of ½ day.

Introduction to x-rays
- Production of x-rays
- Properties of x-rays
- Interaction of x-rays with matter
- Divergence from a point source

Introduction to dose
- Absorbed dose
- Equivalent dose

Sources of radiation

Biological effects of radiation

Principles of the ICRP system of radiation protection

NZ licensing and regulatory requirements
- Radiation Protection Act
- Radiation Protection Regulations
- Responsibilities of licensees and owners
- Code of Safe Practice for the Use of X-Ray Analytical Equipment, NRL C17

Radiation protection practice in the x-ray analysis facility
- Protection from external radiation
- Radiation measurement
- Personal monitoring

CROSS-REFERENCE INDEX

These *Guidance notes* give practical advice for compliance with radiation protection legislation and the relevant *Code, NRL C17*. 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 x-ray analytical equipment* to:

- *Code of safe practice for the use of x-ray analytical equipment, NRL C17 (NRL, August 2001);*
- *Radiation Protection Regulations 1982;*
- *Radiation Protection Act 1965.*

Guidance notes		**NRL C17**	**Regulations**	**Act**
Page No./Contents		*Section*	*No.*	*Section*
1	**LEGAL REQUIREMENTS AND RESPONSIBILITIES**			
1	Selling and buying x-ray equipment			2; 14(1)
2	Notification: responsibilities and procedure			14(2); 26(2)
3	Licences to use irradiating apparatus	1.3; 2.1.1; 2.1.3; 2.2.1; 2.3.1; 2.4.2; 3.1; 3.2; 4.1.1; 4.2.1; 5.1.1; 6.1; 6.2	9(3)	15; 16; 17; 18; 20; 21; 22
4	Use by an unlicensed person	4.2		15
5	Responsibilities of owners	1.2	9(1); 9(3); 9(4)	
6	**RADIATION SAFETY MANAGEMENT**		9(2); 11(a-f)	
6	Radiation safety plan	2.1		
7	Radiation safety audits	2.2; 3.2(a)		
8	Maintenance and servicing	2.4		
8	Disposal of x-ray equipment		9(4)(b)	
9	**FACILITY AND EQUIPMENT SAFETY**	3	21; Second schedule	14
9	Labelling and warning signs	3.2(b)(c)(f)(g)		
11	**OCCUPATIONAL SAFETY**		18; 20(1-3)	
11	Safety during normal use	4	11(a,b)	
11	Personal monitoring		20	
12	Radiation survey meters	2.2.1; 3.2(a)		
13	**PUBLIC SAFETY**	5		
14	**INCIDENTS, ACCIDENTS AND EMERGENCIES**	6	19	
14	Incidents and accidents	6.1; 6.2		
14	Fire and civil defence emergencies	6.3		
15	**COMPLIANCE MONITORING AND ENFORCEMENT**			24; 25; 26; 27; 28; 29