Local Rules for Radiography: Ionising Radiation Regulations 1999

Queen Street Mortuary, Queen Street Police Station, Aberdeen
Equipment covered by these rules: Xograph Canon DRagon mobile X-ray unit

Radiation Protection Supervisor: Dr J Greave, University of Aberdeen. (01224 553847)
Radiation Protection Adviser: Dr S McCallum, NHS Grampian. (01224 553109)

Working Instructions Staff MUST Follow

1. **X-ray equipment must only be operated by staff who have received appropriate training in its safe and correct operation. Records must be kept of this training.**

2. **The operator must be able to hear the audible signal and see the radiation warning light when exposing.**

3. **The room containing the X-ray equipment is designated a controlled area when the unit is switched on. The doors must be locked and radiation warning signs placed outside.**

4. **No person should enter the controlled area unless their presence is essential in order to take the X-ray image.**

5. **The person operating the x-ray equipment must restrict access to the controlled area.**

6. **All persons in the controlled area during an exposure must stand behind the protective lead screen. The operator must ensure this is the case before exposing.**

7. **No person may hold the X-ray tube or detector during a radiographic exposure.**

8. **Authorised operators that are pregnant may take x-rays but must stand behind the protective lead screen. Pregnant operators must wear a monthly personal dosimeter.**

9. **If the unit fails to terminate at the end of an exposure, the unit must be switched off using the emergency off switch. Operators must not to enter the path of the primary beam.**

10. **When it is suspected any person has received a radiation dose in excess of that expected, the RPS and RPA must be informed immediately in order that a dose estimation can be made. It would be helpful to make a note of exposure factors, distances etc.**

11. **When a fault is suspected, the unit must be immediately disconnected from the mains supply and switched off. The fault must be entered into the fault log. Any faults or erratic operation of x-ray equipment must be reported to the RPS as soon as possible for checking and repair by a service engineer.**

12. **Personal monitoring is required for persons remaining in the controlled area during an exposure. University of Aberdeen staff should obtain suitable personal dosimeters from the Radiation Protection Service; the dose investigation level is 0.3mSv in two months. For pregnant staff, a limit of 1mSv applies over the declared term of the pregnancy. Persons who are not employees of the University of Aberdeen may use personal dosimeters issued by their employer.**

13. **These local rules apply to the X-ray unit when located within the mortuary. In the event of the equipment being used outwith the mortuary, new arrangements will be required, including a new prior risk assessment and new local rules.**

Local Rules for Radiography: Ionising Radiation Regulations 1999

All mortuary staff and any persons working within the X-ray controlled area must read the local rules and sign below to indicate that they have read and understood the instructions.

Name	Signature	Date

University of Aberdeen
Ionising Radiation Risk Assessment

See accompanying Notes for Completion

Administration

A1 Date of assessment: 9/6/2011	A2 Previous assessment:	A3 Review Date: July 2012
A4 Department: Pathology	A5 Locality: Queen Street Mortuary	A6 Ward / Team: Pathology

Description

A7 Ionising Radiation Risk Assessment Of: **Radiography using Mobile X-ray unit**	
A8 Risk Category: **Safety**	A9 Sub-Category: **Radiation Protection**

Routine Operational Exposures

Use this Section to describe ionising radiation exposures occurring routinely as a consequence of work with ionising radiation
E.g. occupational exposures

B1 External Radiation Hazards *(describe the source(s), location, exposure scenarios and likelihood)*

During routine diagnostic imaging of corpses and QA tests, the hazard is exposure to X-rays emitted by the X-ray tube and scattered by the object being imaged. Exposure is unlikely if control measures described in the Local Rules document are utilised.

B2 Contamination / Internal Radiation Hazards *(describe source(s), location and the likelihood of contamination and spread)*

N/A

Context (Routine Operational Exposures)

B3 Those Directly Affected

Pathologists, Mortuary Attendants, Radiographers, Radiologists, Police staff, Mortuary Manager, Medical physics staff

B4 Expected Dose Levels *(If you have difficulty completing this section, contact the Radiation Protection Service)*

As appropriate, quote previous personal dosimetry data, radiation measurements, environmental impact assessments or calculations which help to indicate the level of radiation risk and expected annual dose levels.

Primary Beam

The typical dose to a DR detector is between 2 and 5 µGy. The detector is lead-backed and attenuates the beam by a factor of between 5 and 10. At the back of the detector, the typical dose will be approximately 1µGy. Assuming a minimum distance between focal spot and cassette of 1m, the dose 1m from the detector will be approximately 0.25µSv.

Scatter Dose

Example dose levels due to scattered X-rays are shown in the table below.

Examination	Typical DAP ($cGycm^2$)	Typical kVp	Max scatter dose at 2m per exposure* (uGy)
Chest	11	76	0.13
Abdomen	190	77	2.32
Pelvis	180	77	2.2
Extremity	5-15	55	0.15

*Calculated using the method described in Sutton & Williams p13-14 at the angle of maximum scatter (117^o)

Personal Dose Levels

Assuming persons operating the X-ray unit are located behind the lead screen in line with the local rules during exposure, expected routine dose levels will be below 0.3mSv per year. This is based upon a typical scatter dose per exposure of 2.5µSv, a maximum transmission through the lead screen of 5% and the number of exposures being well below 2400 per year.

Persons outwith the controlled area will not receive a measurable radiation exposure due to the building structure and distance. This has been verified by environmental radiation monitoring using TLD badges affixed to the walls by the Radiation Protection Service in 2002.

Controls (Routine Operational Exposures)

B5 Engineering controls and Design Features

Describe & evaluate as specified / installed: shielding (along with any workload assumptions); safety interlocks; local shielding.

The X-ray unit features an emergency-off switch, audible exposure warning, an exposure light, a removable key and a "deadman" exposure switch: these are sufficient control measures.

B6 Area designation

Provide reasoning for area designation.

The room in which the equipment is operated is designated a Controlled Area while the X-ray unit is switched on due to the potential doserate and the need for special procedures to restrict radiation exposures.

B7 Access Restrictions

Describe & evaluate how access is controlled.

The operator will ensure access into the controlled area is restricted and that all persons present are behind the lead screen.

B8 PPE

What PPE is required? Provide justification for selection & use of PPE.

If under exceptional circumstances local shielding, such as a lead screen, is not available, 0.25mm lead-equivalent protective aprons must be worn for examinations utilising a tube potential of less than 100kVp, or 0.35mm lead aprons above 100kVp. These measures are recommended in the Medical and Dental Guidance Notes (IPEM, 2002).

B9 Systems of Work

Describe and evaluate the systems of work required. Are they in the local rules?

The local rules must describe procedures for using PPE and shielding, controlled area entry, use of the X-ray equipment, use of personal monitoring devices and quality assurance testing. Operators of the equipment are responsible for restricting access into the controlled area.

B10 Those especially at risk

Describe any special arrangements required.

☐Children ☒Pregnant women ☐Others:

Duties need not be altered for radiation protection reasons. As with all staff, pregnant women must ensure they are behind the lead screen during an exposure.

In the case of staff routinely issued with a radiation monitoring badge, the Radiation Protection Service must be informed so that an additional monthly radiation badge can be issued to the member of staff to ensure that the dose to the foetus does not exceed 1mSv over the declared term of the pregnancy. These arrangements must be described in the Local Rules.

B11 Manufacturer advice on safe use & maintenance

Is manufacturer advice available and being followed?

Routine servicing is carried out in line with manufacturer recommendations, along with regular radiation protection equipment checks.

The Local Rules must summarise the above control measures and indicate how they should be used.

Analysis (Routine Operational Exposures)

Advice should be obtained from the RPA (Radiation Protection Advisor) before completing this section

B12 Are foreseeable dose levels As Low as Reasonably Practicable?	B13 Are predicted / current dose levels within IRR99 limits and below the values given in Table 2 of the Notes for Completion?	B14 Will staff need to be classified under IRR99?
Yes	Yes	No

Incident/Accident Exposures

Use this Section to describe reasonably foreseeable accidents or incidents which may result in ionising radiation exposures.

C1 External Radiation Hazards *(describe the source(s), location, exposure scenarios and likelihood)*

1. Operator in controlled area without PPE during exposure: Unlikely
2. Other person in controlled area without PPE during exposure: Unlikely
3. Unit fails to terminate: Rare

C2 Contamination / Internal Radiation Hazards *(describe source(s), location and the likelihood of contamination and spread)*

N/A

Context (Incident / Accident Exposures)

C3 Those Directly Affected *(Indicate any persons affected by an accident)*

Pathologists, Mortuary Attendants, Radiographers, Radiologists, Police staff, Mortuary manager, Medical physics staff

C4 Potential Dose Levels *(If you have difficulty completing this section contact the Radiation Protection Service)*
As appropriate, quote radiation measurements or calculations which help to indicate the possible level of radiation risk.

1 & 2: See section B4, dose levels will follow the inverse square law. At 1 m the maximum scatter dose would be less than 10µSv.

3: The unit failing to terminate will not result in additional dose to anyone if the contingency plan is followed.

Controls (Incident / Accident Exposures)

C5 Those especially at risk

Describe any special arrangements required.

☐Children ☒Pregnant staff ☐Pregnant patients ☐Others:

No additional measures are required beyond those specified under Routine Operational Exposures.

C6 Contingency plans

Describe the contingency arrangements for the situations described in sections C1 and C2

1 & 2: The exposure must be halted until corrective action is taken.

4: The emergency off switch should be operated immediately.

In all cases, the incident should be reported to an RPA along with enough exposure information to allow the likely dose to be calculated. An investigation must be carried out by the RPS with the assistance of an RPA.

C7 Analysis (*level of risk*) (Incident / Accident Exposures)

Compete this section using the Radiation Risk Matrices provided in the Notes for Completion

Scenario	E1 Foreseeable Consequences		E2 Probability of Occurrence	E3 Risk Level
	Estimated individual dose	Descriptor		
1: Operator scatter exposure	<0.02mSv	Negligible	Unlikely	Low
2: Other person scatter exposure	<0.02mSv	Negligible	Unlikely	Low
3: Unit fails to terminate	None	Negligible	Rare	Low

D Training requirements

Identify the training required to ensure that staff affected by this risk assessment know the health risks from exposures, the precautions they should take to minimise risks and the importance of complying with the regulations. (List training by staff groups as appropriate)

All mortuary staff must undergo basic radiation protection training.

Persons operating the equipment must undergo basic radiation protection training and training on the use of the equipment. If they are not an employee of the University of Aberdeen, evidence of their training should be obtained.

The RPS should discuss the Local Rules with all staff and all training should be recorded.

E Personal Monitoring

The personal monitoring requirements are indicated by the dose level estimates of Sections C2 and F2, along with any special arrangements for persons at particular risk. Table 3 in the Notes for Completion gives standard arrangements.

Detail the personal monitoring arrangements required (list by staff group as appropriate).

Persons operating the X-ray equipment must wear a 2-monthly TLD badge radiation monitor. Pregnant operators of the equipment should also be issued with a monthly TLD badge. If the operator is not an employee of the University of Aberdeen, it is sufficient for them to wear personal dose monitors provided by their employer as long as dose information is shared between the organisations.

Personal monitoring is not required for staff working outwith the controlled area.

Indicate dose investigation levels (Whole-body typically 0.3mSv/mnth or 2mSv/yr: Extremity typically 2.5mSv/mnth)

Whole-body: 0.3mSv/wear period (monthly or 2 monthly) or 2mSv/yr

For pregnant staff the whole body dose must be limited to 1mSv over the remaining term of the pregnancy.

F Action Plan

Proposed Actions and Resources Required	Responsibility:	Deadline:	Scrutiny Arrangements:
Read and discuss the Local Rules with staff	RPS	Ongoing	Record in staff training records
Review this risk assessment annually and record the action in section H	RPS	Annually	Radiation Protection audit
Carry out audit of radiation protection arrangements	RPA	3-yearly	

G Endorsement of the Risk Assessment

Risk Assessor	**Line Manager**	**RPA**
Name: M WATT	Name: JAMES H-K. GRIEVE	Name: S.J. MCCALLUM
Signature:	Signature:	Signature:
Date: 9/6/2011	Date: 16/06/2011	Date: 9/6/2011

H Review of the Risk Assessment

The risk assessment must be reviewed in accordance with the Review Interval in section A3. Any new actions should be recorded and a new assessment carried out if circumstances have changed.

Describe changes in working arrangements since last review	Are any actions required for continued compliance?	Date:	Name:	Signature

Notes for Completion

Overview

This form is intended for the assessment of workplace risks due to the use of Ionising Radiation. This form is not suitable for assessing any other types of risk. It should only be used by persons who have been specifically trained for ionising radiation risk assessments. A prior risk assessment is required under the Ionising Radiations Regulations 1999 (IRR99) before starting any new work or making changes to existing work.

Using the form

UoA employs a Radiation Protection Advisor (RPA) to provide specialised advice on radiation safety. The RPA should be consulted over parts of the form and must sign the form once completed.
The ionising radiation risk assessment form splits hazards into two categories: occupational and accident radiation exposures. These are assessed slightly differently, and care should be taken to differentiate between the two types of situation. Specific guidance is given below on particular sections of the form.

A: Administration

The Review Date must be completed: the normal interval is 12 months.

B: Routine Operational Hazards

This section refers only to radiation exposures from routine work: **do not** use this section to consider accidents. Radiation exposures in this section must be planned and expected, but must be shown through the risk assessment to be both unavoidable and of a level as low as reasonably practicable.

Sections B1 & B2

Use these sections to describe the radiation hazards you can identify in the workplace, for example:
"X-ray set in X-ray dept Room 1, with controls behind lead-glass screen. X-ray exposure hazard to persons standing outwith the screen during an exposure"
Or
"Unsealed radionuclides administered to patients in Nuclear Medicine Gamma Camera Room. Possible spillage and subsequent spread of contamination, leading to potential external and internal exposure…"

Section B3

Select all persons who may be affected by the routine hazard, for example:
X-ray room: Radiographers, patients, public, X-ray nurse, physicists, technologists, cleaner, comforter/carer

Section B4: Expected Dose Levels

This section is very important for the assessment of radiation risk. It should be used to enter all available information about the magnitude of the radiation exposure of the affected persons. In some cases previous personal dosimetry results may be sufficient, but where possible additional data should be presented. This should consist of radiation measurements or calculations indicating maximum foreseeable exposure levels.

Section B5: Engineering Controls and Design Features.

An important function of this box is to detail and evaluate any structural shielding which is required or installed. This should include details of any calculations or measurements carried out, and in particular the workload assumptions made: if the workload estimate used is incorrect or changes, this could result in inadequate shielding. This section should also give details of any local shielding measures such as movable screens, and any safety interlocks required.

Section B6: Area Designation

An area should be designated as a controlled area under the following circumstances[1]:

- A person entering or working in the area must follow special procedures to restrict exposure or prevent or limit radiation accidents
- A person working in the area is likely to receive a dose greater than 6mSv or 3/10ths of any relevant dose limit.
- The external dose rate exceeds 7.5μSv/hr averaged over the working day
- The hands can enter an area with an 8-hour time averaged dose rate of 75μSv/hr
- There is significant risk of spreading contamination outwith the area
- Access of workers unconnected with radiation work must be prevented or supervised

[1] IRR99 Approved Code of Practice, HSE Books 2000

- The dose rate averaged over 1 minute exceeds 7.5μSv/hr and employees untrained in radiation protection may enter the area, unless the radioactive substance is dispersed in the human body and the above conditions do not apply.

An area should be designated as supervised when:

- The conditions must be kept under review to determine the need for designation as a controlled area
- A person may receive a dose above 1mSv per year or 1/10th of any relevant dose limit.

Section B7: Access Restrictions

This section follows on from conclusions in B6. If access control is required, suitable measures to achieve this must be identified and justified. Measures may include signage, lights, barriers, locks and systems of work. The effectiveness of existing measures should be evaluated.

Section B8: PPE

Suitable personal protective equipment should always be worn where there is a risk of contamination, such as unsealed source work in Nuclear Medicine.

For radiographic procedures with staff in the room, Table 1 below contains recommendations[2] for lead apron thicknesses. Other measures such as thyroid shields must also be considered where exposure levels are likely to be high, such as interventional radiography.

Radiography <100kVp	0.25mm lead equivalence
Radiography >100kVp	0.35mm lead equivalence

Table 1 - PPE Examples

Section B9: Those Especially at Risk

This section should be used to identify persons especially at risk to the radiation hazard, and any special arrangements to be made. Such measures typically consist of altered working arrangements.

Section B10: Manufacturer Advice

This section should detail any advice given by the manufacturers of devices relevant to the radiation hazard. An example would be guidance on servicing and maintenance of an X-ray set from the manufacturer of the device. The measures to comply with advice should be set out, and justification given for any deviation from the advice.

Analysis (Routine Operational Exposures)

Section B11: ALARP

It is a legal requirement that occupational exposures to ionising radiation are As Low As Reasonably Practicable. This should be the case after completing the previous sections of the risk assessment. If additional measures can be conceived, they should be entered in the relevant sections before continuing with the risk assessment. If the answer to this section is "no", the work cannot be carried out.

Section B12: Dose limits

Staff dose levels within UoA should be below the constraints given in Table 2 below. If this is not the case, the work must be discussed with the RPA.

Location	Whole Body	Skin	Eyes	Extremities
UoA dose constraint	3mSv	75mSv	25mSv	75mSv
Public dose constraint	0.3mSv	-	-	-

Table 2 - UoA Occupational Dose limits

Section B13: Classification

If staff doses are expected to be above the levels given in Table 2, consideration must be given to classification of the workers. This must be discussed with the RPA.

C: Accident / Incident Exposures

This section refers to radiation exposures which will occur due to accidents. An accident is defined as *an identifiable but unintended and unexpected occurrence resulting in radiation exposure*.

Section C1 & C2

Use these sections to describe reasonably foreseeable accidents involving exposure to ionising radiation, e.g.:
"X-ray exposure of unintended person in X-ray room due to unlikely failure of staff to notice their presence"
Or
"Unlikely spillage of radiopharmaceutical during administration to patient, resulting in contamination and exposure of patient and staff member."

[2] Medical and Dental Guidance Notes, IPEM 2002, ISBN: 1903613094

Section C3
List all persons who may be affected by each accident scenario

Section C4: Potential Dose Levels
It is vital that this section is fully completed for all accident scenarios described in the previous sections. This box should be used to indicate the doses which could be received by any persons affected by the scenarios, by giving details of relevant radiation measurements or doserate calculations.

Section C5: Those Especially at risk
This section should be used to identify persons especially at risk to the radiation hazard present in each accident scenario, and any special arrangements to be made.

Section C6: Contingency Plans
For each accident scenario, a contingency plan must be created indicating how the accident should be dealt with. The actual plan does not need to be presented on the risk assessment form, but details of arrangements should be given: for example, the contingency plans may be given in the local rules, and staff provided with regular refresher training and rehearsals.

Section C7: Analysis of accident / incident exposures
The risk level must be determined for each accident scenario using the Radiation Risk Matrix shown below. The assessment must be carried out for each scenario and for each group of people affected by the scenario. The boxes in the table are described below:

- Scenario: indicate the scenario & group(s) of people being assessed
- E1 Estimated individual dose: enter the accident dose estimated for the most exposed person in each group. This should reflect the foreseeable "worst-case" dose that would be received.
- E1 Descriptor: Using tables 3 & 4 below, indicate the descriptor of the hazard, e.g. "Minor" or "Extreme".
- E2 Probability: Using table 5, indicate the probability of the accident occurring, e.g. "Rare" or "Likely"
- E3 Risk Level: Use the risk matrix, together with the entries in boxes E1 and E2, to obtain the risk level.

The table "Response to Risk" indicates the level of response required to each risk level. Note that only a "Low" risk is automatically acceptable – at all other risk levels, additional measures are required to reduce the risks. If a risk level is found to be greater than "Low" once all measures have been used, the practice may be accepted by the RPA & management if appropriate scrutiny of arrangements is documented in the action plan.

	Consequences / Whole Body Effective dose (mSv)				
	Negligible	Minor	Moderate	Major	Extreme
Classified worker	<0.02	0.02 - 3	3 - 10	10 - 50	>50
Radiation Worker	<0.02	0.02 - 1	1 - 3	3 - 20	>20
Other staff / Public	<0.02	0.02 – 0.1	0.1 - 0.3	0.3 - 1	>1

Table 3 – Consequences / whole body effective dose

	Consequences / Extremity Equivalent dose (mSv)				
	Negligible	Minor	Moderate	Major	Extreme
Classified worker	<0.02	0.02 - 75	75 - 250	250 - 500	>500
Radiation Worker	<0.02	0.02 - 25	25 - 75	75 - 250	>250
Other staff / Public	<0.02	0.02 – 0.1	0.1 - 0.3	0.3 - 1	>1
Contact the RPA if doses to the eyes of a radiation worker will be above 8mSv per year					

Table 4 – Consequences / extremity equivalent dose

Descriptor	Rare	Unlikely	Possible	Likely	Almost Certain
Probability	• Can't believe this event would happen • Will only happen in exceptional circumstances.	• Not expected to happen, but definite potential exists • Unlikely to occur.	• May occur occasionally • Has happened before on occasions • Reasonable chance of occurring.	• Strong possibility that this could occur • Likely to occur	This is expected to occur frequently / in most circumstances more likely to occur than not

Table 5 – Probability descriptors

Radiation Risk Matrix

Likelihood	Consequences / Impact				
	Negligible	Minor	Moderate	Major	Extreme
Almost Certain	Medium	High	High	V High	V High
Likely	Medium	Medium	High	High	V High
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Medium	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

Level of Risk	*Response to Risk*
Low	No additional controls are required but any existing risk controls or contingency plans should be documented. The line manager should periodically review whether these continue to be effective.
Medium	Further action shall be taken to reduce the risk but the cost of control will probably be modest. The line manager shall document that the risk controls or contingency plans are effective. The relevant Departmental Manager will periodically seek assurance that these continue to be effective.
High	Further action must be taken to reduce the risk, possibly urgently and possibly requiring significant resources. The line manager must document that the risk controls or contingency plans are effective. The relevant General Manager or Director will periodically seek assurance that these continue to be effective and confirm that it is not reasonably practicable to do more.
Very High	Given the gravity of the risk, the Chief Executive and relevant stakeholders must be informed explicitly by the relevant Director or General Manager. The Chief Executive must either urgently divert all possible resources to reduce the risk; suspend the situation presenting the risk until the risk can be reduced; abandon or significantly revise the threatened objective; or explicitly authorise that the risk is worth taking.

D. Training Requirements

It is vital that all staff receive the correct level of training to carry out their jobs with an awareness of the health risks, appropriate radiation protection measures and the importance of the legislation. This section should be used to indicate how these requirements will be fulfilled. For example, this could be through external or internal courses, in house training, online training packages or on-the-job training.

This section should also be used to indicate how training will be recorded and assessed: for example staff may have personal training records with competency levels signed off as training is completed.

E. Personal Monitoring

Personal monitoring is required under the conditions set out in Table 6 below. The selection of personal monitoring methods and dose investigation levels should be carried out in consultation with the RPA.

Monitoring	Criteria
2-monthly TLD badge	Routine body doses above 0.05mSv/month Potential accident dose above 1mSv
Monthly TLD badge	Routine body doses above 0.1mSv/month Pregnancy
TLD finger ring	Routine extremity doses above 1mSv/month
Electronic Personal Dosimeter	Potential accident dose above 3mSv Situations requiring additional dose scrutiny Pregnancy in some situations

Table 6 - Personal Monitoring Criteria

F: Action Plan

An implementation plan must be provided for all measures required by the assessment but not currently in place.

H: Review

The risk assessment must be reviewed in accordance with the review interval, or if circumstances have changed: this may indicate the need for a new assessment to be made. For example, if X-ray room workload or usage has changed, shielding requirements will need to be revised.

If the risk assessment is still valid, the review should be recorded in this section of the form.