

**NRL C6**  
**ISSN 0110-9316**

# **CODE OF SAFE PRACTICE FOR THE USE OF X-RAYS IN CHIROPRACTIC DIAGNOSIS**

The Director  
National Radiation Laboratory  
PO Box 25-099  
Christchurch  
New Zealand

April 1997

© **1997, National Radiation Laboratory**  
**Ministry of Health**

Published with the permission of the Director-General of Health

# CONTENTS

	<i>page</i>
<b>1 INTRODUCTION</b>	<b>1</b>
<b>2 PRINCIPLES AND ADMINISTRATION OF RADIATION PROTECTION</b>	<b>3</b>
Basic radiation protection principles	3
New Zealand radiation protection legislation	3
Education and training of persons using x-rays in chiropractic diagnosis	5
<b>3 PROTECTION OF RADIATION PERSONNEL, NON-RADIATION PERSONNEL AND MEMBERS OF THE PUBLIC</b>	<b>6</b>
Introduction	6
Individual dose limits	6
Radiation personnel	7
Non-radiation personnel and members of the public	7
Protection of non-radiation personnel and members of the public	7
Protection of radiation personnel	8
Radiography	8
Fluoroscopy	8
Protection of persons holding patients or image receptors	8
Personnel monitoring	9
<b>4 PROTECTION OF THE PATIENT</b>	<b>10</b>
Justification of a practice	10
Optimisation of protection	10
Radiography	12
Fluoroscopy	13
Cinefluorography	13
Computed tomography	13
Reference doses	14
Reference filtration, diaphragms and shields	14

Standard projections	14
Reference doses and reference filtration, diaphragms and shields for common radiographic projections	17
Cervical spine, AP	17
Cervical spine, Lateral	17
Cervico-thoracic, AP	17
Lumbar, Lateral	18
Lumbo-pelvic, AP	18
Lumbo-pelvic, Lateral	18
Full spine, AP	19
Exposure of women of reproductive capacity	19
Protection of the embryo/foetus	20
Protection of paediatric patients	21
Procedures	21
Equipment	21
Techniques	22
Patient management	23
Records	23
Research on humans	24
General principles	24
<b>5 X-RAY EQUIPMENT</b>	<b>25</b>
Appropriate x-ray equipment	25
X-ray machine requirements	25
Filtration	25
Leakage radiation	26
Radiography	26
X-ray beam limitation	26
Light beam diaphragms	26
Fixed or adjustable diaphragms	27
Focus-skin and focus-film distance	27
X-ray exposure device	28
Automatic exposure control (AEC) device	28
Fluoroscopy	29
Radiation from components other than the x-ray tube assembly	29

Warning lights at the x-ray controls	29
Warning lights at the x-ray tube	30
X-ray tube assemblies	30
Darkroom	31
Efficient performance of x-ray machines	31
Reproducibility of x-ray output	32
Linearity of x-ray output	32
Accuracy of kilovoltage settings	33
<b>6 X-RAY ROOMS AND AUXILIARY PROTECTION REQUIREMENTS</b>	<b>34</b>
Introduction	34
Standard barriers	34
Primary x-ray barriers	34
Secondary x-ray barriers	35
Standard x-ray room shieldings	35
Barrier materials	36
Primary barriers	36
Secondary barriers	37
Warning signs and lights at the entrances to x-ray rooms	38
Protective equipment in x-ray rooms	39
<b>7 QUALITY ASSURANCE PROGRAMME</b>	<b>40</b>
General requirements	40
<b>REFERENCES AND BIBLIOGRAPHY</b>	<b>42</b>
<b>ANNEX 1 DEFINITION OF TERMS AND GLOSSARY</b>	<b>47</b>

<b>ANNEX 2</b>	<b>QUALITY CRITERIA FOR DIAGNOSTIC RADIOGRAPHIC IMAGES</b>	<b>50</b>
	Introduction	50
	General principles associated with good imaging performance	50
	Image annotation	50
	Quality control of x-ray imaging equipment	50
	Radiographic exposure factors	51
	Technical innovations	51
	Patient positioning	51
	X-ray beam limitation	51
	Protective shielding	52
	Radiographic exposures per examination	52
	Film processing	52
	Image viewing conditions	52
	Examples of good radiographic technique	53
	Projections	54
	Cervical spine, AP	54
	Cervical spine, Lateral	54
	Cervico-thoracic, AP	54
	Lumbar, Lateral	55
	Lumbo-pelvic, AP	55
	Lumbo-pelvic, Lateral	55
	Full spine, AP	56
<b>ANNEX 3</b>	<b>DOSE INDICES FOR ASSESSING RADIATION EXPOSURE OF PATIENTS</b>	<b>57</b>
<b>INDEX</b>		<b>58</b>

# 1 INTRODUCTION

**1.1** This Code of Safe Practice sets out requirements and recommendations for radiation safety associated with the use of x-rays for chiropractic radiographic diagnosis. The requirements and recommendations for chiropractic fluoroscopic diagnosis and for chiropractic research involving the use of x-rays are set out in this Code together with NRL C5, *Code of safe practice for the use of x-rays in medical diagnosis*.

**1.2** Requirements from the *Radiation Protection Act 1965* and the *Radiation Protection Regulations 1982* are incorporated in this Code. Further requirements and recommendations are taken from source material listed in the section of References and Bibliography, or from advice received from experts in the field. Their assistance is gratefully acknowledged.

**1.3** Whenever compliance with this document is required as a condition to a licence under the *Radiation Protection Act 1965* for the purpose of chiropractic radiographic or fluoroscopic diagnosis or research (see paragraph 2.5), the word **shall** is used. The word **should** indicates a practice that is recommended but not mandatory. Whenever a requirement is not specified explicitly, but uses the term suitable or suitably qualified, the judgement as to whether these terms are satisfied rests with the National Radiation Laboratory (NRL).

**1.4** Where a given x-ray technology or practice is not specifically covered by this Code, or by other Codes specifically referred to, guidance in matters of radiation protection **shall** be sought from the National Radiation Laboratory.

**1.5** In instances where a requirement is not complied with, but the radiation protection purpose behind the requirement may be met by alternative means, then compliance with that requirement may not be needed. The alternative means **shall** be assessed as being acceptable or not by the Director of the National Radiation Laboratory.

**1.6** *Radiation protection surveys*\* of the x-ray facilities of persons licensed for the use of x-rays for chiropractic diagnosis **shall** be performed by National Radiation Laboratory personnel for auditing compliance with this Code. The interval between surveys **should not** exceed the following:

---

\* All terms in italics in this Code are defined in Annex 1.

- radiography only facilities - 4 years;
- fluoroscopy facilities - 2 years;

**1.7** All new facilities or facilities with new equipment **shall** undergo an acceptance test for compliance with this Code performed by a *qualified health physicist* as part of commissioning.

**1.8** Measurements performed as part of quality assurance programmes in radiation protection (including commissioning tests) **shall** be performed with instruments whose suitability and calibration have been approved by NRL.

**1.9** The licensee **shall** be responsible for ensuring that corrective action takes place as soon as practicable on items of non-compliance with this Code. Where the owner of the equipment is not the licensee, the owner **shall not** act to oppose this corrective action.

**1.10** The owner of x-ray equipment used for chiropractic exposures **shall** ensure that there is a programme for the progressive replacement of equipment whose performance has deteriorated and will soon fail to comply with the requirements of this Code.

## 2 PRINCIPLES AND ADMINISTRATION OF RADIATION PROTECTION

### Basic radiation protection principles

2.1 Radiation protection **shall** be based on the three principles of *justification*, *optimisation*, and *limitation* (International Commission on Radiological Protection, 1991), as follows:

- (a) No practice **shall** be adopted unless its introduction produces a positive net benefit to the exposed individuals or to society. (The *justification* of the practice.)
- (b) In relation to a particular practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposure **shall** be kept as low as reasonably achievable, economic and social factors being taken into account. (The *optimisation* of protection.)
- (c) The risk either from a dose or potential dose to a class of individuals **shall not** exceed the limits set for that class. (*Limitation* of individual dose and risk.)

### New Zealand radiation protection legislation

2.2 The *Radiation Protection Act 1965* and amendments, and the *Radiation Protection Regulations 1982*, govern the safe use of *irradiating apparatus* and radioactive materials in New Zealand. The Act is administered in the Ministry of Health by the National Radiation Laboratory. The Act establishes the Radiation Protection Advisory Council whose functions are to advise and make recommendations to the *Director-General* of Health and the Minister on matters relating to the Act and the Regulations. The term *Director-General* includes persons to whom his/her powers are delegated under the *Radiation Protection Act*. *Irradiating apparatus* is defined in the Act as any apparatus that can be used for the production of x-rays or gamma rays or for the acceleration of atomic particles in such a way that it produces a dose equivalent rate of or exceeding 2.5  $\mu\text{Sv}$  per hour at a point which could be reached by a human being.

**2.3** The *Radiation Protection Act 1965* does not permit any person to use *irradiating apparatus* for any purpose unless he or she holds a licence under the Act for that purpose, or is acting on the instructions or under the supervision of a person holding such a licence.

**2.4** This Code applies to licences granted under the *Radiation Protection Act* to use x-rays for the purpose of chiropractic diagnosis. Licences to use x-rays for chiropractic diagnosis are granted only to chiropractors.

**2.5** Licences issued under the Act may be subject to special conditions. Compliance with this Code **shall** be a condition on a licence to use x-rays for chiropractic radiographic diagnosis. Where fluoroscopy is used for chiropractic diagnosis, or x-rays are used as part of chiropractic research, then compliance with the appropriate sections as specified in this Code or NRL C5, *Code of safe practice for the use of x-rays in medical diagnosis* **shall** be a condition on the licence.

**2.6** An application for a licence to use x-rays for chiropractic radiographic diagnosis is approved if the applicant is registered in New Zealand to practice chiropractic. An application for a licence to use x-rays for chiropractic fluoroscopic diagnosis is assessed on the basis of the qualifications and experience of the applicant, taking into account the advice of the Radiation Protection Advisory Council when appropriate. When an application is made for a licence to perform chiropractic fluoroscopic diagnosis the applicant **shall** provide information to enable a comparison to be made of the doses from the fluoroscopic technique and from the radiographic technique it replaces. The licence **shall** only be issued if the dose from fluoroscopy is less than the dose from radiography.

**2.7** Whenever more than one licensee is employed in a given area, Regulation 9(3) of the *Radiation Protection Regulations 1982*, requires that the owner of the *irradiating apparatus* either appoints one as principal licensee, or clearly defines the respective areas of responsibility of the individual licensees.

**2.8** The licensee **shall** notify the *Director-General* of any case of *overexposure* or suspected *overexposure* to radiation as soon as possible after becoming aware of it.

## **Education and training of persons using x-rays in chiropractic diagnosis**

**2.9** Persons using x-rays in chiropractic diagnosis **shall** be properly educated and trained appropriately for the work so that they may apply x-radiation efficiently and safely. This includes endeavouring to keep abreast of technical improvements, especially those which affect the efficiency of use of radiation or radiation safety. Appropriate advanced courses, refresher courses, seminars etc, **should** be attended.

**2.10** X-ray personnel who perform any chiropractic radiographic work and who are not licensees themselves but are operating under the instruction and supervision of a licensee **shall** either be a registered chiropractor or a registered *Medical Radiation Technologist*, or hold a specific exemption under the appropriate legislation.

**2.11** Chiropractic fluoroscopy **shall** be performed only by those chiropractors so licensed, or by other chiropractors under the direct supervision of the licensee.

### 3 PROTECTION OF RADIATION PERSONNEL, NON-RADIATION PERSONNEL AND MEMBERS OF THE PUBLIC

#### Introduction

**3.1** Protection of *radiation personnel* and members of the public **shall** be assured by adherence to the 3 basic radiation protection principles of *justification*, *optimisation* and *dose limitation* (see para 2.1).

**3.2** Doses for *radiation personnel* and members of the public **shall** be below their respective individual dose limits (see paras 3.4 - 3.6 below). The individual dose limits represent the boundary between unacceptable doses and doses that are *tolerable*. Doses **should** be well below these limits, and efforts **shall** be made to keep doses to individuals as low as reasonably achievable (*ALARA*), economic and social factors being taken into account.

**3.3** In most circumstances it is feasible to maintain dose rates in areas occupied by *radiation personnel* at levels that would not lead to doses in excess of the dose limits for the public – namely 20  $\mu$ Sv per week summed over the period normally occupied. In accordance with *ALARA* (para 3.2) this **should** be done. There **shall** be an investigation of the working practice of *radiation personnel* receiving an *effective dose* in excess of 5 mSv per year, or one quarter of any of the relevant dose limits for the skin, extremities, or lens of the eye.

#### Individual dose limits

**3.4** The individual dose limits are prescribed by the *Radiation Protection Regulations 1982*. At the time of this Code going to print, new draft legislation for radiation protection in New Zealand has been prepared, and includes adoption of the dose limits in the 1990 recommendations of the ICRP (International Commission on Radiological Protection, 1991). These dose limits have been adopted in this Code. Doses received as a patient from chiropractic diagnostic uses of radiation are exempted from these dose limits. The dose limits are:

### **3.5 Radiation personnel**

- (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<sup>2</sup>) averaged over 1 cm<sup>2</sup>, 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.

### **3.6 Non-radiation personnel and members of the public**

- (a) An *effective dose* of 1 mSv in any one year.
- (b) An *equivalent dose* to the skin of 50 mSv over any 1 cm<sup>2</sup>, regardless of the total area exposed, in any one year.
- (c) An *equivalent dose* of 15 mSv to the lens of either eye in any one year.

## **Protection of non-radiation personnel and members of the public**

**3.7** *Non-radiation personnel* or members of the public **shall not** remain in the x-ray room during any x-ray procedure unless they are required to be in attendance.

**3.8** The occasional use of *non-radiation personnel* to give assistance is acceptable but **shall** involve the full use of protective materials and techniques to minimise personnel dose. Care **shall** be taken to ensure that the same *non-radiation personnel* are not always involved. Women who are pregnant **shall not** be used in this role (see also para 3.14).

## **Protection of radiation personnel**

**3.9** Only those persons required to assist, or being in the course of training, **shall** be present during the performance of x-ray examinations.

**3.10** Movable or adjustable protective barriers and shielded doors **shall** be in their closed or protective positions during the x-ray examination.

## **Radiography**

**3.11** Means **shall** be provided to ensure that the dose rate at the x-ray controls **shall** be such that occupational doses are significantly below the dose limits for *radiation personnel* (see paras 3.2, 3.3, 3.4 and 3.5) . This will normally require a protective barrier at the x-ray controls (see para 6.2).

## **Fluoroscopy**

**3.12** Protection of radiation personnel in chiropractic fluoroscopy shall be according to the appropriate paragraphs (paras 3.13 to 3.19) of NRL C5.

## **Protection of persons holding patients or image receptors**

**3.13** No person **shall** hold a patient during exposures unless it is otherwise impossible to obtain a diagnostically useful image and not merely that it is a matter of convenience. No person **shall** hold an x-ray film cassette, or other imaging equipment or x-ray tube head in position during exposures.

**3.14** Holding of patients during exposures **shall** be done by persons accompanying the patient in preference to *non-radiation personnel* or *radiation personnel*. No pregnant women or young persons (under the age of 18) **shall** do any holding.

**3.15** Any persons holding patients during an x-ray examination **shall** wear a leaded apron and wherever practicable, leaded gloves. No part of the holder's body **shall** be in the primary beam, even if covered with protective clothing.

## Personnel monitoring

**3.16** Personnel that are required to work with fluoroscopic equipment **shall** be continuously monitored.

**3.17** Personnel that are required to work with radiographic equipment only would not normally require continuous monitoring, but guidance **should** be sought from the National Radiation Laboratory.

**3.18** Any such individual monitoring **shall** be provided by a personal monitoring service\* authorised by the *Director-General*.

**3.19** For persons performing radiography only (where a leaded apron is not or is only occasionally worn), or performing both fluoroscopy and radiography duties, the normal wearing position **shall** be on the trunk somewhere between waist level and chest level. For the times when an apron is being worn, the dosimeter **shall** be under the apron.

**3.20** In situations where a leaded apron is always worn, the dosimeter **shall** be worn outside the apron at collar level as a means of assessing doses to the eyes – the likely "critical organ". The personal monitoring service **shall** be notified of the wearing position.

**3.21** It may be preferable in some situations where scattered radiation levels are high and workloads are high, to wear two dosimeters – one under the apron and the other outside the apron. Guidance from the Director, National Radiation Laboratory, **shall** be sought in these situations. Such situations are unlikely to occur in chiropractic diagnosis.

---

\* Details on the NRL personal monitoring service are given in a booklet: Radiation monitoring film service. Christchurch : National Radiation Laboratory, 1996.

## 4 PROTECTION OF THE PATIENT

### Justification of a practice

**4.1** The *justification* of the use of x-rays for chiropractic diagnosis **shall** take into account the merits of other available ways of acquiring the required information, and the risks entailed in the administration of radiation. Guidance in the medical uses of x-rays is given in the *WHO technical report series 795* (World Health Organization, 1990).

**4.2** An x-ray projection **shall not** be performed unless there are valid clinical indications for that patient. Guidelines for medical radiology and which may be helpful are given in *WHO technical report series 689 and 757* (World Health Organization, 1983, 1987), *ICRP publication 34* (International Commission on Radiological Protection, 1982b), *Documents of the NRPB 1(3)* (National Radiological Protection Board, 1990) and in *Making the best use of a department of radiology : guidelines for doctors* (Royal College of Radiologists, 1993).

**4.3** Examinations on children **shall** require a higher level of *justification*, since such patients are at greater risk from radiation than are adults.

**4.4** Previous x-ray images **shall** be readily available across facilities, both chiropractic and non-chiropractic, to minimise the taking of repeat films.

**4.5** Screening programmes of asymptomatic persons which involve the use of x-rays **shall not** be instituted unless there is proven evidence based on sound epidemiological study that the programme is of net benefit to the screened population.

### Optimisation of protection

**4.6** Once radiodiagnosis is chosen as being appropriate, the particular mode of x-ray imaging, the form of the examination, the area to be radiographed, and the technical factors used, **shall** be optimised. This means obtaining the required diagnostic information for a minimum of radiation dose to the patient.

**4.7** The chiropractor **shall not** have a routine set of radiographic views to be applied to all patients regardless of symptoms or clinical findings. The x-rays **should** be limited to those parts of the body where the problem is thought to lie, and to those parts that the chiropractor expects to manipulate. Radiography of other parts of the body **shall** be limited to situations where the chiropractor's training and experience indicates that useful information is likely to be gained from that area. Where possible, the radiographs from the more restricted area of the body **shall** be examined before the extended radiography is performed.

**4.8** Licensees **shall** be aware of the approximate patient doses associated with x-ray examinations as performed in their x-ray facilities (see also paras 4.11 and 4.18).

**4.9** Examinations with the potential for high patient doses, such as CT examinations and examinations involving contrast media, **shall not** be permitted for chiropractic diagnosis. However, images from previously performed medical CT or other high dose examinations can be used, if appropriate, for chiropractic purposes.

**4.10** The need for repeating an x-ray examination due to incorrect patient positioning or equipment malfunction **shall** be minimised by:

- (a) ensuring all *radiation personnel* are appropriately qualified for their work, and undertake additional training as necessary;
- (b) ensuring all x-ray equipment complies at all times with the requirements of this Code (and specified requirements of NRL C5, as appropriate);
- (c) ensuring all ancillary equipment and facilities (such as x-ray cassettes and intensifying screens, x-ray film processor and darkroom, and grids) that can influence the successful outcome of an examination are part of a quality assurance programme.

**4.11** The licensee in all x-ray facilities **shall** institute, with respect to radiation protection, a quality assurance programme appropriate to the type of x-ray facility to ensure the provision of a high quality service for minimum radiation detriment (see Chapter 7). The quality assurance programme **shall** include periodic assessment of patient doses and these values **shall** be compared with the *reference doses* given in this Code.

## Radiography

**4.12** Values for those radiographic technique factors that can influence patient dose for a given exposure **shall** be chosen to result in the required diagnostic image quality for the minimum of radiation dose to the patient. In particular:

- (a) The x-ray beam **shall** be collimated strictly to the region of clinical interest and in any case **shall not** exceed the effective cross-section of the cassette or image receptor.
- (b) While the incident primary beam **shall** comply with para 5.6, additional base filtration will result in lower patient dose and **should** be used where practicable.
- (c) The highest kilovoltage compatible with the image quality requirements of the examination **shall** be selected for each projection.
- (d) The fastest film-screen combination compatible with the image quality requirements of the examination **shall** be selected for each projection.
- (e) The longest focus-to-film distance practicable within the limitations of the x-ray equipment and the x-ray room **shall** be used for each projection (see also para 5.16).
- (f) Antiscatter grids **shall** be used except for radiography of the extremities.
- (g) Film processing systems **shall** be monitored as part of the quality assurance programme to ensure optimum performance, and in particular to avoid under-processing (see para 7.3).
- (h) Where the gonads lie in or very close to the primary beam, and where collimation cannot be used to avoid their irradiation, the gonads **shall** be shielded unless such shielding would obscure structures whose visualisation is relevant to the examination.

- (i) In chiropractic radiography gonad shields can almost always be used. Shields cut to appropriate shapes and placed on or close to the patient are preferred to the so-called "shadow-shields" placed on the light beam diaphragm. The shields **shall** have a lead or copper equivalence as specified in the section on reference doses (para 4.21). Shielding **shall not** be used as an attempt to remedy inadequate collimation.
- (j) With digital radiography, because there is no equivalent to film blackening acting as an upper bound to the radiation exposure, special care **shall** be taken to ensure that settings are used that result in the required diagnostic image quality for the minimum radiation dose to the patient. Typically this process will be limited by quantum mottle considerations.

**4.13** The number of films or projections comprising a radiography examination **shall** be the minimum necessary to provide the required diagnostic information (see para 4.7).

**4.14** The *operator* **shall** observe the patient during the exposure, but in addition **shall** confirm that the exposure terminated properly.

### **Fluoroscopy**

**4.15** Fluoroscopy **shall** be performed according to para 4.15 of NRL C5.

### **Cinefluorography**

**4.16** Cinefluorography **shall not** be performed for chiropractic diagnosis.

### **Computed tomography**

**4.17** Computed tomography **shall not** be performed for chiropractic diagnosis.

## Reference doses

**4.18** While the *International Commission on Radiological Protection* excludes exposures of chiropractic patients from the system of dose *limitations*, it does recommend the introduction of investigation levels for application in common diagnostic x-ray procedures. The term *reference dose* is used in this Code for the dose that under normal circumstances **should not** be exceeded in performing an x-ray examination or projection for an average patient (which in this Code is taken to be 70 kg). The primary quantity for the *reference dose* is *effective dose* (see Annex 1). *Entrance surface dose* (including backscatter) is not used for chiropractic examinations, as the common use of beam-shaping filters means that this parameter can vary significantly over the x-ray field. The values for the *reference doses* have been derived from surveys of clinical practice in New Zealand and are linked to accepted chiropractic radiographic practice (see Annex 2). Doses typically used at a chiropractic x-ray facility **shall** be compared with the *reference doses* and appropriate measures taken to reduce average doses to below the *reference dose* levels.

## Reference filtration, diaphragms and shields

**4.19** Similarly, values of *reference filtration, diaphragms and shields* have been derived from surveys of clinical practice in New Zealand and are linked to accepted chiropractic radiographic practice and image quality (see Annex 2). Beam-shaping filters and diaphragms typically used at a chiropractic x-ray facility **shall** be compared with the *reference filtration, diaphragms and shields* values and if necessary changed to comply with these levels.

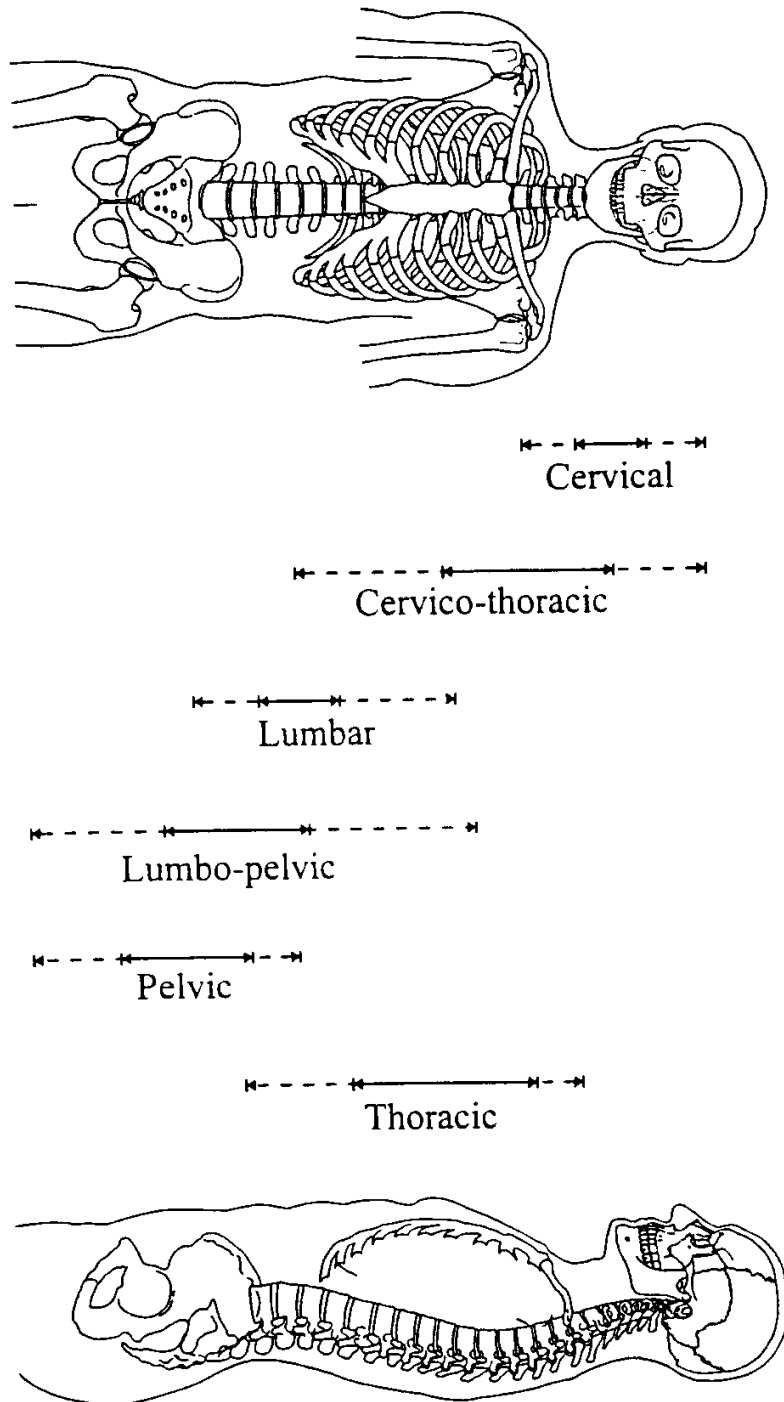
## Standard projections

**4.20** As various projections are given differing names by different chiropractors, it is necessary to group the projections on the basis of the position of the upper and lower limits of the x-ray field, specified in terms of distance from the top of the patient's head. This grouping is necessarily somewhat arbitrary, and some projections used by chiropractors may not fall within the limits.

## Upper and lower limits of standard projections

<b>Projection</b>	<b>Range of upper limit of x-ray field, in cm below top of patient</b>	<b>Range of lower limit of x-ray field, in cm below top of patient</b>
Full Spine	less than 22	greater than 90
Cervical	less than 14	22-32
Cervico-thoracic	less than 18	42-62
Thoracic	26-34	56-70
Lumbar	42-58	68-78
Lumbo-pelvic	40-62	greater than 82
Pelvic	6-70	greater than 90

**Figure 1. Range of field size limits**



**4.21** Based on current technology and chiropractic x-ray practice the following values of *reference dose* and *reference filtration, diaphragms and shields* have been adopted. Other or additional values may be issued by NRL from time to time as required.

### **Reference doses and reference filtration, diaphragms and shields for common radiographic projections**

#### **Cervical spine                      AP Projection**

*Reference dose:*                      0.05 mSv

*Reference filtration,  
diaphragms & shields:*      Nil

#### **Cervical spine                      Lat Projection**

*Reference dose:*                      0.01 mSv

*Reference filtration,  
diaphragms & shields:*      Nil

#### **Cervico-thoracic                  AP Projection**

*Reference dose:*                      0.1 mSv

*Reference filtration,  
diaphragms & shields:*      The x-ray field shall either be coned with the light beam diaphragm so that its maximum width on the film is 14 cm, or additional spinal diaphragms shall be used. These diaphragms shall be of at least 1.2 mm Cu equivalence, and reduce the central x-ray beam to no greater than 14 cm on the film.

A filter at least 6 mm Al thick, and stepped, bevelled, or wedge-shaped, shall be placed over the neck region.

**Lumbar****Lat Projection**

*Reference dose:* 0.1 mSv

*Reference filtration, diaphragms & shields:* The light beam diaphragm or additional diaphragms must be used to ensure that the gonads are not in the primary x-ray beam.

**Lumbo-pelvic****AP Projection**

*Reference dose:* 0.4 mSv

*Reference filtration, diaphragms & shields:* Gonad shields must be used. The female shield is to be heart or oval shaped, and at least 0.3 mm Cu equivalent. The dimensions of its image on the film are to be at least 14 cm wide by 11 cm high. The male shield is to be of at least 1 mm Pb equivalence, and placed over the male gonads.

**Lumbo-pelvic****Lat Projection**

*Reference dose:* 0.2 mSv

*Reference filtration, diaphragms & shields:* Gonad shields must be used if the gonads are not collimated out of the primary x-ray beam. The female shield is to be of at least 1.0 mm Pb equivalence, and placed to block out the area anterior to the sacrum. The male shield is to be of at least 1.0 mm Pb equivalence, placed to cover the area of the male gonads.

## **Full spine**

## **AP Projection**

*Reference dose:*

0.4 mSv

*Reference filtration,  
diaphragms & shields:*

Gonad shields must be used. The female shield is to be heart or oval shaped, and at least 0.3 mm Cu equivalent. The dimensions of its image on the film are to be at least 14 cm wide by 11 cm high. The male shield is to be of at least 1 mm Pb equivalence, and placed over the male gonads. Blocking diaphragms of at least 1.2 mm Cu equivalence are required to narrow the central x-ray field above the iliac crest to no more than 14 cm on the field. A filter at least 6 mm Al thick, and stepped, bevelled, or wedge-shaped, is to be placed over the neck region.

## **Exposure of women of reproductive capacity**

**4.22** Diagnostic x-ray procedures involving the exposure of the abdomen of women likely to be pregnant **shall** be avoided unless there are strong clinical indications for the examination.

**4.23** It **should** be assumed that a woman is pregnant if she has clearly missed her most recent expected menstruation or is overdue, and there is no other relevant information.

**4.24** In order to minimise the possibility of unintentional exposure of the embryo/foetus there **shall** be notices posted at several places within the chiropractic facility (including in the dressing cubicles) with wording similar to, or having the same meaning as, the following:

If you think you might be pregnant notify the chiropractor or assistant **before** your x-ray examination.

**4.25** Upon being so informed by a patient, the chiropractor **shall** decide whether the examination is to proceed, be performed in a modified form or be postponed for further consideration.

## Protection of the embryo/foetus

**4.26** X-ray examinations performed during the course of pregnancy **shall** involve the minimum radiation dose to the foetus consistent with obtaining images of the required diagnostic quality.

**4.27** Low dose techniques **shall** always be used.

**4.28** For examinations where the primary beam unavoidably irradiates the foetus, the methods of minimising dose (paras 4.12 - 4.15) **shall** be used as appropriate, and particular attention **shall** be given to:

- minimising the number of views
- strict beam collimation
- using higher kVps
- using fast image recording media (eg, rare earth screens)
- maximum total filtration in the useful beam; employing appropriate beam-shaping filtration and diaphragms.
- where practicable using PA projections in preference to AP projections; or where it is more desirable to perform the examination AP, then at least a wide (450 mm) compression band **should** be used.

**4.29** X-ray examinations performed during the course of pregnancy and not involving the abdominal or pelvic regions **shall** keep the primary x-ray beam collimated strictly to the region of interest, and hence avoid inadvertent primary beam irradiation of the foetus. Where the primary beam angulation is such that it may incidentally irradiate the abdominal region, that region **should** be shielded with an apron or similar, with a lead equivalence of not less than 0.5 mm.

**4.30** Where the embryo/foetus has been irradiated in the course of an x-ray examination of the mother, and the dose to the foetus may exceed 5 mSv, a *qualified health physicist* **shall** estimate the doses involved and **shall** advise on the ensuing radiation risks.

## Protection of paediatric patients

**4.31** Chiropractic examinations of young patients are expected to be infrequent. The following requirements apply, and guidance is given, where such examinations are conducted. The longer life expectancy of children results in greater potential for the manifestation of possible harmful effects of radiation. In addition children may be more radiosensitive than adults. Moreover, infants and smaller children are likely to be less co-operative than adults, breathe faster than adults and will often not stay still for the examination, thus increasing the chances of retakes. For these reasons particular attention **shall** be given in paediatric x-ray examinations to the selection of procedure, equipment, techniques, and patient management. In addition to the requirements made in this Code for patients in general, the following requirements for paediatric x-ray examinations **shall** be observed.

### 4.32 Procedures

- (a) For a given procedure each view **shall** be examined, where practicable, before deciding whether to take a further view.
- (b) Fluoroscopy of paediatric patients **shall** be limited to those circumstances where the fluoroscopy replaces radiographs that would otherwise be taken, and where it may be reasonably assumed that the radiation dose from the fluoroscopy will be less than the radiation dose from the replaced radiographs.
- (c) For girls who have reached puberty, the requirements and recommendations in this Code for x-ray examinations of women of reproductive capacity **shall** apply (paras 4.22 - 4.25).
- (d) There **shall** be strong *justification* for all x-ray procedures.

### 4.33 Equipment

- (a) The shortest practicable exposure time **shall** be used in paediatric radiography.

- (b) The x-ray generator **shall** have sufficient power and the x-ray tube sufficient rating, to allow the selection of high mA values (at least 200 mA), and hence short exposure times.
- (c) Where a choice of generator exists, the one with the highest power rating **shall** be used.
- (d) Automatic exposure control (AEC) devices, if available, **shall** have a fast response time ( $\leq 10$  ms) because of the short exposure times used. The AEC detectors **shall** be of appropriate size and arranged in a suitable configuration for paediatric patients.

#### 4.34 Techniques

- (a) The x-ray beam **shall** be collimated strictly to the region of clinical interest, bearing in mind that the area of the body examined in infants can often be smaller than the available film, and that inadvertent whole body irradiation must be avoided.
- (b) Clothing, gowns, bandages and nappies may produce artefacts on the film, especially with young children. In young children, all clothing **should** be removed from the body part to be examined whenever possible.
- (c) The x-ray beam **shall** be collimated to exclude the gonads whenever practicable. When the gonads are in the primary beam, gonad shielding **shall** be used whenever its use will not obscure regions of clinical interest. Care **shall** be exercised in examinations of the hand/arm, with the child seated at a table, to ensure that the child is so positioned that the gonads are not inadvertently exposed to the primary beam.
- (d) In general, the highest kVp **shall** be used that is consistent with the required image quality.
- (e) The examination **should** be performed without a grid for small infants since the very small amount of scatter does not necessitate their use. Not using a grid will lead to substantially lower doses.

- (f) Materials with low radiation absorption, such as carbon fibre materials, **should** be used in cassette fronts, and table tops.

#### **4.35 Patient management**

- (a) Devices for immobilisation **shall** be used for small infants whenever practicable, since limiting the motion of the child not only decreases the likelihood of retakes but also permits the use of stricter collimation.
- (b) In very young children immobilisation methods may not be successful and hence attempts **shall** be made by the chiropractor and other persons involved in the procedure to establish rapport with the child before an examination is attempted. Although time consuming, such rapport is worthwhile both in decreasing radiation dose and producing a successful examination.
- (c) Where persons are required to hold the child in position during an x-ray examination (see para 3.14), they **shall** be provided with and required to use adequate protective garments: apron and gloves.

### **Records**

**4.36** Every x-ray exposure of a patient **shall** be recorded on his/her medical record, and **should** be recorded also on an independent record of the facility's x-ray procedures.

**4.37** Each record **should** include date, patient identification, sex, date of birth or age, whether pregnant and the type of x-ray procedure. In addition it would be preferable if additional information that would allow retrospective estimation of patient doses were recorded. Such additional data would be kVp, mAs and FFD for x-ray projections, and screening time and number of films for fluoroscopic procedures.

## **Research on humans**

### **General principles**

**4.38** It is expected that in the course of the practice of chiropractic diagnosis new procedures will be tried in the realistic belief that the treatment of the patient will be improved as a result. This is covered by the licence for the purpose Chiropractic Diagnosis, and the practice is constrained by the principles of radiation protection given elsewhere in this Code. For the purpose of this Code, a procedure is only classified as Research on Humans if the subject receives insufficient personal benefit from it to justify its use purely for patient management. This definition includes the use in clinical trials of diagnostic procedures which the patient would not have needed for normal management.

**4.39** All Research **shall** be carried out according to the requirements laid down in paras 4.40 to 4.54 of NRL C5.

## 5 X-RAY EQUIPMENT

### Appropriate x-ray equipment

**5.1** The x-ray machine and ancillary apparatus **shall** be that most appropriate for the x-ray examination.

**5.2** X-ray machines and ancillary equipment **shall** be capable of the performance specified in Annex 2 as good practice for relevant techniques.

**5.3** X-ray machines for chiropractic radiography **shall** be capable of operating at tube currents of at least 100 mA at 100 kVp.

**5.4** Capacitor discharge x-ray machines **shall not** be used.

**5.5** No x-ray equipment **shall** be used where the x-ray output is so low that multiple exposures are required in an attempt to obtain the required diagnostic information.

### X-ray machine requirements

#### Filtration

**5.6** The total base filtration in the incident primary x-ray beam for all x-ray procedures **shall not** be less than 2.5 mm aluminium equivalence. (See also para 4.12(b) on the use of additional filtration.)

**5.7** Any plain filters which may be added as required to the primary x-ray beam in addition to the minimum amount of 2.5 mm aluminium **should** where practicable be permanently labelled in such a manner that the labels may be read when the filter is in the primary x-ray beam. The labels **shall** state the material of which the filter is composed and its thickness.

**5.8** Rare-earth or other special filters may be used in some circumstances. These **should** be approved by a *qualified health physicist*.

## **Leakage radiation**

**5.9** Every x-ray tube used for chiropractic diagnostic purposes **shall** be enclosed in a housing such that the dose to air from the leakage radiation at a distance of 1 m from the focus **shall not** exceed 1 mGy, and **should not** exceed 100  $\mu$ Gy, in an hour at every rating specified by the manufacturer for that tube in that housing. Diaphragms, cones and other collimating devices **shall** be so constructed that, in combination with the x-ray tube housing, the whole assembly (ie, the x-ray tube assembly) conforms with this criterion.

**5.10** Compliance **shall** be determined by measurements averaged over an area of 100 cm<sup>2</sup> with no linear dimension greater than 20 cm. The significance of narrow leakage beams **shall**, however, be investigated.

## **Radiography**

### **X-ray beam limitation**

**5.11** A device **shall** be installed on the x-ray tube assembly so that the primary beam may be collimated to the desired cross-section.

**5.12** The x-ray cassette **shall** completely intercept the primary beam.

**5.13** A light beam diaphragm **shall** be used wherever it is practicable. A fixed or adjustable diaphragm may be used in some circumstances – approval **shall** be obtained from the Director NRL.

### **Light beam diaphragms**

**5.14** Light beam diaphragms (LBDs) **shall** have the following features:

- (a) **Accuracy:** The misalignment of each edge of the visually defined light field with the respective edge of the x-ray field **should not** exceed 1%, and **shall not** exceed 1.5%, of the distance from the focus to the centre of the visually defined field when the surface on which it appears is perpendicular to the central axis of the useful x-ray beam.
- (b) **Delineation:** The visually defined field (light field) **should** contain cross wires or other acceptable mode of indicating the centre of the x-ray

beam. The centre of the x-ray beam and indicated centre of the light beam **should** coincide to an accuracy of within 1% and **shall** coincide to an accuracy of within 1.5% of the distance from the focus to the point on the illuminated surface at which it appears.

- (c) **Illumination:** The brightness of the light field **shall** be sufficiently great that the light field is clearly visible in ambient illumination. The outer edges of the light field **shall** be clearly shown and sharply defined.

### **Fixed or adjustable diaphragms**

**5.15** Fixed or adjustable diaphragms **shall** have the following features:

- (a) The device **shall** provide an x-ray beam of a cross-section smaller than or congruent with that of the x-ray film being used.
- (b) There **shall** be affixed to the collimating device a notice stating the x-ray beam dimensions at each focus-film distance for which it is used.
- (c) There **should** be some indicator of the central axis of the x-ray beam.
- (d) The misalignment of the edges of the x-ray field with the image receptor **shall not** exceed two percent of the distance from the focus to the image receptor.

### **Focus-skin and focus-film distance**

**5.16** For x-ray projections other than extremity radiography the standard focus-film distance (FFD) **shall not** be less than 1 metre. In general FFDs **should** meet the criteria given in the examples of good radiographic technique in Annex 2. For extremity radiography the focus-skin distance (FSD) **shall not** be less than 500 mm.

**5.17** Means **shall** be provided to indicate distances from the focus to the film. The FFD so indicated **shall** be accurate to  $\pm 10$  mm.

## **X-ray exposure device**

**5.18** A device **shall** be incorporated in the x-ray equipment to terminate radiographic exposures after the elapse of a pre-set time (timer), pre-set exposure to an imaging device (automatic exposure control), or pre-set mAs.

**5.19** It **shall not** be possible to make repeat exposures without release of the exposure-initiating control.

**5.20** It **shall not** be possible to make exposures when the exposure device is set to zero, "0", or "off", or equivalent positions if these are provided.

**5.21** To prevent accidental exposures, operation of the exposure device **shall** require continuous firm pressure on the exposure control throughout the exposure. Premature release of this pressure **shall** cause the x-ray exposure to terminate immediately.

**5.22** The exposure device **shall** determine the exposure accurately and reproducibly. (See para 5.23 for x-ray timers, and paras 5.27 and 5.28 for automatic exposure control devices.)

**5.23** Where the exposure device determines the exposure time, the actual time **should not** differ from the set time by more than 10% when the set time is 0.2 seconds or greater; and successive exposures **shall not** differ by more than 10% (see also para 5.45).

**5.24** A timer **shall** be capable of short exposure times. Single phase x-ray machines **shall** be capable of exposure times of 20 milliseconds, and multi-phase x-ray machines **shall** be capable of exposure times of less than 20 milliseconds.

## **Automatic exposure control (AEC) device**

**5.25** The minimum response time of the AEC device with the appropriate chamber selected for the x-ray projection **shall** be less than 20 milliseconds for single phase x-ray machines, and less than 10 milliseconds for multi-phase, medium and high frequency x-ray machines.

**5.26** A device **shall** be installed which can be set to terminate the exposure after a time no greater than 6 seconds, or after an exposure of no more than 600 mAs, whichever is the lesser.

**5.27** The AEC device **shall** so control exposures that films are produced whose optical density varies by less than  $\pm 20\%$  when the patient thickness, kVp, mA station, and field size, are varied over their normal clinical ranges for which the x-ray machine is used.

**5.28** The AEC device during a series of exposures made at the same settings and with the same absorber in the primary beam **shall** so control exposures that either the variation in film optical density is no more than  $\pm 0.1$  at a density around 1.2, or the variation in radiation output measured after the absorber is no more than  $\pm 5\%$ .

### **Fluoroscopy**

**5.29** Fluoroscopy equipment shall conform with paras 5.32 to 5.54 of NRL C5.

**5.30** Mobile image intensifiers **shall not** be used.

### **Radiation from components other than the x-ray tube assembly**

**5.31** The radiation emitted from any component other than the x-ray tube assembly and which is an integral part of the x-ray machine **shall not** exceed a dose rate of 2.5  $\mu\text{Gy}$  per hour at any accessible position.

### **Warning lights at the x-ray controls**

**5.32** There **shall** be a prominent light on the x-ray control panel which is illuminated when the x-ray machine is switched on to the electrical mains. Alternatively the meters, indicators, etc, of the x-ray control panel may generally become illuminated when the electrical mains are switched on to the x-ray machine.

**5.33** There **should** be a prominent light on the x-ray control panel which is illuminated when the x-ray exposure is in "preparation" mode and another which **shall** be illuminated during the period when x-rays are being produced.

**5.34** Where there is more than one x-ray tube connected to the generator the tube selector switch at the x-ray control panel **shall** be clearly and unambiguously labelled and the x-ray tube presently connected **shall** be indicated by an illuminated sign close to the selector switch or by other clear and unmistakable means.

### **Warning lights at the x-ray tube**

**5.35** When more than one patient may be examined at the same time in the same room or in adjacent rooms using more than one x-ray tube connected to the same generator, and where any patient at each tube will not be in clear view of any operator, each tube **shall** have a prominent warning light which becomes illuminated when that tube is connected to the generator. The light **shall** indicate that an exposure is likely to be made, or is being made. The warning light **should** be red.

### **X-ray tube assemblies**

**5.36** New x-ray tube assemblies **should** bear the following markings on the outer side of the tube housing in a visible position:

- (a) Name or trademark of the supplier and the assembler.
- (b) Type number and serial number of x-ray tube insert.
- (c) Maximum potential difference of x-ray tube assembly.
- (d) Nominal value of the inherent filtration and added filtration of the original tube assembly expressed in thickness of aluminium equivalence.
- (e) Size of nominal focal spot(s).
- (f) Position of focal spot(s).

### **Exceptions:**

- (a) For a double focus x-ray tube, a single indication of mean position of the focal spots is permissible.
- (b) Where the type number or the serial number of the tube assembly incorporates in a clear manner any part of the information required in items (c), (d), or (e) above, it is not necessary for this information to be repeated separately on the tube assembly.

## **Darkroom**

**5.37** Darkroom fog **shall** be minimised. In particular, the density increase of the mid-density portion of the film (OD = 1.2 to 1.6) **shall not** be greater than 0.05, for the fastest film used in the facility, after an exposure on the workbench to the safelights of 1 minute duration.

## **Efficient performance of x-ray machines**

**5.38** X-ray equipment **shall** perform properly and consistently.

**5.39** X-ray equipment **should** be maintained in radiographic calibration such that examinations performed on one machine are capable of reproduction on another of similar characteristics, at the same or closely similar settings.

**5.40** Any assessments of the performance of x-ray machines in respect of efficient performance **should** be made with the x-ray machine connected to an electrical power supply as specified by the manufacturer for that machine. Electrical line volts, during the assessment tests, **shall** be properly adjusted to the indicated value where such adjustment is available to the operator.

**5.41** Any set of measurements assessing one of the factors below **should** be made within one hour. Measurements **shall** be made at least at those kV, mA, mAs, and time settings likely to be used on that machine.

## Reproducibility of x-ray output

**5.42** The x-ray output, as assessed by the coefficient of variation of a series of not less than 5 consecutive exposures at the same settings, **shall** be reproducible. The coefficient of variation of the x-ray output **shall not** exceed 0.10 and **should not** exceed 0.05. Between each exposure the x-ray machine settings **should** be shifted significantly away from, and then returned to, those being used.

## Linearity of x-ray output

**5.43** Where a choice of x-ray tube current settings is available the linearity of the output of the x-ray machine with nominal x-ray tube current **shall** be assessed in terms of the following relationship between any pair of x-ray tube current settings where the larger mA setting is no more than 4 times the smaller mA setting.

If  $X_1$  = the average x-ray output expressed in terms of dose to air per mAs at mA setting 1, and

$X_2$  = the average x-ray output expressed in terms of dose to air per mAs at mA setting 2, then

$$\frac{|X_1 - X_2|}{X_1 + X_2}$$

**shall not** exceed 0.1.

**5.44** Where a choice of mAs settings is available the linearity of the output of the x-ray machine **shall** be assessed in terms of the following relationship between two mAs settings that do not differ by more than a factor of 4.

If  $X_1$  = the average x-ray output expressed in terms of dose to air per mAs at mAs setting 1, and

$X_2$  = the average x-ray output expressed in terms of dose to air per mAs at mAs setting 2, then

$$\frac{|X_1 - X_2|}{X_1 + X_2}$$

**shall not** exceed 0.1.

**5.45** Where a choice of time settings is available the linearity of the output of the x-ray machine **shall** be assessed in terms of the following relationship between two exposure time settings that do not differ by more than a factor of 4.

If  $X_1$  = the average x-ray output expressed in terms of dose to air per mAs at time setting 1, and

$X_2$  = the average x-ray output expressed in terms of dose to air per mAs at time setting 2, then

$$\frac{|X_1 - X_2|}{X_1 + X_2}$$

**shall not** exceed 0.1.

### **Accuracy of kilovoltage settings**

**5.46** The deviations, whether positive or negative, of actual peak kilovoltages from indicated or pre-set peak kilovoltage settings during exposure **shall not** exceed 5% of the indicated or pre-set value over the range of kV, time, current, and mAs settings for which the x-ray machine is normally used.

## 6 X-RAY ROOMS AND AUXILIARY PROTECTION REQUIREMENTS

### Introduction

**6.1** The walls, floors, ceilings and other material constructions of the x-ray room **shall** have a protective value such that the radiation transmitted through them will not lead to exposures of persons to levels in excess of the requirements for *non-radiation personnel* and members of the public (see para 3.6). In recognition that it should not be assumed that proximity to an x-ray facility is going to be the only source of radiation exposure to a member of the public, the levels of radiation in areas of public access outside x-ray rooms **should not** lead to doses in excess of 0.3 mSv to any member of the public in any one year.

**6.2** The operator position at the x-ray controls **shall** be so shielded and located that the radiation levels there are as low as is reasonably achievable, social and economic considerations being taken into account, and in any case these levels **shall not** lead to exposures of persons to levels in excess of the requirements for *radiation personnel* (see para 3.5).

**6.3** If a mobile x-ray machine is used then the room **shall** still be shielded according to paras 6.1 and 6.2 above.

**6.4** Wherever practicable the protective barrier and x-ray controls **shall** be located so that they are not exposed to the primary x-ray beam for any of its normal orientations. If the barrier or controls are exposed to the primary beam then the shielding **shall** be individually specified by a *qualified health physicist*.

### Standard barriers

#### Primary x-ray barriers

**6.5** All *primary barriers* in standard chiropractic x-ray facilities **shall** have a lead equivalence of 2.0 mm with an allowable tolerance of  $\pm 10\%$ .

**6.6** The *primary barrier* **shall** extend at least 300 mm beyond each boundary of the area normally exposed to the primary x-ray beam.

**6.7** The lead equivalence stated **shall** be applicable for all the kilovoltages applied to the x-ray tube or tubes in the x-ray room. The shielding **shall** be uniform throughout the barrier and be effective over all openings and penetrations in the barrier.

### **Secondary x-ray barriers**

**6.8** All *secondary barriers* in standard chiropractic x-ray facilities **shall** have a lead equivalence of 1.0 mm with an allowable tolerance of  $\pm 10\%$ .

**6.9** The lead equivalence stated **shall** be applicable for all the kilovoltages applied to the x-ray tube or tubes in the x-ray room. The shielding **shall** be uniform throughout the barrier and be effective over all openings and penetrations in the barrier.

### **Standard x-ray room shieldings**

**6.10** All x-ray rooms **should** have affixed to a wall at a position close to the x-ray controls, a permanent dated notice stating the nature and lead equivalence of any shielding materials in or on the walls or constructions, including the protective barrier at the controls and its window.

**6.11** An x-ray room **shall** be deemed to comply with the requirements of paras 6.1 and 6.2 if the shielding between the x-ray room and any other occupiable space complies with the following:

- (a) Walls, ceilings and floors **shall** satisfy the requirements for a *secondary barrier*, and any wall, ceiling or floor or part of these to which the primary x-ray beam is usually directed **shall** satisfy the requirements for a *primary barrier*. Operator barriers internal to the x-ray room **shall** satisfy the requirements for a *secondary barrier* (see also para 6.2 above).
- (b) When a wall or other construction is common between two adjoining x-ray rooms:
  - (i) It **shall** meet the requirements of a *secondary barrier*.

- (ii) Such areas of the wall as are required to be *primary barriers* in either room **shall** be so shielded in each room.
- (c) A *secondary barrier* **shall** be constructed at the controls of every x-ray machine to protect the operator. Means **shall** be provided for viewing the patient from the x-ray machine controls. Any viewing window in this barrier **shall** be of the same lead equivalence as the barrier.

**6.12 Exception:** In some conditions of low workload or where the operator's position and other occupied positions are distant from the x-ray machine, lesser amounts of shielding may be satisfactory. This is often the case in chiropractic radiography. In such cases advice **shall** be obtained from a *qualified health physicist* before the shielding requirements are relaxed.

6.13 Advice **shall** be obtained from a *qualified health physicist* before plain glass of a lead equivalence less than 1 mm is used for a viewing window.

## **Barrier materials**

### **Primary barriers**

**6.14** An acceptable *primary barrier* may be one of the following:

- (a) Lead sheet of nominal total thickness 2 mm. The lead sheet may be used as such, sandwiched between two layers of plywood ("Plymax"), or bonded to decorative laminate board.
- (b) Double thickness of barium plasterboard (plasterboard incorporating barytes). Each thickness **shall** have a lead equivalence of 1 mm  $\pm$  0.1 mm at 100 kVp.
- (c) Concrete, solid concrete block or concrete block filled with grout or sand, and having a total thickness of not less than 150 mm.
- (d) Double thickness of standard solid building bricks, having a total thickness of not less than 150 mm.

- (e) Any other building material whose thickness used in the construction leads to a lead equivalence of  $2 \text{ mm} \pm 0.2 \text{ mm}$ .

### **Secondary barriers**

**6.15** An acceptable *secondary barrier* for chiropractic radiography or fluoroscopy may be one of the following:

- (a) Any *primary barrier*.
- (b) Lead sheet of thickness not less than 1 mm.
- (c) Barium plasterboard of 1 mm lead equivalence.
- (d) Any building material, such as brick or concrete whose use in construction leads to a thickness having a lead equivalence of  $1 \text{ mm} \pm 0.1 \text{ mm}$ .
- (e) Lead glass or lead acrylic of 1 mm lead equivalence.
- (f) Plain glass of 1 mm lead equivalence (typically a thickness of at least 100 mm of glass).

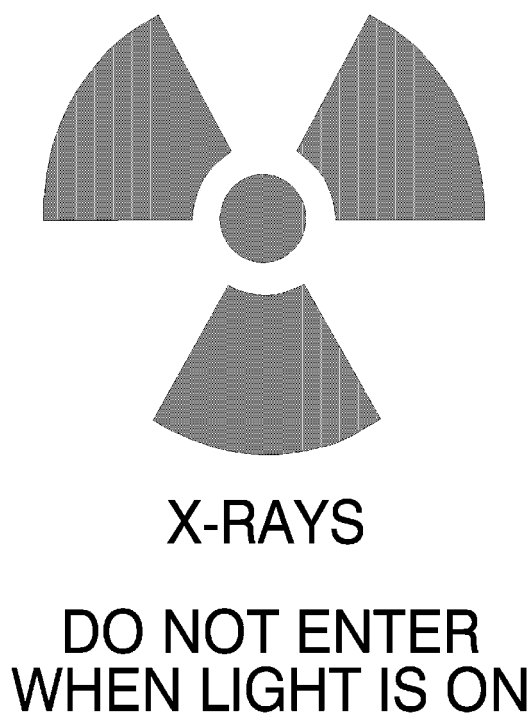
**6.16** Materials which offer a limited absorption of x-rays and are not to be regarded as shielding materials, include plaster boards based on calcium compounds, "gibraltar" board and similar boards based on calcium compounds and pumice, hardboards, decorative wallboards, laminated plastics boards, fibre-reinforced cement boards, timber linings. A *qualified health physicist* **shall** be consulted to establish the acceptability or not of non-standard building materials.

**6.17** For new or altered x-ray facilities, the licensee **shall** send to the National Radiation Laboratory a statement of the position and degree of shielding actually installed, and a copy of the *qualified health physicist's* report where this was done.

## Warning signs and lights at the entrances to x-ray rooms

**6.18** The entrance of the x-ray room **shall** be marked with a sign containing either a recognised symbol together with appropriate wording or appropriate wording to warn of the possibility of x-ray exposures. An acceptable example is given in Figure 6.1. All entrances to x-ray rooms **should** have a light that is illuminated when the x-ray machine is in the "preparation" mode or when fluoroscopy is in progress. The warning sign and warning light may be combined.

**Figure 6.1**



The colours of the "trefoil" sign may be black on a yellow ground or magenta on a yellow ground. The relative dimensions of wording and "trefoil" sign may be varied. The "trefoil" sign **should** have a diameter not less than 200 mm. The wording may be varied to suit each individual situation.

## **Protective equipment in x-ray rooms**

**6.19** If patients are required to be held then sufficient protective aprons and gloves **shall** be provided.

**6.20** The aprons and gloves **shall** be checked at least annually by the licensee for basic integrity of the radiation shielding.

**6.21** The apron and gloves **shall** be clearly labelled with their lead equivalence.

## 7 QUALITY ASSURANCE PROGRAMME

### General requirements

**7.1** The principal licensee for any facility that uses x-rays for chiropractic diagnosis or research on humans **shall** ensure that a suitable programme of quality assurance (with respect to radiation protection), is instituted and maintained (see para 4.11). This specific quality assurance programme is referred to as the *programme*, hereafter.

**7.2** The *programme* **shall** ensure as a primary goal, accurate and timely diagnosis. As secondary goals the *programme* **shall** ensure minimisation of radiation exposure and risk and of discomfort and cost to patient and community. These secondary goals **shall** always be balanced against the primary goal.

**7.3** The *programme* **shall** comprise such routine checks and procedures as are required to give reasonable confidence in the continuing compliance with this Code of Practice. The *programme* **shall** be approved by a *qualified health physicist*, to ensure that the quality control procedures are sufficient to ensure compliance with this Code. The *programme* **shall** include quality control of x-ray film processing facilities (manual or automatic). Note: A *programme* is not to be confused with a *radiation protection survey* (see paras 1.6 - 1.8 and Annex 1).

**7.5** Procedures **shall** be standardised and set down in protocols or local rules (a quality assurance manual) wherever possible.

**7.6** All equipment **shall** be checked at suitable regular intervals to ensure it is operating within suitable tolerances of accuracy and consistency. The tests performed and their frequency **shall** be approved by a *qualified health physicist*. All measurements and maintenance **shall** be recorded in an equipment log. As well as routine tests any faults or breakdowns **shall** be logged and reported to superiors where appropriate.

**7.7** Acceptance tests **shall** be performed on all new equipment to

(a) ensure that it meets the manufacturer's specifications;

- (b) ensure that it complies with this Code;
- (c) establish baseline data for subsequent quality assurance.

**7.8** Control charts **shall** be established for all parameters measured. Control limits **shall** be established for all parameters. If a measured value of any parameter exceeds a control limit, action **shall** be taken to correct the parameter.

**7.9** A retake analysis **shall** be performed at regular intervals to monitor the effectiveness of the *programme*.

**7.10** The frequency with which a particular parameter is tested **should** be determined by both the likelihood and the consequences of an error beyond the acceptable tolerances.

**7.11** The *programme* **should** conform to the procedures and tolerances given in *NCRP report 99* (National Council on Radiation Protection and Measurements, 1988) or *Assurance of quality in the diagnostic x-ray department*. Guidelines for quality assurance programmes in radiation protection have been issued by NRL for medical diagnostic x-ray facilities (Poletti J L, 1995, 1996a and b). The guidelines for small x-ray facilities (Poletti J L, 1996b) are applicable to most chiropractic x-ray facilities.

## REFERENCES AND BIBLIOGRAPHY

American National Standards Institute, 1982. American national standard method for the sensitometry of medical x-ray screen-film-processing systems. N.Y. : ANSI. *ANSI PH2.43-1982*.

*Assurance of quality in the diagnostic x-ray department* / prepared by the Quality Assurance Working Group of the Diagnostic Methods Committee of the British Institute of Radiology. London : British Institute of Radiology, 1988.

British Standards Institution, 1987. Medical electrical equipment. Part 2. Particular requirements for safety. Section 2.7. Specification for high-voltage generators of diagnostic x-ray generators. London : BSI. *BS 5724:section 2.7:1987*. (IEC 601-2-7:1987).

British Standards Institution, 1989. Medical electrical equipment. Part 2. Particular requirements for safety. Section 2.15. Specification for capacitor discharge x-ray generators. London : BSI. *BS 5724:section 2.15:1989*. (IEC 601-2-15:1988).

Cartwright P H, Stirling D G and Le Heron J C 1996. Patient doses in chiropractic radiography in New Zealand. Christchurch : National Radiation Laboratory. *Report NRL 1996/3*.

Criteria and methods for quality assurance in medical x-ray diagnosis : proceedings / edited by G. Drexler... et al. London : British Institute of Radiology, 1985. *British journal of radiology supplement 18*.

Health effects of exposure to low levels of ionizing radiation / Committee on the Biological Effects of Ionizing Radiations, Board on Radiation Effects Research, Commission on Life Sciences, National Research Council. Washington, D.C. : National Academy Press, 1990. *BEIR V*.

International Commission on Radiological Protection, 1982a. Protection against ionizing radiation from external sources used in medicine. Oxford : Pergamon Press for the ICRP. *Annals of the ICRP 9(1); ICRP publication 33*.

International Commission on Radiological Protection, 1982b. Protection of the patient in diagnostic radiology. Oxford : Pergamon Press for the ICRP. *Annals of the ICRP* 9(2/3); *ICRP publication* 34.

International Commission on Radiological Protection, 1987. Data for use in protection against external radiation. Oxford : Pergamon Press for the ICRP. *Annals of the ICRP* 17(2/3); *ICRP publication* 51.

International Commission on Radiological Protection, 1990. Radiological protection of the worker in medicine and dentistry. Oxford : Pergamon Press for the ICRP. *Annals of the ICRP* 20(3); *ICRP publication* 57.

International Commission on Radiological Protection, 1991. 1990 recommendations of the International Commission on Radiological Protection. Oxford : Pergamon Press for the ICRP. *Annals of the ICRP* 21(1-3); *ICRP publication* 60.

International Commission on Radiological Protection, 1993. Radiological protection in biomedical research. Oxford : Pergamon Press for the ICRP. *Annals of the ICRP* 22(3); *ICRP publication* 62.

International Electrotechnical Commission, 1993. Evaluation and routine testing in medical imaging departments – part 1 : general aspects. Geneva : IEC. *IEC 1223-1*.

International Electrotechnical Commission, 1993. Evaluation and routine testing in medical imaging departments – part 2-1 : constancy tests – film processors. Geneva : IEC. *IEC 1223-2-1*.

International Electrotechnical Commission, 1993. Evaluation and routine testing in medical imaging departments – part 2-2 : constancy tests – radiographic cassettes and film changers – film-screen contact and relative sensitivity of the screen-cassette assembly. Geneva : IEC. *IEC 1223-2-2*.

International Electrotechnical Commission, 1993. Evaluation and routine testing in medical imaging departments – part 2-3 : constancy tests – darkroom safelight conditions. Geneva : IEC. *IEC 1223-2-3*.

International Electrotechnical Commission, 1993. X-ray tube assemblies for medical diagnosis – characteristics of focal spots. Geneva : IEC. *IEC 336*.

Le Heron J C, 1990. Half value layer versus total filtration for general diagnostic x-ray beams. Christchurch : National Radiation Laboratory. *Report NRL 1990/5*.

*Making the best use of a department of radiology : guidelines for doctors / Royal College of Radiologists Working Party. London : RCR., 1989.*

National Council on Radiation Protection and Measurements, 1981. Radiation protection in pediatric radiology : recommendations. Washington, D.C. : NCRP. *NCRP report 68*.

National Council on Radiation Protection and Measurements, 1988. Quality assurance for diagnostic imaging equipment : recommendations. Bethesda, Md : NCRP. *NCRP report 99*.

National Council on Radiation Protection and Measurements, 1989. Radiation protection for medical and allied health personnel : recommendations. Bethesda, Md : NCRP. *NCRP report 105*.

National Council on Radiation Protection and Measurements, 1990. Implementation of the principle of as low as reasonably achievable (ALARA) for medical and dental personnel : recommendations. Bethesda, Md. : NCRP. *NCRP report 107*.

*National protocol for patient dose measurements in diagnostic radiology / prepared by Dosimetry Working Party of the Institute of Physical Sciences in Medicine, National Radiological Protection Board, College of Radiographers. Chilton, Oxon. : NRPB., 1992.*

National Radiological Protection Board, 1990. Patient dose reduction in diagnostic radiology. Chilton, Oxon. : NRPB. *Documents of the NRPB 1(3)*.

Poletti J L, 1994. Factors affecting patient dose in diagnostic radiology. Christchurch : National Radiation Laboratory. *Report NRL 1994/2*.

Poletti J L, 1995. Guidelines for quality assurance in radiation protection for diagnostic x-ray facilities: large x-ray facilities. Christchurch : National Radiation Laboratory. *Report NRL 1995/1.*

Poletti J L, 1996a. Guidelines for quality assurance in radiation protection for diagnostic x-ray facilities: limited x-ray facilities. Christchurch : National Radiation Laboratory. *Report NRL 1996/6.*

Poletti J L, 1996b. Guidelines for quality assurance in radiation protection for diagnostic x-ray facilities: small x-ray facilities. Christchurch : National Radiation Laboratory. *Report NRL 1996/7.*

*Quality criteria for diagnostic radiographic images : working document / CEC Study Group.* 2nd ed. Luxembourg : Commission of the European Communities, 1990.

Technical and physical parameters for quality assurance in medical diagnostic radiology : tolerances, limiting values and appropriate measuring methods / edited by B. M. Moores... et al. London : British Institute of Radiology, 1989. *British Institute of Radiology report 18.*

United Nations Scientific Committee on the Effects of Atomic Radiation, 1988. *Sources, effects and risks of ionizing radiation : report to the General Assembly.* N.Y. : United Nations.

United Nations Scientific Committee on the Effects of Atomic Radiation, 1993. *Sources and effects of ionizing radiation : report to the General Assembly.* N.Y. : United Nations.

Williamson B D P, Le Heron J C, Poletti J L and Cartwright P H, 1985. *A glossary of physics, radiation protection and dosimetry in medical diagnostic imaging.* Christchurch : National Radiation Laboratory.

World Health Organization, 1983. A rational approach to radiodiagnostic investigations : report of a WHO Scientific Group on the Indications for and Limitations of Major X-ray Diagnostic Investigations. Geneva : WHO. *WHO technical report series 689.*

World Health Organization, 1987. Rational use of diagnostic imaging in paediatrics : report of a WHO Study Group. Geneva : WHO. *WHO technical report series 757*.

World Health Organization, 1990. Effective choices for diagnostic imaging in clinical practice : report of a WHO Scientific Group. Geneva : WHO. *WHO technical report series 795*.

## ANNEX 1 DEFINITION OF TERMS AND GLOSSARY

The meanings for the following terms are in the context of this Code.

*ALARA.* An acronym for the *optimisation* principle – As low as reasonably achievable, social and economic factors being taken into account.

*Chiropractor.* A person who is registered in New Zealand to practice chiropractic.

*Director-General.* The Director-General of Health under the Health Act 1956; and includes any person to whom his/her powers are delegated under the Radiation Protection Act and Regulations. For the purpose of this Code the Director, NRL, has the delegated authority of the Director-General of Health.

*Dose-area product.* The dose-area product is the absorbed dose to air averaged over the area of the x-ray beam in a plane perpendicular to the beam axis, multiplied by the area of the beam in the same plane.

*Effective dose.* The effective dose, E, is the sum of the weighted equivalent doses in all the tissues and organs of the body. It represents the uniform whole body dose that would have the same radiation detriment as the actual dose distribution arising from a given irradiation.

*Entrance surface dose (ESD).* The entrance surface dose is the absorbed dose to air at the point of intersection of the x-ray beam axis with the entrance surface of the patient, including backscatter.

*Equivalent dose.* The equivalent dose in tissue T,  $H_T$ , is the absorbed dose averaged over that tissue or organ and weighted for the radiation quality of interest. (For diagnostic radiation, the radiation weighted factor for x-rays equals one.)

*International Commission on Radiological Protection (ICRP).* Internationally recognised body established to make recommendations on matters of radiation protection.

*Irradiating apparatus.* A term used in the New Zealand Radiation Protection legislation and this Code to mean any apparatus that can be used for the production of x-rays or gamma rays or for the acceleration of atomic particles in such a way that it produces a dose equivalent rate of or exceeding 2.5 microsieverts per hour at a point which could be reached by a living human being.

*Justification.* The justification of a practice is a fundamental principle of the ICRP radiation protection system. No practice involving exposures to radiation **should** be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes.

*Limitation.* A principle of the ICRP approach to radiation protection where a limit is placed on doses and risks that may be received by persons from ionizing radiation. Doses or risks over these limits are not acceptable.

*Medical radiation technologist (MRT).* A person who has undergone a recognised course of training of duration of several years, including requisite experience, and is registered or certificated to perform radiography occupationally. Previously known as radiographers.

*Non-radiation personnel.* Any person who is employed at an x-ray facility but whose work does not directly and centrally involve the use of x-rays.

*Optimisation.* The optimisation of protection is a fundamental principle of the ICRP radiation protection system. In relation to any particular source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received **should** all be kept as low as reasonably achievable, economic and social factors being taken into account.

*Overexposure.* An overexposure for a patient refers to a situation where the patient receives a radiation dose substantially greater than intended. It does not include the usual small percentage of repeats of projections normally encountered in a radiology facility, but does include situations such as failure of the exposure to terminate correctly. An overexposure for *radiation personnel* means an exposure to radiation that exceeds the dose limits given in Para 3.5, or exceeds one-tenth of the limits given in Para 3.5 during a period of one month, or exceeds three-tenths of the same limits during a period of three months. An overexposure for *non-radiation personnel* and members of the

public means an exposure to radiation that exceeds the dose limits given in Para 3.6, or exceeds one-tenth of the limits given in Para 3.6 during a period of one month, or exceeds three-tenths of the same limits during a period of three months.

*Primary barrier.* A barrier sufficient to attenuate the primary x-ray beam to the required level.

*Programme.* A quality assurance programme in radiation protection which, in addition to its main goals of adequate diagnosis for minimum dose, provides reasonable confidence in an x-ray facility complying with NRL C6 at any time.

*Qualified health physicist.* Any person who could be expected to qualify for membership of a professional organisation (such as the ACPSEM, IPSM, AAPM) who, in the opinion of the Director of the National Radiation Laboratory, has special knowledge and experience in the measurement and evaluation of hazards arising from the use of x-rays for chiropractic diagnosis.

*Radiation personnel.* Any persons whose work involves directly and centrally the use of x-rays.

*Radiation protection survey.* A survey performed by NRL to check an x-ray facility's compliance with NRL C6. (See also *programme*.)

*Reference dose.* A dose that under normal circumstances **should not** be exceeded when performing a given x-ray procedure on an average patient.

*Reference filtration, diaphragms and shields.* A minimum level of beam-shaping filters, diaphragms and shields that under normal circumstances **shall** be used when performing a given x-ray procedure on an average patient.

*Secondary barrier.* A barrier sufficient to attenuate secondary radiation to the required level.

*Tolerable.* Refers to a level of dose that is below but close to the dose limits. Such a dose is not welcome but can reasonably be tolerated in some circumstances.

## ANNEX 2 QUALITY CRITERIA FOR DIAGNOSTIC RADIOGRAPHIC IMAGES

### Introduction

Requirements relating to the *justification* and *optimisation* of the x-ray examination and to *reference doses* are given in Chapter 4. The optimal use of x-rays in chiropractic diagnosis involves the interaction of three important aspects of the imaging process:

- the diagnostic quality of the image
- the radiation dose to the patient
- the choice of radiographic technique

This Annex provides guidance on the last two aspects.

This guidance is given for a selection of radiographic projections, and is largely based on the report, *Patient doses in chiropractic radiography in New Zealand* (Cartwright, 1996). It is primarily directed to the clinical and technical staff involved in taking the radiographs and in reporting on them.

### General principles associated with good imaging performance

The following general principles are common to all radiographic x-ray examinations. All persons who either request, carry out, or report on the results of diagnostic x-ray procedures **should** be aware of them.

#### Image annotation

The patient identification, the date of examination, positional markers and the name of the facility must be present and legible on the film. These annotations should not obscure the diagnostically relevant regions of the radiograph.

#### Quality control of x-ray imaging equipment

Quality control *programmes* form an essential part of dose-effective radiological practice. Such *programmes* **shall** be implemented in every

chiropractic x-ray facility and **shall** cover a selection of the most important physical and technical parameters associated with the types of x-ray examination being carried out (see Chapter 7).

### **Radiographic exposure factors**

Knowledge and correct use of appropriate radiographic exposure factors, eg, radiographic kilovoltage, nominal focal spot size, base filtration, shaping filters, shields, grid characteristics, focus-film distance, is necessary because they have a considerable impact on patient dose and image quality.

### **Technical innovations**

Technical innovations can sometimes lead to dose reductions. The use of the following may result in reduced doses, which also may be accompanied by improvement in image quality.

- rare earth screens,
- carbon fibre products in table tops or bucky fronts, grid facing and interleaving, and cassette fronts,
- digital radiography,
- advanced film emulsions.

### **Patient positioning**

Correct patient positioning plays a major role in determining the success of any radiological examination. Routine positioning may need to be altered in the light of specific clinical circumstances, in order to delineate an area of special interest. Correct positioning of the patient is the responsibility of the person who is physically directing the examination. The use of suitable immobilisation and compression techniques can have an important role to play in the production of satisfactory images.   

### **X-ray beam limitation**

Image quality is improved and the radiation dose to the patient is reduced by limiting the x-ray beam to the smallest field giving the required diagnostic information. Limitation of the radiation beam **should** also consider the need to exclude radiosensitive organs from the primary irradiation whenever possible. On no occasion **shall** the x-ray beam fall outside the image receptor area. In chiropractic radiography beam-shaping diaphragms that result in

non-rectangular fields are routinely used in addition to collimation with the light beam diaphragm.

### **Protective shielding**

For radiation protection purposes radiosensitive tissues or organs **should** be shielded wherever possible. In particular, for patients of high reproductive capacity, testes or ovary shields **shall** be used in examinations which are likely to give a high radiation dose to the gonads.

### **Radiographic exposures per examination**

The number of radiographic exposures within one examination must be kept to a minimum consistent with obtaining the necessary diagnostic information. This requires that those factors which can lead to high reject or retake rates are subject to reject analysis. This will help to delineate the areas of concern in each chiropractic x-ray facility. In particular, the chiropractor **shall not** have a standard set of projections used on all patients irrespective of their symptoms.

### **Film processing**

Optimal processing of the radiographic film has important implications both for the diagnostic quality of the image and for the radiation dose to the patient. Film processors or manual processing systems **shall** be maintained at their optimum operating conditions as determined by regular and frequent (ie, daily) quality control procedures. Consistent imaging performance is not necessarily an indication of optimal performance, eg, the developer temperature may well be set too low.

### **Image viewing conditions**

The proper assessment of image quality and accurate reporting on the diagnostic information in the radiographs can only be achieved when the viewing conditions meet the following requirements:

- (a) The person viewing the radiographs requires a brightness through the film of about  $100 \text{ cd/m}^2$  (ie, a light intensity of  $100 \text{ cd/m}^2$  incident on the viewer's eye). To achieve this, the film illuminator needs to have a uniform brightness of at least  $2000 \text{ cd/m}^2$  (between  $2000$  and  $4000 \text{ cd/m}^2$  for films in the optical density range  $0.8$  to  $2.1$ ).

- (b) The colour of the illuminator **should** be white or blue and **should** be matched throughout a complete set of film illuminators.
- (c) Means **should** be available to restrict the illuminated area to the area of the radiograph to avoid dazzling.
- (d) Means for magnifying details in the displayed radiographic image **should** be available. These means **should** magnify by a factor of 2 to 4 and contain provisions to identify small image details of sizes down to 0.1 mm.
- (e) For viewing exceptionally dark areas in the radiographic image an additional spotlight with iris diaphragm providing a brightness of at least 10 000 cd/m<sup>2</sup> **should** be available.
- (f) A low level of ambient light in the viewing room is essential.

## **Examples of good radiographic technique**

These provide sets of values for various radiographic technique parameters that have been found to result in good imaging performance for selected projections. These examples of good technique can act as a guide to improving techniques that do not result in good quality images and/or do not meet the dose criteria.

### **Note:**

- 1) The anti-scatter grid is specified in terms of the grid ratio,  $r$ , and the number of absorbing strips per cm.
- 2) The sensitivity of film-screen combinations is defined in terms of speed (see *ANSI PH2.43-1982* (American National Standards Institute, 1982)). The speed of the film-screen combination is one of the most critical factors affecting the patient dose. Speed classes of 200 and above usually require the use of rare-earth or equivalent intensifying screens.

## Projections

### Cervical spine

Radiographic device

Focal spot size

Base filtration

Additional filtration

Anti-scatter grid

Film-screen combination

FFD

Radiographic voltage

Exposure time

### AP Projection

: stationary or moving grid

:  $\leq 1.6$  mm

:  $\geq 3.0$  mm Al equivalence

: Additional filtration of about 3 mm Al equivalence may be used over the neck region

:  $r = 8$  (or 10); 40/cm

: speed class 200 (range 200-400)

: 165 (150-200) cm

: 70-100 kVp

:  $< 400$  ms

### Cervical spine

Radiographic device

Focal spot size

Base filtration

Additional filtration

Anti-scatter grid

Film-screen combination

FFD

Radiographic voltage

Exposure time

### Lat Projection

: stationary or moving grid

:  $\leq 1.6$  mm

:  $\geq 3.0$  mm Al equivalence

: Additional filtration of about 3 mm Al equivalence may be used over the neck region

:  $r = 8$  (or 10); 40/cm

: speed class 200 (range 200-400)

: 165 (150-200) cm

: 70-100 kVp

:  $< 400$  ms

### Cervico-thoracic

Radiographic device

Focal spot size

Base filtration

Additional filtration

Anti-scatter grid

Film-screen combination

FFD

Radiographic voltage

Exposure time

### AP Projection

: stationary or moving grid

:  $\leq 1.6$  mm

:  $\geq 3.0$  mm Al equivalence

: Extra filtration in the neck or neck and head region, up to 10 mm Al equivalent total.

:  $r = 12$  (or 10); 40/cm

: speed class 200 (range 200-400)

: 150 (130-200) cm

: 80-100 kVp

:  $< 400$  ms

**Lumbar**

Radiographic device

Focal spot size

Base filtration

Additional filtration

Anti-scatter grid

Film-screen combination

FFD

Radiographic voltage

Exposure time

**Lat Projection**

: stationary or moving grid

:  $\leq 1.6$  mm:  $\geq 3.0$  mm Al equivalence

: Extra plain filtration of up to 6 mm Al equivalence, over the top half of the film.

:  $r = 10$  (or 12); 40/cm

: speed class 400 (range 400-600)

: 160 (130-200) cm

: 90-110 kVp

: &lt; 400 ms

**Lumbo-pelvic**

Radiographic device

Focal spot size

Base filtration

Additional filtration

Anti-scatter grid

Film-screen combination

FFD

Radiographic voltage

Exposure time

**AP Projection**

: stationary or moving grid

:  $\leq 1.6$  mm:  $\geq 3.0$  mm Al equivalence

: blocking diaphragms of at least 1.2 mm Cu equivalence to narrow the central x-ray field above the iliac crest to no more than 14 cm on the film. Extra plain filter can be placed over the top part of the field.

:  $r = 12$  (or 10); 40/cm

: speed class 400 (range 400-600)

: 160 (130-200) cm

: 90-110 kVp

: &lt; 400 ms

**Lumbo-pelvic**

Radiographic device

Focal spot size

Basic filtration

Additional filtration

Anti-scatter grid

Film-screen combination

FFD

Radiographic voltage

Exposure time

**Lat Projection**

: stationary or moving grid

:  $\leq 1.6$  mm:  $\geq 3.0$  mm Al equivalence

: Extra plain filtration of up to 6 mm Al equivalence, over the top half of the film.

:  $r = 12$  (or 10); 40/cm

: speed class 400 (range 400-600)

: 160 (130-200) cm

: 90-110 kVp

: &lt; 400 ms

**Full spine**

Radiographic device

Focal spot size

Base filtration

Additional filtration

Anti-scatter grid

Film-screen combination

FFD

Radiographic voltage

Exposure time

**AP Projection**

: stationary or moving grid

:  $\leq 1.6$  mm:  $\geq 3.0$  mm Al equivalence: Extra filtration in the neck region, up to  
10 mm Al equivalent total.:  $r = 12$  (or 10); 40/cm

: speed class 400 (400-600)

: 160 (130-200) cm

: 90-110 kVp

:  $< 400$  ms

### ANNEX 3      DOSE INDICES FOR ASSESSING RADIATION EXPOSURE OF PATIENTS

Patient doses resulting from the use of x-rays in diagnosis are measured because x-rays are potentially harmful. The "amount" of radiation used to perform an x-ray examination **should** be expressed in terms of a dose quantity that relates closely to the radiation risks associated with x-ray examinations. The partial body exposures invariably used in diagnostic x-ray examinations make the task of choosing an appropriate dose index suitable for use across all types of x-ray examinations difficult.

The 1990 recommendations of the ICRP define radiation detriment in terms of cancer (fatal and non-fatal), serious hereditary effects over all generations, and years of life lost. The ICRP also sets up a dose quantity called *effective dose*, which converts the actual dose distribution in the body (and its ensuing detriment) into an equivalent uniform whole body dose that would have the same detriment. Although *effective dose* is intended for use in occupational and public protection, its link to a sound definition of detriment and its ability to cope with partial body irradiations make it very attractive as a dose index for assessing the amount of radiation being used in diagnostic x-ray procedures. Although the age and sex distributions of the worker and public populations used to formulate *effective dose* are not the same as the distributions typically found for x-ray patients, this is not a serious drawback for using *effective dose* as a means of monitoring the amount of radiation being used for "average patients".

For these reasons *effective dose* has been used in this Code as the dose quantity for expressing the *reference doses*. While *effective dose* cannot be measured directly, *effective dose* for chiropractic x-ray examinations can be calculated, using a dosimetry program such as the NRL computer program CHIRODOS, provided the x-ray output for the base filtration is known; the composition, thicknesses, sizes and positions of the shaping filters, diaphragms and shields are known; and the total field size is known.

## INDEX

- Acrylic
  - lead, 37
- AEC (*see* Control, automatic exposure)
- ALARA, 6, 47
- Aluminium equivalence, 25, 30, 54, 55, 56
- Apparatus
  - irradiating, 3, 4, 48
- Apron
  - lead equivalence, 39
  - lead, 8, 9
  - protective, 20, 23, 39
- Area
  - controlled, 9
- Assurance
  - quality, 2, 11, 12, 40, 41, 49
  
- Barrier
  - operator, 34, 36
  - primary, 34, 35, 36, 37, 49
  - protective, 8, 34, 35
  - secondary, 35, 36, 37, 49
- Beam
  - primary, 8, 12, 18, 20, 22, 25, 26, 29, 34, 35, 49, 51
- Bricks, 36
  
- Capacitor discharge, 25
- Cinefluorography, 13
- Collimation, 12, 13, 18, 20, 22, 23, 26, 27, 52
- Compression, 20, 51
- Concrete, 36, 37
- Control
  - automatic exposure, 22, 28, 29
  - quality, 40, 50, 52
  - x-ray, 8, 29, 30, 34, 35, 36
- Copper equivalence, 13, 17, 18, 19, 55
- CT (*see* Tomography, computed)
- Current, 22, 32, 33
- Darkroom, 11, 31

Device  
  exposure, 28, 29

Diaphragm  
  fixed or adjustable, 26, 27  
  light beam, 13, 17, 18, 26, 52

Director-General, 3, 4, 9, 47

Discharge  
  capacitor, 25

Distance  
  focus-to-film, 12, 23, 27, 51, 54, 55, 56  
  focus-to-skin, 27

Dose  
  effective, 6, 7, 14, 47, 50, 57  
  entrance surface, 14, 47  
  equivalent, 3, 7, 47, 48  
  indices, 57  
  limit, 3, 6, 8, 48, 49  
  occupational, 6, 8  
  patient, 6, 10, 11, 12, 13, 22, 23, 48, 50, 51, 52, 53, 57  
  reference, 12, 13, 14, 17, 18, 19, 49, 50, 57

Dose-area product (*see* Product, dose-area)

Embryo, 19, 20

Equipment  
  x-ray, 2, 8, 11, 12, 21, 25, 28, 31, 39, 40, 50

Equivalence  
  aluminium, 25, 30, 54, 55, 56  
  copper, 13, 17, 18, 19, 55  
  lead, 13, 18, 19, 20, 34, 35, 36, 37, 39

Eyes, 9

FFD (*see* Distance, focus-to-film)

Field, x-ray (*see* Beam, primary)

Filter, 14, 17, 19, 25, 49, 51, 55, 57  
  rare earth, 25

Filtration, 12, 14, 17, 18, 19, 20, 25, 30, 49, 51, 54, 55, 56, 57  
  total, 20, 25

Fluoroscopy, 2, 4, 5, 8, 9, 13, 21, 29, 37, 38

Focal spot, 30, 31, 51, 54, 55, 56

Foetus, 19, 20

FSD (*see* Distance, focus-to-skin)

Generator

x-ray, 22, 30

Glass

lead, 37

plain, 36, 37

Glove

leaded, 8

protective, 23, 39

Gonads, 12, 13, 18, 19, 22, 52

Grid, 11, 12, 22, 51, 53, 54, 55, 56

ICRP, 3, 6, 10, 47, 48, 57

Illuminator

film, 52, 53

Image intensifier

mobile, 29

International Commission on Radiological Protection (*see* ICRP)

Iris, 53

Justification, 3, 6, 10, 21, 48, 50

Kilovoltage, 12, 20, 22, 23, 29, 31, 33, 35, 51, 54, 55, 56

Lead

acrylic, 37

glass, 37

Lead equivalence, 13, 18, 19, 20, 34, 35, 36, 37, 39

Leaded

apron, 8, 9

glove, 8

Leakage, 26

Licence, 1, 4, 24

Licensee, 2, 4, 5, 11, 37, 39, 40

Lights

warning, 29, 30, 38

Limit  
dose, 3, 6, 8, 48, 49

Limitation, 3, 48  
beam, 26, 51  
dose, 3, 6, 14

Linearity, 32, 33

mA (*see* Current)

mAs, 23, 28, 29, 31, 32, 33

Material  
protective, 7, 34, 35, 36, 37

MRT (*see* Technologist, medical radiation)

Optimisation, 3, 6, 10, 48, 50

Overexposure, 4, 48, 49

Owner, 2, 4

Paediatric, 21, 22

Personnel  
non-radiation, 6, 7, 34, 48, 49  
radiation, 2, 5, 6, 7, 8, 9, 11, 34, 48, 49

Physicist  
qualified health, 2, 20, 25, 34, 36, 37, 40, 49

Plasterboard  
barium, 36, 37

Pregnant, 7, 8, 19, 20, 23

Procedures  
fluoroscopic, 23

Processing  
film, 12, 40, 52

Processor  
film, 11, 12, 52

Product  
dose-area, 47

Programme (*see also* Assurance, quality)  
quality assurance, 11, 12, 40, 41, 49

Public  
members of, 6, 7, 34, 49, 57

QA (*see* Assurance, quality)

## Radiation

leakage, 26, 29

scattered, 9, 34

Radiography, 2, 4, 8, 9, 11, 12, 13, 21, 25, 26, 27, 36, 37, 48, 51

Records, 23

Reproducibility, 32

Research, 1, 4, 24, 40

Screens, 11, 12, 20, 51, 53, 54, 55, 56

film, 11, 12, 53, 54

rare earth, 20, 51, 53

Survey

radiation protection, 1, 2, 14, 40, 49

Technologist

medical radiation, 5, 13, 19, 20, 48

Time

exposure, 21, 22, 23, 28, 29, 31, 33, 54, 55, 56

Tolerable, 6, 49

Tomography

computed, 11, 13

Tube

x-ray, 8, 22, 26, 29, 30, 31, 32, 35

Warning lights, 29, 30, 38

Warning signs, 38

Window

viewing, 35, 36