

NRL C7
Version 1.1
ISSN 0110-9316

**CODE OF SAFE PRACTICE FOR THE USE OF
X-RAYS IN DENTISTRY**

(June 1991)

(Revised December 2007)

This Code applies to dental diagnostic uses of x-rays. Comments and suggestions for improvement are invited from radiation users and will be taken into account when revision is being performed. Correspondence on the Code and requests for copies should be addressed to:

The Director
National Radiation Laboratory
PO Box 25-099
Victoria Street
CHRISTCHURCH

© **National Radiation Laboratory**
Ministry of Health

Published with the permission of the Director-General of Health

Contents

	<i>page no</i>
1. Introduction	1
2. Protection of the patient	1
2.1 Clinical and administrative aspects	1
2.2 Protection of the gonads	2
3. Protection of personnel	3
3.1 Protection of non-radiation personnel	3
3.2 Protection of operator at the x-ray controls	3
3.3 Protection from exposure to the useful x-ray beam while holding patients or image receptors in position during radiography	4
4. X-ray equipment	5
4.1 Appropriate x-ray equipment	5
4.2 Efficient performance of x-ray machines	7
4.3 X-ray beam limitation	8
4.4 Filtration in the x-ray beam	10
4.5 Source-skin distance (SSD)	10
4.6 X-ray exposure device	11
4.7 Leakage radiation	12
4.8 X-ray films and intensifying screens	12
4.9 X-ray film processing	13
5. Organisation and administration of radiation protection	13
5.1 Personnel monitoring	13
5.2 Radiation protection surveillance	13
5.3 Dose limits for occupational exposure	14
6. Radiation protection legislation and responsibilities of licensees	14
6.1 Radiation Protection Act 1965	14
7. Services from the National Radiation Laboratory	16
8. Bibliography	16
Appendix	17

1. Introduction

1.1 The purpose of this Code is to provide criteria for working procedures, x-ray equipment and protective materials necessary for the use of x-rays in dental diagnosis according to currently accepted standards of safety. Conformity with this Code may be taken as a primary indication of compliance with radiation protection legislation.

1.2 A copy of this Code is provided to all licensees in dental radiography. Licensees shall provide free and convenient access to this Code to all persons using x-ray equipment under their control.

1.3 This Code is compatible with the Recommendations of the International Commission on Radiological Protection (ICRP). Relevant ICRP publications are listed in the bibliography.

1.4 Throughout this Code, measures which are considered necessary for the achievement of satisfactory protection are denoted by the imperative "shall" and those which are desirable protective measures by "should".

2. Protection of the patient

2.1 Clinical and administrative aspects

2.1.1 An x-ray examination should not be performed unless the benefits accruing to the patient outweigh any radiation risks. Judgement of whether benefits outweigh risks may be possible in cases where the potential radiation injury is the result of acute excessive doses where the effects are observed in the short term. However, the estimates of risks of delayed injury, such as carcinogenesis, resulting from chronic exposure at the low radiation dose levels typical of most diagnostic radiology are derived from epidemiological studies and can be expressed only on a statistical basis. The simpler question of whether the x-ray examination is necessary for adequate diagnosis should always be examined. In many cases examinations may routinely be requested to exclude the possibility of unexpected causes or conditions and not be based on clear-cut clinical indications. Implicitly the diagnosis provided by dental radiography determines subsequent patient management. If management is expected to be unaffected by the result of an x-ray examination then the need for the examination should be questioned.

2.1.2 Radiobiological evidence has demonstrated that certain tissues such as the red marrow, gonads, breast (female), gastro-intestinal tract, lungs, thyroid and bone surfaces may be particularly sensitive to radiation. An expression of the total biological effect of the x-ray dose delivered in a diagnostic x-ray examination has been that formulated by the ICRP in 1990 as the Effective Dose (E). This is the sum of the doses to certain specified organs, weighted according to their relative radiosensitivities, plus an allowance for remaining organs. For dental radiography the effective dose will be lower than for most other diagnostic x-ray procedures because most sensitive organs are in the trunk and receive only small amounts of scattered radiation during dental radiography.

The longer life expectancy of children results in a greater potential for the eventual manifestation of possible deleterious effects of radiation. Children may also be more radiosensitive. Therefore particular attention should be given to minimising doses to children and indeed, whether the examination is essential.

2.1.3 The useful x-ray beam should be restricted to the area of clinical interest, and restricted to as small an area as possible. Where extra-oral intensifying screen cassettes are used the beam shall be collimated to within the cross section of the x-ray film cassette.

2.2 Protection of the gonads

2.2.1 Irradiation of the testes and ovaries shall be minimised.

2.2.2 As far as it is possible the useful x-ray beam shall not be directed towards the pelvic and lower abdominal regions of patients. Where a special angulation is needed which does not comply with this requirement, a leaded apron or other suitable shield should be draped over the pelvis of the patient or otherwise interposed.

Note: Compared with the amounts of radiation reaching the foetus or ovaries in the case of direct irradiation of the abdomen in diagnostic radiology, the scattered radiation reaching these organs during irradiation of the head and neck in dental radiography is small. The testes receive considerably more radiation than do the ovaries.

3. Protection of personnel

3.1 Protection of non-radiation personnel

3.1.1 Persons who are not radiation workers but who work in, or frequent, the dental clinic shall not be exposed to more than 20 $\mu\text{Gy}/\text{week}$.

3.1.2 The walls, floors, ceilings and other material constructions of dental rooms shall have a protective value such that no radiation in excess of the limits stated in 3.1.1 is transmitted through them to occupied positions or areas.

3.1.3 Only those personnel who are required to assist, or who are in the course of training, should be present during the performance of x-ray examinations.

3.1.4 If installed, movable or variable protective barriers and leaded doors, etc, shall be maintained in closed or protective position during x-ray examinations.

3.1.5 The occasional use of non-radiation personnel to give assistance is acceptable but shall involve the full use of protective materials and procedures. Care shall be taken to ensure that the same non-radiation personnel are not always involved.

3.1.6 There are many factors determining amounts of radiation reaching areas which non-radiation personnel may occupy or traverse. Where the resultant of these factors is uncertain, the use of integrating dosimeters (eg, thermoluminescent dosimeters, radiation monitoring film area monitors) is recommended to estimate the actual amounts of radiation in the occupied areas.

3.2 Protection of operator at the x-ray controls

3.2.1 The exposure position shall be so shielded and/or located that the exposure rate is as low as reasonably achievable, social and economic considerations being taken into account (ALARA), but shall not exceed 400 $\mu\text{Gy}/\text{week}$ averaged over a year and should not exceed 40 $\mu\text{Gy}/\text{week}$.

3.2.2 Where the radiation workload is sufficiently low, or where the control position is at a sufficient distance from the x-ray tube and patient that the exposure rate at the operator's position is most unlikely to exceed 10 $\mu\text{Gy}/\text{week}$, a protective barrier is not required. The level of 10 $\mu\text{Gy}/\text{week}$ will in virtually all circumstances guarantee compliance with the ALARA requirement.

Note: The mean exposure to operators of dental machines in New Zealand is about 2.3 $\mu\text{Gy}/\text{week}$, while 92% of operators receive less than 5 $\mu\text{Gy}/\text{week}$. This low dose rate is achieved in practice by maximising the distance between the operator and the patient, and by using existing walls and doors as shielding. As a result operator barriers are seldom required for dental radiography.

3.3 Protection from exposure to the useful x-ray beam while holding patients or image receptors in position during radiography

3.3.1 No person shall hold a patient, film, x-ray film cassette, other imaging equipment or x-ray tube head in position during exposures unless it is otherwise impossible to obtain a diagnostically useful image.

Note: Many cases of delayed radiation injury have been reported in the past resulting from frequent exposure to the useful x-ray beam while holding x-ray films in position. Injury was almost invariably to the hands. Those who suffered these injuries were lulled into a false sense of security by the latent period for radiation effects, there being no untoward effects in the early stages.

3.3.2 Motion-restricting devices shall be applied to the patient insofar as it is practicable; and devices for remote holding of the films in patients' mouths shall be used wherever feasible.

3.3.3 Holding of patients, films, or x-ray film cassettes during exposure shall be done by persons accompanying the patient in preference to non-radiation personnel. If it is necessary to use non-radiation personnel it should not always be the same person who does the holding. No pregnant woman or young person should do any holding.

3.3.4 Any persons holding patients' films or film cassettes in position during exposures shall wear a leaded apron and, wherever practicable, leaded gloves. They should ensure as far as is practicable that no part of their body is in the useful beam.

4. X-ray equipment

4.1 Appropriate x-ray equipment

X-ray equipment of any type or model may be submitted to the National Radiation Laboratory for testing for compliance with this Code. The National Radiation Laboratory may in any case require an example of any type or model of x-ray equipment to be so submitted.

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

Note: The central considerations in this requirement are that the x-ray equipment be of maximum effectiveness in image production, and that excessive radiation doses are not delivered to patients during vain attempts to obtain acceptable images with underpowered or otherwise inadequate x-ray machines. In the main these considerations will be related to the ratings of the x-ray machine.

4.1.2 The radiation output of the machine shall be sufficient to allow the use of short exposure times so that patient movement effects are minimised.

4.1.3 For radiography using intra-oral film, the kilovoltage (kVp) used should be in the region of 60-65 kVp, and shall be not less than 50 kVp. The radiation output at the tip of the positioning device normally fitted shall be sufficient that radiographs may be obtained with exposure times of 1 second or less.

Note: The entrance dose necessary to obtain radiographs of good diagnostic quality varies with kilovoltage; at 60 kVp the entrance dose required is half that required at 50 kVp.

4.1.4 Machines shall be easily manoeuvrable at short focal distances around the head of the patient, and shall maintain a stable, vibration-free, position when positioned for radiography.

4.1.5 The machine shall be fitted with a positioning device which results in source-skin distances not less than those given in section 4.5. The positioning device should be parallel-sided and lined with lead-foil. Where this type is not available a parallel-sided unlined device is preferred. The "pointer cone" type should not be used.

4.1.6 For short focal distance radiography using intensifying screens, such as the lateral projection of the mandible, x-ray machines shall be operated at not less than 50 kVp and should be operated at not less than 60 kVp. Examinations involving thicker skull portions shall be carried out on equipment operating at 60 kVp or more.

4.1.7 For cephalometric and similar examinations, the x-ray machine should be operated at not less than 80 kVp and not less than 15 mA.

4.1.8 Where an x-ray machine is used for both short and long focal distance radiography the x-ray beam size shall be limited to that appropriate to the examination.

4.1.9 *Panoramic dental x-ray machines*

- The machine shall incorporate a primary barrier equivalent to 2 mm of lead or more. It shall not be possible to operate the x-ray machine without the Beam Stopper in position if it is easily removable.

- It shall be possible to preset the exposure factors without x-rays being produced.

- The patient shall be adequately restrained and held so that movement effects are minimised.

- The machine shall incorporate provision for varying the size of the focal trough to enable dentition of sizes typical of children and adults to be radiographed.

- An indicator shall be provided to indicate to the patient that x-rays are being produced.

- It shall be possible to demonstrate to the patient rotation of the unit without the production of x-rays.

- The image receptor shall incorporate intensifying screens. Non-screen film shall not be used. It shall not be possible to irradiate the patient without the x-ray film cassette in position.

4.1.10 *Cone Beam Volumetric Tomographic x-ray equipment*

Following installation and prior to initial clinical use, absorbed dose to air levels around the equipment shall be measured to verify compliance with the relevant requirements of sections 3.1 and 3.2.

4.1.11 *Purpose-designed hand-held intra-oral x-ray equipment*

- These units should not be used routinely in a permanent facility, but where their use is justified, they should be used with a positioning stand and an exposure switch that allows the operator to stand at least 2 metres away from the x-ray source and patient. If this is not possible, then the operator shall wear a protective lead apron with at least 0.25 mm Pb equivalence.

- For all other situations, where the unit is held by hand during exposures, the operator should, if practicable, wear a protective lead apron with at least 0.25 mm Pb equivalence.

- The requirements for personal monitoring described in section 5.1 shall be considered in relation to the use of these units (including need for extremity monitoring). Note that personal monitoring is mandatory in situations where the x-ray units are hand-held, and no lead apron is worn.

- Any attached operator shielding shall not be removed from the x-ray unit.

- These units shall bear a permanent label in a prominent position with the following or similar wording: "Danger, equipment produces x-rays when energised".

4.2 Efficient performance of x-ray machines

4.2.1 To contribute towards an optimal level of efficiency in imaging, the x-ray equipment should perform in such a way that a close correspondence exists between actual and nominal technique factors (kVp, mA, mAs, s) and the radiation output is consistently reproducible.

4.2.2 Any assessments of the performance of x-ray machines in respect of efficient performance should be made in terms of the parameters in paragraphs 4.2.4 - 4.2.5 inclusive. For these assessments the x-ray machine should be connected to an electrical power supply as specified by the manufacturer for

that machine. Electrical line volts shall be properly adjusted to the indicated value where such adjustment is available to the operator. Measurements shall be made with radiation dosimeters and other equipment calibrated and used in a manner acceptable to a qualified expert.

4.2.3 The reproducibility of x-ray output should be assessed in terms of the coefficient of variation for specified combinations of selected x-ray machine settings. The coefficient of variation of a series of consecutive radiation exposures should not exceed 0.10 and preferably should not exceed 0.05. (For any sample of observations the coefficient of variation is the ratio of the standard deviation of the sample to the mean value of the sample.)

Note: Experimental evidence suggests that x-ray output variations of $\pm 10\%$ may be readily perceptible on radiographs.

4.2.4 The x-ray output should be linearly related to the mA* and mAs** settings within $\pm 10\%$.

4.2.5 The deviations of actual peak kilovoltages from indicated or preset peak kilovoltage settings during exposure should not exceed $\pm 5\%$ of the indicated or preset value at any x-ray tube current for which the x-ray machine is properly operable.

4.3 X-ray beam limitation

4.3.1 The useful x-ray beam on the patient shall be limited to the area of clinical interest and, where possible, completely intercepted by the image receptor.

4.3.2 A device shall be installed on the x-ray tube assembly so that the useful x-ray beam may be restricted to the desired cross-section. As far as it is practicable the image receptor should completely intercept the useful beam.

4.3.3 For normal intra-oral film radiography the diameter of the x-ray beam at the end of the positioning device shall not exceed 60 mm.

Note: A device which restricts the x-ray beam to a rectangular cross-section of dimensions close to those of intra-oral films is available for a number of x-ray machines. This device is recommended.

* mA: X-ray tube current in milliamperes.

** mAs: The product of x-ray tube current in milliamperes and exposure duration in seconds.

4.3.4 For techniques using extra-oral films or cassettes, the x-ray beam limiting device may be:

- A light-beam diaphragm conforming with 4.3.7, or,
- A fixed or adjustable diaphragm. The device should provide an x-ray beam of rectangular cross-section suited to the x-ray film being used. There shall be indicated on the device the x-ray beam size of each source to image distance for which it is used, or,
- A conventional cone or cylinder of circular cross-section. This should not be used unless it is the only beam limiting device available.

4.3.5 For panoramic radiography the dimensions of the unattenuated primary x-ray beam shall be less than the image receptor slit dimensions. The primary x-ray beam should not irradiate the patient's eyes.

4.3.6 For intra-oral tube radiography the angle of emission shall be such that the x-ray film completely intercepts the primary x-ray beam, and the patient's eyes are not irradiated. When it is necessary that separate films of the maxillary and mandibular regions be exposed, the angle of emission shall be such that the maxillary region is not irradiated during radiography of the mandibular region and vice versa. (See also section 4.5.4)

4.3.7 *Light-beam diaphragm*

- The total misalignment of the edges of the light field with the respective edges of the x-ray field along either the length or the width of the visually defined field shall not exceed 2% of the distance from the x-ray tube 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.
- The centre of the light field shall be clearly indicated. The centre of the x-ray beam and the centre of the light field shall coincide to an accuracy of within 2% of the distance from the x-ray tube focus to the point on the illuminated surface at which it appears.
- The brightness of the light field should be sufficiently great that the light field is clearly visible in ambient illumination. The outer edges of the light field should be clearly shown with a high edge-field contrast ratio.

4.4 Filtration in the x-ray beam

4.4.1 Filtration shall be inserted in the useful x-ray beam to remove the "softer" or lower energy components which otherwise contribute to patient dosage and to scattered radiation levels, without usefully affecting the diagnostic image.

4.4.2 The total filtration in the useful x-ray beam shall be not less than the values given in the following table.

Useful Beam Filtration Requirements

Maximum peak kilovoltage of the x-ray machine:	Total filtration in the useful x-ray beam <u>shall</u> be not less than:
below 70 kVp	1.5 mm aluminium equivalent
in the range 70-100 kVp	2.5 mm aluminium equivalent

4.4.3 The total filtration in the useful beam from materials it traverses in the x-ray tube and its housing (ie, the inherent filtration) shall be permanently marked on the x-ray tube housing as thickness of aluminium equivalent at a nominated kilovoltage.

4.4.4 The filtration of materials in the path traversed by the useful x-ray beam through x-ray collimation devices and the like attached to the x-ray tube should be permanently marked on the outer cover of the diaphragm as thickness of aluminium equivalent at a nominated kilovoltage.

4.5 Source to skin distance (SSD)

4.5.1 To minimise the radiation dose to the superficial tissues of the patient and to minimise focal spot penumbra, the x-ray equipment shall be so designed and operated as to permit the maximum practicable distance between the source and the patient. Wherever practicable, positive means shall be employed to ensure this.

4.5.2 Positive means shall be employed to ensure that for intra-oral film x-ray machines operating at up to 60 kVp, the minimum SSD shall be 100 mm and should be 200 mm; and for machines operating above 60 kVp the minimum SSD shall be 200 mm. A parallel-sided, lead-lined positioning device is the preferred method of achieving this objective.

4.5.3 For panoramic radiography the source to skin distance shall be as long as is practicable so as to minimise magnification and patient dose. The focus should be positioned towards the rear of the tube housing where this will assist in lengthening the focal distance.

4.5.4 Because the short source to skin distances of intra-oral tube x-ray machines result in high doses to the oral tissues adjacent to the applicator these units should be used only for examination of patients suspected to require oral surgery, especially following trauma.

4.6 X-ray exposure device

4.6.1 The onset, duration and termination of x-ray exposures require to be precisely determinable for efficiency of image production and for limiting radiation doses.

4.6.2 A device shall be incorporated in the x-ray equipment to terminate radiographic exposures after the elapse of a preset time, preset exposure to an imaging device, preset mAs or other predetermined event. Except in special techniques where a sequence of repeated exposures is required, 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. To prevent accidental exposures, the exposure device shall require continuous firm pressure on the exposure control for its operation.

4.6.3 The worst fault which may be exhibited by an exposure device is failure to terminate the exposure. It shall therefore become habitual for the operator to observe the meters (if any) at the controls and the warning lights and notice that their indications are consistent with the prior settings and that clear indication of termination independent of the exposure device is given.

4.6.4 The exposure device shall determine the exposure accurately and reproducibly.

(1) In many cases the exposure device interrelates exposure time and x-ray tube current (mAs) or selects a setting based on the tooth being radiographed. Criteria for accuracy and reproducibility of exposures are then expressed in terms of x-ray output.

(2) 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 should not differ by more than 10%. For individual x-ray machines the linearity of the set/actual exposure time relationship with no zero error may be more important than accuracy.

4.7 Leakage radiation

4.7.1 Leakage radiation emerging from diagnostic x-ray tube housing assemblies should not add significantly to scattered radiation already, and unavoidably, present.

4.7.2 Every x-ray tube used for diagnostic purposes shall be enclosed in a housing such that the exposure from the leakage radiation at a distance of 1 m from the source shall not exceed 1 mGy and should not exceed 100 μ 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) complies with this requirement.

4.8 X-ray films and intensifying screens

4.8.1 X-ray film and intensifying screen combinations should be the most sensitive to radiation which it is practicable to use consistent with the maintenance of optimum image quality.

4.8.2 When intensifying screens are used these should be of the rare earth type, contained where possible in cassettes of high radiation transparency.

4.8.3 Intensifying screens and cassettes shall be maintained in clean condition, free from blemishes.

4.9 X-ray film processing

4.9.1 X-ray films shall be processed properly so that the inherent quality of the latent image is not adversely affected.

4.9.2 Any darkroom shall be light-tight, have installed adequate safe-lights, and be protected from ionizing radiation. Processing solutions shall be correctly prepared, replenished and replaced at intervals necessary to maintain optimum performance.

4.9.3 Notes on processing x-ray films are given in the Appendix.

5. Organisation and administration of radiation protection

5.1 Personnel monitoring

Where it can be demonstrated that x-ray personnel are unlikely to receive significant doses of radiation in the course of their work, monitoring of occupational exposure is unnecessary, although monitoring may still be performed for the purpose of confirming that occupational exposure is insignificant. The current expectations of dental radiography are that it would be described by this situation. The need for personnel monitoring, the monitoring frequency and personnel to be monitored in dental facilities therefore shall be determined for each individual facility separately.

5.2 Radiation protection surveillance

5.2.1 The licensee is legally obliged to ensure that safe working procedures, as laid down in the licence, or in the Regulations, are being adhered to. This includes amongst other things the regular and correct use of radiation monitoring film badges or other personnel monitoring procedures if these have been required.

5.2.2 For most dental x-ray installations it is unlikely that either x-ray room shieldings or personal monitoring procedures will be required.

5.3 Dose limits for occupational exposure

5.3.1 Dose equivalent limits for occupational exposure to radiation are prescribed in the Radiation Protection Regulations 1982, which are currently under review. The latest international recommendations (ICRP 60) contain new dose limits for the effective dose, calculated according to their new definition of effective dose. In the interim, until the new regulations are in place, it would be prudent to follow the new ICRP recommendations.

Calculations of the effective dose in any particular case require dose estimates for specified organs and the complexity of this procedure may not be justified on a routine basis. For all practical purposes in dental radiography, it will suffice that the working dose limit for occupational exposure be 400 $\mu\text{Gy}/\text{week}$ measured as absorbed dose to air in occupational areas and allowing for occupancy factors. Since doses to internal organs are always less than the absorbed dose in air at the same position, compliance with the working limit of 400 $\mu\text{Gy}/\text{week}$ will automatically ensure compliance both with the limits specified in the regulations, and with the new recommendations of ICRP.

5.3.2 The dose equivalent limit is used only as a guide in dose limitation, being viewed by the ICRP as the borderline between unacceptable doses and tolerable doses. Doses "should be as low as reasonably achievable, social and economic considerations being taken into account" (ALARA). This means that a dose level already below the limit, shall be reduced to the minimum practicable.

6. Radiation protection legislation and responsibilities of licensees

6.1 Radiation Protection Act 1965

The Radiation Protection Act 1965 and amendments, and its Regulations, 1982, govern the safe use of irradiating apparatus (in the main, x-ray machines) and radioactive materials in New Zealand. The Act is administered in the Department of Health by the National Radiation Laboratory (NRL). The legislation is compatible with international recommendations such as those of the International Commission on Radiological Protection (ICRP). Radiation protection inspection visits may be made periodically by officers from the National Radiation Laboratory to assess compliance with the legislation and

this Code. The following points arising from the Act and Regulations are noted, but the reading of these is neither intended as a substitute for reading of the Act and Regulations themselves, nor is it claimed to be an exhaustive coverage of points of interest for users of diagnostic x-ray machines. Copies of the Act and relevant Regulations together with any codes of safe practice (such as this one) are required to be made readily available to persons who use x-ray equipment by the licensee in any establishment.

6.1.1 No person may use a diagnostic x-ray machine unless that person is the holder of a licence issued under the Act, or is acting under the supervision or instruction of a licensee (Clause 15 of the Act). Registered dental surgeons are eligible for licences to use x-ray machines for dental diagnosis.

6.1.2 Licences are issued subject to conditions prescribed in the Act and Regulations. Individual licences may additionally be subject to conditions such as restriction to a specified machine or to machines of a specified kind, or to a specified range of x-ray examinations (Clause 17 in the Act). In the case of dental radiography there are no conditions, but use of the term "radiographic" implies that fluoroscopy is not permitted.

6.1.3 Licensees may not perform or instruct performance of x-ray examinations not included specifically or implicitly in the purposes of their licences. For example, dentists shall not perform medical radiography.

6.1.4 The licence issued is personal to the holder and is not transferable. This is because a licence is granted to a person only when NRL is satisfied that person is able, with a knowledge of safe working and with the equipment to be used, to carry out the proposed use safely.

6.1.5 All licensees are responsible for the safe care and use of x-ray machines which come under their control, and they retain this responsibility until it has been properly transferred to another person or terminated in accordance with the Regulations.

6.1.6 If the owner of any irradiating apparatus sells or transfers it in any manner to another person, the owner is required to ensure that the purchaser is the holder of an appropriate licence or employs a person appropriately licensed. The owner is required to notify NRL of the sale or transfer.

6.1.7 A licensee is required to notify the Director-General of Health (which can be done by notice to NRL) of any case of overexposure or suspected overexposure to radiation, as soon as possible after becoming aware of it.

7. Services from the National Radiation Laboratory

Licensees may consult NRL for advice and for provision of personnel monitoring and other services such as protection surveys, measurements of patient dosage or x-ray machine radiation output, and advice on the need for, and specification of shieldings for x-ray rooms. Charges may be made for some of these services.

Radiation protection inspection visits may be made from time to time by National Radiation Laboratory Officers to assess compliance with the legislation and this Code. Such visits may also be made where there is a new or unusual type of x-ray machine, or where some particular circumstance indicates that the level of hazard may be higher than usual.

8. Bibliography

Radiation Protection Act (Reprint of principal act, 1965 and amendments 1973, 1974, 1977, 1981, 1986). Wellington, Government Printer, 1987.

The Radiation Protection Regulations 1982. Wellington, Government Printer, 1982.

Annals of the ICRP:

v 1(3). ICRP Publication 26. Recommendations of the International Commission on Radiological Protection. Adopted 17 January 1977. Oxford, Pergamon Press.

v 9(1). ICRP Publication 33. Protection against ionizing radiation from external sources used in medicine. Adopted March 1981. Oxford, Pergamon Press.

v 9(2/3). ICRP Publication 34. Protection of the patient in diagnostic radiology. Adopted May 1982. Oxford, Pergamon Press.

v 21(1/3) ICRP Publication 60. 1990 recommendations of the International Commission on Radiological Protection. Adopted November 1990. Oxford, Pergamon Press.

Williamson, BDP. Radiation doses to patients from dental radiography in New Zealand. NRL Report 1990/6.

Appendix

Notes on the processing of dental x-ray films

The most common fault found during routine radiation protection surveys in dental practices is in the processing of x-ray films. In many practices the dentist takes little or no direct part in film processing, preferring to leave this routine chore to the practice nurse. Often development time for films is shortened and the exposure time used on the x-ray machine is lengthened, ie, the films are underdeveloped and overexposed. The manufacturer of the film states a recommended development procedure, usually 4.5-5 minutes development at 20°C, or shorter times at elevated temperatures (as in most automatic processors). These time/temperature techniques are chosen as a compromise between minimizing the optical density of the light areas of the film and maximising the blackness of dark areas of the film, ie, they result in the maximum contrast for the speed of film. Any change from this optimal time thus results in a loss of contrast. Pathology which should be evident on the radiograph is often not detectable. The following is intended to assist dentists and their assistants to not only achieve better quality radiographs, but also to make the most efficient use of radiation.

Manual processing techniques

The darkroom or processing cabinet should not allow the entry of white light, and any safe-light in use should be compatible with the film in use. To test that levels of light are sufficiently low, a dental film may be half removed from its wrapper (ie, so that incident light strikes half the film only, the second half being shielded by the wrapping), and left in this condition near the processing tank for about five minutes. Subsequently the film should be processed as for the normal dental x-ray film. Some fogging of the exposed half is to be expected, but if it is easily discernible then ambient light levels are probably causing a loss of contrast. To test whether the fogging is caused by white light

leaking in, or the safe-light, the test may be repeated with the safe-light turned off.

Processing solutions need not be heated provided their temperature is within the values given by the manufacturer for time-temperature development (usually a minimum of 16°C). A thermometer and timer are essential. Development times should be as follows:

°C	Temperature		Time min
		°F	
16		60	8
18		65	5
20		68	4
21		70	4
24		75	3
27		80	2

The fixing time is about equal to the development time but is less critical in any case. Ten minutes or so is necessary for complete hardening of the films.

The films should be washed in clean water and may be force-dried if necessary.

The solution should be replaced about every month, or after several hundred films per litre have been processed, whichever occurs first. Where higher temperatures are used, solutions will need to be changed more often as oxidation of the developer occurs.

Solutions should be made up at dilution rates as specified by the chemical manufacturer (usually 1 part developer - 4 parts water).

Automatic processing

Automatic processors can be divided into two groups. The first group consist of basic units which are really only automated versions of manual development, usually operating at close to normal temperature. The second

group are more sophisticated units with roller film transport system, usually operating at elevated temperatures.

The temperature of the processing solution should be checked with a thermometer. The unit may need to be turned on for some time before films are processed to allow heating of the solutions. The speed of the film through the developer can be timed and checked against the following approximate time-temperature relationship.

Temperature		Time
°C	°F	seconds
27	80	60
29	85	35
32	90	22
35	95	17

If using the above figures the unit passes the film too quickly through the developer, then solutions should be made up more concentrated than normally recommended, probably 1 part developer to 2 parts water.

The solutions will probably last about 3 weeks in the lower temperature processors (around 20°C) and will develop about 300 films/litre of developer. However, for processors operating at elevated temperatures, replacement of the chemicals will probably be necessary weekly.

Where the temperature of operation is higher than 28°C chemicals designed for use in automatic processors at elevated temperatures must be used. Chemicals intended for use in manual processing are not suitable for use at high temperatures.

Replenishment of developer solution may be necessary, and on units operating at around 32°C or more, 20% replenishment every two or three days is required.