RADIATION HEALTH SERIES

No. 4

GUIDANCE NOTES

ON

RADIATION PROTECTION

FOR

DENTAL RADIOLOGY

Radiation Health Division
Department of Health

Foreword

The Radiation Health Series serves to provide some basic information on the safe use of ionizing radiation in medicine, industry and education in the Hong Kong SAR.

We have prepared these information brochures on the basis of the recommendations made by notable international authorities, such as the International Commission on Radiological Protection (ICRP), World Health Organisation (WHO), International Labour organization (ILO) and International Atomic Energy Agency (IAEA). We hope you find the information useful in safeguarding your own health, as well as the health of your neighbours, when you work with ionizing radiation.

If you have questions on the contents of these documents or have suggestions on improvements, please contact us at the

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Preface

This booklet is prepared for those who use ionising radiation in dental radiology. It applies to the use of equipment specifically designed for radiography of the teeth or jaws including radiography using an intra-oral film (or, with the same equipment, an extra-oral film), panoramic tomography with an extra-oral X-ray tube, panoramic radiography with an intra-oral X-ray tube and cephalometric radiography. While primarily concerned with the use of the equipment for the examination of patients, the guidance is also relevant during testing, measurement of the radiation produced, staff training, research into examination techniques, the examination of volunteers in approved research projects and other uses at the place where the equipment is normally used.

All persons (e.g. employer, technical staff, and medical staff) whose work directly concerns radiation protection in dental practice should find some sections of these guidance notes relevant to their work.

With regard to any future developments in protection from usage of ionising radiation that are not covered by these guidance notes, advice may be sought from the Radiation Health Division.

INTERPRETATION AND REGULATIONS

Ionising Radiation means electromagnetic radiation (e.g. x-ray, gamma ray) or corpuscular radiation (e.g. alpha particles, beta particles, electrons, positrons, protons, neutrons or heavy particles) being electromagnetic radiation or corpuscular radiation capable of producing ions and emitted from a radioactive substance or from a machine that is intended to produce ionising radiations, or from a machine in which electrons are accelerated by a voltage of not less than 5 kilovolt.

Irradiating Apparatus means any apparatus which –

(a) is intended to produce or emit ionising radiation; or

(b) is capable of producing or emitting ionising radiation at a dose rate exceeding of 5μSv per hour at a distance of 5cm from any accessible point of the surface of the apparatus.

Radioactive Substances means any substance which consists of or contains any radioactive chemical element whether natural or artificial and whose specific activity exceeds 75 becquerel of parent radioactive chemical element per gram of substance.

Radiation Work means work by any person involving the operation of irradiating apparatus in which the person may be liable to receive a dose of radiation exceeding 6 millisievert to any part of the body in any calendar year. Such a person shall be classified as a radiation worker.

THE RADIATION ORDINANCE

All activities involving ionising radiation in Hong Kong are controlled by the Radiation Ordinance (Cap 303), Laws of Hong Kong and its subsidiary Regulations:

Radiation Ordinance (Cap 303)

Radiation (Control of Radioactive Substances) Regulations

Radiation (Control of Irradiating Apparatus) Regulations

Under this Ordinance and Regulations,

(1) No persons shall, except in accordance with a licence issued under this Ordinance and Regulations:-

(a) manufacture or otherwise produce; or

(b) sell or otherwise deal in or with; or

(c) have in his possession or use,

any radioactive substance or irradiating apparatus.

(2) Any person who contravenes any of the provisions shall be guilty of an offence and shall be liable to a fine of $50,000 and to imprisonment for 2 years.

Radiation Units and Basic Concept

1.1 Radiation Units

Radiation
It is the term used to describe the transfer of energy through space or matter in the form of electromagnetic wave or sub-atomic particles.

Ionisation
It is the process by which atoms lose, or sometimes gain, electrons and thus become electrically charges, being then known as ions. Ionising radiation encountered in medicine and dentistry comprises x-rays, gamma rays, electrons and sub-atomic particles.

Absorbed Dose
In simple term is the energy imparted by ionising radiation to unit mass of matter. The unit of absorbed dose is **gray (Gy)**.

Radiation Weighting Factors
It is recognised that different types of ionising radiations will have different degree of harmless to human body even the absorbed dose is the same. Radiation weighting factors are used to account for the difference. For example, neutrons are more damaging than x-ray and a factor of 20 is given to neutrons. The radiation weighting factor for x-ray is 1.

Equivalent Dose (H_T)
It is defined as the product of average absorbed dose in an organ or tissue and the radiation weighting factor. The unit of equivalent dose is **sievert (Sv).** A millisievert (mSv) is one-thousandth of a sievert and a microsievert (μSv) is one-millionth of a sievert.

Tissue Weighting Factors (W_T)
The probability of occurrence of some radiation effects in an organ or tissue is assumed to be proportional to the equivalent dose in the organ or tissue for radiation protection purposes. The effects of radiation may differ for various tissues of the

body. Tissue weighting factors are therefore introduced to represent the proportion of the risk resulting from irradiation of an organ or tissue of the body to the total risk when the whole body is irradiated.

Effective Dose (E)

The effective dose, E is the sum of the weighted equivalent doses in all the tissues and organs of the body. It represents the total risks to the whole body due to partial irradiation of body organs. It is given by the expression $E = \Sigma W_T H_T$

1.2 Biological Effects of Radiation

Radiation energy absorbed in living tissues initiates physical and chemical reactions that may result in biological changes. The detrimental effects that may arise from these changes are either somatic (i.e. they occur in tissues of the irradiated person) or hereditary (i.e. they occur in progeny of the irradiated person).

In many organs and tissues of the body there is a continuous process of loss and replacement of cells. An increase in the rate of loss, for example following exposure to radiation, may be compensated for by an increase in the replacement rate, but there will be a transient, and sometimes permanent, net reduction in the number of cells available to maintain the functions of the organ or tissue. Most organs and tissues of the body are unaffected by the loss of even substantial numbers of cells, but if the number of lost is large enough, there will be an observable injury or loss of tissue function. The probability of causing such an injury will be zero at small doses up to some hundreds of millisievert or more, the severity of the injury increases with dose. This type of effect is called “deterministic”.

Deterministic effects that may arise in specific tissues include, among others, cataract in the lens of the eye; non-malignant damage to the skin; gonadal cell damage (leading to impairment of fertility); cell depletion of the bone marrow (causing haematological deficiencies); and cell depletion in other organs causing, if severe, impairment of organ functions.

The outcome will be very different if the irradiated cells are modified rather than killed. The clone of cells resulting from the reproduction of a modified but viable somatic cell is almost always eliminated or isolated by the body defences. If it is not, it may well result, after a prolonged delay called the latent period, in the development of a malignant condition, a cancer. The probability of causing a cancer usually increases with dose in a way that is roughly proportional to dose, probably with no threshold. The severity of the malignant condition is not influenced by the initiating dose. This kind of injury is called "stochastic", meaning "of a random or statistical nature". If the original damage is done in stem cells in the testes or ovaries whose function is to transmit genetic information to later generations, the effect may be expressed in later generations.

1.3 Hazard and Risks

When radiation was initially used in medicine, concern was primarily with the hazard arising from the exposure of a few workers to relatively large doses. Concern has now been extended to include deleterious effects that might be expected to arise from the exposure of a large number of workers to relatively small radiation doses. The anticipated detriment is mainly a small increase in the incidence of cancer.

Epidemiological data on cancer are being collected for a number of groups — principally persons who have been medically irradiated, atomic bomb survivors and occupationally exposed person. The risk for radiation induced fatal cancers at low doses and low dose rate was of the order of 5×10^{-2} per Sv average for both sexes and ages.

Hereditary effects caused by ionizing radiation have not been observed in human beings, and genetic risk estimates are based on laboratory animal data. The risk factor for severe hereditary disorders from low dose and dose rate over all generations of offspring is estimated to be 0.5×10^{-2} per Sv.

The effects on the conceptus of exposure to radiation depend on the time of exposure relative to conception. When the number of cells in the conceptus is small and their nature is not yet specialized, the effect of damage to these cells is most likely to

take the form of a failure to implant or of an undetectable death of the conceptus. It is thought that any cellular damage at this stage is much more likely to cause the death of the conceptus than to result in stochastic effects expressed in the live-born child, despite the fact that the central nervous system and the heart are beginning to develop in the third week. During the rest of the period of major organogenesis, malformations may be caused in the organ under development at time of exposure. These effects are deterministic in character with a threshold in man, estimated from animal experiment, to be about 0.1Gy.

1.4 The Aim of Radiological Protection

The primary aim of radiological protection, as stated in *ICRP Publication 60*, is "to provide an appropriate standard of protection for mankind without unduly limiting the beneficial practices giving rise to radiation exposure".

Several features of medical practice require an approach to radiological protection that is slightly different from that in other practices:

(a) The exposure of patients is deliberate. Except in radiotherapy, it is not the aim to deliver a dose of radiation, but rather to use the radiation to provide diagnostic information or to conduct interventional radiology. Nevertheless, the dose is given deliberately and cannot be reduced indefinitely without prejudicing the intended outcome.

(b) The patient needs a special relationship with the medical and nursing staff. For this reason, the system of protecting the staff from the source, e.g. shielding, should be designed to minimise the sense of isolation experienced by the patient. This is particularly relevant in nuclear medicine and brachytherapy, where the source is within the patient.

(c) In radiotherapy, the aim is to destroy the target tissue. Some deterministic damage to surrounding tissues and some risk of stochastic effects in remote non-target tissues are inevitable.

(d) Hospital and radiology facilities have to be reasonably accessible to the public, whose exposure is thus more difficult to control than it is in the industrial premises.

2. General Measures for Radiological Protection

2.1 The Three Principles of Radiological Protection

(a) Justification of a Practice

No practice involving exposure to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes.

Most of the assessments needed for the justification of a practice are made on the basis of experience, professional judgement, and common sense, but quantitative decision-aiding techniques are available and, if the necessary data are accessible, should be considered.

There are three levels of justification of a practice in medicine:

i) At the first and most general level, the use of radiation in medicine is accepted as doing more good than harm. Its justification is now taken for granted.

ii) At the second level, a specified procedure with a specified objective is defined and justified, e.g. chest radiographs for patients showing relevant symptoms. The aim of this generic justification is to judge whether, in most cases, the radiological procedure will improve the diagnosis or treatment or will provide necessary information about the exposed individuals.

The generic justification of the procedure is a matter for national professional bodies, sometimes in conjunction with national regulatory authorities. The total benefits from a medical procedure include not only the direct health benefits to the patient, but also the benefits to the patient's family and to society. Although in medicine, the main exposure is to patients, the exposures to staff and to member of the public who are not connected with

procedures should be taken into account. The possibility of accidental or unintended exposures should also be considered. The decisions should be reviewed from time to time as new information becomes available about the risks and effectiveness of the existing procedure and about new procedures.

The justification of diagnostic investigations for which the benefit to the patient is of the primary objective needs special consideration. In the use of radiography for insurance purpose, the primary benefit usually accrues to the insurer, but there may be some economic benefit for the individual examined.

iii) At the third level, the application of the procedure to an individual patient should be justified, i.e. the particular application should be judged to do more good than harm. Beyond checking that the required information is not already available, no additional justification is needed for the application of a generically justified simple diagnostic procedure to an individual patient with the symptoms or indications for which the procedure has already been justified generically. For complex diagnostic procedures and for therapy, generic justification may not be sufficient. Individual justification by the radiological practitioner and the referring physician is then important and should take account of all the available information. This includes the details of the proposed procedure and of any alternatives, the characteristics of the individual patient, the expected dose to the patient, and the availability of information on previous or expected examinations or treatment.

(b) **Optimisation of Protection**

In relation to any particular source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposure where these are not certain to be received should all be kept as low as reasonable achievable, economic and social factors being taken into account.

The Optimisation of protection is the most powerful of the components of the system of radiological protection. It should pervade all stages of the use of radiation in medicine. The underlying idea of Optimisation can be expressed by the question:

Are There Any Reasonable Steps That I Can Take To Improve Protection?

The basic aim of Optimisation of protection is to adjust the protection measures relating to the application of a source of radiation within a practice in such a way that the net benefit is maximized.

As with justification, experience, professional judgement, and common sense play major roles in the procedures of Optimisation, all of which are consistent with the good practice of medicine.

(c) Dose Limits

The exposure of individuals resulting from the combination of all the relevant practices should be subject to dose limits as stipulated in the Radiation Ordinances (Cap 303), Laws of Hong Kong.

Individual dose limits have been set for occupational and public exposure so that a continued exposure just above the dose limits would result in additional risks from the relevant practices that could reasonably be described as ‘unacceptable’ in normal circumstances.

Provided that the doses to patients have been properly justified, it is not appropriate to apply dose limits to medical exposures, because such limits would often do more harms than good. They would sometimes prevent diagnostic information from being obtained and would prevent all radiotherapy. Furthermore, the benefits and detriments from medical exposures apply to the same individual, the patient; there is no inequity.

The dose limits stipulated in the Radiation Ordinance (Cap 303), Laws of Hong Kong are mainly given in Table 1:

Table 1 Dose Limits

Exposure Scenario	Exposed body regions	Dose Limit
Public	Whole body	1mSv in any calendar year
Occupational	Whole body	20mSv in any calendar year
	Individual organ / tissue (other than lens of the eye) or any body extremity or area of skin average over any $1cm^2$	500mSv in any calendar year
	Lens of the eye	20mSv per calendar year, averaged over any 5 consecutive calendar years or 50mSv in any calendar year
	Abdomen of a woman with reproductive capacity	5mSv in any consecutive 3 months interval
	Fetus	1mSv during the pregnancy of the women

2.2 Classification of Areas

One of the most important functions of management requirements is that of maintaining control over the sources of exposure and over the workers who are occupationally exposed. The control of sources of exposure is helped by requiring that the workplaces be formally designated. There are two designations of workplaces:

a) Controlled Areas

A controlled area is one in which normal working conditions, including the possible occurrence of minor mishaps, require the workers to follow well-established procedures and practices aimed specifically at controlling radiation exposures.

The entrance to controlled area should be marked with a warning notice which should state that the area is controlled. It should incorporate a radiation warning sign; it may also include other precise information, such as the reason why the area is controlled, e.g. "x-radiation", and whether or not entry is permitted together

with any conditions. Appendix A shows some samples of these warning notices.

In Radiology Department, certain areas will normally be classified as controlled areas. The requirements will vary depending upon whether fixed, mobile or portable x-ray equipment is in use. In fixed installations the entire x-ray room should be a controlled area, unless the equipment is switched off from the electrical main supply. The use of controlled areas around mobile/portable x-ray equipment is less useful than in the case of fixed equipment. It is more appropriate to establish ***working procedures*** to control access to the vicinity of the equipment. In particular, the procedures should require an assessment to establish whether additional temporary shielding is needed to provide protection for staff in nearby areas. In areas where there may be regular use of mobile equipment, the need for permanent shielding should be considered.

b) Supervised Area

A supervised area is one in which the working conditions are kept under review, but special procedures are not normally needed. The supervised area is set up with the aim of ensuring that the doses to workers can confidently be predicted to be less than 3/10 of the occupational dose limit.

In defining these areas, account should be taken both of the expected levels of exposure and of the likely variations in these exposures. The aim should be to ensure that any one outside the designated areas will not need to be regarded as occupationally exposed. The dose limits are intended to apply to all workers, but should enable the actual doses received outside the designated areas to be kept below the dose limits for public exposure.

2.3 Personal Monitoring

Employer should provide to their employees, who are classified as radiation workers or required to work in controlled areas under a written system of work, a suitable personal radiation

monitoring device of a type approved by Radiation Board, to monitor their radiation doses. Each dosimeter is normally worn for 1 month. Dosimeters should be returned promptly after use for dose assessment and replaced with new ones.

Employees who are issued with dosimeter should wear it as instructed **all the time** they are at work. Care should be taken to prevent the dosimeter, while not being worn, from being exposed inadvertently to ionising radiation or subject to other conditions, e.g. heat, which could affect the assessment of doses. A dosimeter should normally be worn on the trunk at chest or waist height.

2.4 Medical Surveillance

Persons who are classified as radiation workers shall be medically examined by the *Medical Panel* of the Radiation Board within 4 months immediately preceding their first employment and again in a period of not more than 14 months for continued employment.

3 Examinations Directly Associated with Illness or Injury

3.1 All diagnostic procedures including exposure to radiation for medical purposes may carry some personal risk. The direct or indirect irradiation of patients' gonads may constitute a risk to future generations and in pregnancy there may be a risk to the foetus also. It is important therefore that only those medical exposures that are necessary should be undertaken. Alternative methods of obtaining the required diagnostic information should be considered, for example, by the use of non-ionising radiation. A person who requests an examination should be satisfied that it is necessary, taking into consideration the benefits expected from the examination and the radiation dose involved. They should ascertain first whether there are records of previous examinations which are relevant to the proposed examination. When an examination is requested, the clinical indications, the provisional diagnosis, and the information required should be stated.

3.2 To reduce unnecessary examinations, administrative services should provide for the ready availability of previous films and for the rapid transfer on request of films or copies from one establishment or practice to another. Access to reports, filed in patients' records, can help to avoid or limit the need for further examinations.

3.3 If a person requested to undertake the examination has any doubt about its advisability or about the nature of the examination required, the matter should be resolved by consultation between the medical officers responsible for the clinical and radiological care of the patient. Case discussions attended by clinicians, radiologists and other staff, as appropriate, provide an opportunity for the critical assessment of the value and possible hazards of proposed X-ray examinations.

4 Examinations not Directly Associated with Illness or Injury

4.1 Screening programs should be undertaken only if the expected medical benefits to the individuals examined and to the population as a whole exceed the economic and social costs, including the risks associated with the radiation dose involved. Since benefits are not always the same for all members of the population, screening should be limited normally to particular groups.

4.2 Some type of examinations result in benefits which are shared by the person who is examined, the employer and a third party (e.g., an insurer). Such an examination should be requested only on specific medical advice and if it is expected to show net benefit to the subject. It should not be requested if the results of a previous examination, giving the required information, can be obtained.

5. Procedures to Reduce Radiation Doses in Dental Radiology

5.1 Location and installation

Dental radiography should be carried out in a room (the X-ray room) from which all persons whose presence is unnecessary are excluded while X-rays are being produced. This room,

which may be a dental surgery or a separate examination room, should not be used for other work or as a passageway whilst radiography is in progress.

5.1.1 The X-ray room should be large enough to provide safe accommodation for those persons who have to be in the room during X-ray examinations. Dental X-ray equipment should be installed so that the person operating it can be at least 2m from the X-ray tube and from the patient and therefore well outside the radiation harm.

5.1.2 Persons in all occupied areas outside the X-ray room should be adequately protected. Adjacent areas, for example, those used as waiting rooms, should not be controlled or supervised areas. The X-ray room should be arranged so that:

(a) the radiation beam is directed away from those area;

(b) use is made of the natural shielding of the walls, floor and ceiling of the X-ray room where these are relatively thick or dense, e.g., of brick or concrete; and

(c) advantages are taken of the reduction in radiation level by distance.

If the normal structural materials do not provide sufficient shielding (e.g., a light-weight partition wall may sometimes be in the radiation beam), protective materials such as lead ply should be attached to the wall concerned. The equipment should be installed so that the useful beam is directed away from any door or window, if the space immediately beyond is occupied.

5.2 Warning Notices and Room Warning Signals

5.2.1 There should be a radiation warning sign, together with any appropriate words on any X-ray room door that opens directly into an area where the radiation dose rate is greater than 3μSv/h.

5.2.2 When the controlled area extends to any entrance of the X-ray room an automatic warning signal should be given at that entrance while radiation is emitted.

5.2.3 If more than one X-ray source is sited in any room, e.g.,

in open plan accommodation, suitable arrangements should be made to ensure that patients and staff are adequately protected.

5.3 Maintenance

5.3.1 The radiation safety features of equipment should be maintained and checked in accordance with the advice of the manufacturer or the supplier.

5.3.2 Electrical and mechanical faults sometimes give rise to inadvertent radiation exposure, for example, a faulty cable to a hand switch or failure of the mechanical stops which limit rotational movement and such faults should be borne in mind when routine maintenance is undertaken.

5.3.3 Routine checks should be made to detect if any deterioration in quality or repeatability of radiographs occurs and if so whether this is due to deterioration in processing procedures or to faulty X-ray equipment.

5.3.4 A record of maintenance including any defects found and their repair should be kept for each item of X-ray equipment.

5.4 General Procedures

5.4.1 Since the radiation beam is not always fully attenuated by the patient, it should be considered as extending beyond the patient until it has been attenuated by distance or intercepted by primary protective shielding, e.g., a brick wall.

5.4.2 If it is necessary to support a handicapped patient or a child, this should be done by their parents or other accompanying adults, but this should not be done by pregnant women. Any person supporting a patient should be given adequate instructions and if practicable should wear protective clothing.

5.4.3 The tube housing should never be held by hand during an exposure. The operator should stand at least 2m away, making use of the full length of cable to the exposure switch. Where a protective panel is provided the operator should stand behind it.

5.4.4 Any staff member who enters a controlled area should

either be classified persons or do so under a written system of work, which may include the need to wear a personal dosimeter and annual medical examinations.

5.4.5 Where equipment provides a choice of beam sizes, the smallest reasonably practicable should be used.

5.4.6 The operator should check that the equipment warning light and, where provided, any audible warning signal operates at each exposure and ceases at the end of the intended exposure time. If the warning does not operate or there is reason to think that the timer is defective or that there may be some other faults (e.g., signs of damage, excessive X-ray tube temperature), the equipment should be disconnected from the supply and not used again until it has been checked and, if necessary, repaired.

5.5 Films and Processing

5.5.1 The fastest available films consistent with satisfactory diagnostic results should be used. Intra-oral films should be of ISO speed group D or faster. Extra-oral films should be of the 'screen' type and should be used in a cassette with intensifying screens.

5.5.2 Strict attention should be paid to correct and consistent film processing so as to produce good quality radiographs and avoid the necessity for repeat examinations. The temperature of the developer should be checked prior to film processing and the development time adjusted in accordance with the film manufacturer's instructions. The developer should be changed at least once a month.

5.6 Intra-oral film Radiography

This section applies to the use of intra-oral films wholly (standard or small periapical or bitewing) or partly (occlusal) in the mouth: also to the use of extra-oral films with similar equipment.

5.6.1 A field-defining spacer-cone should be used. When alternative cones are available or interchangeable cones are provided, the one most suited to the technique to be employed should be fitted. The tip or open end should be placed as close as

possible to the patient's head to minimise the size of the incident beam: beam diameters should not exceed 6cm. If it is desired to use a larger focal-spot to skin distance a longer cone should be employed.

5.6.2 The beam should not be directed towards the gonads. If the patient is a woman who is, or who may be, pregnant, care should be taken that the foetus is not irradiated inadvertently. Where such a beam direction cannot be avoided, the patient's body should be covered by a protective apron having a protective equivalence of not less than 0.25mm lead.

5.6.3 The dental film should be held by the patient when it cannot otherwise be kept in position. It should never be hand-held by anyone else. Exceptionally it may be held by someone other than the patient using a pair of forceps to avoid direct irradiation of their fingers, for example, when a child or a handicapped person cannot hold it themselves. In such cases protective gloves and aprons should be worn.

5.6.4 The exposure factors should be checked by the operator on each occasion before an examination is made. This is particularly important when a short cone is used after a long cone and when there is more than one beam size setting; the larger apertures may be quite unsuitable for use with intra-oral films.

5.6.5 Intensifying screens should be used with extra-oral films and for vertex occlusal views.

5.7 Panoramic Tomography

The irradiation switch should be released immediately to avoid high localised exposure of the patient if the rotational movement fails to start or stops before the full arc is covered.

5.8 Panoramic Radiography with an Intra-oral X-ray Tube

Beam applicators should be used to minimise the absorbed dose to tissues, such as the tongue, which do not have to be irradiated for the production of a satisfactory radiograph. Care should be taken in positioning the X-ray tube in order to get satisfactory and consistent results. Intra-oral panoramic units still in use

should be phased out as soon as practicable.

5.9 Cephalometry

5.9.1 The focal-spot to skin distance should never be less than 30cm. It will usually be greater than 100cm.

5.9.2 The patient should be positioned in relation to the X-ray field by means of a cephalostat. An ordinary dental X-ray set should not be used for cephalometry, other than with specially designed ancillary equipment.

6. Equipment for Dental Radiography

6.1 General Recommendations

This section applies to equipment specifically designed for radiography of the teeth or jaws including panoramic radiography and tomography, and cephalometric radiography.

6.1.1 Dental X-ray equipment should be designed, constructed and installed to be in compliance with IEC 601-1 or other recognised standards of construction that will enable the recommendations in this chapter to be met. It should be maintained in accordance with the recommendations of its manufacturer or manufacturer's authorised representative. It cannot be considered safe, from a radiation point of view, unless it is in good order both mechanically and electrically.

6.2 X-ray Source Assembly

6.2.1 Every X-ray source assembly (comprising an X-ray tube, an X-ray tube housing and a beam limiting device) should be constructed so that, at every rating specified by the manufacturer for that X-ray source assembly, the air kerma from the leakage radiation at a distance from the focal spot of 1m averaged over an area not exceeding 100cm^2 does not exceed 1mGy in one hour. In practice, for equipment intended for dental radiography with an intra-oral film, leakage radiation will not exceed 0.25mGy per hour.

6.2.2 The X-ray source assembly should be marked to identify the nominal focal spot position.

6.3 Beam Filtration

6.3.1 The total filtration of the beam (made up of the inherent filtration and any added filtration) should be equivalent to not less than the following:

(a) 1.5mm aluminium for X-ray tube voltages up to and including 70kV;

(b) 2.5mm aluminium of which 1.5mm should be permanent for X-ray tube voltages above 70kV.

The use of filtration significantly greater than these values may be undesirable.

6.3.2 The inherent filtration should be marked clearly on the housing and every added filter should be marked with its filtration in millimetre aluminium equivalent. The value of the added filtration should be marked clearly on the tube housing.

6.4 X-ray Tube Voltage

The X-ray tube voltage should not be lower than 50kV and for intra-oral radiography should be preferably about 70kV.

6.5 Beam Size and Distance Control

6.5.1 Equipment for radiography using an intra-oral film should be provided with a field-defining spacer-cone which will ensure a minimum focal-spot to skin distance of not less than 20cm for equipment operating above 60kV and not less than 10cm for equipment operating at lower voltages. The correct setting of the equipment is particularly important where two or more interchangeable cones for different radiological techniques are available. The field diameter at the patient end of the cone should not exceed 6cm.

6.5.2 For panoramic tomography the beam size at the cassette holder should not exceed 10mm x 150mm. The total beam area should not exceed the area of the receiving slit of the cassette holder by more than 20%.

6.5.3 Equipment for cephalometry should have a light beam diaphragm or other suitable means for confining the useful beam to the area of diagnostic interest.

6.6 Signal and Marking

6.6.1 There should be a visible indication on the control panel, preferably including an indicator light, to show that the mains is switched on. In the context of the control panel signal this indicates a state of readiness to emit radiation.

6.6.2 All dental equipment control panels should be fitted with a light which gives a clear and visible indication to the operator that an exposure is taking place. The light should be triggered by conditions associated uniquely with the commencement and termination of the emission of radiation, but arranged to be seen irrespective of the exposure duration. For equipment fitted with an audible warning the warning should be triggered by the same conditions.

6.7 Exposure Control

6.7.1 The exposure should be terminated automatically when a predetermined conditions, such as a pre-set time, has been attained.

6.7.2 Exposure switches on all dental X-ray equipment should be arranged so that an exposure continues only while continuous pressure is maintained on the switch and terminates if pressure is released. To guard against automatic timing failure, an additional means of termination should be provided which is independent of the normal means. The release of the exposure switch may be regarded as the additional means when this action overrides the timer.

6.7.3 Exposure switches should be designed to prevent inadvertent production of X-rays. If re-setting is automatic it should be ensured that pressure on the switch has to be released completely before the next exposure can be made.

6.7.4 The exposure switch should be arranged so that the operator can be at least 2m away from the tube and the patient during exposure.

Appendix A

Radiation Warning Signs

Local Rules for Dental X-ray Room

1. Before making an exposure, close the doors of the x-ray room.

2. The direct beam must not irradiate any person other than the patient being radiographed.

3. During radiography all staff must stand behind the protected control panel and may observe the patient through the lead glass window.

4. No patient should wait or change in the x-ray room while another patient is being radiographed.

5. Whenever possible the dental film should be fixed in position, otherwise it should be held by the patient. It should never be held by the dentist or staff.

6. When making an exposure, the staff should stand as far away from the patient as possible to avoid the radiation that is scattered in all directions. If it is necessary to be as near as 1m, a protective apron should be worn.

7. Patients should be protected by lead apron (at least 0.25mm lead equivalent) large enough to cover the whole trunk.

8. The x-ray beam size should be restricted by suitable cylindrical cones to the minimum aperture appropriate to the particular examination.

9. Radiological examinations should not be made in the absence of clear-cut clinical indications. Extensive or repeated x-ray examinations of children or pregnant women should not be undertaken without considerable forethought.

10. If anyone is ever required to support a patient or film during an exposure, he must :

    (i) wear a protective apron and gloves and avoid the direct beam by standing to one side and away from the x-ray tube;

    (ii) record, in the notebook provided, his name, the date, the number of exposures, and the radiographic techniques used.

Radiation Health Series

No. 1	Guidance Notes on Radiation Protection for Diagnostic Radiology
No. 2	Safe Handling of Radioactive Consignments
No. 3	Techniques to Reduce the Radiation Hazards from Using Phosphorus-32
No. 4	Guidance Notes on Radiation Protection for Dental Radiography
No. 5	Code of Practice for the Handling, Storage, Packaging, Transportation and Disposal of Radioactive Wastes
No. 6	Ionising Radiation
No. 7	Guidance Notes on the Design of Protective Shielding for Medical, Dental and Veterinary Diagnostic X-ray Facilities
No. 8	Safe Handling of Nuclear Moisture and Density Gauges