The Safe Use of X-rays Overview

This module is based on a number of documents to include the latest legislation and the most recent dental guidance notes (2020). It has been designed as a ready-source of information for your reference only (ultimately any radiation protection advice will need to be verified by your Radiation Protection Adviser (RPA)/Medical Physics Expert (MPE) for your particular practice requirements and circumstances.

- The Ionising Radiations Regulations 2017 (IRR17) came into force on 1st January 2018 and replaced (IRR99). They cover the radiation protection of staff, the workplace and the public. These regulations are enforced by the Health and Safety Executive

- The Ionising Radiation (Medical Exposure) Regulations 2017 (IR(ME)R2017) came into force on 6th February 2018 and replaced (IR(ME)R2000). They cover the radiation protection of persons undergoing medical exposures and now include additional aspects such as regulation of 'non-medical imaging' and 'carers and comforters' (which was originally in IRR99). These regulations are enforced by the Care Quality Commission (CQC)

- If you use X-ray equipment in your practice you must register the 'use of a radiation generator' with HSE. It costs £25 to register and you only need to do it once for each business, no matter how many sites you have

- You must formally appoint 2 external experts; a Radiation Protection Adviser (RPA) and a Medical Physics Expert (MPE) to advise on both IRR17 and IR(ME)R2017

- You must appoint a suitable Radiation Protection Supervisor/s (RPS) in writing, this is normally the practice principal or a nurse qualified in dental radiography, although a competent practice manager could also be an appropriate appointee

- You must ensure continuity of RPS cover. For example, if one RPS only works at a practice for part of the week the appointment of an additional 'deputy' would be appropriate

- Practices must carry out a Radiation Risk Assessment before their work with x-rays begins and when there are any changes in working conditions at the practice (e.g. introducing a Cone Beam CT (CBCT) unit). Employers must consult their RPA about the areas to be covered - using either the Health and Safety Risk Assessment document (M 250B) or a template provided by their RPA

- Employers must notify their enforcing authority about any accidental or unintended exposures using Unintended Exposure -– Internal Assessment Forms (M 275B)

- If an accidental exposure was due to equipment malfunction and it affected team members, or a member of the public, you must also notify HSE

- You must keep a log of x-ray equipment and testing as part of your quality assurance programme. Practices can use either the Equipment Log (M 271A) and Individual Equipment Records (M 271B) or templates provided by their RPA

- The frequency of routine (radiological) testing for intra-oral and panoramic dental x-ray equipment (i.e. testing with RPA/MPE involvement) is at least once every 3 years

- For CBCT units this could be at 3 yearly intervals if regular QA tests using a manufacturer supplied 'phantom' are carried out at the practice - otherwise this routing testing needs to be undertaken annually by your RPA/MPE.

- Handheld dental equipment must be tested once a year

- Day-to-day checks must also be recorded. iComply members can use Radiograph Quality Record forms (G 125A)

- Referrers, Practitioners and Operators must be adequately and appropriately trained with the scope of their roles indicated by the Employer in their written procedures. This list must be kept up-to-date

- GDC registered staff must carry out at least 5 hours of radiation protection CPD as part of their 5-yearly 'Enhanced CPD' recertification cycle. All team members (and particularly anyone appointed as an RPS) must ensure that this CPD contains the required IRR17 elements

- Team members identified as practitioners and operators in the practice Employers Procedures must ensure that their CPD contains the required IR(ME)R2017 information

- Inspectors from HSE would check that the required IRR17 CPD has been undertaken and inspectors from a regulator such as CQC/HIW/NHS/HIS/RQIA will check that team members are up-to-date with the IR(ME)R aspects of their CPD. Any inspector would want to see that practices monitor compliance in this area (provision of copies of course programmes would assist this). Isopharm's practice reporting for CPD would allow you to monitor this easily

- Employers must carry out regular quality assurance programmes related to radiograph quality and written procedures. Your RPA/MPE is required to discuss this with you and help construct an appropriate programme for your practice. Alternatively, CODE has provided documents you can use. For more information see Radiology Quality Assurance (G 125)

- Practices must ensure that they have a Radiation Protection File (a file containing IRR17 and IR(ME)R2017 compliance documentation such as the Radiation Risk Assessment, the practice Local Rules and the Employers Written Procedures) that is relevant to the work they undertake at the practice - and that it is kept up-to-date. The practice's RPA and MPE must be involved in helping to create the file. For more information see The Radiation Protection File section (M 275D)

- IRR17 requires doses to staff to be assessed by personal dosimetry or other suitable means. The 2nd Edition Dental Guidance Notes recommend that doses to staff are assessed either with the issue of personal dose badges, or by using environmental badges with an audit of the number of exposures each staff member is involved with. If the results of this dosimetry (over a period of around 6 months) confirms very low doses then it can be discontinued.

- The updated guidance suggests considering the issue of personal dosimetry to pregnant staff members from the declaration of their pregnancy to the start of their maternity leave

- Employers are required to set a Dose Investigation Level as part of the risk assessment process. This is an annual Effective dose level which if exceeded would require an investigation to determine why this has happened. The Dose Investigation Level is usually set at 1 mSv for dental practices

- There is no justification for the routine use of lead rubber aprons for patients in dental radiography and their use in panoramic or CBCT examinations is to be discouraged. Thyroid collar use needs to be considered if the thyroid gland is likely to be in the direct beam

- There are additional considerations when introducing a CBCT unit into the practice, including training (Level 1 and Level 2) and ongoing CPD requirements

- There are additional considerations when introducing hand-held x-ray sets into a practice

The Regulations
Ionising Radiations Regulations 2017 (IRR17)
Ionising Radiation (Medical Exposure) Regulations 2017 (IR(ME)R2017)
Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2018 / IR(ME)R(NI)18

Guidance
Working with ionising radiation. Ionising Radiations Regulations 2017. Approved Code of Practice and guidance (L121)
Guidance Notes for Dental Practitioners on the Safe Use of X-ray Equipment 2nd Edition (2020)
Medical and Dental Guidance Notes. The Institute of Physics and Engineering in Medicine (IPEM)
Guidance on the Safe Use of Hand-held Dental X-ray Equipment, PHE-CRCE-023

Additional Information
Enforcing Authorities

These are:

- Care Quality Commission (CQC) for England
- Scottish Ministers for Scotland
- The Health Inspectorate of Wales (HIW)
- Regulation and Quality Improvement Authority (RQIA) for Northern Ireland

(2) Non-medical imaging
These are defined as exposures deliberately undertaken using medical radiological equipment which do not confer a health benefit to the individual exposed.

Examples include but not limited to:

- Health assessment for employment purposes
- Health assessment for immigration purposes
- Health assessment for insurance purposes
- Radiological age assessment
- Identification of concealed objects within the body

The new regulations require that employers have a procedure in place for non-medical exposures. However, all professional associations including CODE and The Faculty of General Dental Practice advise that clinicians avoid taking Non-medical images as the majority will not be indemnified for these procedures.

(3) Carers and comforters
Carers and comforters are individuals who are knowingly and willingly exposed to ionising radiation through support and comfort of those undergoing exposure. The definition makes clear that individuals undertaking this role are commonly relatives or friends of those undergoing exposure and not those doing so as part of their employment.

Where there is to be an exposure to a carer or comforter, the practitioner is required to justify the exposure and if a practice does have cause to use a carer or comforter then they will need to determine a local diagnostic reference level for this situation on consultation with their MPE. Appropriate instructions will also need to be given to ensure that the dose to the carer/comforter will be kept as low as reasonably practicable.

Employer's Responsibilities and Duties

The 'Employer' is defined as a person or body that has the legal responsibility for implementing the Ionising Radiation Regulations 2017 and the Ionising Radiation (Medical Exposure) Regulations 2017. The 'Employer' must be named on any Local Rules and Employers Procedures – and carry out the duties as indicated below.

Summary

- Complete registration with HSE
- Appoint a Radiation Protection Adviser and Medical Physics Expert
- Carry out a Radiation Risk Assessment
- Appoint a suitable Radiation Protection Supervisor
- Construct Local Rules (including contingency arrangements)
- Keep documentary records of all x-ray equipment and their testing (e.g. critical examinations and acceptance testing, routine (radiological) testing and general electrical and mechanical maintenance)
- Ensure team members (Referrers, Practitioners, Operators and others) receive adequate training appropriate to their positions and responsibilities
- Have a quality assurance programme in place
- Have in place referral guidelines for radiographic examinations
- Ensure the Radiation Protection File is constructed and kept relevant and up-to-date
- Ensure that radiation doses to staff, patients and the public are restricted so far as is reasonably practicable
- Collect dose estimates from dental radiographic exposures (with input from the RPA/MPE)

1. Complete registration with HSE

If you use X-ray equipment in your practice you must register with HSE. It costs £25 to register and you only need to do it once for each business, no matter how many sites you have. The application can be submitted by an authorised employee, but can't be submitted by a third party on your behalf (e.g. your RPA).

2. Appoint a Radiation Protection Adviser and Medical Physics Expert

Radiation Protection Adviser (RPA)

A suitable Radiation Protection Adviser must be appointed in writing with a clear description of the required scope of advice. This includes:

- Prior examination of plans for installation and acceptance of dental x-ray equipment. The critical advice given will relate to shielding and compliance with the IRR17 hierarchy of control measures
- Helping draw up appropriate Radiation Risk Assessments
- The implementation of the requirements for designated (controlled) areas, local rules and contingency arrangements.
- Advice on the suitability, use and checking of radiation dosimeters
- Periodic examination and testing of engineering controls, design features, safety features and warning devices
- Contingency plans
- The conduct of any investigations, required by the regulations (following an incident or accident situation)
- QA programmes

Medical Physics Expert (MPE)

- This is an individual having the appropriate knowledge, training and experience to act or give advice on the application of physics to the diagnostic uses of ionising radiation in the dental area

- The new regulations have formalised the recognition of medical physics experts by certification through RPA2000

Please note that it is the Employers responsibility to ensure that the RPA/MPE that is appointed has the relevant experience to be able to advise appropriately in the Dental area and you should ask them to provide evidence to confirm this.

3. Carry out a risk assessment

What is a risk assessment?

This is an assessment of the risk to any employee and any other person for the purpose of identifying the measures to restrict the exposure to ionising radiation. The employer must consult the RPA about the matters to be considered. iComply members can use the Health and Safety Risk Assessment (M 250B) or a template supplied by their RPA.

It should demonstrate that:

- All hazards with the potential to cause a radiation accident have been identified and evaluated
- Reasonable steps have been taken by the employer to prevent such accidents and limit their consequences should they occur

Matters needing to be considered:

- The nature of the sources of ionising radiation
- Estimated radiation dose rates to which anyone can be exposed
- The results of any previous personal dosimetry
- Advice from the equipment manufacturer about its safe use and maintenance
- Engineering control measures and design features.
- Planned or current systems of work
- The effectiveness and the suitability of PPE to be provided
- Access to working areas during exposures
- Possible accident situations, their likelihood and potential severity
- Consequences of failure of control measures
- Steps to prevent identified accidents, or limit their consequences

What will the radiation risk assessment help to identify?

- The actions needed to make sure the radiation exposure of all people is kept as low as reasonably practicable (ALARP)
- Steps necessary to achieve this control of exposure using the IRR17 Hierarchy of Control measures – i.e. engineering controls, design features, safety devices, warning devices and written systems of work
- The need for PPE and if so, which
- Whether it is appropriate to establish any dose constraints
- The need to alter the working conditions of any pregnant employee
- An appropriate dose investigation level
- The maintenance and testing schedules
- What contingency plans are necessary
- The training needs for employees to equip them with the information, instruction, training and equipment necessary to restrict their exposure to ionising radiation
- The need to designate specific areas as controlled or supervised areas
- An appropriate programme of monitoring or auditing of arrangements to check the requirements of these regulations are being met

How often should the risk assessment be reviewed?

- At intervals not exceeding one year
- At the introduction of new types of equipment
- When significant changes to working systems occur
- At the introduction of new legislation

4. Appoint a suitable Radiation Protection Supervisor
The Radiation Protection Supervisor (RPS)

- This is normally the practice principal or a nurse qualified in dental radiography, although a practice manager with other Health and Safety responsibilities would also be an appropriate appointee

- An RPS should be clear about the role they are expected to fulfil. This should be confirmed in writing so there is no confusion about the work expected of them

- Employers should consider the need for advice from the RPA about the suitability of RPS appointments

- RPSs help in ensuring compliance with IRR17 essentially through supervising staff compliance with the Local Rules of the practice.

- RPSs should receive appropriate training. This should include periodic refresher training to maintain competency levels and if changes are made to local rules

- It may not always be necessary for an RPS to be present all the time, however the number of RPSs must be sufficient to make sure that the work is adequately supervised

5. Have Contingency Plans in place
Where a risk assessment shows that a radiation accident is reasonably foreseeable, the employer must prepare contingency plans. A copy of the plans must be included in the Local Rules and any employees given sufficient instructions. It's recommended that rehearsals are carried out regularly.

Contingency plans are triggered by equipment related unintended exposures such as:

- Failure of exposure control to terminate automatically
- Failure of a panoramic/CBCT x-ray set's rotational motion due to machine malfunction
- Failure of a panoramic/CBCT x-ray set's rotational motion due to human error, for example the machine gets stuck over the shoulder of the patient
- Failure of a cephalometric x-ray set's scanning motion due to machine malfunction

Or operation related unintended exposures such as:

- The wrong patient being exposed
- The wrong body part including the wrong side being exposed
- A member of staff walks in to the controlled area while the x-rays are generated

Example plan

- Immediate actions
  - Isolate the machine from the mains supply using the switch located outside the controlled area
  - Inform the patient or staff member of the error that occurred
  - If the error is due to equipment malfunction, place a notice on the machine that the equipment should not be used again until the fault has been investigated and rectified by an adequately qualified service engineer
  - Inform the RPS, the Employer and subsequently the RPA/MPE
  - If the operator suspects that a patient has received a significant accidental or unintended exposure, follow the procedure for managing and reporting these exposures clearly marked in the Local Rules

- Investigate
  - Established what happened
  - Confirm this is an unintended exposure
  - Complete an Unintended Exposure - Internal Assessment Form (M 275B)
  - Identify the causes and contributory factors of the failure
  - Remedial action to minimise the chance of a similar failure
  - Estimate the doses involved with the help of the RPA/MPE

Notification

Employers must notify their enforcing authority about any accidental or unintended exposures, including the outcome of the detailed investigation and any corrective action taken. If the exposure was due to equipment malfunction and it affected team members, or member of the public, you must also notify HSE. Always consult with the RPA/MPE and have all the evidence to hand before contacting any of the enforcing authorities.

Notification to HSE

England, Scotland and Wales: HSE notifications of over exposure by email to: irrnot@hse.gov.uk	Northern Ireland: Email the form to HSE NI to: mail@hseni.gov.uk

Notification to enforcing authority

England to CQC: Online only https://www.cqc.org.uk/content/reporting-irmer-incidents	**Northern Ireland** to RQIA: All notifications should be reported directly to registration@rqia.org.uk using notification forms from the RQIA website.
Scotland: to HIS: Notifications should be made using their eForms notification portal. To access the portal you will need to register. Please email hcis.irmer@nhs.net with the name, email address and job title of the person to be registered. You will then be issued with a log-in that will allow you to submit notifications.	**Wales** to HIW: Download the form from the Notifying IRMER Incidents page on HIW website The form contains instructions on the various ways it can be submitted to HIW.

6. Keep an equipment log of X-ray equipment and their testing

Equipment log

Details of all X-ray equipment in practice including:

- Make
- Model
- Serial number
- Date of manufacture
- Date of installation
- Location in surgery

All maintenance and fault fixing records/reports should be kept and available for inspection. Practices can use either the Equipment Log (M 271A) and Individual Equipment Records (M 271B) or templates provided by their RPA. You must also retain disposal records including dates and approved company details if the machine has been disposed of.

Relevant testing:

i) Critical examination

- The responsibility of the installer who must consult with their (or the practice's) RPA
- It provides a description of the equipment and their location
- Its purpose is to ensure that any safety features and warning devices operate correctly and that there is sufficient protection for persons from exposure to the ionising radiation

ii) Acceptance test

- The responsibility of the Employer
- It provides baseline values so subsequent routine tests results can be compared
- The essential content is:
    - All tests carried out in the critical examination
    - Performance parameters (kV, mA, timer, output, etc.)
    - Typical patient dose compared to national Diagnostic Reference Levels

iii) Routine tests

- The responsibility of the Employer – carried out by the RPA/MPE
- It confirms that there have been no significant changes to the previous testing. It can identify possible deterioration
- The essential content is:
    - All tests carried out in the critical examination
    - Performance parameters (kV, mA, timer, output, etc.)
    - Typical patient dose compared to Diagnostic Reference Level
- The frequency of routine (radiological) testing for intra-oral and panoramic dental x-ray equipment (i.e. testing with RPA/MPE involvement) is at least once every 3 years
- For CBCT units this could be at 3 yearly intervals if regular QA tests using a manufacturer supplied 'phantom' are carried out at the practice - otherwise this routing testing needs to be undertaken annually by your RPA/MPE.
- Handheld dental equipment must be tested once a year

iv) General Maintenance/Servicing

- Manufacturers of x-ray equipment recommend that they need to have general electrical and mechanical maintenance conducted annually
- The engineer should provide a report detailing the checks undertaken and any issues/repairs performed (this should be kept as part of the quality assurance programme for the practice)

iv) Day-to-day checks for safe working of equipment
These can include:

- Warning light and sound system
- Cables
- Mains lights
- Switch cut out
- Hydraulics of the arm

Please check for any signs:

- Damage to x-ray tube/shielding with or without oil leakage
- Fraying or damage to the control lead or switch
- Any loose components of the x-ray machine

Day-to-day checks can be recorded on the Radiograph Quality Records forms (G 125A).

7. Ensure team members receive adequate training (Referrers, Practitioners and Operators)
Referrers, Practitioners and Operators must be adequately trained - and 'entitled' (named and authorised) by the employer, in their written procedures - to perform these roles in the practice. In most practices a dentist performs all three roles.

The following can act as referrers or practitioner within their scope of practice if they are adequately trained:

- Dentists
- Hygienist and therapists
- Clinical dental technician (removal dentures only related exposures)

The regulations require employers to make sure that practitioners and operators are adequately trained and carry out relevant CPD. The employer doesn't have to provide this CPD, but must take steps to ensure that they are able to access this.

The Referrer
A registered healthcare professional entitled by the employer to refer individuals for medical exposure to the practitioner. The referrer must supply the practitioner with sufficient medical data to enable them to decide whether there is a sufficient net benefit to exposing the patient.

The Practitioner
A registered healthcare professional entitled by the employer to take responsibility for an individual medical exposure. The main role of the practitioner is to undertake the justification of individual exposures.

The Operator
An operator is anyone who is entitled by the employer to carry out any practical aspect of the production of a radiographic image.

The range of practical aspects covered by this term is wide and includes the supporting functions **prior** to the exposure taking place, such as routine quality assurance testing of equipment, as well as setting up the patient, **performing** the exposure itself or processing/archiving the image.

They can include but are not limited to:

1. Patient identification
2. Positioning the film/ sensor, the patient and the x-ray tube head
3. Setting the exposure parameters
4. Pressing the exposure button to initiate the exposure
5. Pressing the exposure button to initiate the exposure under direct supervision
6. Processing films or Phosphor Plates
7. Manage solutions in a manual/automatic processor
8. Clinical evaluation of radiographs
9. Exposing test objects as part of the QA programme

The following can act as an operator practitioner within their scope of practice if adequately trained:

Practical duties of operator		Dentists	Hygienists and therapists	Dental nurses	Dental nurses with certificate of radiography	Clinical dental technician (only exposures related to denture removal)	Dental technician
1	Patient identification	Yes	Yes	Yes	Yes	Yes	No
2	Positioning the film/ sensor, the patient and the X-ray tube head	Yes	Yes	No	Yes	Yes	No
3	Setting the exposure parameters	Yes	Yes	No	Yes	Yes	No
4	Pressing the exposure button to initiate the exposure	Yes	Yes	Under direct supervision	Yes	Yes	No
5	Processing films or phosphor plates	Yes	Yes	Yes	Yes	Yes	No
6	Manage solutions in a manual processor	Yes	Yes	Yes	Yes	Yes	No
7	Clinical evaluation of radiographs	Yes	Yes	No	No	No	No
8	Exposing test objects as part of the QA programme	Yes	Yes	Yes	Yes	No	No

Duties of employees

- To not knowingly expose themselves or any other person to x-rays to an extent greater than is reasonably necessary for the purposes of their work
- To exercise reasonable care when working on any aspect of dental radiology
- To immediately report to the Employer whenever they have reasonable cause to believe that an incident or accident has occurred with the x-ray equipment, or that they or some other person have received an overexposure.

Continuing Professional Development
IR(ME)R practitioners and operators should receive continuing education and training in all aspects of dental radiology and radiation protection as part of their 5-yearly recertification cycle.

This CPD refresher training is expected to cover:

- Radiation physics
- Risks of ionising radiation
- Radiation doses in dental radiography
- Factors affecting doses in dental radiography
- The principles of radiation protection
- Statutory requirements (IRR17 and IR(ME)R
- Selection criteria
- Quality assurance

Inspectors from a regulator such as the HSE/CQC/HIW/NHS/HIS/RQIA may well check that team members are appropriately trained for their roles and up-to-date with their CPD and want to see that practices monitor compliance in this area.

8. Have a quality assurance programme in place
Employers must carry out regular quality assurance related to radiograph quality and written procedures. CODE has provided documents you can use or alternatively your RPA should have supplied you with a programme. For more information see Radiology Quality Assurance (G 125).

9. Have in place guidelines for radiographic examinations
These are the accepted guidelines practices can follow:

Selection Criteria for Dental Radiography
Based on a comprehensive review of all of the available data, guidance, wide consultation with relevant professional bodies and specialist groups to provide consensus on best practice; it gives clear, simple and practical advice on the safe and effective use of radiography in practice.

First published in 1998, and now in its third edition, it covers the use of radiographs for the developing dentition, endodontic assessment, caries diagnosis, periodontal assessment, and implantology. It has been updated since the second (2004) edition to reflect more recent developments in radiography and dentistry, including digital radiography and CBCT, as well as to include expanded guidance on the use of radiography in implantology along with additional guidance on paediatric radiography.

Guidelines for the use of radiographs in clinical orthodontics
These guidelines are designed to assist the general practitioner, the orthodontic specialist and the hospital practitioner on the choice and timing of radiographs in clinical orthodontic practice.

Radiation Protection 172
One objective of the SEDENTEXCT project has been to review the current literature on CBCT and to derive useful guidelines that will clarify those clinical situations in which this imaging technique would be found to be beneficial to both the clinician and the patient.

10. Ensure the Radiation Protection File is relevant and up-to-date
The practice's RPA and MPE must be involved in helping to create this file. For more information see The Radiation Protection File (M 275D).

11. Ensure that radiation doses to staff, patients and the public are restricted so far as is reasonably practicable

Employers must take all necessary steps to restrict the extent to which its employees and other persons are exposed to ionising radiation using a combination of:

- Engineering controls, design features and by the provision and use of safety features and warning devices
- Systems of work including access to the controlled area
- Appropriate training (to include practical dose reduction methods
- RPS appointments
- Personal protective equipment such as lead aprons and thyroid collars
- Practising dose reduction

The Controlled Area
You must consult with your RPA for accurate descriptions of any controlled areas in your practice.
Below is only guidance

Where practicable, the whole room should be designated as the controlled area while the equipment is in a state of readiness to emit X-rays. This makes use of the room boundaries to physically demarcate the area and assists with the restriction of access by permitting entry to be controlled at the doorways.

Where this is not practicable, the controlled area may be designated as: within 1.5 metres of the X-ray tube and the patient, in any direction, while the equipment is in a state of readiness to emit X-rays, and in the case of intra oral equipment, within the primary X-ray beam until it has been sufficiently attenuated by distance or shielding. This has the disadvantage that the controlled area boundary is not physically demarcated and the restriction of access relies solely on the operator exercising effective supervision.

If the electrical supply to the x-ray unit has been disconnected after images have been taken or at the end of a working session, this permits the surgery to then be de-designated as a controlled area, thereby reducing the amount of time when access to the controlled area has to be restricted.

Computer-controlled X-ray equipment may require the exposure settings to be selected and confirmed using the operating software before an exposure can be initiated. If unauthorised use of the software can be prevented effectively by means of a password, this will be an acceptable alternative to switching off the power and will avoid the need for the controlled area to be designated throughout the time that power is switched on.

Dose Investigation Levels

- A dose investigation level of no higher than 1 mSv per year is recommended as generally appropriate for dental radiography
- The chosen dose investigation level must be specified in the Local Rules

Personal Dosimeters
Doses to operators and any other non-classified persons who enter controlled areas must be assessed, using personal dosimetry or other suitable measurements, to confirm that the written arrangements are effective.

Whichever method is used must allow the individual annual doses to be either directly measured, estimated or calculated, so that they can be compared to the dose investigation level set by the employer.

Decisions regarding the most appropriate method of assessing personal doses should be made as part of the risk assessment process in consultation with your RPA.

Due to the anticipated low annual doses received by staff if proper procedures are followed, personal dosemeters may be provided initially for a trial period of six months. On the advice of your RPA, continuous monitoring may not be considered necessary after the trial

As the dose received by any employee from dental radiography is expected to be significantly lower than 1 mSv per year, the dose to the foetus over the term of pregnancy should also be lower than this level and therefore no special protection measures will usually be necessary.

However, the employer may, having consulted their RPA, opt to provide personal dosimetry for employees who have declared that they are pregnant, should they wish to confirm that doses are low.

Lead Aprons

- There is no justification for the routine use of lead aprons for patients in dental radiography
- An apron may be used when the patient is pregnant and with carers and comforters
- Lead aprons must be stored over a hanger, not folded and must be inspected annually

Thyroid Collars

- These need to be used when the thyroid gland is in the primary beam for example when taking an upper standard occlusal view or when taking periapical radiographs of maxillary incisors that are proclined

Pregnant employees

- Employers must ensure that employees are informed about the possible risks and the importance of notifying the employer (in writing) as soon as the employee knows that they are pregnant

- In consequence employees must understand the importance of notifying the employer in writing, even if the employee would prefer to keep their condition completely confidential

- After the Employer has been notified of the pregnancy, the Employer will need to ensure that the dose to the foetus will be kept as low as is reasonably practicable and will certainly not exceed 1 mSv during the remainder of the pregnancy. Advice from the RPA can be sought for this

Pregnant patients

- Most practitioners (and probably pregnant patients) will tend to avoid dental radiography during pregnancy most likely for psychological reasons
- Dental radiography does not expose the pelvic area so the only dose to the foetus can be from scattered radiation
- It is acceptable to explain to the pregnant patient that dental radiography delivers such a small dose to the foetus that the associated risk can be regarded as negligible
- The patient should be given the option of delaying the radiography

Providing adequate information to patients
You may find the following phrases useful when speaking to patients about taking radiographs:

- We are committed to using the lowest dose possible to achieve a diagnosis of the condition of your teeth. We only take x-rays when we consider them absolutely necessary
- We have invested a lot in the infra-structure and the equipment to ensure this is delivered. We have also invested a lot in the training of our staff in radiation protection
- The dose received from two dental x-rays is (for a digital imaging system) less than the additional dose you would receive from cosmic radiation on a flight to Spain
- The dose received from a panoramic x-ray which shows all your teeth is (for a digital imaging system) less than the additional dose you would receive from cosmic radiation on a flight across the Atlantic to New York.
- We don't use lead aprons because it has been shown that there is no benefit due to the very small amount of scattered radiation from a dental x-ray
- If you are pregnant, it has been shown that there is a negligible risk to the baby from dental x-rays, however you may decide to delay the x-rays until after the birth
- If you have any question, please do not hesitate to discuss this with your dentist

Dose reduction: Justification
The benefit to the patient from the exposure should outweigh the detriment
Consider:

- The availability and findings of previous radiographs
- The specific objectives of the exposure in relation to the history and examination of the patient
- The total potential diagnostic benefit to the individual
- The radiation risk associated with the radiographic examination
- The efficacy, benefits and risk of available alternative techniques having the same objective but involving no, or less, exposure to ionising radiation

Dose reduction: Optimisation
To keep patient doses as low as reasonably practicable consistent with the intended purpose

Radiographic technique (Digital Imaging)	Typical Effective dose (µSv)
Intra-oral radiograph	2 to 3
Panoramic radiograph	10 to 15
Lateral cephalometric radiograph	5 to 10
CBCT (small field of view)	11-214 (Image resolution dependent)
CBCT (extended field of view)	30-1025 (Image resolution dependent)
CT scan (mandible)	250-1410
CT scan (mandible and maxilla)	430-860

Dose reduction: Limitation

Examination	National diagnostic reference level (Patient Entrance Dose – PED Or Dose Area Product - DAP)
Intraoral (adult molar)	1.2mGy (PED)
Intraoral (adult molar)	0.7mGy (PED)
Panoramic (adult)	81mGy cm^2 (DAP)
Panoramic (child)	60mGy cm^2 (DAP)
Lateral cephalometric radiograph (adult)	35mGy cm^2 (DAP)
Lateral cephalometric radiograph (child)	24mGy cm^2 (DAP)
CBCT (adult maxillary molar implant)	265mGy cm^2 (DAP)
CBCT (child maxillary canine implant (12 year old))	170mGy cm^2 (DAP)

12. Collect dose estimates from dental radiographic exposures
As of 2018 practices must collect dose estimates from exposures, including gender and age, and provide this data to the Secretary of State if asked for it.

As dental X-ray sets standardly use pre-sets for each type of exposure (which include kV, mA and exposure time etc.) this data collection can be achieved simply by noting the type of exposure in a patient's clinical records.

Where it is not possible to use a pre-set, e.g. when taking a panoramic, the dose given should be taken from the machine and recorded in the patient's clinical records.

Other measurements of patient doses can be obtained from the reports provided by your RPA/MPE subsequent to the routine (radiological) testing they will have carried out on your units, or from PHE 'film pack' testing.

Additional requirements for Cone Beam Computed Tomography (CBCT)

Equipment Selection
CBCT equipment should be able to provide:

- Adequate diagnostic quality
- Restriction of patient exposure
- In addition, this equipment should be supplied with:
    - Safety and warning features
    - Imaging software
    - Display screen equipment
    - Test object
    - CE marking

Design of Facilities
You must consult with your RPA and MPE regarding the design and shielding of the room/area housing the CBCT machine. Consider the following as guidance.

The room

- Dedicated Room with means for continuous observation of the patient during exposures (e.g. lead glass viewing window in door or CCTV type system viewing the patient on a monitor screen)
- The position and construction of walls, doors, ceiling and floor are important to communicate to the RPA
- Lead equivalence of shielding will need to be determined if relevant
- Scattered radiation scatter patterns will help the RPA
- Dose rate outside the room does not exceed 7.5 µSv per hour (averaged over a minute)
- An instantaneous dose rate of 100 µSv per hour would indicate that the controlled area was extending outside the confines of the room

Designation of Controlled Areas

- The entire room due to higher levels of radiation
- Exists whenever equipment is switched on and the exposure control enabled
- Restricted access controlled by trefoil warning signs and the operator
- Staff should understand the meaning of any room entrance warning signs (or lights if installed)

Safety and Warning Systems

- Warning signs including the radiation trefoil and wording to include X-rays, Controlled Area, No Unauthorised Access, Emergency stop switch/isolator outside the controlled area
- Sufficient systems of work safeguards are in place

Personal Protective Equipment (PPE)

- Not normally necessary to employees as they will be operating from outside the room/behind a protective shielded door
- In common with conventional radiography, there is no need for the routine use of lead aprons for patients undergoing dental CBCT examinations
- There is no need for the routine use of thyroid shields for patients undergoing dental CBCT examinations. This should be considered on a case by case basis
- For carers or comforters lead rubber aprons should be used
- Any lead rubber aprons should be stored correctly

Patient Pregnancy

- Routinely asking the pregnancy question prior to dental CBCT examinations is not necessarily required, but consideration of pregnancy would be appropriate to be part of the imaging protocols
- The practice policy on this matter should be documented within the written procedures

Personal Dosimetry

- Recommend this be considered for an initial trial period following the commissioning of a CBCT unit
- Continuous monitoring may be considered if doses are not adequately restricted
- Any significant change should trigger a review of the risk assessment
- No special protection measures are necessary for pregnant employees as the room should be adequately shielded

QA Programme

- Critical examination
- Acceptance test immediately after installation
- Annual routine test (this could become every three years with the institution of a regular documented image QA programme using a manufacturer supplied phantom)
- Monthly QA checks please consult with the RPA and the manufacturers for an appropriate list
- Maintenance and examination of engineering controls please consult with the RPA and the manufacturers for the required list (generally annually).

QA of Dental CBCT Image Quality
Subjective image quality ratings and minimum targets for dental CBCT

Quality Rating	Basis	Target
Diagnostically acceptable (A)	*No (or minimal) errors in patient preparation, exposure, positioning or image reconstructions and of sufficient image quality to answer the clinical question. Minimal errors to be audited as part of the practice quality assurance programme to improve image quality ongoing.*	Not less than 95%
Diagnostically not acceptable (N)	Errors in either patient preparation, exposure, positioning or image reconstruction which render the image diagnostically unacceptable	Not greater that 5%

Dose Audit

- Local DRL to be determined with MPE input
- National Diagnostic Reference Levels (DRL) are below

CBCT (adult maxillary molar implant)	265mGy cm^2 (DAP)
CBCT (child maxillary canine implant (12 year old))	170mGy cm^2 (DAP)

Recommended Minimum Training for CBCT

The 2020 dental guidance notes recommendation is for CBCT training to be undertaken by relevant duty holders at 'Level 1 and level 2'

Level 1 ('Core') Training In Dental CBCT

Intended recipients
All personnel involved with dental CBCT imaging (dentists, dental nurses with the CDR, dental hygienists and dental therapists).

Content

- The fundamentals of 3D imaging and dental CBCT radiography
- The principles of radiological imaging
- Radiation hazards and radiation protection
- Referral criteria for 3D imaging
- Regulations relating to dental CBCT imaging
- Appreciation of the different diagnostic yield but increased hazards presented
- by dental CBCT imaging in comparison with conventional 2D imaging
- Understanding how to optimise patient doses from dental CBCT for the specific imaging task and how to avoid unnecessary exposure
- Recognition of 3D anatomy sufficiently to correctly localise both small and large volume CBCT scans and to make an initial assessment of the image to confirm correct positioning and diagnostic value (e.g., freedom from artefacts etc.).
- Limited to imaging of the dento-alveolar region only)

Presentation Format
A formal course, 12 hours total (of which 5 hours may be provided by verifiable CPD in radiography and radiation protection as recommended by the GDC for all dentists and dental care professionals whose work involves dental radiography).

Level 2 ('further') training for operators performing dental CBCT imaging

Intended recipients
All personnel who may be entitled to act as operators undertaking dental CBCT examinations (dentists, dental nurses with the CDR, dental hygienists and dental therapists).

Content
The practical aspects of dental CBCT radiography, including: exposure protocols, patient positioning, dose optimisation, QA test exposures and fault identification. This should be provided in tandem with core training.

Presentation Format
Hands-on training, ideally delivered at the place of work immediately following commissioning. An initial 6 hours to allow the operator to become familiar with the equipment and to begin imaging patients safely and confidently. A second 6-hour period should be undertaken after a short period of initial usage to provide further detailed training on patient positioning, dose and image optimisation, further machine options, to answer queries and problem-solve.

Level 2 ('further') training in dental CBCT justification and image interpretation

Intended recipients
All personnel who may be entitled to act as IRMER practitioners and operators undertaking the justification and clinical evaluation (radiological reporting) of CBCT images that are confined to the dento-alveolar region. (At the time of writing the clinical evaluation of dental CBCT images is restricted to appropriately trained and indemnified dentists and radiologists.) Successful completion of Level 1 training should be a prerequisite for attending this training.

Content

- The development of dental CBCT imaging knowledge, enabling appropriate justification, accurate dose and image optimisation and quality control
- Understanding of the regulatory requirements if offering a CBCT imaging and/or reporting service
- Reporting of normal anatomy, normal variants, dento-alveolar pathology and abnormalities, and pre-surgical planning as seen on dental CBCT images

Delivery
A mixture of theoretical and practical training in dental CBCT reporting, including hands-on training in use of imaging software and case-based interpretation exercises. Formal training should last at least 6 hours with a further 6 hours for self-study and small group study, including case-based discussions, interpretation exercises and mentoring.

Additional Considerations for Hand-held Dental X-ray Sets

Summary of essential actions

- Consult a suitable radiation protection adviser (RPA) and medical physics expert (MPE) about the decision to use hand-held dental X-ray equipment, the choice of model and the situations and locations in which it is to be used
- Confirm with the equipment supplier that the X-ray set will be subject to tests meeting the standards in this guidance (critical examination and acceptance testing or equivalents (e.g. certificate of conformity), prior to delivery. Alternatively, make arrangements with your RPA and MPE for this to be done before clinical use commences.
- Draft or revise the radiation risk assessment, taking advice from your RPA
- Draft or revise the local rules, taking advice from your RPA. Ensure that suitable key working instructions, written arrangements and contingency plans are included
- Arrange for a trail period of personal dosimetry to ensure that working instructions are being followed
- Make suitable arrangements for the security of the unit when not in use and (if applicable) when being transported
- Include the hand-held X-ray equipment in the in-house QA programme, making provision for adequate routine (radiological) testing at annual intervals, routine in-house surveillance of the equipment's safety and warning features and general condition and general maintenance and servicing according to manufacturer's recommendations.
- Ensure relevant staff are adequately trained to use hand-held X-ray equipment, including the requirements of the local rules and practical aspects of radiation safety and radiography. Record details of training

Key questions regarding risk assessment

- Does the position of the exposure switch allow the operator to keep their hands outside the primary beam at all times?
- Is the main X-ray beam always directed away from the operator or other staff, unshielded walls and unshielded room entrances?
- Does each X-ray set have warning lights that indicate both when power is supplied and when an exposure is taking place?
- In the event of an incident, can the operator quickly remove the battery without having to position their hands in the primary beam?
- Is a backscatter shield provided and attached at the far end of the director cone for all radiographic views?
- Is the X-ray set always used such that the operator is stood directly behind the backscatter shield?
- Can the operator restrict access to the area within 1.5 m of the X-ray set, and within the primary beam until attenuated by a solid or adequately shielded wall or shielded locked door?

You must consult your RPA/MPE before commencing radiography.

Additional items

- Sketch plan of the room(s) in which the X-ray set will be used (include the floor level, dimensions and construction of walls, positions of doors and windows, beam directions, and positions of the operator, patient and any other people during radiography) would be appropriate for inclusion into the local rules for the use of these units.

- Describe the arrangements at this location for the safe storage and security of the hand-held X-ray set when not being used.