

Dental X-Ray



BC Centre for Disease Control

AN AGENCY OF THE PROVINCIAL HEALTH SERVICES AUTHORITY

Radiation Protection Services

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Dental X-ray Facts

Radiography is one of the most useful and powerful diagnostic tools available to the dental practitioner. The use of x-rays as a standard diagnostic procedure is well established in the profession. This use places an obligation on the dental practitioner who must weigh the benefits of additional diagnostic information against the risk from radiation exposure to the patient.

In keeping with current radiation protection philosophy, exposure to all persons should be kept **As Low As Reasonably Achievable**. Therefore, it is imperative that radiographic procedures are optimized to provide acceptable diagnostic information to the dental practitioner with the minimum radiation exposure to the patient and dental office staff.

The information contained in this booklet is aimed primarily at dental office staff, to help them achieve and maintain an acceptable level of radiation protection.

Introduction

This booklet provides the dental practitioner, dental clinic staff and patients with a number of facts on the use of x-rays in dentistry. These facts have been compiled into eight sections, as follows:

	<u>Page</u>
1. The Dental X-ray Tube	1
2. The X-ray Beam	2
3. Effects on the Patient	3
4. Inside the X-ray Room	4
5. Processing the X-ray Film.....	4
6. Checking Your Film Processing	6
7. The Radiation Protection Survey.....	7
8. Workers' Compensation Board	8
Review	8
Responsibility.....	8
Glossary	9

This is followed by a review of the methods that can be used to help keep radiation exposures to the patient and other persons **As Low As Reasonably Achievable**. The question of who decides whether an x-ray should be taken is also discussed. A glossary of the commonly used terms in the x-ray protection field is included at the back of this booklet.

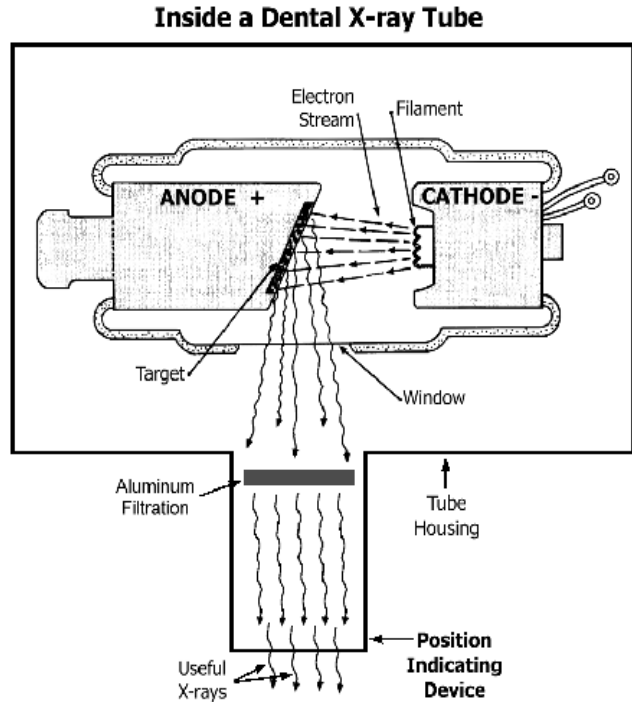
1. The Dental X-ray Tube

To help you visualize the workings of the x-ray tube, please see *Figure 1*.

- a) The filament is heated by the filament current. Electrons are emitted by the hot filament and travel to the anode. This flow of electrons from the cathode to the anode is called **TUBE CURRENT** and is measured in units of milliamperes (mA). The tube current determines the **QUANTITY** of x-radiation, which will be produced for a given applied high voltage.
- b) A high voltage potential, measure in kilovolts peak (kVp), is maintained during the exposure between the cathode and the anode. The higher this voltage the faster the electrons will travel to the anode. Consequently, the x-rays produced will have a higher energy and, therefore, will be capable of greater penetration. Thus, kVp determines the **QUALITY** of the radiation emitted. A change in the kilovoltage will also produce a change in the **AMOUNT** or **INTENSITY** of the x-ray beam.
- c) When an electron strikes the anode target material the electrons will be slowed down or stopped, resulting in the emission of x-rays with varying energies. The heavier the target material the greater the intensity of the emitted radiation.
- d) The target material in an x-ray tube is usually made of tungsten. However, since 99% of the energy of the bombarding electrons manifests itself as heat, the target has a copper backing for more efficient cooling of the tube.
- e) The useful beam of x-rays emitted from the tube contains a mixture of low and high energy x-rays (soft and hard x-rays respectively). Aluminum filters and high kVp are required to increase the ratio of the useful hard x-rays. Very soft x-rays are not likely to penetrate the patient and, hence, are of no use in producing an image on dental x-ray film. To remove these very soft x-rays from the useful beam, a minimum thickness of 1.5 mm of aluminum (or equivalent) is required for the tube operating up to 70 kVp. For tubes operating above 70 kVp, 2.5 mm of aluminum (or equivalent) is required.

Figure 1

- f) The x-ray tube housing is fitted with a **Position Indicating Device (PID)** through which the useful x-ray beam passes. Inside the **Position Indicating Device (PID)**, where it attaches to the tube housing, is a beam collimating device, which restricts the size of the useful beam, to 7 cm at the end of the PID. The **PID** must maintain a minimum distance of 18 cm between the x-ray source and the patient's skin.



The maximum size of the emerging x-ray beam at the end of the **PID** of an intra-oral film x-ray unit must not exceed 7 cm.

Modern dental x-ray equipment imported or sold in Canada is required under federal law to meet these standards, and should not be an issue for users.

2. The X-ray Beam

When a beam of x-rays reaches the patient, several things happen:

- a) Most of the useful x-ray beam is absorbed in the tissues of the area under investigation.
- b) Some of the x-rays are scattered by this tissue.
- c) The transmitted beam then reaches the dental x-ray film placed in the mouth and produces a latent image of the teeth being x-rayed.
- d) The remaining beam is then either absorbed or scattered by the other tissues of the mouth.
- e) Only a very small amount of x-ray radiation passes through the patient without interaction.

3. Effects on the Patient

For routine dental x-ray procedures, the amount of x-ray exposure is small and will not cause any immediate, acute health effects on the patient.

Since x-rays are a type of **IONIZING RADIATION**, it is assumed, however, that any exposure has associated with it a very small additional health risk. The significance of this risk may best be understood by a comparison with other risks in life (see *Table 1*).

However, if the radiation exposure is increased, it is assumed that there is an increase of the added health risk. Therefore, it is important to keep radiation exposures to **As Low As Reasonably Achievable**, bearing in mind the benefits the patient derives from the diagnostic procedure. Causes of additional exposure are:

- a) Improper processing of the dental x-ray film.
- b) Repeat dental x-ray film due to incorrect positioning of the x-ray tube or selection of inappropriate technique factors.
- c) Unnecessary requests for dental radiographs (i.e. requests in the absence of prior clinical evaluation).

Table 1

Activities Carrying a Risk of Death of One in One Million (cause)
• One complete mouth radiographic survey (<i>Leukemia</i>)
• Male, age 60, living for 20 minutes (<i>Cardiovascular and malignancy</i>)
• Living in Denver for 2 months (<i>Background radiation</i>)
• Riding in a canoe for 6 minutes (<i>Accident</i>)
• Riding in a car for 300 miles (<i>Accident</i>)
• Smoking 1.4 cigarettes (<i>Cardiovascular and malignancy</i>)
• Drinking 500 ml wine (<i>Cirrhosis</i>)

*(from Council on Dental Materials, Instruments, and
Equipment of American Dental Association, 1992)*

4. Inside the X-ray Room

Whenever x-rays are being taken, a small percentage of the useful beam of radiation scatters in many directions. Personnel in the vicinity can receive radiation exposure even though they are not exposed to the primary beam. Chronic exposure to this stray radiation is undesirable and must be avoided. Therefore, only the patient should be inside the x-ray room during an exposure.

The operator should be able to stand outside the room or be as far as possible from the x-ray tube while operating the control, and be able to view the patient during the exposure.

Protective aprons are recommended for use by the patient in order to provide protection against scattered radiation as well as leakage radiation coming through the tube housing. A thyroid collar, to cover the neck region, is also recommended.

5. Processing the X-ray Film

Processing the dental x-ray film is a critical procedure in obtaining an acceptable diagnostic image on the dental x-ray film with the lowest radiation exposure necessary. Studies done in British Columbia indicate that incorrect processing techniques with both **MANUAL** and **AUTOMATIC** methods result in increased exposure of the patient in many dental facilities.

By following the processing instructions issued by the manufacturer, exposures can be kept to within acceptable ranges. *Table 2* shows the acceptable x-ray exposure ranges for the two common film groups ("D" series and "E" series) as a function of the kilovoltage selected on the x-ray unit. When a radiation protection survey is carried out, the exposure can be measured for the technique you are using for a standard bitewing x-ray. The result is then compared with the appropriate lower/upper mR limit values for the kVp and film type, as shown in *Table 2*.

To help you evaluate your processing, the Radiation Protection Branch has produced a "self-help" guide. This guide is provided in Section 6 of this booklet, as a convenient reference and aid to helping dental facilities establish and maintain the correct procedures for processing the films, to achieve good quality images and prevent unnecessary exposure to patients and staff.

Dental X-ray Facts

Table 2

"D" Speed Film *

kVp	Lower mR Limit	Upper mR Limit
50	425	550
55	350	500
60	310	440
65	270	400
70	240	350
75	170	260
80	150	230
85	130	200
90	120	180
95	110	160
100	100	140

*** Exposure conditions:**

- 10 mA, 20 cm SSD
- 50-70 kVp, 1.5 mm Al
- 71-100 kVp, 2.5 mm Al

"E" Speed Film **

kVp	Lower mR Limit	Upper mR Limit
50	220	280
55	190	270
60	165	230
65	140	200
70	120	170
75	100	140
80	90	120
85	80	105
90	70	90
95	60	80
100	50	70

**** Exposure conditions:**

- 10 mA, 30 cm SSD
- 50-70 kVp, 1.5 mm Al
- 71-100 kVp, 2.5 mm Al

6. Checking Your Film Processing

If manual processing is used, make sure that the dental x-ray film is immersed in the developer for the correct amount of time. Otherwise, if the development time is reduced, an increase in exposure must be delivered to the dental x-ray film, and therefore to the patient, to compensate for under-development.

Where automatic processing is used, it is important to follow the manufacturer's recommendations for maintenance and housekeeping to achieve optimal film quality.

The correct processing of the radiographic film is critical to ensure the lowest radiation exposure required to produce an acceptable image (or radiograph). Owners of x-ray equipment should refer this problem to your staff members who are trained in Standardized Darkroom Technique and can evaluate all the items discussed below. Others should refer to their film and chemistry supplier representatives for technical assistance.

Under development of the films in the developer tank leads to **overexposure** of the patient, as well as increased levels of stray radiation exposing staff. The problem with under development compensated for by over-exposure, is that the radiograph appears to have received the correct exposure and, therefore, provides no radiographic evidence of over-exposure. To determine if you are over-exposing your patients, ask yourself the following questions:

1. Are you using your developer for more than approximately one month? yes no
2. Are you ignoring manufacturer's instructions for preparing developer and fixer? yes no
3. Have you shortened recommended developing times and/or reduced temperatures from what the film manufacturer recommends (applies to both manual and automatic processors)? yes no

If you answered **YES** to questions 1, 2 or 3 you may be over-exposing your patients and under-developing the films.

4. Do you measure the developer temperature daily with a darkroom thermometer to ensure developer temperature is at the recommended setting? yes no
5. Are you replenishing developer/fixer as recommended by the chemistry and/or film manufacturer? yes no

If you answered **NO** to questions 4 or 5 you may be over-exposing your patient and under-developing the films.

Are there any clues to help you with these concerns? Try the following:

- A. Make up new developer according to manufacturer's directions. If the new developer produces dark radiographs, then you are likely over-exposing your films. Problem: the developer was allowed to get too old.
- B. Make up chemicals according to manufacturer's instructions. If you get dark films, then you are likely over-exposing the patient and the film. Problem: the previous developer was not made up correctly.
- C. Are you 'sight developing'? That is, viewing the film **during** developing and shortening developing times to get correct density? If you are, you are likely over-exposing the patient and the film. Try correct time/temperature developing, i.e. standardized darkroom technique. If you get dark films, you are likely over-exposing.
- D. Bring developer up to manufacturer's recommended temperature. If films are dark, you are likely over-exposing.

If you are producing dark films when trying any of **A** through **D** above, reduce the timer setting automatic exposure controls to get the correct exposure to the film. This will reduce exposures to the patient. Reducing exposures to the patient may also result in **reduced exposures to staff**.

7. The Radiation Protection Survey

When a radiation protection survey is carried out at a dental facility, its purpose is to determine whether an acceptable standard of protection is being provided for the patients and all dental facility personnel, as well as for any other persons in the vicinity of the facility.

To this end, the inspection focuses on the following items:

- 1. *Technique factors* used are evaluated to determine the radiation exposure to the patient, and whether the exposure is within the acceptable range for the techniques used (see *Table 2* on page 7). This will determine if the x-ray unit and the film processing system are performing satisfactorily.
- 2. The *safeguards* that are in place to ensure the safe use of the dental x-ray unit for the protection of the operator and other personnel close by.
- 3. The *intensity of stray radiation* occurring outside the protective barriers or at other important locations where the general public may have access.

Where any deficiencies are identified, they are brought to the attention of the dental practitioner and the appropriate professional association/college, that are responsible for ensuring that corrective action is carried out. Quality control and assurance is achieved through an on-going partnership program, between the dental practitioner, the association/college and the Radiation Protection Services, BC Centre for Disease Control, which readily identifies changes that could lead to a reduction in standards and, therefore, increased exposure.

Some of the more common problem areas and ways to correct them are identified in the [Review](#).

8. Workers' Compensation Board

Requirements for protection of workers against hazards, as specified in the *WCB Occupational Health and Safety Regulation (BC Regulation 296/97)*, became a legal requirement on April 15, 1998. The owner of x-ray equipment must ensure that exposure of staff to ionizing radiation is kept **As Low As Reasonably Achievable**, below the maximum permissible dose. In addition, the *Regulation* specifies an Action Level of 1 mSv/year for workers. When workers exceed, or are likely to exceed, the Action Level, the *Regulation* requires the employer to carry out certain tasks. Please consult the *Regulation* for details.

Review

- a) By correcting any errors in processing, the x-ray technique factors can be changed to reduce exposure to both patients and staff.
- b) To reduce unsharpness on the film, a shorter timer setting may be selected by adjusting the other technique factors (i.e. mA and/or kVp).
- c) An increase in Position Indicating Device (PID) length might be required to ensure that a minimum source-to-skin distance of 18 cm is obtained.
- d) Suitable collimation of the x-ray beam is necessary to restrict the useful beam size to not more than 7 cm at the end of the Position Indicating Device (PID), for intra-oral film x-ray units.
- e) An inaccurate or inconsistent timer (particularly an older type mechanical timer) must be replaced with a modern, reliable electronic timer.
- f) When making an exposure, the operator should stand in a position outside the x-ray room or as far as possible from the x-ray unit and be able to **view the patient** while remaining **behind a barrier during the exposure**.
- g) The ultimate objective is to keep radiation levels to both the patient and operator **As Low As Reasonably Achievable (ALARA)**, while achieving satisfactory diagnostic images.

Responsibility

NOTE: Only after careful oral examination of the patient, the dental practitioner may recommend taking an x-ray film to verify the diagnosis or to obtain more information for planning treatment. It is the dental practitioner's responsibility to weigh the reasons for and against the taking of an x-ray and to advise the patient accordingly. Nevertheless, the final decision for taking an x-ray film rests with the patient.

Glossary

Commonly Used Terms:

Absorbed Dose: Absorbed dose is the measure of the amount of energy absorbed from radiation exposure by material at the point of interest. This is dependent upon the nature of the absorbing material as well as on the quality of the radiation. The original unit of absorbed doses is the rad. The International System of Units (SI) uses a unit called Gray (Gy). The relationship between the two units is as follows:

$$\begin{array}{l} 1 \text{ Gy} = 100 \text{ rad} \quad 1 \text{ rad} = 10 \text{ mGy} \\ 1 \text{ mGy} = 100 \text{ mrad} \quad 1 \text{ mrad} = 10 \text{ } \mu\text{Gy} \end{array}$$

Collimation: The restriction of the useful beam to the appropriate area size.

Equivalent Dose: Equivalent dose is the measure of the potential for biological harm, associated with the absorbed dose arising from exposure to radiation. The original unit of equivalent dose is the rem. The SI system unit of equivalent dose is the SIEVERT (Sv). The relationship between the two units is as follows:

$$\begin{array}{l} 1 \text{ Sv} = 100 \text{ rem} \quad 1 \text{ rem} = 10 \text{ mSv} \\ 1 \text{ mSv} = 100 \text{ mrem} \quad 1 \text{ mrem} = 10 \text{ } \mu\text{Sv} \end{array}$$

Exposure: Exposure is the measure of the quantity of radiation delivered at a particular point. The original unit of exposure is the Roentgen (R). The SI unit of exposure is the Coulomb/Kilogram (C/kg). The relationship between the two units is as follows:

$$\begin{array}{l} 1 \text{ C/kg} = 3876 \text{ R} \quad 1 \text{ R} = 258 \text{ } \mu\text{C/kg} \\ 1 \text{ mC/kg} = 3876 \text{ mR} \quad 1 \text{ mR} = 258 \text{ nC/kg} \end{array}$$

Filter; Filtration: Material in the useful beam that absorbs preferentially the less penetrating radiation.

Protective Barrier: A body of material (e.g. a wall) used to shield against, or reduce the intensity of, radiation to an acceptable level.

Radiation - Ionizing: Radiation capable of removing one or more electrons, directly or indirectly, by interaction with atoms.

Leakage Radiation All radiation, except the useful beam, coming from within the tube housing.

Scattered Radiation Radiation deviated in direction during passage through matter; it may also have been modified by a decrease in energy.

Stray Radiation The sum of leakage and scattered radiation.

Useful Beam Radiation which passes through the window, aperture, **Position Indicating Device (PID)** and/or other collimating device of the tube housing.

Technique Factors: Variables of kVp, mA, time and distance factors that the operators may select for a particular dental radiographic examination.

Dental X-ray Facts

X-rays: X-rays are a form of ionizing radiation produced when high energy electrons are slowed down or stopped by the target material of an x-ray tube.

NOTE: Additional information is available in "*Safety Code 30, Radiation Protection in Dental Practice, Recommended Safety Procedures for Installation and Use of Dental X-Ray Equipment*". Health Canada, Canadian Publishing Centre, Ottawa Ontario K1A 0S9 or from the Health Canada website:

http://www.hc-sc.gc.ca/ehp/ehd/catalogue/rpb_pubs/99ehd177.pdf

For information on the *WCB Occupational Health & Safety Regulation* (particularly Sections 7.32 - 7.45 on Ionizing Radiation) contact the WSBC website:

<http://www2.worksafefbc.com/publications/OHSRegulation/Part7.asp>

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