

Flight Dental Systems



A Division of HR Dental Products
Inc.



X-VISION PORTABLE X-RAY TRAINING MANUAL

MODEL : XR-3800

Flight Dental Systems

21 Kenview Blvd. Unit 9, Brampton, ON, Canada

TEL: 905-799-0517; FAX: 905-793-2406

www.flightdentalsystems.com

Copyright ©HR Dental Products Inc.

Table of Contents

Flight X-Vision Portable X-Ray	3
Introduction	3
What are X-rays?	4
How are X-rays Generated?	4
What is Radiation and Why Should We Be Concerned?	6
What are the possible Effects of Radiation?	7
X-Ray Safety	8
How to Minimize the Risk of Radiation during an X-ray Procedure	8
Operator Radiation Dose Limits	11
Safety Precautions	12
Backscatter Shield	12
Exposure Time	15
Dosimetry	17
Pregnant X-Ray Users	17
Accidental Exposure Prevention	17

Flight X-Vision Portable X-Ray

Introduction

Flight Dental System's X-VISION Portable Handheld X-ray emits ionizing radiation that inherently has many risks associated with its use. This training manual is designed to educate the operator on proper safety training and handling that would reduce the risk of unnecessary radiation exposure. We recommend all operators carefully read the associated user's manual to familiarize themselves with the parts and technical specifications along with fully understanding the safety training guidelines found in this training manual before attempting to utilize this piece of equipment.



Flight Dental Systems X-VISION Portable X-ray was designed to obtain x-ray images and be read by personnel specifically trained in that field. The benefits and risk must be ascertained by the prescribing physician/dentist/veterinarian before its implementation.

This unit is only to be operated by authorized personnel. **DO NOT** operate the X-Vision in any manner other than what is specified herein, and in the User's Manual. Only authorized personnel trained in the safety and utilization of Flight's Dental System's X-VISION Portable X-Ray should be allowed to operate this equipment.

What are X-rays?

X-Rays are a penetrating form of high energy electromagnetic radiation. A photon of X-Ray and Gamma Ray Radiation can ionize matter. Other radiation sources such as radio, infrared, visible and ultraviolet radiation are non-ionizing forms of electromagnetic radiation.

Most X-rays have a wavelength ranging from 10 picometers to 10 nanometers, corresponding to frequencies in the range of 30 petahertz to 30 exahertz and energies in the range of 124eV to 124 KeV.

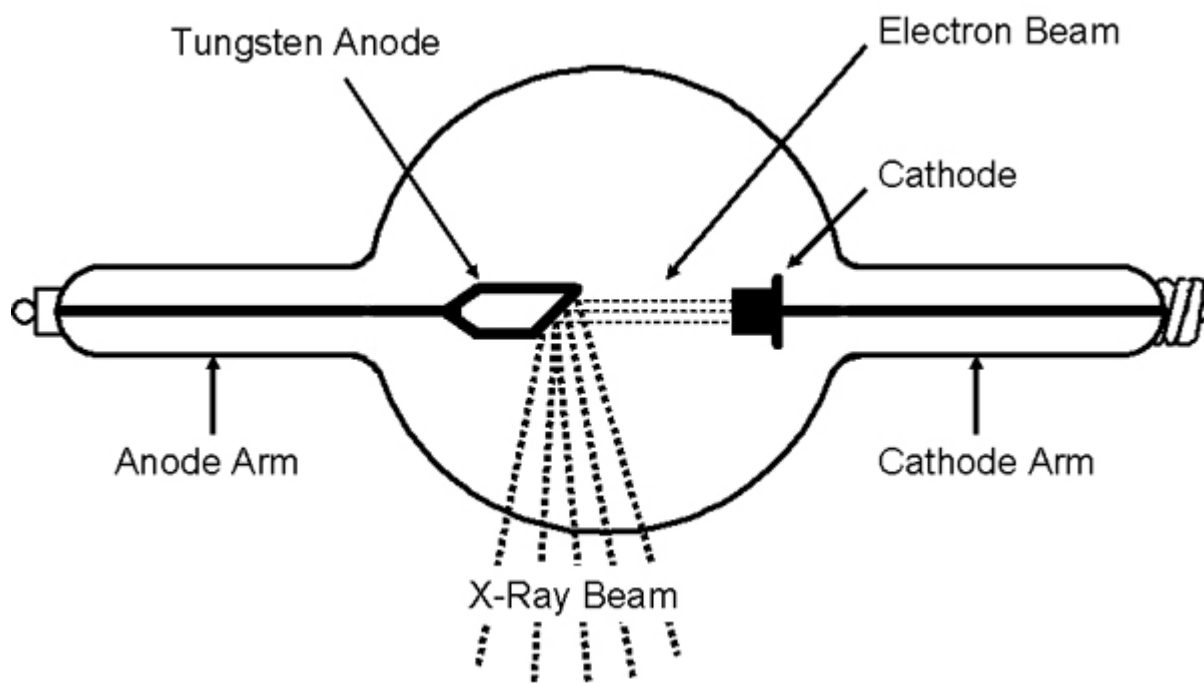
X-rays with high photon energies above 5–10 keV (below 0.2–0.1 nm wavelength) are called *hard X-rays*, while those with lower energy (and longer wavelength) are called *soft X-rays*. Due to their penetrating ability, hard X-rays are widely used to image the inside of objects.

When a hard x-ray penetrates into human tissue and bone, the photons are absorbed by the human tissue and reduces the amount of x-rays reaching the detector or digital sensor used in dental offices, thus creating a contrast of dark and light colors on a radiograph.

When humans are exposed to radiation from an x-ray source there is risk for adverse effects, however, this is relatively safe with the proper precautions in place. Most radiation can be attenuated by shielding made for dense materials such as lead and concrete.

How are X-rays Generated?

X-rays are generated in a vacuum tube specifically designed for that function. As power is applied to the tube, x-rays are emitted in a prescribed fashion from a shielded housing.



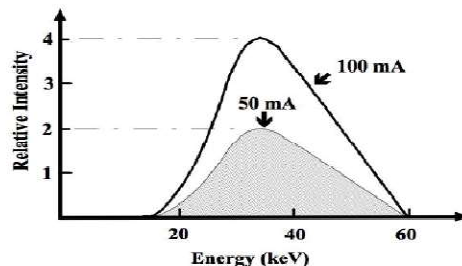
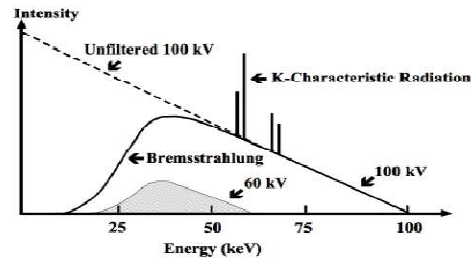
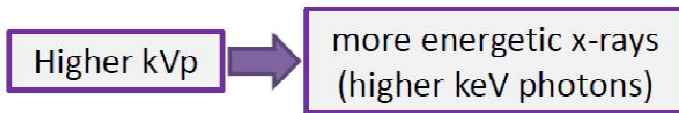
Flight Dental System's X-VISION Portable X-Ray comes equipped with a generator that provides high voltage power into the cathode of the X-Ray vacuum tube. The tungsten filament located at the cathode end, when heated, emits electrons in a process called thermionic emission. As a result of thermionic emission, these emitted electrons hover around the cathode atoms. While they are attracted to the positive anode end of the vacuum tube, and will be directed towards the anode by a focusing cup, no x-ray beam is produced until the kV is applied to the cathode and anode. This kV energizes the released cathode electrons to travel at half the speed of light (within the vacuum of the x-ray tube) to interact with the positively charged anode's atoms. The electrons slow down as they go around a nucleus which produces Bremsstrahlung x-rays. They also interact with electrons in different shells/orbits to produce characteristic x-rays. They interact with the anode in the following 3 ways to produce characteristic and Bremsstrahlung x-rays that are measured by the x-ray sensors in the patient's mouth. The third interaction has been added for completions sake:

- a) Interaction with the K-shell electron: causes the production of *characteristic radiation*. As the K-shell electron is displaced, an electron from an outer shell replaces it and produces X-rays that are detected by the X-Ray sensors located in the patient's mouth.
- b) Interaction with the nuclei: causes *bremsstrahlung radiation*. The high energy electron reaches the anode target and begins to "brake" or slowdown in speed.
- c) Interaction with outer shell electrons: causes *line spectrum*. As the electrons move closer to or farther from the nucleus of an atom (or of an ion), energy in the form of light (or other radiation) is emitted or absorbed.

Kilovoltage peak (kVp) is the highest potential difference applied across the x-ray tube. It determines the quantity and quality of the x-ray photons generated during a designated exposure time. An increase in kV extends and intensifies the x-ray emission spectrum at that setting. This results in the maximal and average/effective energies at the new setting to be higher and the number of x-ray photons (i.e. beam intensity) would also be higher. The relationship between kV and number of x-rays produced is exponential.

The negatively charged electrons racing from the cathode to the anode are also known as the "mA" or x-ray tube current. The mA and number of x-rays produced are directly related or proportional (i.e. if the mA is doubled, the number of x-rays produced are doubled). This process occurs in dental, general radiology and computed tomography x-ray tubes.

The duration of time these electrons interact with the target to produce x-rays is the beam on time. The product of tube current and on-time duration is mAs. Tube voltage, in turn, determines the quantity and quality of the photons generated. An increase in kVp extends and intensifies the x-ray emission spectrum, such that the maximal and average/effective energies are higher and the photon number/intensity is higher.



Source: Oregon State University "X-Ray Safety training for Analytical and Cabinet X-Ray" Accessed November 20th, 2023 from <https://slideplayer.com/slide/3912131/>

The X-Ray tubes produced by Flight Dental are equipped with a 1.6mm or greater of filtration. At the bare minimum every unit is equipped with 1mm of glass, 0.2mm of Al, and 0.4mm plastic cap and oil. Filters are material (i.e. Aluminum, copper, etc.) that are inserted between the x-ray port and collimator to remove the low energy x-rays that are not used to create an image but would otherwise increase patient skin dose if not present. The collimator centers the beam onto the desired area and the X-ray tube also contains a focusing cup that helps maximize the number of electrons that reach the anode target to produce x-rays. Lastly, there is a back scatter shield that prevents the radiation from bouncing off surfaces and hitting the operator.

The Flight X-Vision X-Ray has a fixed kVp and only allows changes to the exposure time to determine x-ray dosage.

Note: There is a large amount of heat released during the production of this primary beam of X-ray. Although there are automatic sensors in Flight Dental System's X-VISION Portable X-Ray that prevent it from overheating, if you feel that your unit is overheating after taking multiple radiographs, place the unit in the cool dark place to let it cooldown.

What is Radiation and Why Should We Be Concerned?

Radiation is the transmission of energy in the form of waves or particles through a medium. They are nominally categorized according to their wavelength and frequency which are inversely proportionate. The higher the frequency (lower wavelength), the more energy the

radiation type emits, meaning that the source has an increased capability of transferring its energy to another medium. This is particularly concerning to living organisms because the more capable this source of energy is of detaching electrons from atoms, the more readily it can alter the properties of the medium such as human cells. When living cells are ionized there are three things that can occur – the cell either dies, repairs itself, or mutates and can ultimately become cancerous.

The most affected cells are ones that reproduce the most such as Reproductive/GI/Thyroid cells and especially those found in the fetus. Hence, it is imperative to reduce the amount of radiation exposure to pregnant females. If you, as the operator of an X-Ray are or become pregnant, notify your employer immediately to address the risks of radiation.

NOTE: Before use on female patients, be sure to ask if they are pregnant, and if they are indeed pregnant, notify the prescribing physician so that they can weigh the risks and benefits of the procedure.

What are the possible Effects of Radiation?

The cells in our bodies are extremely efficient at repairing the damage caused by ionizing radiation. However, if the damage is not repaired correctly, a cell may die or potentially become cancerous. Efforts should be made to evaluate the benefit and potential risk in order to avoid unnecessary radiation exposure. The biological effects are typically categorized into two categories.

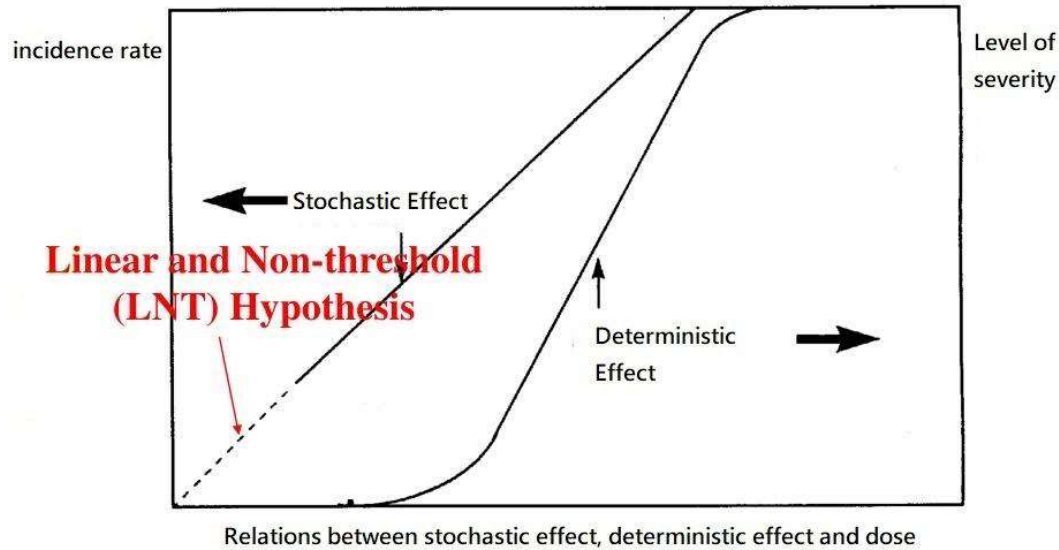
Tissue Reactions/Deterministic Effects

Tissue Reactions generally result from the receipt of a relatively high dose over a short time period. Skin erythema (reddening) and radiation-induced cataract formation are examples of tissue reactions that are dose dependant and noticeable above a certain threshold.

Stochastic Effects

Effects that occur by chance, generally occurring without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose. In the context of radiation protection, the main stochastic effects are cancer and genetic effects.

Because the random chance of cancer is so small, science must use a small set of existing data to predict cancer probability. Currently, the prediction is based on what's called a "linear, no-threshold model" and is intended to convey that cancer risk is thought to be proportional (linear) to dose, with zero dose resulting in zero risk (no-threshold). This model is conservative and follows the philosophy that it is better that risk be overestimated rather than underestimated.



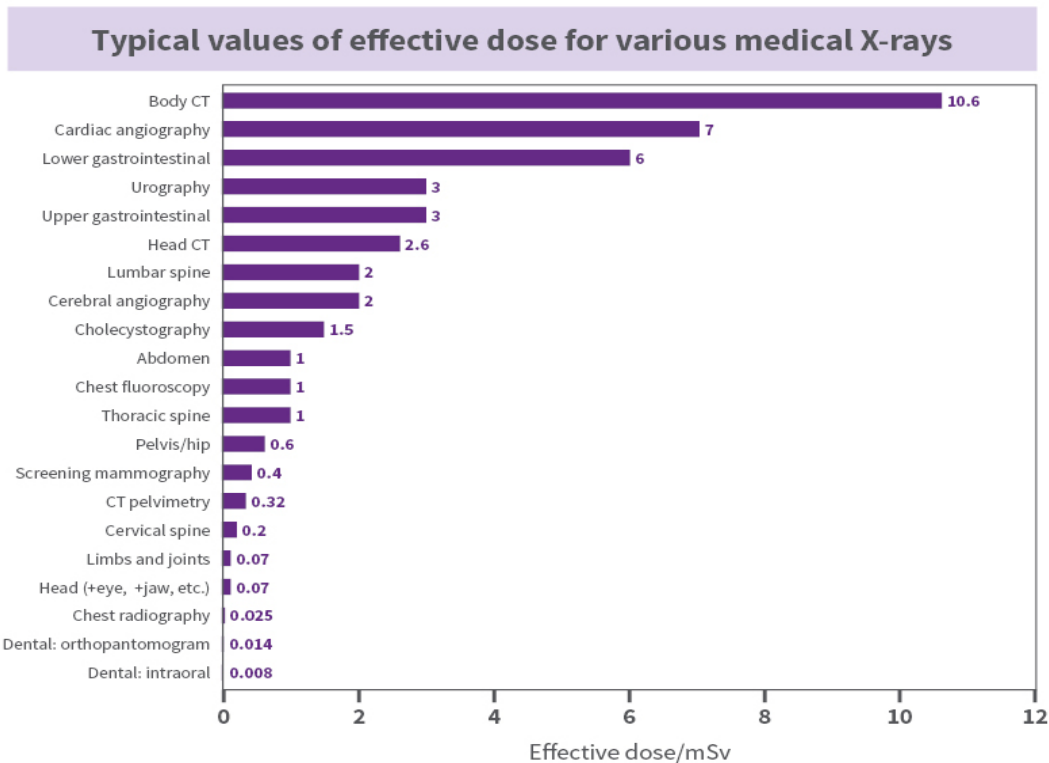
X-Ray Safety

How to Minimize the Risk of Radiation during an X-ray Procedure

A broader classification according to whether radiation is ionizing or non-ionizing will be used for this purpose to illustrate the difference between these 2 types of radiation and furthermore what needs to be minimized. Ionizing radiation means that the electromagnetic waves (Gamma or X-Ray) or particles (alpha, beta, and neutron) is adept at detaching electrons from atoms and thus is the more dangerous type of radiation that should be minimized. The damage to living cells of ionizing radiation is dependent on the sensitivity of tissue and also on the dose of radiation absorbed, also referred to as the absorbed dose which is measured in Grays(Gy) or Rads. Furthermore, the effective dose is dependent on the absorbed dose received by a population and adjustments of that dose for radiation type and relative organ sensitivity to develop an indicator for the potential for long-term health effects (i.e. Cancer and Hereditary effects) from an exposure. Effective dose is calculated to predict the probability of an exposed population dying from cancer and used to set regulatory limits that protect against long-term health effects in a population. Since it's a calculated approximation and not a physically measured quantity it cannot accurately predict individual health effects.

NOTE: The operator of the unit should never stand in direct line of the primary beam radiation.

If the x-ray dose is low and/or delivered in small fractions over an extended period of time, human cells generally repair themselves. As a result, risk of tissue deterministic effects from the dental x-rays is significantly lower. To date, there is no reported link associating dental x-rays with stochastic effects. However, there is still the long term risk of cancer which can still appear later in the life of these patients.



Source: Australian Radiation Protection and Nuclear Safety Agency Accessed September 27th, 2023 from <https://www.arpansa.gov.au/understanding-radiation/what-is-radiation/ionising-radiation/x-ray>

The above graph illustrates the effective dose of various medical imaging procedures. Although the amount of radiation emitted from Flight Dental System’s Portable X-Ray is minimal and completely safe when used as intended, we insist that you follow your local Federal and Provincial/State guidelines in order to minimize the risk.

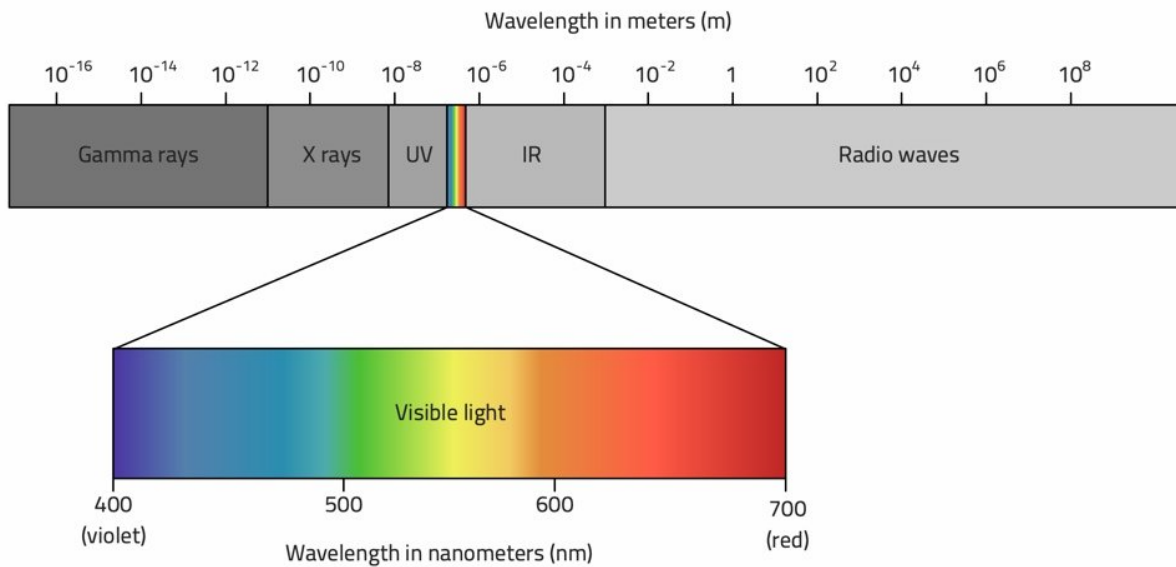
Minimizing patient risks reduces the possibility of dental x-ray exposures as a cause of patients developing cancer later in life.

ALARA which stands for “As Low As Reasonably Achievable” is the principle used for radiation safety. For diagnostic x-ray, the ALARA principle requires that the radiation exposure be kept as low as reasonably achievable to accomplish the purpose of the x-ray examination. It signifies that even if a radiation dose is small, if it has no direct benefit, then there is no reason to undergo it and should be avoided. In order to preserve ALARA, the triad of time, distance, and shielding should be implemented to maximize radiation safety.

- a) Time refers to limiting the amount of time that an individual spends near an ionizing radiation.
- b) Distance refers to the space from the source of ionizing radiation.
- c) Shielding refers to placing something between the radiation source and yourself. Lead

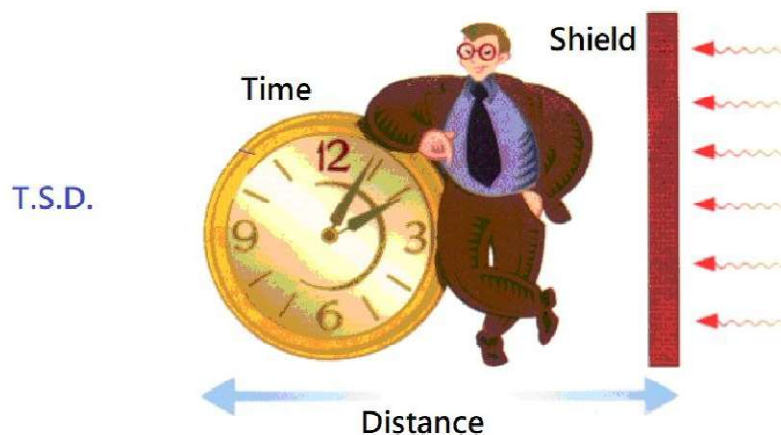
(Pb) mixed with an array of other heavy metals such as tin (Sn), antimony, tungsten (W), are the most commonly used materials for shielding. Check with local and state regulations for shielding requirements. Flight Dental Systems recommends the use of lead aprons and thyroid collars for the patient as it is always still safer than no protection at all. However, please note that these recommendations are optional in certain states.

Radiation Shielding

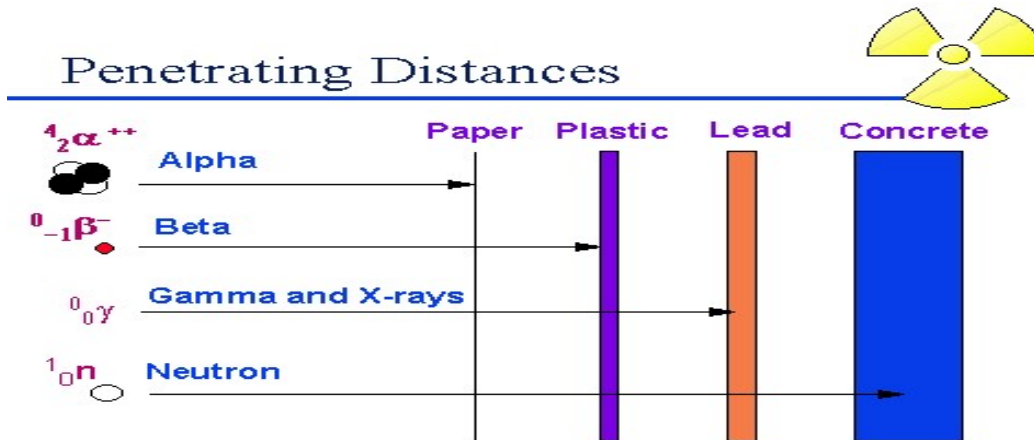


Ionizing Radiation consists of Gamma Rays and X-Rays which are all seen above on the electromagnetic spectrum as shorter in wavelength as it appears to the left of the visible light spectrum. Ionizing Radiation is undetectable by human senses, so a Dosimetry badge can be used to measure it.

Principle of Radiation Protection



The most effective shielding for X rays is lead or concrete. Patients should be shielded to protect their thyroid and reproductive organs. Our handheld X-ray systems also comes equipped with a lead equivalent backscatter shield to protect the operator as well.



Operator Radiation Dose Limits

According to dose limits set up by the United States Nuclear Regulatory Commission (NRC). Title 10, Part 20, of the Code of Federal Regulations (10 CFR Part 20), "Standards for Protection Against Radiation," establishes the dose limits for radiation workers. Although the limits vary, depending on the affected part of the body, the annual total effective dose equivalent (TEDE) for the whole body is 5,000 mrem (5 rem).

Occupational Dose Limits (Per Annum)

Type	Occupational Dose Limit
Total effective dose equivalent	5000mrem/yr
Lens of the eye	15,000 mrem/yr
Skin	50,000 mrem/yr
Hands and feet	50,000mrem/yr

Embryo/Fetus	500 mrem (over the length of pregnancy)
--------------	---

Specified in 10 CFR 20.1201 and 10 CFR20.1208

The operator's skin, eyes, and thyroid are the parts of the body most sensitive to the primary beam, leakage, and scatter exposures. Refrain from holding the x-ray at the collimator cone to reduce leakage radiation to the hands.

NOTE: Dosimetry badges are the same devices that X-ray technologists and other radiological workers wear when operating x-ray equipment. Depending on state regulations, each of these individuals should receive one or more of this product to measure the amount of their annual occupational radiation dose.

Safety Precautions

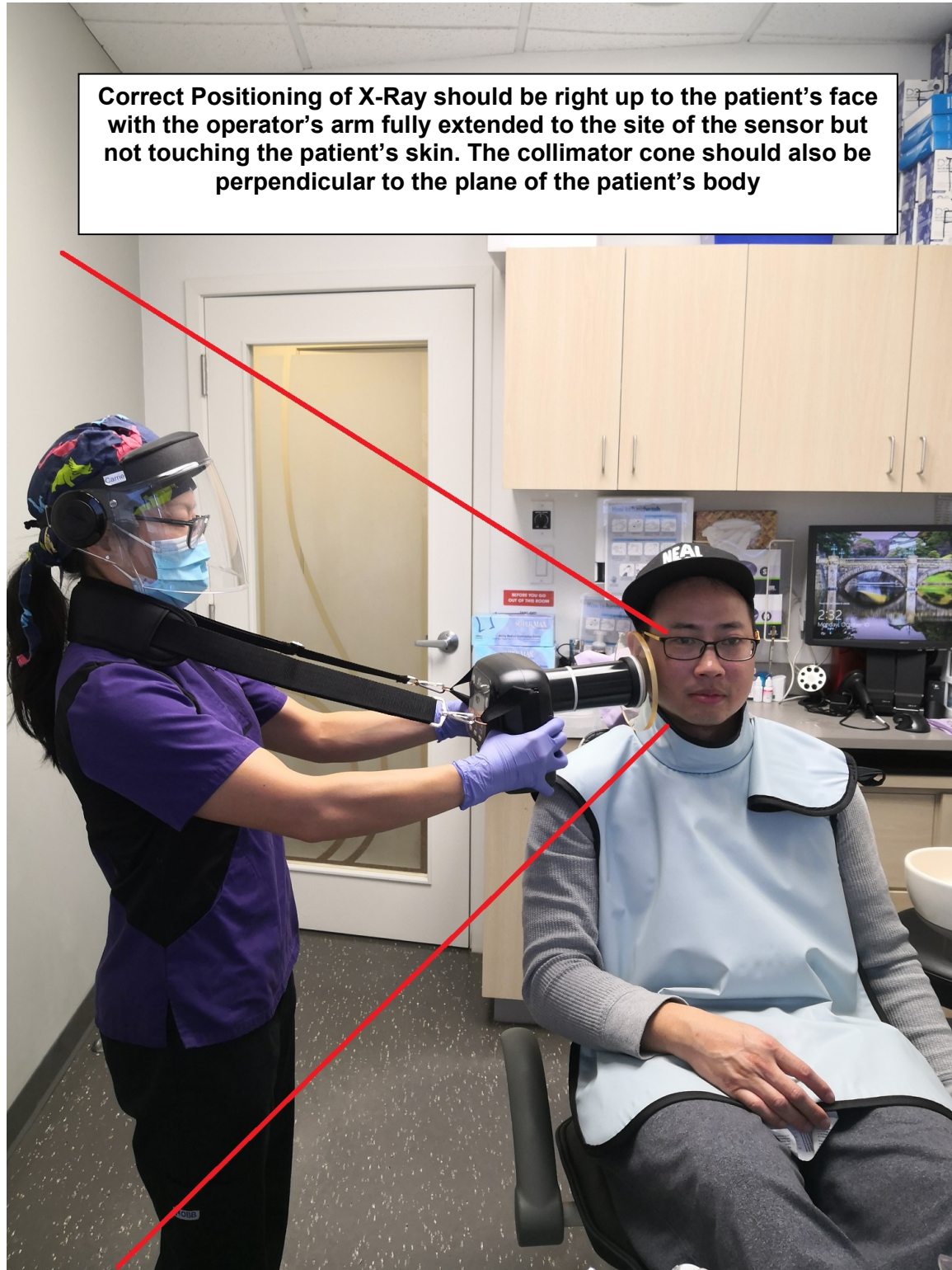
Flight Dental System's X-VISION X-Ray produces 2 types of radiation that are pertinent to the understanding of a safe utilization of this unit. The useful X-rays leaving the vacuum tube housing move down the collimator cone (which itself has a layer of structural shielding in its design) and is directed towards the patient. This beam of radiation is called primary radiation and is linearly correlated with the exposure time (seconds), tube current (mA), and tube potential (kVp).

Once this primary radiation leaves the vacuum tubing, it attenuates with matter (i.e. the patient) and produces what is known as secondary radiation. Secondary radiation also known as stray radiation is the sum of scatter radiation and leakage radiation.

- a) *Scatter Radiation* is defined as the new and less energized radiation that is given off when the X-rays beam from the primary radiation interacts with matter i.e. the patient and disperses. The backscatter shield on Flight Dental System's X-VISION X-ray has been designed to prevent excessive scatter radiation.
- b) *Leakage Radiation* is the radiation that escapes from the vacuum tube emitting the source of X-rays minus the primary radiation. Leakage radiation is minimized by the collimator cone on the X-VISION X-Ray unit that directs the useful X-ray beams towards the patient.

Backscatter Shield

The X-Vision has a circular, lead infused plastic disc (0.35 mm lead-equivalent) surrounding the X-ray beam emission port. The purpose of this "backscatter shield" is to absorb radiation scattered from the patient's jaw so that it doesn't reach the operator. The backscatter shield should never be removed, as this shield is very effective at reducing radiation scatter in the direction of the operator. As seen by the figure, the shield, in relation to the patient's head, provides a safety zone in which the operator should remain during exposures. Therefore, standing behind the back scatter shield during operation is very important for the operator.



(Please Note: These are models used in the pictures. If required the operator should be wearing lead protection and dosimeter badge)

Incorrect Positioning of X-Ray due to the large distance from the sensor. The ring on the optional positioning device is also separating the X-ray too far away from the sensor which would increase backscatter radiation to the operator.

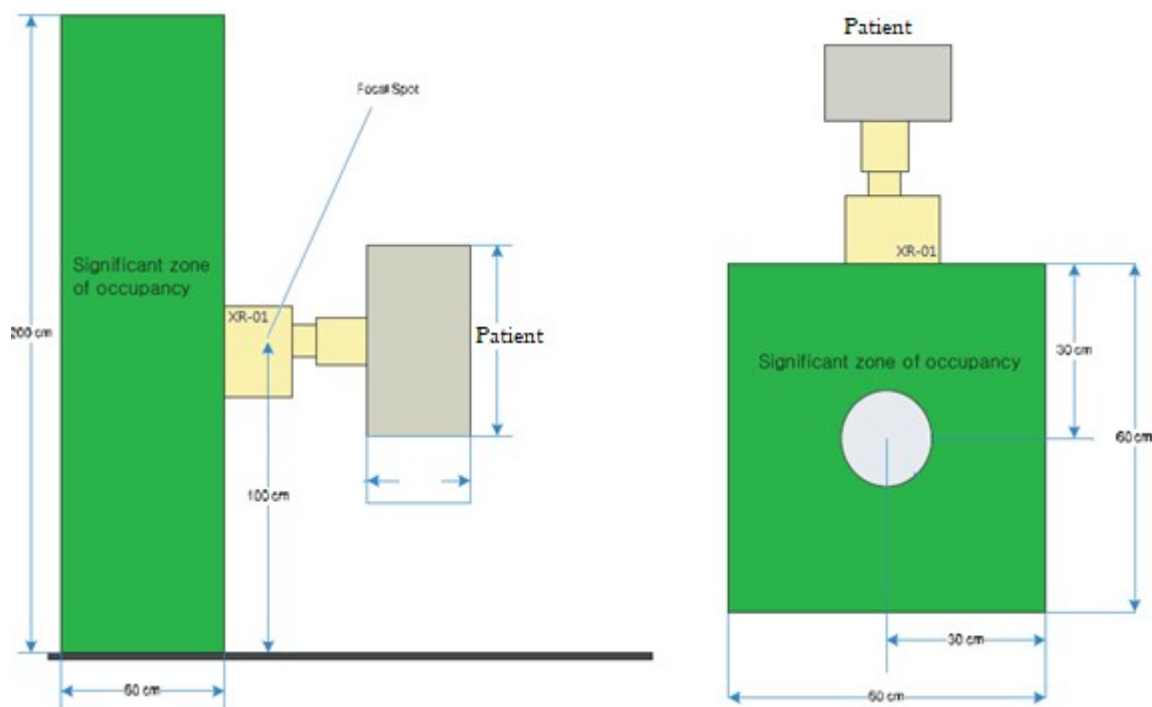


(Please Note: These are models used in the pictures. If required the operator should be wearing lead protection and dosimeter badge)

Additionally, the emission port should be held close to the patient to maximize the backscatter protection zone. As the cone and shield move farther from the cheek, the angle defining the backscatter protection zone decreases.

NOTE: To effectively minimize the amount of radiation that the operator and patient are exposed to, maintain the backscatter shield parallel to the operator and the collimator cone perpendicular to the area that is being radiographed.

As shown below, there is a significant zone of occupancy as indicated in green that illustrates a safety zone that the operator should stand within to minimize the amount of secondary radiation (Leakage and Scatter radiation) received.



Exposure Time

Only the exposure time of the unit can be changed because the tube potential and tube current are fixed. Depending on the age of the patient, the type of image sensors, and the location of the teeth that are being imaged, Flight Dental System's X-VISION X-ray has preset exposure times that can simply be changed by the press of a button. To maintain the ALARA principle, do not adjust the exposure time excessively just to capture a clearer image. As long as a dental diagnosis can be ascertained from the radiograph, exposing the patient with larger amounts of radiation is not recommended. For complete instructions on setting the exposure times, please refer to Section 7.2 of the User's Manual.

For further information on precautions and handling instructions refer to Section 3 and 4 of the User's Manual.

Note: Film Sensors generally require a longer exposure time when compared to digital sensors or phosphor plates

Item	Part		Exposure Time
Phosphorus Plate	Adult	Anterior	0.27 sec
		Posterior	0.32 sec
		Bite Wings	0.34 sec
	Child*	Anterior	0.15 sec
		Posterior	0.26 sec
		Bite Wings	0.27 sec
Digital Sensor	Adult	Anterior	0.20 sec
		Posterior	0.27 sec
		Bite Wings	0.29 sec
	Child*	Anterior	0.15 sec
		Posterior	0.22 sec
		Bite Wings	0.24 sec
Film	Adult	Anterior	0.50 sec
		Posterior	0.65 sec
		Bite Wings	0.68 sec
	Child*	Anterior	0.31 sec
		Posterior	0.50 sec
		Bite Wings	0.55 sec

There is a direct correlation between exposure time and dose. If exposure time is increased, patient dose increases. There is certainly a trade-off between image quality and patient dose. It is important to practice ALARA by keeping dose as low as possible while maintaining adequate image quality for diagnosis. Exposure to the operator and the patient should be limited and having to repeat images should be avoided.

Dosimetry

X-Vision has been shown to be a very safe portable X-ray system when used as intended. The occupational dose from leakage radiation at 1 cm from the case is less than 0.05 mSv / 5mrem to the fingers for an entire work year. And, as long as the operator remains within the safety zone (provided by the backscatter shield), their dose to the whole body is less than 0.20 mSv/20mrem. These dose estimates assume that the operator makes 7,200 dental X-rays each year; the unit is very safe. For reference, the regulatory dose limits are 500 mSv/50,000mrem to the fingers and 50 mSv/ 5000mrem to the whole body.

Pregnant X-Ray Users

Confirmed pregnant individuals should take all precautions possible to keep exposure to the embryo or fetus as a low as possible. The maximum exposure applies to declared pregnant individuals and the amount for a fetus/embryo is 5mSv/ 500mrem (over the length of pregnancy) and the embryo/fetus may not receive more than 0.5mSv/ 50 mrem in any one month

Accidental Exposure Prevention

Accidental exposures are easy to prevent as long as the operator is aware and careful of the direction they are pointing the x-ray emission. The operator should NEVER point the X-Vision X-Ray at anyone, except in the area of the patient that is being exposed. Exposure occurs only when the activation button is pressed. The operator should remain alert and keep their finger off the activation button until ready for the intended exposure. As the operator, it is important to be aware of your surroundings in order to maintain ALARA. Always ensure that you are within the backscatter protection zone, and that all unnecessary persons are out of the room prior to initiating an exposure. When taking an image, the operator first enables the ready button and will have a short amount of time to press the exposure button. If the exposure button is not pressed the ready button will turn to orange and will need to be activated again before the exposure button will be active. Once the exposure button is pressed the operator will hear a steady tone during the exposure; this sound will end when the selected time has passed. As a safety feature, the exposure will stop when the activation button is released, even if the selected time cycle is not complete i.e. activation button must be depressed the entire exposure to obtain an image.

1. Ready Button and Indicator Light:
Press the "Ready Button" to disable the safety lock in order to start an exposure. The indicator light will appear green when the safety lock is disabled. The indicator light will be orange when initiating or cooling, and the user will be unable to adjust any parameters on the equipment other than turning the unit off during this period as the equipment warms up or cools down.
2. Exposure Warning Light: A yellow light will appear while generating X-Rays beams and a beeping sound will be heard. Stabilize the equipment at this point to generate a clear image.

