CHAPTER 1

DENTAL RADIOLOGY

INTRODUCTION

The purpose of dental radiography is to record images of a patient's oral structures on film by using X-rays. When the X-ray films are processed, the resulting radiographs provide the dental officer with a valuable diagnostic aid. In the case of death, radiographs can be used to aid in identification as discussed in chapter 10, "Forensic Dentistry."

The first section of this chapter covers the basic fundamentals of dental radiography. Included are the physics and biology of radiography. Since X-radiation can be harmful, you must observe certain safety precautions when using an X-ray machine or working in an area where one is being used. These precautions are covered in the second part of this chapter.

The major portion of this chapter is devoted to explaining how to operate a dental X-ray machine, expose intraoral radiographs (radiographs taken inside the patient’s mouth), process the X-ray films, and mount the finished radiographs.

The last part of this chapter covers the panoramic X-ray machine, which you will use to make extraoral radiographs (radiographs made outside the patient’s mouth).

FUNDAMENTALS OF DENTAL RADIOLOGY

Oral radiography is the art of recording images of a patient’s oral structures on film by using X-rays (roentgen rays). The rays were recognition of Wilhelm Konrad Roentgen, a scientist, who first discovered X-rays in 1895. While experimenting with a device called a Crookes tube, which generated cathode rays, he noted that a photographic plate completely wrapped in black paper and lying near the tube was fogged when developed. He realized that some form of invisible ray, able to pass through the black paper, must be coming from the tube. Later, while in his darkened laboratory, he noticed that a fluorescent screen located six feet away was glowing. He knew that the cathode rays could travel only short distances outside the cathode tube and realized he was observing a new, unknown ray, which he called an X-ray because the symbol "X" is used for the unknown in mathematics.

The first dental radiograph was taken the same year by Dr. Otto Walkoff. Within 10 years, radiographs were being used for diagnosis of medical and dental conditions, for X-ray therapy, and for scientific studies. Although technology over the years has made tremendous improvements in X-ray equipment, the basic concepts are the same.

Like visible light rays, X-rays are electromagnetic rays that travel in a wave motion. The measurement of this wave motion is called a wavelength. The basic difference between X-rays and other electromagnetic rays is in their wavelength. X-rays have an extremely short wavelength, which enables them to penetrate matter that usually absorbs or reflects light or other electromagnetic rays with longer wave-lengths.

Although X-rays share the properties of other electromagnetic rays, their action is considerably different. Some of the characteristics and properties of X-rays are:

- They travel in straight lines at the speed of light.
- They affect photographic film by producing a hidden image made visible by processing.
- They cause certain substances to fluoresce (glow).
- They cause irritation of living cells and, in large amounts, can cause necrosis (death) of the cells, a fact that necessitates caution in using X-rays.

X-rays are produced when a metal (tungsten) target is bombarded by a stream of electrons. The X-rays are emitted in the tubehead and directed by the tubehead cone through the subject, producing an image on the film.

The density of the X-ray image is controlled by four factors: kilovoltage (kVp), exposure time, milliamperage (mA), and target-film distance (TFD). All of these factors are interrelated and may be varied by the operator. The procedures for setting these factors will be discussed later.
RADIATION SAFETY

Proper safety precautions must be observed by all persons working in or near an area where X-rays are being generated. X-rays can be dangerous. Long term overexposure to radiation may result in loss of hair, redness and inflammation of the skin, blood count change, cell atrophy (wasting away), ulcerations, sterility, genetic damage, cancer, leukemia, and death.

There are safety measures designed to protect the patient and the health care team from the dangers of overexposure to radiation and the operation of X-ray equipment. You must observe these safety measures when working in radiology. Your command will have instructions and standard operating procedures (SOP) for the operation of dental radiographic (X-ray) units and equipment. You will be required to read these procedures if you are newly assigned to the radiology department. There are other numerous responsibilities that include providing radiology support for oral diagnosis, log maintenance, infection control, testing for quality control, and processor maintenance.

PATIENT PROTECTION

A number of precautions are taken to prevent the patient from being exposed to inappropriate diagnostic radiation. The decision to order dental radiographs is determined by the dental officer on a case by case basis for each patient. Only a dental officer is authorized to order and diagnostically interpret dental radiographs.

Perhaps the most important safety measure is the responsibility of the assistant: When taking radiographs, you should always have patients wear lead aprons and thyroid collars to shield their reproductive organs and thyroid glands. There is only one exception to this rule; when obtaining a panorex radiograph, the thyroid collar is not used since it blocks part of the X-ray beam. In addition, always ask a female patient whether or not she is pregnant or if pregnancy is questionable, before taking radiographs. If she is pregnant, consult the dental officer.

Other radiation safety measures include X-ray machines that have built-in safeguards that filter out harmful radiation and restrict the central X-ray to the smallest possible area. Fast film is used to shorten exposure time; and only essential radiographs are taken on patients.

ASSISTANT PROTECTION

When you work near a source of radiation, your X-ray department will be issued an environmental dosimetry radiation film badge (fig. 1-1).

Appropriately placed environmental film badges are used to monitor stray radiation that may occur in and around the X-ray department. The badges are placed in the X-ray room behind the technicians protective lead-lined barrier or at least 6 feet from the tube head and never in the direct line of radiation during exposure. These film badges contain X-ray sensitive film in a light-tight packet. The film packets are collected every 6 to 7 weeks. After collection, the film is sent to the radiation detection laboratory for processing and evaluation. Any abnormally high readings (i.e., greater than 0.010 REM [Radiological Equivalent Mammel]) shall be referred to the Radiation Health Office for investigation.

When you take radiographs on a patient, observe the following precautions to avoid unnecessary exposure to radiation:

- NEVER stand in the path of the central X-ray beam during exposure.
- NEVER hold the X-ray film packet in the patient's mouth during exposure.
- NEVER hold the tube head or the tube head cylinder of the X-ray machine during exposure.
- ALWAYS stand behind a lead-lined screen during an exposure.

X-RAY FILM LOG

Another portion of radiation safety is to account for all radiographs that are taken. An X-ray film log
shall be maintained in all X-ray rooms and will contain the following information:

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
<th>Column 5</th>
<th>Column 6</th>
<th>Column 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient’s Name</td>
<td>Patient’s SSN</td>
<td>Patient’s Unit</td>
<td>Rank/Rate/Retired/Dependent/etc.</td>
<td>Number of X-ray exposures and type: bitewing, periapical, occlusal, panograph</td>
<td>kVp, mA, exposure time</td>
<td>Reason retake X-ray required (if applicable)</td>
</tr>
</tbody>
</table>

When stating the reason for a retake X-ray, be specific on the nature of the retake, for example: cone-cut, elongated, foreshortened, dark image, etc.

**DENTAL X-RAY MACHINES**

The most commonly used X-ray machine is the wall-mounted dental X-ray unit [fig. 1-2]. Because the basic components and operating techniques of all dental X-ray machines are similar, we will only discuss the wall-mounted unit. The component parts of the wall-mounted machine discussed here are the tube head, cylinder, extension arm, ready light, and a separate control panel.

**TUBE HEAD**

The tube head [fig. 1-3] contains the X-ray tube and other components necessary for generating X-rays. When an exposure is made, X-rays pass through an aluminum filter that screens out unnecessary radiation. Angulation scales are on both sides of the tube head for precise positioning technique.

**CYLINDER**

The cylinder (or cone) is affixed to the tube head and is used to align the tube head with the patient and the X-ray film. It is open-ended and composed of lead laminated material that establishes the minimum distance from the X-ray source to the patient’s skin.
The X-ray beam passes from the aluminum filter through an opening in a lead diaphragm, which restricts the beam to 2.6 inches at the cylinder tip. There are two commonly used cylinder lengths. A tube head with an X-ray source to cylinder end distance of 8 inches is referred to as a "short cone" machine, while a tube head with an X-ray source to cylinder end distance of 16 inches is referred to as a "long cone" machine. It is essential that the technician knows the X-ray source to cylinder end distance in order to set the appropriate exposure settings.

The tube head is attached to an extension arm. The extension arm is movable, allowing you to adjust the position of the tube head for each patient.

**CONTROL PANEL**

The operational controls on the control panel are covered in the discussion on the operational check.

**OPERATIONAL CHECK (WITHOUT PATIENT)**

At the beginning of each workday, you should activate the X-ray machine to ensure that it is working properly. This operational check is conducted without a patient in the chair. In order to check the machine, you must be thoroughly familiar with its operation. Read the manufacturer's instructions carefully.

Throughout this discussion of the operational check, refer to figure 1-4. The steps of procedure are:

1. Energize the control panel. The control panel shown in figure 1-4 has three push buttons in the upper left corner. By depressing either the 10 mA or the 15 mA pushbutton, you will energize the machine and select the milliampere setting at the same time. Once the button is depressed the "power on" light will glow amber, indicating that the system is turned on. (A setting of 10 mA is normally used for intraoral radiographs.)

   **NOTE:** Some machines have separate master on/off switches. On these machines, you should FIRST activate the master switch, and then select the milliampere(s) (10 mA or 15 mA) setting. A 10 mA setting is used for most dental radiographs. Some units use a combination master on/off switch and mA selector to energize the machine.

   2. Set the tube head selector. On units with multiple tube head capabilities, depress the pushbutton that corresponds to the tube head to be used, normally...
tube 1. The depressed button and a lamp on the selected tube head will glow.

3. Select the kilovoltage. Adjust the kilovoltage (kV) until the desired kilovolt peak (kVp) is registered on the kilovolt meter. The kVp setting will vary, depending on the patient's bonesize and density; specific settings will be given later in this chapter.

**NOTE:** Some X-ray machines shut off automatically if the setting exceeds 90 kVp. Refer to the manufacturer's instructions for resetting procedures.

4. Set the exposure time. Check the X-ray film manufacturer’s recommended time setting for the type of film being used, the kVp and mA settings, and the film focal distance (FFD). The time settings may be in fractions of a second or impulses. An impulse equals 1/60 of a second. To protect the patient from needless exposure to radiation, use the minimum exposure time necessary to produce the desired results.

5. Check to see that the machine is emitting X-rays. Place an unexposed packet of X-ray film on the seat of the dental chair. Put a penny on top of the film packet and position the tube head. The tube head cylinder should be pointed down, 6 inches above and centered on the penny. When the tube head is correctly positioned, prepare to make the exposure.

**WARNING:** You must be behind a lead-lined shield or at least 6 feet from the tube head when making the exposure.

6. Make the exposure by depressing the exposure button located on the control panel. Exposure start is delayed approximately 1/2 second. If the machine is working correctly, you will hear a click and the tone signal, and the "X-ray" lamp on the control panel will glow. This indicates that an exposure is being made. **Do not release the exposure switch until the selected exposure time is completed.**

7. After making the exposure, process the X-ray film. If the processed film shows a light area where the penny was, the X-ray machine is working properly. Processing techniques will be discussed later in this chapter.

**MACHINE OPERATION (WITH A PATIENT)**

Once the X-ray machine's operational readiness check has been completed, it is a simple matter to prepare it to take radiographs on a patient. Set the mA selector, the tube head selector (if necessary), the kVp selector, and the exposure time. Before you make the exposure, position the patient, the film packet, and the tube head cylinder. These patient positioning procedures are discussed later.

**SECURING THE X-RAY MACHINE**

At the end of each work day, deactivate the off switch and secure the machine (e.g., the tube head extension arm should be completely folded to minimize the weight of the tube head on the arm and wall mounting plate).
USER MAINTENANCE

An X-ray machine is very expensive. Do everything possible to keep it in good working order by following the user maintenance procedures contained in the manufacturer's instructions.

General user maintenance includes dusting the X-ray machine daily, and removing blood and debris from all surfaces using a cloth moistened with detergent solution. Follow disinfection procedures discussed later in the chapter.

NOTE: DO NOT use a wet cloth; moisture might enter the control panel causing an electrical short circuit that could cause severe damage to the machine and possible harm to the operator. DO NOT use cleaners or solvents.

Never attempt to repair the X-ray machine yourself. If it breaks down, report it to your supervisor. All repairs are the responsibility of the dental equipment repair technician.

INTRAORAL RADIOGRAPHHS

Intraoral radiographs are made with the X-ray film placed inside the patient’s mouth. There are three types of intraoral radiographic examinations: periapical examination, interproximal (bitewing), and the occlusal.

To ensure diagnostic quality radiographs, you must properly align the X-ray film, the area to be X-rayed, and the tube head cylinder of the X-ray machine. Alignment can be accomplished by using either the parallel film placement technique (preferred method) or the bisecting angle technique. The following discussion provides detailed information on how to take periapical and interproximal (bitewing) radiographs, using both techniques. For the occlusal examination, you will use only the bisecting angle technique.

INTRAORAL FILM

The X-ray films used for intraoral examinations differ in size, depending on the type of examination. Figure 1-5 compares the sizes of periapical, interproximal (bitewing), and occlusal film.

There are different speeds of film. The most commonly used is an ultraspeed film known as D speed film. Ektaspeed (or E speed) film requires less radiation per exposure than D speed film. Some commands are now using E speed film. The exposure times given in the following sections are for D speed film.

Intraoral film comes in film packets, with a lightproof and waterproof outer wrapper. Inside the wrapper, the film is sandwiched between black protective paper and backed with lead foil. Figure 1-6 shows a partially unwrapped periapical film.

STORAGE

Intraoral film can be ordered through normal supply channels. It must be stored in a cool, dry area. In very hot or damp climates, the film should be refrigerated. Never store it near steam lines or radiators, and never store it near film processing...
solutions, since the escaping fumes could damage the film.

Because the unprocessed film is sensitive to X-rays, it must be stored in lead lined containers, as shown in **Figure 1-7** in the open and closed position. Remove only one film at a time from the lead film dispenser, make the exposure, and place the film in a clean paper cup or disposable container. Place the cup or disposable container in a lead container or behind a protective screen before making the next exposure. Repeat this procedure for each exposure. Maintain a minimum stock of film, and use the oldest film first so the stock is always fresh.

**PRECIOUS METALS RECOVERY PROGRAM (PMRP)**

The precious metals recovery program is designated to save Department of Defense (DOD) money by recycling precious metals and using those funds to offset the cost of supplies for DOD activities. Both silver and lead are precious metals that are found in the X-ray department. The silver is found in used fixer solutions and on dental films. The lead is found in X-ray packets. These precious metals should be saved and turned into the supply department following the guidelines in BUMEDINST 4010.3, "Precious Metals Recovery Program."

**ASSISTANT PREPARATION**

To protect yourself and the patient from diseases, perform the handwashing and gloving procedures covered in *Dental Technician*, Volume 1, chapter 9, "Infection Control ."

**PATIENT PREPARATION**

To properly prepare a patient for an X-ray procedure, you should employ the following techniques:

- Ensure all infection control procedures are followed.

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**Figure 1-7**—Lead lined container.
Seat and position the patient. Positioning varies according to the type of radiographic examination and the film placement technique you are going to use. Specific positioning procedures will be discussed later.

If the patient is a woman, ask her if she is pregnant. If she is or you suspect that she might be, consult the dentist.

Ask the patient to remove eyeglasses, complete dentures, removable partial dentures, earrings, or any other objects about the head and neck.

Explain the X-ray procedures to the patient. If the patient is nervous about being X-rayed, explain the safety precautions taken to prevent overexposure to radiation.

Drape the patient with a lead apron and thyroid collar.

Quickly examine the patient's mouth to determine its anatomy. Such things as a small mouth, an abnormally shallow vault, crooked teeth, and bony protrusions can affect the placement of the film packet. The patient's overall bone size and density will determine the kVp setting. For a patient with a normal bone size and density, use a kVp setting of 87; for a patient with a thick bone size and density, use a 90 kVp setting.

Position the patient's head securely against the headrest.

Place the film packet in the patient's mouth. Film placement procedures will be discussed later. Occasionally patients may gag when the film is placed in their mouth. The gagging reflex may be caused by nervousness, so remain calm and reassure the patient. You might recommend that patients breathe through their nose, since it is difficult to gag while doing so, having patients rinse out their mouth with cold water may also help or have patients concentrate on something other than gagging. Whatever technique you use you will have to be swift in placing the film and making the exposure because the chance of keeping the gag reflex from returning for an extended period is highly unlikely.

After the X-ray procedure is completed, you must store the lead apron and thyroid collar properly to avoid damage as shown in Figure 1-8.

PERIAPICAL EXAMINATION

A periapical examination is conducted to obtain radiographs of the crowns, roots, and supporting structures of the teeth. Figure 1-9 shows a typical periapical radiograph.

There are two techniques available to take periapical radiographs: paralleling and bisecting-angle. Both techniques use the long axis of the tooth as a focal point. The paralleling technique is the preferred method and the bisecting-angle technique is used as an alternative. Film placement and techniques are discussed in the following sections.

PARALLELING TECHNIQUE

When using the paralleling technique, you must center the X-ray film packet behind, and parallel with
the long axis of the tooth being X-rayed. A tube head with a 16-inch X-ray source to cylinder end distance (long cone) should be used with the paralleling technique. The tube head must be positioned so that the central X-ray beam is projected perpendicular to the tooth and the film packet. To properly position the film and the tube head, use paralleling devices.

There are two different paralleling devices. One is used for radiographs of the anterior teeth; the other is used for radiographs of the posterior teeth. Each paralleling device consists of a bite-block, an indicator rod, and locator ring (fig. 1-10). The bite-block has a slot and a film backing support to hold the X-ray film packet.

Assembling The Anterior Device

Figure 1-11 shows a fully assembled anterior paralleling device. Refer to this figure during the following explanation on assembling the paralleling device:

- Grasp the periapical film packet between the thumb and first two fingers of your right hand. The printed surface of the packet should be facing you, and the side with the raised dot should be in the film positioning slot of the paralleling device.
- Hold the base of the anterior bite-block between the thumb and first two fingers of your left hand. Ensure that the plastic film support is pointed upward and the film positioning slot is away from you.
- Holding the film packet in position, press it against the plastic support and slide the film down into the positioning slot. The printed side of the packet should be facing the plastic support, and the raised dot should be located toward the positioning slot.
- The two prongs of the indicator rod are inserted into the openings in the bite-block.
- Slide the anterior locator ring onto the indicator rod. Look through the locator ring. If the bite-block and
film are centered in the locator ring, the device is properly assembled and ready for positioning in the patient’s mouth.

**Assembling The Posterior Device**

[Figure 1-12] shows a fully assembled posterior paralleling device. Refer to this figure during the following discussion.

- Insert the film into the posterior bite-block as previously discussed.

**NOTE:** The posterior device shown in [figure 1-11] is used for film placement in the right maxillary and left mandibular quadrants. You must reassemble the device, rotating the locator ring and the bite-block, before using it in the left maxillary or right mandibular quadrants. Only the posterior device must be reassembled in this manner, the anterior device does not require reassembly.

**Placing The Device**

Once you have assembled the posterior paralleling device, place it in the patient’s mouth. Be very careful not to injure the oral tissue. If the patient gags, use the remedies discussed earlier.

Guide the bite-block and the film packet into position, centering the packet behind the area being X-rayed. The film packet should be positioned far enough behind the tooth so it will be parallel to the long axis of the tooth.

After positioning the film packet, slide the locator ring down the indicator rod until the ring almost touches the surface of the patient’s face. Then, position the tube head cylinder. The end of the cylinder should be parallel with the locator-ring, and its side should be parallel with the indicator rod.

Once these procedures have been accomplished, the film packet and the tube head are in proper alignment. You are now ready to expose the film.

![Assembled posterior paralleling device.](image)

**EXPOSURE ROUTINE FOR FULL MOUTH PERIAPICAL EXAMINATION**

The full mouth periapical examination consists of 14 periapical radiographs (7 maxillary and 7 mandibular). The series includes the following films and sequence starting with the maxillary arch and proceeding to the mandibular arch:

1. Incisor area
2. Left cuspid area
3. Left bicuspid area
4. Left molar area
5. Right cuspid area
6. Right bicuspid area
7. Right molar area

**GUIDELINES FOR TAKING PERIAPICAL RADIOGRAPHS, PARALLELING TECHNIQUE**

The following guidelines apply if you are taking either a full mouth series, or an individual periapical radiograph. For training purposes, infection control barriers are not used in the photographs in this section.

In most cases, the X-ray machine is set at 10 mA for dental radiographs. The kVp may vary, depending upon the thickness or the region being radiographed. If the area being radiographed is edentulous (no teeth present), reduce the recommended kVp by 5. When you are taking radiographs on a child, reduce the recommended kVp to 70. Always consult the dentist before taking radiographs on a child. Because of the different types of X-ray equipment in use, the exposure time selector you use may not have the settings suggested. Consult the film manufacturer's instructions regarding the desired time setting to use.

Before you perform an individual radiograph or a full mouth periapical examination, prepare the patient, using the procedures explained earlier. When you are using the parallel film placement technique, the position of the patient's head is not critical. But, it is best to adjust the head rest on the dental chair so that the patient's "plane of occlusion" is parallel with the floor and the "midsagittal plane" is perpendicular to the floor ([fig. 1-13]).

It is important to properly position the paralleling devices and the tube head cylinder when using the paralleling placement technique.
Figure 1-13.—Midsagittal and occlusal planes.

When taking a full mouth series or an individual periapical radiograph, follow the given guidelines for the specific area listed:

**NOTE:** After each exposure, put the exposed film in a clean paper cup or disposable container. Then place the cup or disposable container in a lead container or behind a protective screen.

- **Maxillary Incisor Area**
  1. Set the exposure time selector to manufacturer's suggested impulses.
  2. Prepare the anterior paralleling device.
  3. Position the paralleling device with film in the patient's mouth. Center the film on the midline so that it is parallel with the long axis of the incisors (fig. 1-14).
  4. Place a cotton roll under the bite-block. Have the patient close gently but firmly.
  5. Adjust the locator ring and align the tubehead cylinder as previously described.
  6. Make the exposure.

- **Maxillary Cuspid Area**
  1. Set the exposure time selector to manufacturer's suggested impulses.
  2. Prepare the anterior paralleling device.
  3. Position the paralleling device with film in the patient's mouth. Position the film on the cuspid and parallel with the tooth's long axis (fig. 1-15).
  4. Place a cotton roll under the bite-block and have the patient close.

- **Maxillary Bicuspid Area**
  1. Set the exposure time selector to the manufacturer's suggested impulses.
  2. Prepare the posterior paralleling device.
  3. Position the paralleling device with film in the patient's mouth. Center the second bicuspid and parallel with the tooth's long axis. The film should be parallel with the long axis of the molars (fig. 1-16).
  4. Place a cotton roll under the bite-block and have the patient close.
  5. Adjust the locator ring and align the tubehead cylinder.
  6. Make the exposure.

- **Maxillary Molar Area**
  1. Set the exposure time selector to the manufacturer's suggested impulses.
  2. Prepare the posterior paralleling device.
  3. Position the paralleling device with film in the patient's mouth. Center the film on the second molar, so the anterior edge of the film includes at least the distal half of the second bicuspid. The film should be parallel with the long axis of the molars (fig. 1-17).
  4. Place a cotton roll under the bite-block and have the patient close.
  5. Adjust the locator ring and align the tubehead cylinder.
  6. Make the exposure.

- **Mandibular Incisor Area**
  1. Set the exposure time selector to the manufacturer's suggested impulses.
  2. Prepare the anterior paralleling device.
  3. Position the paralleling device with film in the patient’s mouth. Center the film on the midline and parallel with the long axis of the incisors (fig. 1-18).
  4. Place a cotton roll on the upper surface of the bite-block and have the patient close.
  5. Adjust the locator ring and align the tubehead cylinder.
  6. Make the exposure.
Mandibular Cuspid Area

1. Set the exposure time selector to the manufacturer's suggested impulses.
2. Assemble the anterior paralleling device.
3. Position the paralleling device with film in the patient's mouth. Center the film on the cuspid and parallel with its long axis [Fig. 1-19].
4. Place a cotton roll on the upper surface of the bite-block and have the patient close.

Figure 1-14—Film and cylinder placement: maxillary incisor area.
5. Adjust the locator ring and align the tubehead cylinder.

6. Make the exposure.

- Mandibular Bicuspid Area

1. Set the exposure time to the manufacturer's suggested impulses.

2. Assemble the posterior paralleling device.

3. Position the paralleling device with film in the patient's mouth. Position the film packet so that it is centered on the second bicuspid and parallel with its long axis (fig. 1-20).

4. Place a cotton roll on the upper surface of the bite-block and have the patient close.

5. Adjust the locator ring and align the tubehead cylinder.

6. Make the exposure.

- Mandibular Molar Area

1. Set the exposure time to the manufacturer's suggested impulses.

2. Assemble the posterior paralleling device.

3. Position the paralleling device with film in the patient's mouth. Position the film packet. Center the film on the second molars, so the anterior edge of the film includes at least the distal half of the second bicuspid. The film should be parallel with the long axis of the molars (fig. 1-21).

4. Place a cotton roll on the upper surface of the bite-block and have the patient close.

5. Adjust the locator ring and align the tubehead cylinder.
6. Make the exposure.

VARIATION TO THE EXPOSURE FACTORS AND FILM ALIGNMENT

Some variations to the exposure factors and film alignment may be necessary for a specific area of the patient's anatomy.

The dentist may request a radiograph of an impacted third molar. If so, you would prepare the paralleling device in the usual manner, placing the film packet off center in the backing support so the film extends posteriorly to cover the entire third molar area. When you place the paralleling device in the patient's mouth, position it so the anterior edge of the film includes the distal half of the first molar.

Use special film placement procedures when a patient has a low palatal vault or edentulous arches. Place one cotton roll on each side of the bite-block as shown in figure 1-22. This ensures that the X-ray film will be parallel with the long axis of the teeth being radiographed.

BISECTING-ANGLE TECHNIQUE

Use the bisecting-angle technique when paralleling devices are not available; or when a patient finds it painful or impossible to close on the bite-block; or when an X-ray is needed when a rubber dam is in place. This technique incorporates the use of a tube head with an X-ray source to cylinder end...
Figure 1-17—Film and cylinder placement: maxillary molar area.

distance of 8 inches (short cone). The bisecting-angle technique is not recommended for routine use.

Since paralleling devices are not used with the bisecting-angle technique, you must pay special attention to positioning the patient, the film packet, and the tube head.

**Positioning the Patient**

For all maxillary periapical radiographs, position the patient's head as shown in figure 1-23 from the ala of the nose (the outer portion of the nostril) to the tragus of the ear (a projection of the cartilage on the front center of the ear). This ala-tragus line should be parallel with the floor. The patient's head should also be positioned so that the midsagittal plane is perpendicular to the floor.

For mandibular periapical radiographs, lower the headrest so the patient's head is positioned as shown in figure 1-24. The figure shows a line running from the corner of the patient's mouth to the tragus of the ear. This line should be parallel with the floor. Again, the mid-sagittal plane is perpendicular to the floor.

**Positioning the Film**

Once the patient is positioned, insert the film packet in the patient's mouth with a pair of hemostats or other holding device. Never slide the packet in; this might irritate the oral mucosa or cause the patient to gag. Gently direct the holding device to the desired
position. In order to adapt the packet to the area being radiographed and to relieve patient discomfort, it may be necessary to shape the packet. Do this by gently flexing the corners of the packet and holding it over the end of your thumb. Do not crease the packet.

Center the packet behind the tooth to be radiographed. The printed side of the packet should face away from the tooth, with the printed dot toward the occlusal surface. The film is held as close to the tooth as possible. At this point the long axis of the tooth
and the plane of the film should be nearly parallel. In order to project the proper image of the tooth onto the film, you must visualize an imaginary line bisecting the long axis of the tooth and the plane of the dental film [fig. 1-25]. The central ray is then directed perpendicular (a 90° angle) to the bisecting line. This will project the proper dimensions of the tooth onto the film without elongation or foreshortening. If the anterior curvature of the patient's arch is narrow, insert a cotton roll between the packet and the teeth. This prevents the film from bending excessively and producing a distorted image.

Once the film packet is properly positioned, guide a free hand of the patient to the holding device. The patient gently holds the device with the hand from the opposite side of the arch being radiographed.

**WARNING:** The assistant should never hold the film packet in position during an exposure.

Each time you take radiographs, use the standard film positions. This helps when comparing radiographs made at different times.

**Positioning the Tube Head**

After the film is inserted in the patient's mouth, position the tube head so the end of the cylinder is near the area to be radiographed. Then, position the tube head for correct vertical and horizontal angulation...
using anatomical landmarks on the patient's face. Tell your patient to maintain the position of the placement of the dental film and not to move while you expose the radiograph.

**VERTICAL ANGULATION.**—This is the up-and-down positioning of the tube head. A 0° vertical angulation indicates that the tube head is positioned with the cylinder parallel with the floor [fig. 1-26]. Angling the tube head so the cylinder points upward from 0° will give you a minus (−) degree of vertical angulation. Angling the tube head so the cylinder points downward from 0° will give you a plus (+) degree of vertical angulation.

Different areas of the mouth require different degrees of vertical angulation. The correct vertical angulation can usually be obtained by using the angles shown on the chart in figure 1-26. Notice the tube head is angled downward for maxillary radiographs, and usually angled upward for mandibular radiographs. The tube head may be horizontal (0°) when X-raying mandibular molars.

A wrong angulation results in a distorted radiograph. Too little vertical angulation elongates the radiographic image [fig. 1-27]; too much vertical angulation foreshortens the image [fig. 1-28].

A standard vertical angulation cannot be used for all patients because of differences in their oral
structures. A patient may have an unusually high maxillary vault or an unusually deep palatal vault. In either case, you would decrease the standard vertical angulation by about 5°. On the other hand, for a patient with an unusually shallow vault, you would increase the angulation by about 5°. The more experienced you become in X-ray techniques, the easier it will be for you to determine when to alter standard vertical angulation to suit the needs of a particular patient.

After you have determined the correct vertical angulation for the area to be radiographed, adjust the tube head using the angle dial on the tube head as a reference.
When the tube head has been set for the proper vertical angulation, center the tube head cylinder on the area to be radiographed. The cylinder should almost touch the surface of the patient's skin. Then, position the tube head for correct horizontal angulation.

**HORIZONTAL ANGULATION.**—This is the side-to-side positioning of the tube head. Position the tube head so the central X-ray beam is directed straight through the embrasures of the teeth being radiographed. If the horizontal angulation is faulty, the central ray will be directed at an angle to the embrasures. This will produce a faulty radiograph, with the images of the teeth overlapping one another. [Figure 1-29] illustrates the correct and incorrect cylinder direction.
GUIDELINES FOR TAKING PERIAPICAL RADIOGRAPHS, BISECTING-ANGLE TECHNIQUE

Take the same 14 radiographs using the same exposure sequence as that discussed for the paralleling technique. Complete the following steps:

1. Program the X-ray machine for the discussed mA and kVp settings. The exposure time varies, just as it did with the paralleling technique. Refer to the film manufacturer’s instructions for correct time/impulse settings. Remember to reduce the kVp by 5 when taking radiographs in edentulous areas, and to 70 when taking radiographs on children.

<table>
<thead>
<tr>
<th>Maxillary</th>
<th>Mandibular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incisor</td>
<td>-15 to -20</td>
</tr>
<tr>
<td>Cuspid</td>
<td>-20 to -25</td>
</tr>
<tr>
<td>Bicuspid</td>
<td>-10 to -15</td>
</tr>
<tr>
<td>Molar</td>
<td>-5 to 0</td>
</tr>
</tbody>
</table>

**Figure 1-25**—Relationship of central ray, tooth, and film packet in bisecting-angle technique.

**Figure 1-26**—Average vertical angulation.

**Figure 1-27**—Elongated image.

**Figure 1-28**—Foreshortened image.

**Figure 1-29**—Correct and incorrect cylinder direction.
2. Position the patient as shown in figure 1-23 for maxillary radiographs or figure 1-24 for mandibular radiographs. Remember that the patient's midsagittal plane must be perpendicular to the floor.

3. Position the film packet in the patient's mouth. Have the patient hold the film packet in place with a pair of hemostats or other holding device.

4. Set the vertical angulation of the tube head according to the chart in figure 1-26.

5. Center the tube head cylinder on the area to be radiographed. To simplify this process, the numbered anatomical landmarks are provided in figure 1-30. Take radiographs of the area by centering the tube head cylinder on these landmarks:

   - Maxillary incisor area: Landmark 1, the tip of the nose.
   - Maxillary cuspid area: Landmark 2, beside the ala of the nose.
   - Maxillary bicuspid area: Landmark 3, below the pupil of the eye.
   - Maxillary molar area: Landmark 4, below the outer angle of the eye and below the zygomatic bone.
   - Mandibular incisor area: Landmark 5, the tip of the chin.
   - Mandibular cuspid area: Landmark 6, directly below landmark 2 1/4 inches above the lower border of the mandible.
   - Mandibular bicuspid area: Landmark 7, directly below landmark 3 1/4 inches above the lower border of the mandible.
   - Mandibular molar area: Landmark 8, directly below landmark 4 1/4 inches above the lower border of the mandible.

6. When you have the tube head cylinder centered on the horizontal landmark, double check to make sure that you have the correct horizontal angulation. The central X-ray beam should be projected straight through embrasures of the teeth to be radiographed.

7. Make the exposure.

8. Remove the film packet from the patient's mouth and place it in a clean paper cup. Place the disposable container in a lead container or behind a protective screen before making the next exposure.

**INTERPROXIMAL (BITEWING) EXAMINATION**

The interproximal examination reveals the presence of interproximal caries, certain pulp conditions, overhanging restorations, improperly fitting crowns, recurrent caries beneath restorations, and resorption of the alveolar bone.

A typical interproximal radiograph records in a single exposure the coronal and cervical portions of both maxillary and mandibular teeth, along with the alveolar bone of the region.

Bitewing X-ray film packets are used for the interproximal examination. The bitewing film packet has a paper tab, or wing, that the patient bites on to hold the packet in place during the exposure (thus the name bitewing).

Interproximal radiographs can be made using either the paralleling technique or the bisecting angle technique.
PARALLEL PLACEMENT TECHNIQUE

The following procedures describe this technique:

1. Program the X-ray machine for the discussed time, mA settings, and kVp settings.

2. Prepare the inter-proximal paralleling device (fig. 1-33). Fold the bitewing tab against the film packet and insert the packet into the bite-block so that the printed side faces the backing support. Insert the end of the indicator rod into the holes in the bite-block. Slide the locator ring onto the indicator rod. Look through the locator ring to see if the bite-block is centered in the ring. If it is, the paralleling device is ready for positioning in the patient's mouth.

3. Position the paralleling device with film in the patient's mouth so that the anterior edge of the film touches the distal surface of the mandibular cuspid (fig. 1-34). Have the patient close gently but firmly on the bite-block to hold the film in position.

4. Slide the locator ring down the indicator rod until the ring almost touches the surface of the patient's face. Then, align the tube head using the same technique as previously described for the paralleling device.

5. Make the exposure. After making the exposure, put the exposed film in a lead lined container or behind a protective screen. You are now ready to take the radiograph on the opposite side of the patient's mouth.

BISECTING-ANGLE TECHNIQUE

The following procedures describe this technique:

1. Program the X-ray machine for the discussed time, mA settings, and kVp settings.

2. Position the patient so that the ala-tragus line is parallel with the floor, and the midsagittal plane is perpendicular to the floor.

3. Position the film packet in the patient's mouth. Hold the wing of the packet between your thumb and index finger. Place the lower edge of the packet between the tongue and the lingual surfaces of the mandibular teeth. Position the packet so that its anterior edge touches the distal surface of the mandibular cuspid. Rest the wing of the packet on the occlusal surfaces of the mandibular teeth. Instruct the patient to close slowly. As the patient's maxillary teeth contact your index finger, roll your finger out facially, permitting the patient's teeth to close on the wing (fig. 1-35). The film packet is now positioned.

4. Set the vertical angulation of the tube head at +5° to +10°.
5. Center the tube head cylinder on the wing of the film packet. Be sure that the central X-ray beam passes through the embrasures as shown in figure 1-36.

6. Make the exposure. After making the exposure, put the exposed film in a clean paper cup and place in a lead lined container or behind a protective screen. You are now ready to take the radiograph on the opposite side of the patient's mouth.

**OCCLUSAL EXAMINATION**

An occlusal examination is usually conducted when fractures of the jaw or gross pathological conditions are suspected. A typical occlusal radiograph (fig. 1-37) shows a large area of the maxillary or mandibular arch.

The occlusal film packet is shaped much like the periapical packet, only larger. Unlike the periapical
Figure 1-37.—Typical maxillary anterior occlusal radiograph.

The occlusal packet contains two X-ray films. This allows different developing times to be used for these films. The finished radiographs can then be compared for diagnostic purposes.

Occlusal radiographs are exposed using the bisected angle technique.

**MAXILLARY OCCLUSAL RADIOGRAPHS**

Maxillary occlusal radiographs are taken by using the following procedures:

1. Set the X-ray machine at 10 mA, 90 kVp, and 60 impulses (1 second). (Reduce the kilovoltage 5 kVp if the arch is edentulous. Use 70 kVp if the patient is a child.)

2. Position the patient so that the ala-tragus line is parallel with the floor, and the mid-sagittal plane is perpendicular to the floor.

3. Place the film in the patient's mouth. Occlusal films are normally very comfortable. Have the patient relax the muscles of the mouth and cheek as much as possible. The pebbled surface of the packet should be toward the occlusal surfaces of the maxillary teeth, and the narrow side of the packet toward the patient’s cheeks. To place the packet, retract one corner of the patient’s mouth until the packet can be inserted. Position the packet far enough in the mouth so that it covers all the teeth. Special care must be taken to avoid gagging the patient. Have the patient close gently but firmly on the packet to hold it in place.

4. Position the tube head.

   a. For maxillary anterior occlusal radiographs, set the vertical angulation of the tube head at +65°. Center the tube head cylinder on the bridge of the patient's nose so that the central X-ray beam will be projected as shown in fig. 1-38.

5. Make the exposure.

**MANDIBULAR OCCLUSAL RADIOGRAPHS**

Mandibular occlusal radiographs are taken by using the following procedures:

1. Program the X-ray machine for 10 mA, 90 kVp, and 60 impulses (1 second). (Reduce the kVp setting for edentulous patients and children as discussed earlier.)

   b. For maxillary posterior occlusal radiographs, set the vertical angulation of the tube head at +75°. Center the tube head at the top of the patient's nose so that the central X-ray beam will be projected as shown in fig. 1-39.

5. Make the exposure.
2. Position the patient.

   a. For mandibular anterior occlusal radiographs, position the patient so that the ala-tragus line is at a 45° angle with the floor, and the midsagittal plane is perpendicular to the floor.

   b. For mandibular posterior occlusal radiographs, position the patient so that the ala-tragus line and mid-sagittal plane are perpendicular to the floor.

3. Place the film packet in the patient's mouth with the pebbled surface toward the occlusal surfaces of the mandibular teeth, and the short sides of the packet are toward the patient's cheeks. Have the patient close gently on the packet to hold it in place.

4. Position the tube head.

   a. For mandibular anterior occlusal radiographs, set the vertical angulation of the tube head at -10°. Center the tube head cylinder on the tip of the patient's chin so that the central X-ray beam will be projected as shown in Figure 1-40.

   b. For mandibular posterior occlusal radiographs, set the vertical angulation of the tube head at 0°. Center the tube head cylinder beneath the patient's chin so that the central X-ray beam will be projected as shown in Figure 1-41.

5. Make the exposures.

   a. For mandibular anterior occlusal radiographs, set the vertical angulation of the tube head at -10°. Center the tube head cylinder on the tip of the patient's chin so that the central X-ray beam will be projected as shown in Figure 1-40.

   b. For mandibular posterior occlusal radiographs, set the vertical angulation of the tube head at 0°. Center the tube head cylinder beneath the patient's chin so that the central X-ray beam will be projected as shown in Figure 1-41.

   Figure 1-41.—Projection of central ray (CR) for mandibular posterior occlusal radiographs.

patients, dental personnel must maintain infection control standards in the radiology area similar to those used in the DTR. Information and procedures on the Dental Infection Control Program can be found in BUMEDINST 6600.10.

HANDWASHING

Follow rigid handwashing procedures when treating a radiology patient. Wear gloves when placing intraoral films and handling contaminated film packets.

DARKROOM

Disinfect all counter surfaces daily, and any other areas that might become contaminated such as doorknobs, light switches, and other surfaces that you might come in contact with.

FILM POSITIONING DEVICES

Film positioning devices should be disposable (single use) or heat sterilized between patients. Your command should have an adequate supply of film positioning devices to treat your daily patient load. If supplies are short, you may disinfect film positioning devices between patients by immersion in an EPA-registered chemical disinfection such as a 2 percent glutaraldehyde. Rinse thoroughly after disinfection. Follow manufacturer's instructions for high-level disinfection.

PANORAMIC UNIT BITE-BLOCKS

Use a disposable panoramic unit bite block cover for each patient. When disposable covers are not available, disinfect bite blocks as you would a film holding device.
INTRAORAL FILM PACKETS

Intraoral film packets become contaminated when they are placed in a patient's mouth during exposure. We will explain procedures on how to handle and process contaminated intraoral film packets from the X-ray room to the dark room to avoid cross contamination. Procedures using an automatic film processor with and without a daylight loader are explained next.

Automatic Film Processors Without a Daylight Loader

Procedures for using an automatic film processor without a daylight loader are as follows:

1. Wearing disposable gloves, expose an intraoral radiograph.

2. Place intraoral film packets removed from the patient's mouth directly into a clean paper cup previously set aside for this purpose. Do not contaminate the cup with soiled gloves.

3. Transfer cup to dark room.

4. While wearing the gloves used to take the radiograph, open the film packets and drop the film onto a clean paper towel without touching the film.

5. Discard film wrappers directly into a lined refuse container to prevent contamination of the darkroom work surfaces.

6. Place lead foil backing in a designated storage container.

7. Remove gloves and feed the uncontaminated film into the developer without special precautions.

8. Disinfect all areas and set up for your next patient.

Automatic Film Processors With a Daylight Loader

When using an automatic film processor with a daylight loader, contamination of the fabric light shield is likely to be a problem. Since there is no way to disinfect this shield, disposable plastic film packet covers should be used to eliminate contamination of the fabric light shield by oral fluids and glove residue. Daylight loaders should be used only when a darkroom is not available.

Disposable Plastic Film Packets

The following is a recommended technique for processing X-ray film with disposable film packet covers when using a daylight loader:

1. Wearing disposable gloves, expose an intraoral radiograph film with a disposable plastic film packet cover on it.

2. Still wearing the contaminated gloves, open the disposable plastic film packet containing the exposed X-ray film and using a sterile drop method, release the X-ray film into a clean paper cup previously set aside for this purpose.

3. Dispose of contaminated plastic film cover and gloves in a lined refuse container. Wash hands to remove powder from gloves and dry.

4. Open daylight loader and place the clean paper cup containing the exposed X-ray film inside. Close lid.


6. Open daylight loader and separate lead foil backing from film wrappers. Place lead foil in a designated storage container.

7. Discard film wrappers and paper cup into a lined refuse container.

Alternate Method When Not Using Disposable Film Covers

Some X-ray departments may not have disposable plastic film covers for use with automatic film processors with a daylight loader. The following is an alternate method to prevent the fabric light shield from being contaminated:

1. Place the exposed film in a clean paper cup previously set aside for this purpose.

2. Remove soiled gloves and put on a pair of clean gloves.

3. Place the cup through the top of the processing box and close the lid.

4. Place clean gloved hands through the fabric light shield as shown in Figure 1-42, unwrap the film packet, and drop the film onto the surface inside the loader.

5. Place the film wrapping into the cup. Remove the gloves, turn them inside out, and place them in the paper cup.
6. Carefully grasp the film by its edges to avoid transferring powder from your hands onto the film, drop the film in the chute for developing.

7. Remove hands from the loader, lift the lid, and dispose of paper cup and waste. Ensure all lead foil is collected and stored.

8. Wash hands thoroughly.

9. If the fabric light shield sleeves become contaminated, they may be gas sterilized.

**X-RAY CHAIR**

Use an EPA-registered intermediate-level disinfectant on the X-ray chair daily or when visibly contaminated. Change paper or plastic headrest covers after each patient.

**X-RAY TUBEHEAD AND CONTROLS**

Cover those areas contacted by the staff and patients with plastic wrap or disposable drapes. Be careful that these coverings do not interfere with the flow of cooling air to the X-ray tube head. Change after each patient. When wiping the tubehead and controls with liquid disinfectants, exercise care to prevent disinfectant from leaking into the tube head seams and exposure controls.
FILM PROCESSING

After the patient has been radiographed, the X-ray film is processed to produce the finished radiographs. There are five basic steps involved in processing X-ray film: developing, rinsing, fixing, washing, and drying. You can process the film manually, or use an automatic film processor. For the most part, manual processing is used for a backup method for the automatic film processor and will not be discussed. If your command has manual processing capabilities, refer to the manufacturer's operating instructions. Because our discussion concerns both darkroom procedures and film processing, we will cover the darkroom first.

DARKROOM PROCEDURES

The darkroom has two sources of illumination: white light and safelight. A white light is a standard ceiling light. It provides regular illumination for mixing solutions and cleaning the darkroom. An unwrapped, unprocessed X-ray film must never be exposed to white light.

Exposed film is useless. A safelight, which contains a 15 watt bulb with a special filter, is the only safe source of illumination in the darkroom when processing intraoral and panoramic X-ray film. The safelight must be located no less than 4 feet from the work surface so that you can open film packets and process films safely. Limit the length of exposure of undeveloped dental films to the safelight for no more than 2 minutes. Films left out exceeding this time might get a fogged image (discussed under faulty radiographs).

Occasionally, films are ruined because of light leakage. White light may leak through the filter on the safelight or it may leak into the darkroom from an outside source. A simple test will enable you to detect leakage.

To check for possible light leakage from an outside source, perform the test with all lights off, including the safelight.

Take a packet of unexposed X-ray film, open the film packet, and remove the film. Lay the film on the workbench, and place a penny over it for a period of 5 minutes. Then, process the film using the procedures provided later in this chapter. The processed film should show no image. If the outline of the penny can be seen, there is light leakage and you should inform your supervisor. You should perform this test at every location in the darkroom where unwrapped film is being processed.

SAFETY PRECAUTIONS

Because of the alkaline and acid nature of the developer and fixer solutions, minor chemical irritation or burns can occur when they come in contact with the skin, the eyes, and the mouth. Use caution when stirring or mixing solutions. Always wear rubber gloves and protective eye wear or a protective face shield and an apron when working around these solutions. If the solutions come in contact with the skin, flush the area with large amounts of water. If the solutions accidentally splash into the eyes or mouth, flush with large amounts of water and immediately seek medical attention. Fixer solution can stain and discolor clothing.

AUTOMATIC PROCESSING

Automatic processing is the most commonly used method of processing dental radiographs in the Navy. The automatic film processor mechanically transports exposed X-ray film through the developing, fixing, washing, and drying cycles. Automatic processing is quicker than manual processing, and it produces finished radiographs of uniform quality. A variety of automatic film processors are in use in the Navy and they can be generally classified as small or large.

Large Automatic Film Processor

The large automatic processor processes all sizes of dental radiographs including intraoral, occlusal, panoramic, and 8-inch x 10-inch cephalometric films.

This processor will be located in the darkroom. The X-ray film must be inserted in the processor under safelight conditions. Large automatic processors can be equipped with daylight loaders, eliminating the need for a darkroom.

Operational Check

Perform the operational check at the beginning of each day to ensure that the processor is in good working order. It is a complex piece of equipment, so read the manufacturer's operational manual very carefully. Never attempt to repair the components inside the processor. There are a variety of large automatic processors used in the Navy today. The automatic processor's components, procedures, and
Figure 1-44.—Large automatic processor.

Figure 1-45.—External components of a large automatic processor.
maintenance described next are for the specific processor shown. If you work with a different make or model of an automated processor, refer to that manufacturer's operational manual for operating instructions.

**Figure 1-45** shows the main external components of the large automatic film processor. **Figure 1-46** shows the internal components when the top cover is opened from the processor. **Figure 1-47** shows the functions of the operator’s control panel.

The daily operational check of the large automatic processor is performed as follows:

1. Plug the power supply cable into the power outlet.
2. Check the solutions. Most automatic processors are equipped with a replenisher, which automatically replenishes solutions when the power is turned on. An automatic processor without an automatic replenisher requires that you manually replenish the developer and fixer solutions. Pour the solutions slowly to avoid splashing. Direct the pouring stream to the center of the tank away from the drain tubes.
3. Turn on the external water supply valve. This valve is normally located close to and above the automatic processor. If not equipped with external water supply, change the water in wash water container and refill with fresh water.
4. Activate the automatic processor by depressing the power on switch. If equipped with an automatic replenishing system, the internal oscillating pumps will now cycle and fill the solution tanks to their proper levels. When the low solution level lamp has gone out, the solution heater will start and the transports will turn. **Do not process films at this time.**
5. After 10 to 15 minutes, The ready lamp will illuminate. This indicates that the proper processing temperature has been reached.
6. Depress the run/standby switch to the run position. Insert an 8-inch x 10-inch cleaning film into the processor receiving tracks. The cleaning film cleans the rollers of accumulated deposits, dirt, and debris. Use a new cleaning film every week. After the cleaning film exits the processor, depress the run/standby switch to the standby position.
7. **Do not depress the on/off switch.** It should remain on for the entire working day. As long as the on/off switch is in the on position, several functions will occur throughout the day.

   a. Approximately every 4 minutes, the oscillating pumps will cycle for several seconds. This action will maintain a uniform solution strength.

   b. The solution heater will maintain a proper processing temperature.

   c. The solution agitators will intermittently cycle, keeping the solutions well mixed.

   d. The roller transports will intermittently turn, allowing the solutions to wet the rollers. This will prevent dried solution deposits from forming.

   e. At the end of the working day, depress the on/off switch to the off position.

8. Some models may require that you turn the water inlet valve on the plumbing line to the off position.

**Procedures For Processing Film**

If you are processing a large quantity of X-ray film, you must avoid any mixup. To do this, after you insert one patient’s X-ray films, wait 15 seconds before inserting the next patient’s films. After inserting the X-ray films of each patient, set the X-ray mount, envelope, or identification label aside, making sure to keep them in the order in which they were processed. This will help you match the processed radiographs to the patient’s unit, envelope, or identification label when the film exits the processor.

To process X-ray films, you should follow these procedures:

1. The recommended complete processing time is 5 minutes at normal speed. If your processor has an endo speed button, this can process X-rays in 2 minutes. Endo speed is used when the dentist wants to process the film quickly. The developer temperature should be at 82°F (28°C) and the water temperature 50°F to 90°F.

2. Depress the run/standby switch to the run position to begin automatic processing.

3. Insert the X-ray film. Unwrap the film and insert it into the film receiving slot. (Remember to open the film under safelight conditions). The automatic processors can have up to six tracks to accept intraoral films. To prevent overlapping, feed the film lengthwise into every other track (e.g., insert first three films into tracks 1, 3, and 5; insert the second three films into tracks 2, 4, and 6). Feed large films lengthwise one at a time, allowing at least 15 seconds between films. Allow 15 seconds to expire after the last film disappears before inserting another film or turning on the lights or opening the darkroom door. Once the films have been inserted, the total processing time will take 5 minutes unless on the endo cycle.
To obtain the best quality radiographs, follow the film manufacturer's processing guidelines. If radiographs processed at 5 minutes and 82°F (28°C) are too dark, reduce the X-ray exposure time setting.

When the films have been processed, the finished radiographs will exit the processor on the film track and fall into the film receptacle. When the last film has exited the unit, depress the run/standby switch to the standby position. The unit will remain on standby throughout the day.

Securing The Processor

The processor should be secured at the end of the day. The securing procedures are as follows:

1. Depress the on/off switch to the off position.
2. Turn the water supply valve to the off position. (Some models without water plumbing will not require this step.)
3. Unplug the power supply cable.
4. Wipe the cover and housing of the processor with a damp sponge or cloth.

Chemistry Change

Change the developer and fixer at a minimum of once every 3 to 4 weeks. If a large quantity of X-rays has been processed, change the developer sooner. Replenish the solutions following the manufacturer’s instructions.

NOTE: The solutions used for automatic processing are not the same as those used for manual processing.

Maintenance Schedule

You are responsible only for user maintenance on the processor; repairs are the responsibility of the dental equipment repair technician.

Monthly maintenance consists of cleaning the roller transports and solution tanks. Weekly maintenance consists of soaking the transport rollers, solution agitators, and other removable internal parts for 5 to 10 minutes with a processor cleaner.

NOTE: Any time the processor cover is lifted and maintenance is being performed, you must wear a safety face shield, apron, and protective gloves.

The quality of the processed radiographs are reflected in the maintenance of the processor. Improper maintenance can cause radiographs of poor diagnostic quality, and may cause patients to have their radiographs taken over. Always follow manufacturer’s instructions for correct maintenance and operating procedures.

To keep the processor in good operating condition, do not place heavy objects on top of the processor or use the top as a film loading or storage area. Do not turn the power switch on when the solution tanks are empty. Also, do not use steel wool or abrasive scouring powder when cleaning tanks or metal parts of the processor.

Small Automatic Film Processor

The small automatic processor processes only bitewing and periapical dental radiographs. The processor solutions are self contained and require no plumbing.

The small processor in figure 1-48 may be located in a darkroom, but because of its small size and compatibility with a daylight loader, it is commonly found in endodontic departments, small dental clinics, and on board Navy ships where no darkroom is available.

Operational Check and Processing

Refer to the instruction manual for the assembly and disassembly of processor components. The daily operational check for the small automatic processor is performed as follows:

1. Remove process cover and check the level of the solutions. Tank capacity for the developer and fixer tanks is 1 quart each. The wash tank holds 1 1/2 quarts of water. Figure 1-49 shows the solution tanks.
2. Plug the power supply cable into the power outlet.
3. Depress power (left) switch [fig. 1-50]. Directly above the left switch, the red light goes on, indicating the chemistry heaters are on. When the green light (right) flickers (in about 15 minutes, depending on room temperature) X-rays may be processed.
4. To process films, depress the process (right) switch. The green ready light will alternate between flickering and full on, indicating an optimum 74° to 76°F temperature is being maintained.
5. Refer to the manufacturer's instruction manual procedures for processing bitewing and periapical films.
Securing The Processor

Turn off the power switch (left) and unplug power supply cable from outlet.

Chemistry Change

Change the developer and fixer every 300 to 350 films or in 2 weeks, whichever is sooner. The water in the wash tank is changed every 100 to 125 films or in 1 week, whichever is sooner. When changing chemicals, clean the tanks with water and dry prior to placing new chemicals in them. Use the same safety precautions as mentioned before when handling chemicals.

Maintenance Schedule

Daily, wipe the external parts of the processor with a dry or slightly moist, lint free cloth. Refer to the instruction manual for the complete maintenance schedule.

FAULTY RADIOGRAPHS

Faulty radiographs are usually caused by the incorrect positioning of the film packet or the tube head; incorrect kVp, mA and time setting; or by incorrect processing procedures.

Some common causes of faulty radiographs due to tube head and film misalignment have already been
discussed (e.g., incorrect horizontal angulation produces superimposed radiographic images, and incorrect vertical angulation produces images that may be foreshortened or elongated.) The following are additional causes of faulty radiographs:

- No image [fig. 1-51]: The film was immersed in the fixer before the developer. If the film is completely clear, it was never exposed.

- Very light image [fig. 1-52]: The film was underexposed (kilovoltage too low); the developer was weak; or the film was not left in the developer long enough.

- Very dark image: The film was over-exposed (kilovoltage too high); the developer was too warm; or the film was left in the developer too long.

- Partial image [fig. 1-53]: The film was not completely immersed in the developer; the film came into contact with other film or the side of the tank while in the developer; or the film or tube head was incorrectly positioned (cone cutting).

- Blurred image: The patient or tube head moved during the exposure.

- Fogged film: The film was outdated or contaminated; the film was overexposed by being held too close to the safelight; the film was exposed to stray radiation, excessive heat, chemical fumes, or light leaks in the darkroom; the developer was improperly mixed, contaminated, or too hot.

- Streaked or stained film: The film was insufficiently washed or fixed; the processing solutions were dirty; or the film hanger was dirty.
• Reticulation: There was a too rapid change in temperature during processing (e.g., the film was taken from a warm developer to a cold rinse).

• Crescent-shaped lines [fig. 1-54]: The film packet was creased or bent.

• Herringbone image [fig. 1-55]: The wrong side of the film, packet was facing the source of the X-ray beam during exposure causing the embossing pattern from the lead backing to appear on the film.

• Black areas: The film was pulled too rapidly from its black paper wrapping, causing a discharge of static electricity.

• White spots: The developer failed to work on these areas because of dirt or air bubbles.

• Foreign object image [fig. 1-56]: Dentures or other objects were in the patient’s mouth during the exposure.

FILM VIEWERS

The film viewer consists of a metal case with a back-lighted screen. The viewer is used to mount and examine radiographs. Figure 1-57 shows a typical desk mount film viewer. Never light the film viewer in the darkroom when you are working with unwrapped, unprocessed film. Keep the viewer screen clean at all times.

MOUNTING RADIOGRAPHS

After processing the X-ray film, you will mount the finished radiographs in cardboard or plastic holders. Mounting makes the radiographs easy to view, keeps them in a chronological order, and protects them from damage.

Mounted radiographs may be viewed from either the front or back of the mount. If viewed from the front, the teeth appear on the film as if you were looking directly into the patient's mouth. If viewed from the back, the teeth appear on the film as if you were sitting on the patient's tongue looking out. Always mount X-rays in anatomical order. After you mount the radiographs, file the mount in the patient's Dental Record. There will be times when the dental officer will want to retain the radiographs for diagnostic purposes (e.g., endodontics). These are normally placed in a drug envelope, labeled and dated, and placed in the dental record.
INTERPROXIMAL (BITE-WING) MOUNTING

Figure 1-58 shows a serial mount for inter-proximal (bite-wing) radiographs. The mount contains slots for mounting five pairs of interpromixal radiographs for a patient taken at different times and mounted in chronological order. Serial mounting enables the dental officer to compare radiographs taken at different time intervals to detect changes in the patient’s oral structures.

The front of the mount contains spaces for the patient’s name and social security number, mount number, and the date of each exposure. Fill in this information whenever you start a new mount. After you have completed the necessary information on the front side, turn the mount over and lay it face down on a table top.

Place the radiographs on a flat, dry surface with the convex surface of the identifying "dimple" toward the observer. Pick up a radiograph by the edges. Hold it up to the, film viewer. The line representing the occlusal surface of the bicuspids and molars should gradually curve upward, forming one-half of a smile. If the line curves upward on the right, slide the radiograph into the right-hand slot on the back of the mount with the upward curve toward the outside of the mount. Keep the raised dimple facing you. If the line curves upward on the left, slide the radiograph into the left-hand slot. If both radiographs are mounted correctly, they will appear as shown in Figure 1-58 forming a complete smile. Each time an additional pair of inter-proximal radiographs is mounted, enter the date on the line beneath the mounting slots.
FULL MOUTH PERiapICAL MOUNTING

Figure 1-59 shows a full mouth periapical film mount. The mount contains 14 slots for periapical radiographs and 2 slots for interproximal (bite-wing) radiographs.

When mounting full mouth periapical radiographs, you will be working with 14 radiographs; take care to sort and mount them correctly. To do this, you must be able to recognize certain maxillary and mandibular anatomical landmarks.

ANATOMICAL LANDMARKS

During the following discussion, locate each anatomical landmark on figure 1-60. The landmarks are indicated by arrows.

Maxillary Incisor Area

Radiographs of this area usually show a large white region caused by the bone of the nasal septum (A in fig. 1-60).

Mandibular Incisor Area

Mandibular incisors are smaller than maxillary incisors. The mandibular incisor area has a network of tiny white lines around and below the roots (D in fig. 1-60).

Maxillary Cuspid and Bicuspid Areas

Radiographs of these areas usually show a distinct wavy white line above or near the apices of the teeth (B in fig. 1-60). The wavy white line identifies the floor of the maxillary sinus. This white line is not found in radiographs of the mandibular arch.

Mandibular Cuspid and Bicuspid Areas

Radiographs of these areas show a fine network of tiny white lines around and below the roots and a dark area in the cuspid area representing the mental foramen (E in fig. 1-60).

Maxillary Molar Area

Radiographs of these areas show the maxillary arch and the roots of the maxillary molars curving slightly toward the rear of the mouth (C in fig. 1-60). Maxillary molars have three roots, they tend to be indistinct on radiographs. In addition, the radiographs will usually show a distinct wavy white line above or near the apices of the teeth.

Mandibular Molar Area

Mandibular molars show two roots that are distinct on radiographs. The mandibular nerve canal frequently shows as a dark, narrow band running horizontally under the apexes of the mandibular molars. The mandibular arch and the roots of the molars curve slightly toward the rear of the mouth. An impacted third molar will often be present on radiographs of the mandibular molar areas (F in fig. 1-60).
MOUNTING PROCEDURES

Place all the radiographs in the full mouth periapical series on a dry, flat working surface with the dimple side up. On the front of the film mount, enter the patient’s name, social security number, rank/rate, the date, and the name of the dental treatment facility. Place the mount face down on the working surface. The two small arrows on the back of the mount should point toward you. Follow these steps to mount the radiographs:

1. Check each radiograph and make sure that the surface with the raised dimple faces you.

2. Mount interproximal radiographs. If interproximal (bite-wing) radiographs are included in the full mouth series, insert them in the slots provided as previously discussed.

3. Divide the radiographs into maxillary and mandibular groups. Using the film viewer, locate the anatomical landmarks discussed earlier. The maxillary radiographs are inserted in the 7 slots across the top of the film mount and the mandibular radiographs in the 7 slots across the bottom.

4. Insert the maxillary radiographs. First, identify the radiograph of the central incisor area. Keeping the side with the raised dimple facing toward you, rotate the
radiograph until the incisal edges of the teeth point down. With the back of the mount toward you, slide the radiograph into the incisor slot. When the radiograph is properly mounted, the side with the raised dimple will face you, and the incisal edges pointing down toward the center of the mount.

5. Work outward from the central incisor slot, inserting the rest of the maxillary radiographs in the following order: cuspid areas, bicuspid areas, and molar areas.

6. Insert the mandibular radiographs. Start with the radiographs of the central incisor areas and work outward. As before, the raised dots will be toward you and the incisal/occlusal surfaces of the teeth should be pointing upward toward the center of the mount.

When you have inserted all of the radiographs, hold the mounted radiographs up to the viewer. Double check to see that each radiograph is mounted correctly.

**PANORAMIC RADIOGRAPHS**

The panoramic X-ray machine is used to produce an extraoral radiograph that shows both dental arches and the temporomandibular joints [Fig. 1-61]. The radiograph is made by rotating the tube head and film around the patient while the patient remains stationary. Because of the different manufacturers and models of panoramic X-ray machines used in the Navy, this operation and maintenance will vary. Always refer to manufacturer's instruction manual prior to use.

The panoramic X-ray machine and control panel are shown in figures 1-62 and 1-63. Refer to these figures throughout the following discussion. You must be thoroughly familiar with the components shown before operating the machine.

**OPERATIONAL CHECK**

The operational check for the panoramic X-ray machine is accomplished without a patient. To perform the operational readiness check, perform the following procedures as follows:

1. Turn on the pilot switch; the pilot light will illuminate.
2. Set the kVp selector switch to the desired voltage. Adjust the kVp meter as a reference for the desired kVp setting.
3. Select the mA settings, to be used. Adjust them according to the manufacturer's instructions. When you find the mA and kVp settings that give the best results, enter them on a technique values chart. Remember each manufacturer's film is different, so follow the recommendations.

![Figure 1-61.—Typical panoramic radiograph.](image)
Figure 1-62.—A panoramic X-ray machine.

Figure 1-63.—A panoramic control panel.
WARNING: When performing the operational check, keep the collimator covered with the lead cap.

PREPARING THE FILM

When the X-ray machine is operational, prepare the panoramic film. Load the film into a cassette drum, label it, and then mount it in the cassette drum assembly on the X-ray machine. To load and mount the cassette drum, follow the manufacturer's instructions.

LABELING THE CASSETTE

The cassette is labeled for the purposes of orientation and patient identification.

To properly orient the finished radiograph so you can distinguish the left from the right side of the patient's dentition, tape a lead letter "R" in the lower right-hand corner on the outside of the cassette cover.

There are two ways to label the cassette for patient identification. You can use a self-adhesive label or an X-ray film identification printer. Follow the manufacturer's instructions when using the printer. The patient information includes: the patient's name (last name, first name, and middle initial), family member prefix code, social security number, and the date of the exposure.

REQUIREMENTS FOR A GOOD PANORAMIC RESULT

Follow the manufacturer's operating instructions for complete operation of the panoramic X-ray machine before you attempt to use it. The following is a list of important procedures that must be followed to ensure a good quality X-ray is produced.

- Make sure patient's back and cervical spine are as straight as possible.
- Check that the patient's mid-sagittal plane is centered within the unit.
- Ensure the patient's frankfurt plane is horizontal.
- Check that the anterior maxillary and mandibular teeth are located on the indents of the bite-block. If the patient's bite is abnormal, adjust mandible forward or backward to compensate.
- Observe patient to assure there is no movement during the radiographic procedure.

OPERATING THE PANORAMIC-RAY MACHINE

With the machine operational and the film cassette drum in the cassette drum assembly, you are now ready to take the radiograph on the patient. Follow the manufacturer's instructions for patient positioning and operation. When the patient is positioned, explain the exposure procedures. Then make the exposure and process the film. You must wait 5 minutes between exposures to prevent overheating of the X-ray head.

USER MAINTENANCE

The panoramic X-ray machine requires very little user maintenance. Wipe the metal and painted parts with a soft, dry cloth daily.

Never attempt to repair the panoramic X-ray machine yourself. Report malfunctions to your supervisor. All repairs are the responsibility of the dental equipment repair technician.