This program is a collaborative effort between the Minnesota Dental Association and the Minnesota Department of Health X-ray Unit. It has been developed to help your office in constructing your own Radiation Safety Manual. Our goal is to make compliance with the statutes and rules as simple as possible and streamline the task of review by your employees and the MDH X-ray Unit.
GETTING STARTED

This guide is organized to help you organize your Radiation Safety Program. The outline and addendums are made to assist you in implementing your office’s program as easily as possible. The sections are divided as follows:

Section I. Office Policies
Section II. Radiation Biology
Section III. Employee Training
Section IV. Periodic and Special Documentation Requirements
Section V. Addenda

The examples given for you are to be used as a guide. Modify these to fit your practice. A very good, and simple way to start is to use a 3 ring notebook to organize these documents. This allows flexibility in the order in which you wish to store them. Using clear plastic “sheet protectors” will keep documents clean and securely held in the binder. They can be replaced with new sheets as they become dated.

The addenda are also examples which can be modified to fit your practice policies. Be sure that all required information is retained on each addendum when it is modified.

The enclosed dvd/cd is provided to assist you in the procedures necessary to comply with the MDH Regulations. In the accompanying outline, commentary is provided to assist you in building your manual.

We hope this Manual provides you with all of the tools to make your Radiology Program successful. It is our intent to help you in every way possible, making the regulatory requirements easily fulfilled.

--Radiology Workgroup, Environment and Safety Committee
Registration of Equipment

If you are a new owner of ionizing radiation equipment, you must register your units with the Minnesota Department of Health. The registration form is (ATTACHMENT A). If you are an existing facility and need to add or change information see forms (ATTACHMENTS B-D).

All questions regarding Registration should be directed to MDH X-ray Unit 651-201-4545. Emails are also welcomed to health.xray@state.mn.us.

Registrations should be kept in your manual, along with all copies of equipment repairs. Annually, registration fees are paid for all x-ray units. A form is sent to the practice listing the current units registered. If there are no changes to what they have listed, you can pay the registration fee as is and a new registration certificate will be sent from the MDH.

If you would like to get updates from the MDH X-ray Unit please send an email to kelly.sabanjo@state.mn.us to receive MDH’s X-ray Bulletin via email.
SECTION I OFFICE POLICY

This section contains elements that are required to be in your manual. The items that are followed by two asterisks ** can be copied into your manual verbatim when the item applies to your practice.

Page one of your manual should include:
Practice letterhead and your MDH X-ray Unit registration number for your office.

A.L.A.R.A. (As Low As Reasonably Achievable) Statement:
THE OVERRIDING PRINCIPLE OF OUR RADIOLOGY PROGRAM IS TO RECORD ALL THE NECESSARY INFORMATION AND TO ACHIEVE A DIAGNOSIS WITH THE LEAST AMOUNT OF RADIATION EXPOSURE TO OUR PATIENTS. (As Low As Reasonably Achievable). **For background information view, “THE USE OF DENTAL RADIOGRAPHS” (MDH Attachment E).

ROUTINE RADIOGRAPHIC EXAMINATIONS
List all of the routine radiographic examinations performed in your office. List the examination, and include any short hand used to list the examination in your computer/chart.
Example: 2 BW- Two routine bitewing x-rays
PAN- Routine panoramic x-ray

NON-ROUTINE X-RAYS
All routine and non-routine x-ray examinations must include written orders prior to the examination being performed. Standing order for recall patients is allowed in the practice of dentistry when the following requirements are met:
A. The standing orders are in writing;
B. Limited to recall patients;
C. Signed by all the dentists; and
D. The facility establishes a policy that defines the scope of the recall patient standing order.

LEAD PROTECTIVE DEVICE USE (APRONS, GLOVES, THYROID COLLAR, ETC.)
Lead protective aprons and thyroid collars for patient protection is not required in the practice of dentistry. A lead protective apron is required only when the primary x-ray beam is within 2 inches of the gonads.

Individuals other than the patient who must remain in the operatory, and are within six (6) feet of the patient or the x-ray tube must wear a lead protective apron of at minimum 0.5 mm lead equivalency.
If your office uses lead aprons for the psychological well being of the patient you may state:

“We recognize the genetically significant dose from dental radiography is small, however because of the public’s expectation of the issue, we will use a lead apron whenever feasible.” ** (When using lead aprons in the manner described, the aprons need not be tested)

For practices using lead aprons and other shielding devices to protect any person from direct exposure, as in the case of a lead lined glove used to help stabilize a patient’s head, those devices must be tested biennially (i.e. every 24 months) and the testing documented and recorded in this section. (See Addendum 1.)

USE OF IMAGE RECEPTOR HOLDERS
The following statement should be recorded in your manual and followed by all personnel and patients:

“Image receptor holders, i.e. bite blocks, hemostats, etc should be used whenever possible, when the quality of the image is not affected by the holder or the holding method. Direct holding of the x-ray film or recording device by dental personnel is prohibited. If dental personnel need to help a patient hold a film or recording device, they can only do so by using a device that assures they will not be exposed by the primary x-ray beam. Patients are allowed to hold the image receptor when the use of image receptor holders is not feasible, as in the case of endodontic procedures.” **

Dental x-ray equipment has a defined x-ray field that limits the radiation exposure to the patient’s area of interest. When the image receptor, image receptor holder and x-ray equipment are used properly it can significantly reduce unnecessary radiation exposure to the patient. This can be done by:

- Use appropriate techniques for adults and children
- Place the cone of the x-ray tube as close to the patient’s skin as possible to reduce potential exposure to the thyroid, eyes and other radiosensitive areas

Follow image receptor holders and alignment tool procedures for use
SECTION II. RADIATION BIOLOGY

BIOLOGICAL EFFECTS OF RADIATION

Have both of these documents in your manual. Use them for training new staff and staff declaring pregnancy in writing.

RADIATION SAFETY OFFICER
List the Radiation Safety Officer for the practice. If the Radiation Safety Officer is not the owner of the practice, include the proper documentation stating the identity and qualifications of the Radiation Safety Officer. Also include a current copy of the agreement between the owner and the Radiation Safety Officer. Both the owner (or owner/management representative) and the Radiation Safety Officer must be listed with their signatures next to their listing. (Addenda #4 and #5)

PREGNANCY
When an employee declares, in writing, that she is pregnant, the Radiation Safety Officer will countersign the written declaration and include it in this section of the manual. The Radiation Safety Officer and the pregnant employee will then review the practice’s policy for pregnant employees and institute the policy for the full term of the employee’s pregnancy. (Addendum #6)

Stated below is an acceptable policy:

When an Employee declares pregnancy in writing, the Radiation Safety Officer will initiate a review of radiation hygiene. A review of barriers will also be done. Under no circumstances will the pregnant employee be allowed to assist holding a patient or a film for a patient. The employee will be required to stand behind barriers during the exposure of the radiograph(s).

This policy is to be signed by the owner and Radiation Safety Officer. A copy of this policy is to be signed and dated by the Radiation Safety Officer and the pregnant employee, as soon as feasible after the written declaration of pregnancy is received and entered into this manual.

Duplicate information from the first paragraph in this section.

If your office chooses to use radiation monitoring devices, you will be required to keep records of all the employees, devices, results for the required period of time as outlines in MDH X-ray Rule. (4732.0440 INDIVIDUAL MONITORING)
SECTION III. EMPLOYEE TRAINING

There is no requirement for Annual Training, however it is encouraged, especially in practices with many employees and multiple offices.

New Employees- New employees must be trained in the following areas:

1. Trained in all radiographic procedures performed in the practice.
2. Review of the Radiation Biology section.
4. Review of the developing procedures and dosimetry testing (Film).
5. Review of software and hardware procedures (Digital).
6. Review of the emergency operating procedures for the x-ray equipment

New Procedures- All employees must be trained when a new radiographic procedure is begun in a practice. Any documentation for the new procedure such as new software must be included in this manual.

New Equipment- Whenever different x-ray equipment, darkroom equipment, scanning equipment, and/or software is installed, all personnel are required to train with the new equipment/software. The only exception would be a replacement piece of equipment that is identical to another already in use. An example is when an intraoral x-ray machine is replaced with a machine identical to one other already in use in that practice.

All training must be documented. (Addendum 7)

Pregnancy- When an employee declares pregnancy in writing, Review of all radiographic procedures; safety and radiation biology must be done and recorded. (See Section III under “New Employees” 1.-5.)
SECTION IV. PERIODIC AND SPECIAL DOCUMENTATION

OFFICE RELOCATION/CONSTRUCTION/REMODELING
Whenever an x-ray machine is relocated whether it is to another part of the office occupied by the practice or to a completely different office space, or the space around the x-ray machine is remodeled, a review of the blueprints of the shielding around the x-ray machine must be submitted to the MDH X-ray Unit BEFORE any move or remodeling is made. The plans/blueprints will be reviewed by the department to determine that the appropriate amount of shielding is being incorporated into the area of the x-ray machine. Verification of the shielding must be documented with the documentation made a permanent part of the Radiation Safety Manual. ALL of this documentation must remain in the Radiation Safety Manual of this practice as long as the practice is in existence or the practice is sold and remains in the same location. At the end of any installation, repair, or remodeling calibration of the x-ray equipment must be performed on all x-ray equipment affected.

CALIBRATIONS
Whenever any X-ray machine is repaired or relocated a calibration of the x-ray equipment must be performed. All functions must be checked and verified to be working properly. This must be documented in the Radiation Safety Manual.

PROOF OF LICENSURE OF X-RAY OPERATORS
A copy of the licenses of all x-ray operators must be in the Radiation Safety Manual. These must be retained until the next inspection/successful self audit is completed. Proof of all operators must be provided for the time between inspections/audits. i.e. if the previous inspection was performed in 2008 and the new inspection is performed in 2011, all of the licenses of all operators working in the practice between 2008 and 2011 inspections must be in the Radiation Safety Manual. This includes float staff, temporary staff, and staff that are no longer employed. Some operators working during that entire time will have multiple licenses. Proof of licensure of each operator must be kept in the Radiation Safety Manual from the date of the last inspection by MDH until the completion of the next inspection by MDH.

ANNUAL X-RAY AUDIT
The Radiation Safety Officer must complete an annual X-ray audit of all radiographic procedures used, review all documentation pertaining to radiography in the manual, identify and document any remedial actions needed along with the date(s) the remediations were completed. Documentation of all annual audits must be kept in the Radiation Safety Manual from the date of the last inspection by MDH until the completion of the next inspection by MDH. (MDH ATTACHMENT E)
PERFORMANCE TESTING
(Biannual) Performance Testing of Equipment- Biannual testing of equipment must be performed every 24 months. The service Provider is to test all x-ray equipment producing radiation and make sure the Radiation Safety Officer is given written performance documents for all machines including any remedial action(s) that need(s) to be completed. In addition the Service Provider must show documentation that he/she is registered with the MDH X-ray Unit. This documentation must be kept in the Radiation Safety Manual from the date of the last inspection by MDH until the completion of the next inspection by MDH. Service providers are also required to retain records of inspections for four years.

PROCESSING
The stability of your processor is very important to the diagnostic quality, reproducibility of your patient films and dose to the patient. Unless proper quality control measures are taken, staff may not know they are under developing their patient films. Instead technique factors are adjusted on the x-ray equipment to compensate for under development. This practice increases unnecessary radiation dose to the patient and sacrifices the image quality.

Two methods of processing quality control currently used in the dental practice that comply with MDH rules are:

- The Crabtree test for processing intraoral film
- The Stepwedge test for processors used to develop extraoral and intraoral film.

Processor quality control testing must be performed on the film that is most sensitive to development conditions

- When extraoral film is processed
  - 11-step Step wedge
- When only intraoral film is processed
  - Crabtree test device

Follow the manufacturer’s directions for performing the Crabtree test and guidance for the step wedge test and charts for recording the test results are in Addendum 9. Results of the test must be documented each day the developing system is used and must be kept in the Radiation Safety Manual from the date of the last inspection by MDH until the completion of the next inspection by MDH (Addendum 9).

Fog Test
The fog test is conducted every six months and whenever a safe light bulb is changed or safe light filter is changed. Fog test evaluations are required for all darkroom and glovebox conditions used when processing. The results and corrective actions are noted on the log for the fog test. The log and films must be kept in the Radiation Safety Manual from the date of the last inspection by MDH until the completion of the next inspection by MDH.
Two methods for performing the darkroom/glove box fog test currently used in the dental practice that comply with MDH rules are:
   The coin test when only intraoral film is processed
   The step wedge test when extraoral film is processed
   The step wedge test when extraoral and intraoral film is processed under the same conditions in the darkroom or glove box.

Instructions for conducting these tests and a chart to record results are in Addendum 10.

Screen/Film Match
The Speed/Match test verifies that the film being used matches the intensifying screen of the cassette. This test is done every 24 months and must be kept in the Radiation Safety Manual from the date of the last inspection by MDH until the completion of the next inspection by MDH. (Addendum 11).

Screen Film Contact Test
The contact test is performed every 24 months to verify that the screens and film are evenly in contact. This ensures your radiograph image is not distorted. The record of this test must be kept in the Radiation Safety Manual from the date of the last inspection by MDH until the completion of the next inspection by MDH. (Addendum 12)

Specialized test tools are necessary for the screen contact test and screen/film speed match tests and it is recommended that these tests are performed by your service provider at the same time of your x-ray equipment calibrations or performance evaluations.

DIGITAL SYSTEMS

You must follow the manufacturer’s recommendations for quality control of your digital imaging system. A copy of your digital radiography software program operating guide must be kept in the Radiation Safety Manual. If your manual is online only please record vendor and web address here for reference:

Vendor_________________________________ Website: ____________________________________

INTRAORAL, PANORAMIC, CEPHALOMETRIC, and C. T. SYSTEMS
For Panoramic, Computerized Tomography, and Intraoral Radiography, your manual must contain the manual for the software, the sensor system, (or scanner/phosphor plate system). These documents provide the information necessary to correct problems encountered with these systems.
Performance Evaluations:

Daily-Monthly Performance Evaluations

Daily and monthly evaluations following manufacturer’s procedures or the procedures outlined in 4732.1100, including all processing procedures outlined in 4732.0510. A phantom must be used. (Addendum 13)

Bi-annual (24 month) Performance Evaluation

Performance evaluations must be performed by a registered service provider at 24 month intervals or a change/replacement of component(s) that could cause an increase in radiation hazard or could result in the minimum performance criteria not being met. The measurements must be made with a calibrated system traceable to national standards.

Annual Spot Checks

Spot checks must follow all manufacturers’ recommendations for performance testing and are to be performed at intervals not exceeding 12 months or an interval specified by the manufacturer, which ever is less. All tests must use a phantom under the same conditions as the biannual performance evaluation. Photographic images or digital images obtained from the spot checks must be retained until a new equipment performance test is completed. The documentation of all tests must be retained from one inspection to the next inspection.

The Radiation Safety Officer or Registrant must review and sign and date the performance evaluations, with the interval not to exceed 12 months. (Addendum 14)

The Registrant must ensure that the CBCT system is operated by an individual who is qualified and properly trained on that CBCT unit.

The Registrant must ensure that the following information is displayed at the control panel of the CBCT machine:

(1) A current technique chart available at the control panel, which specifies for each routine examination, the CBCT conditions of operation and the number of scans per examination; and
(2) Instructions on the use of the CBCT dosimetry or image quality phantoms including the allowable variations for the indicated parameters.
Corrective Actions for CBCT Equipment Problems

A. Correction of the problem must take place and be verified by performing the equipment performance measurements according to:
(1) Code of Federal Regulations, title 21, section 1020;
(2) the manufacturer's specifications; or
(3) part 4732.1100.

B. The equipment must not be used until corrective actions have been taken, verified, and documented, if the equipment performance measurement or spot check of the CT system indicates that a system operating parameter has exceeded a tolerance established:
(1) in part 4732.1100;
(2) by the manufacturer; or
(3) by a registered service provider.

CBCT software and instructional manual

A copy of your CBCT (cone beam computed tomography) software program operating guide and machine operating guide must be kept in the Radiation Safety Manual. If your manual is online only please record vendor and web address here for reference:

Vendor_______________________ Website: __________________________________.

Further Information

“Operational Principles for Cone Beam Computed Tomography” JADA Vol. 141(10), Oct 2010, pp. 3S-6S. (Addendum 15)

Minnesota Department of Health Inspections-
All records including letters, inspection reports, correction orders, and the practice’s response to the correction orders of the current inspection must be maintained until the successful closure of the next Minnesota Department of Health inspection.
References


*Given that there is an overlap of clinical skills with patient protection, we have highlighted areas that are primary clinical skills that assist in keeping radiation doses to a minimum.*
MDH ATTACHMENTS

A. Initial Registration of Ionizing Producing Equipment
B. Additional Equipment Registration
C. Change in Facility Information for X-ray Machine
D. X-ray Machine Equipment Transfer Form
E. ALARA Model Program
## Minnesota Department of Health

### Initial Registration of Ionizing Radiation-Producing Equipment

(See instructions for completing form)

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Registration Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Address:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Federal Tax ID Number</th>
<th>State Tax ID Number</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Facility Telephone Number:</th>
<th>Facility Fax Number:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Facility Email:</th>
<th>Administrator Telephone Number:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Type of Facility:</th>
<th>Administrator Telephone Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiropractic</td>
<td>Government</td>
</tr>
<tr>
<td>Educational</td>
<td>Industrial</td>
</tr>
<tr>
<td>Hospital</td>
<td>Medical Office</td>
</tr>
<tr>
<td>Medical Office</td>
<td>Portable X-ray Service</td>
</tr>
<tr>
<td>Radiation Therapy</td>
<td>Veterinary</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility Administrator:</th>
<th>Facility Radiation Safety Officer:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Quality Assurance/Quality Control Program in Place:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Calibration completed: Date: Company:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NEW CONTROL CONSOLE INFORMATION

<table>
<thead>
<tr>
<th>Console Type</th>
<th>Manufacturer</th>
<th>Model Name/Number</th>
<th>Serial Number</th>
<th>Console Location</th>
<th>Max kVP</th>
<th>Max mA or mAs</th>
<th>Tube Type</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Tube Manufacturer</th>
<th>Tube Head Serial Number</th>
</tr>
</thead>
</table>

Please choose one

### NEW CONTROL CONSOLE INFORMATION

<table>
<thead>
<tr>
<th>Console Type</th>
<th>Manufacturer</th>
<th>Model Name/Number</th>
<th>Serial Number</th>
<th>Console Location</th>
<th>Max kVP</th>
<th>Max mA or mAs</th>
<th>Tube Type</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Tube Manufacturer</th>
<th>Tube Head Serial Number</th>
</tr>
</thead>
</table>

Please choose one

---

I understand the applicable requirements of Minnesota Rules, Chapter 4732, Ionizing Radiation. The information provided in this registration is correct to the best of my knowledge. I will notify the Minnesota Department of Health, Radiation Control Unit, immediately of any changes in this registration.

Person responsible for administrative control of equipment

Date
**Instructions for completion of registration of new ionizing radiation-producing equipment**

The registration form, when properly completed and filed with the Minnesota Department of Health, Radiation Control Unit, constitutes registration of x-ray machines or devices under Minnesota Rules, Chapter 4732, Ionizing Radiation. Complete registration consists of completed registration forms as described in 4732.0200 and fee payment as described in 4732.0210.

1. Please complete the applicable sections of this form.
2. Please make additional copies of the forms if necessary.
3. Console type (please list one of the following):
   - Accelerator
   - Bone Densitometer
   - Cabinet Radiography
   - C-Arm R/F
   - CT Scanner (Incl. Dental)
   - Cyclotron
   - Dental Radiographic
   - Experimental Research
   - Industrial Fluoroscopic
   - Industrial Radiographic
   - Lithotripsy
   - Mammography
   - Medical Fluoroscopic
   - Medical Portable
   - Medical Radiographic
   - Medical Therapy
   - PET/CT
   - Veterinary Fluoroscopic
   - Veterinary Radiography
   - Veterinary Therapy
   - X-ray Diffraction
   - X-ray Fluorescent Analyzer
   - Veterinary Dental
   - Other (please specify)

4. Enter the manufacturer, serial number and tube serial number. If the console controls more than one tube, please fill in the information under the second box of the tube information.
5. Console location is the room name or number in which the console is located.
6. mA means the maximum milliampere for the unit. kVp means the kilo voltage of the unit.
7. Tube type (Type of Use) (please list one of the following):
   - Bone Densitometer
   - Cephalometric
   - C-Arm R/F
   - CT Scanner
   - Digital
   - Extraoral
   - Fluoroscopic
   - Industrial
   - Introral
   - Introral/Cephalometric
   - Lateral
   - Linear Accelerator
   - Lithotripsy
   - Mammographic
   - Panoramic/Cephalometric
   - Radiographic
   - Single Tube R/F
   - Therapy
   - Other (please specify)

8. If this is a replacement unit, be sure to list what unit was replaced. There is no fee required for a replacement unit.

<table>
<thead>
<tr>
<th>Tube Type</th>
<th>Fee per Tube</th>
<th>Number of Tubes</th>
<th>Total Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental (including Veterinary Dental and Dental CT)</td>
<td>$40.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical, Chiropractic, Veterinary, Industrial (including CT, excluding Mammographic)</td>
<td>$100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Devices with sources of ionizing radiation not used on humans</td>
<td>$100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerators and cyclotrons - single fee for all units</td>
<td>Med/Vet - $500.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial -</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$150.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mammographic</td>
<td></td>
<td>$53.00</td>
<td></td>
</tr>
<tr>
<td>Facility Base Fee</td>
<td></td>
<td></td>
<td>+ $100.00</td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

9. Please sign and date form.

BEFORE MAILING THE REGISTRATION FORMS, BE SURE TO:
- Fill out all applicable sections of the form.
- Sign and date the form.
- Enclose forms and check made payable to "Minnesota Department of Health".

MAIL TO: MN DEPARTMENT OF HEALTH
          RADIATION CONTROL
          625 ROBERT STREET NORTH
          P.O. BOX 64497
          ST. PAUL, MN 55164-0497

Questions call the Radiation Control Unit at 651-201-4545
Registration of Additional Ionizing Radiation-Producing Equipment

(See instructions for completing form)

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Registration Number: (MDH Use Only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Address:</td>
<td>Federal Tax ID Number</td>
</tr>
<tr>
<td></td>
<td>State Tax ID Number</td>
</tr>
<tr>
<td></td>
<td>Facility Telephone Number:</td>
</tr>
<tr>
<td></td>
<td>Facility Fax Number</td>
</tr>
<tr>
<td>Email:</td>
<td></td>
</tr>
<tr>
<td>Facility Administrator:</td>
<td>Administrator Telephone Number:</td>
</tr>
<tr>
<td>Facility Radiation Safety Officer:</td>
<td>RSO Telephone Number:</td>
</tr>
</tbody>
</table>

Installation Calibration completed: Date: _______________ Company: ________________________

**NEW CONTROL CONSOLE INFORMATION**

<table>
<thead>
<tr>
<th>Console Type</th>
<th>Manufacturer</th>
<th>Model Name/Number</th>
<th>Serial Number</th>
<th>Console Location</th>
<th>Max kVp</th>
<th>Max mA or mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Old Control Console Replacement Information (If applicable)**

<table>
<thead>
<tr>
<th>Console Type</th>
<th>Manufacturer</th>
<th>Model Name/Number</th>
<th>Serial Number</th>
<th>Console Location</th>
<th>Max kVp</th>
<th>Max mA or mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I understand the applicable requirements of Minnesota Rules, Chapter 4732, Ionizing Radiation. The information provided in this registration is correct to the best of my knowledge. I will notify the Minnesota Department of Health, Radiation Control Unit, immediately of any changes in this registration.

Person responsible for administrative control of equipment ___________________________ Date _________________
Instructions for completion of additional ionizing radiation-producing equipment

The registration form, when properly completed and filed with the Minnesota Department of Health, Radiation Control Unit, constitutes registration of x-ray machines or devices under Minnesota Rules, Chapter 4732, Ionizing Radiation. Complete registration consists of completed registration forms as described in 4732.0200 and fee payment as described in 4732.0210.

1. Please complete the applicable sections of this form.
2. Please make additional copies of the forms if necessary.
3. Console type (please list one of the following):
   - Accelerator
   - Bone Densitometer
   - Cabinet Radiography
   - C-Arm R/F
   - CT Scanner (Incl. Dental)
   - Cyclotron
   - Dental Radiographic
   - Experimental Research
   - Industrial Fluoroscopic
   - Industrial Radiographic
   - Lithotripsy
   - Mammography
   - Medical Fluoroscopic
   - Medical Portable
   - Medical Radiographic
   - Medical Therapy
   - PET/CT
   - Veterinary Dental
   - Veterinary Fluoroscopic
   - Veterinary Radiography
   - Veterinary Therapy
   - X-ray Diffraction
   - X-ray Fluorescent Analyzer
   - Other (please specify)

4. Enter the manufacturer, serial number and tube serial number. If the console controls more than one tube, please fill in the information under the second box of the tube information.
5. Console location is the room name or number in which the console is located.
6. mA means the milli amperage for the unit. kVp means the kilo voltage of the unit.
7. Tube type (Type of Use) (please list one of the following):
   - Bone Densitometer
   - Cephalometric
   - C-Arm R/F
   - CT Scanner
   - Digital
   - Extraoral
   - Fluoroscopic
   - Industrial
   - Intraoral
   - Intraoral/Cephalometric
   - Linear Accelerator
   - Lithotripsy
   - Mammographic
   - Panoramic
   - Panoramic/Cephalometric
   - Radiographic
   - Single Tube R/F
   - Therapy
   - Other (please specify)

8. If this is a replacement unit, be sure to list what unit was replaced. There is no fee required for a replacement unit.

<table>
<thead>
<tr>
<th>Tube Type</th>
<th>Fee per Tube</th>
<th>Number of Tubes</th>
<th>Total Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental (Including Veterinary Dental and Dental CT)</td>
<td>$40.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical, Chiropractic, Veterinary, Industrial (Including CT, excluding Mammographic)</td>
<td>$100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Devices with sources of ionizing radiation not used on humans</td>
<td>$100.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Accelerators and cyclotrons - single fee for all units
  - Med/Vet - $500.00
  - Industrial - $156.00                                                   |              |                 |           |
| Mammographic                                                              | $53.00       |                 |           |

9. Please sign and date form.

BEFORE MAILING THE REGISTRATION FORMS, BE SURE TO:
• Fill out all applicable sections of the form.
• Sign and date the form.
• Enclose forms and check made payable to "Minnesota Department of Health".

MAIL TO: MN DEPARTMENT OF HEALTH
         RADIATION CONTROL
         625 ROBERT STREET NORTH
         P.O. BOX 64497
         ST. PAUL, MN 55164-0497

FAX TO: 651-201-4606

Questions call the Radiation Control Unit at 651-201-4545
Change in Facility Information for X-ray Machine or Devices

A. General Information (Please select at least one)

- [ ] Facility Name Change
- [ ] Address Change (Due to Move)
- [ ] Administrator Change
- [ ] Equipment Changes
  - [ ] Sold
  - [ ] Disposed
  - [ ] Inoperable
  - [ ] Storage
- [ ] Radiation Safety Officer Change
- [ ] Location Change
- [ ] Sold Practice
- [ ] Date of Sale __________
- [ ] Tax Id Number

B. OLD Information

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Registration Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Tax Id Number:</td>
<td>State Tax Id Number:</td>
</tr>
<tr>
<td>Facility Address:</td>
<td>Facility Phone Number:</td>
</tr>
<tr>
<td>Facility Fax Number:</td>
<td></td>
</tr>
<tr>
<td>Facility Administrator:</td>
<td>Administrator Phone Number:</td>
</tr>
<tr>
<td>Facility Radiation Safety Officer (RSO):</td>
<td>RSO Phone Number:</td>
</tr>
</tbody>
</table>

C. NEW Information

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Registration Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Tax Id Number:</td>
<td>State Tax Id Number:</td>
</tr>
<tr>
<td>Facility Address:</td>
<td>Facility Phone Number:</td>
</tr>
<tr>
<td>Facility Fax Number:</td>
<td></td>
</tr>
<tr>
<td>Console Type &amp; Manufacturer:</td>
<td>Console number (if known)</td>
</tr>
<tr>
<td>Console Serial Number:</td>
<td></td>
</tr>
<tr>
<td>Tube Type &amp; Manufacturer:</td>
<td>Tube Serial Number:</td>
</tr>
<tr>
<td>Console or Tube Status:</td>
<td></td>
</tr>
</tbody>
</table>
  - [ ] Sold
  - [ ] Disposed
  - [ ] Inoperable
  - [ ] Storage
| Sold to: |
| Facility Administrator: | Administrator Phone Number: |
| Facility Radiation Safety Officer (RSO): | RSO Phone Number: |

Registrant’s Signature ___________________________ Title ___________________________ Date ___________________________
X-ray Machine Equipment Transfer Form
Transfer x-ray equipment from one MDH registered location under same ownership to another

A. TRANSFER TO (New location of transferred equipment)

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Registration Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Tax Id Number:</td>
<td>State Tax Id Number:</td>
</tr>
<tr>
<td>Facility Address:</td>
<td>Facility Phone Number:</td>
</tr>
<tr>
<td>Facility Email Address:</td>
<td>Facility Fax Number:</td>
</tr>
<tr>
<td>Facility Administrator:</td>
<td>Administrator Phone Number:</td>
</tr>
<tr>
<td>Facility Radiation Safety Officer (RSO):</td>
<td>RSO Phone Number:</td>
</tr>
</tbody>
</table>

B. TRANSFER FROM (Old location of transferred equipment)

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Registration Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Address:</td>
<td>Facility Phone Number:</td>
</tr>
</tbody>
</table>

C. CONSOLE Information

<table>
<thead>
<tr>
<th>Console Type:</th>
<th>Console number (if known)</th>
<th>Console Manufacturer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console Serial Number:</td>
<td></td>
<td>Console Location at OLD Facility:</td>
</tr>
<tr>
<td>Tube Manufacturer:</td>
<td></td>
<td>Console Location at NEW Facility:</td>
</tr>
<tr>
<td>Tube Type:</td>
<td></td>
<td>Tube Head Serial Number:</td>
</tr>
<tr>
<td>Last Registration Date:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D. Signature
I understand the applicable requirements of Minnesota Rules, Chapter 4732, Ionizing Radiation. The information provided in this form is true and complete. I will notify the Minnesota Department of Health, Radiation Control Unit, of any additional changes.

Applicant’s Signature ___________________________ Date ____________

BEFORE MAILING THE APPLICATION, BE SURE TO:
- Fill out all applicable sections of the application.
- Sign and date the application.

MAIL TO: MN DEPARTMENT OF HEALTH RADIATION CONTROL 625 ROBERT STREET NORTH P.O. BOX 64975 ST. PAUL, MN 55164-0975

FAX TO: (651) 201-4606
Information Notice 2007-01
October 2007
MODEL PROGRAM FOR MAINTAINING OCCUPATIONAL RADIATION EXPOSURE USING THE ALARA CONCEPT
(AS LOW AS REASONABLY ACHIEVABLE)

You may use the text as it appears here or if you prefer, you may develop your own ALARA program for MDH review at the time of an inspection.

Management commitment:

• We, the management of this facility, are committed to the program described herein for keeping individual and collective doses as low as is reasonably achievable (ALARA). In accord with this commitment, we hereby describe an administrative organization for radiation safety and will develop the necessary written policy, procedures, and instructions to foster the ALARA concept within our institution. The organization will include a radiation safety officer.

• We will perform a formal annual review of the radiation safety program, including ALARA considerations. This will include reviews of operating procedures and past dose records, inspections, etc., and consultations with the radiation safety staff or outside consultants.

• Modifications to operating and maintenance procedures and to equipment and facilities will be made if they will reduce exposures unless the cost, in our judgment, is considered unjustified. We will be able to demonstrate, if necessary, that improvements have been sought, that modifications have been considered, and that they have been recommended but not implemented, and we will be prepared to describe the reasons for not implementing the changes.

• In additions to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the doses received by all exposed individuals will also be maintained at the lowest practicable level.
Radiation Safety Officer (RSO) Commitment:

Annual review:
- The registrant and/or the radiation safety officer will perform an annual review of the radiation safety program for adherence to ALARA concepts. Reviews of specific procedures may be conducted on a more frequent basis.
- The registrant and/or the RSO will review at least quarterly the radiation doses of the workers to determine that the doses are ALARA in accordance with the policy.

Education responsibilities for ALARA program:
- The RSO will schedule briefing and educational sessions as needed to ensure that the workers and other personnel who may be exposed to radiation are instructed in the ALARA philosophy. They should also be informed that management and the RSO are committed to implementing the ALARA concept.

Cooperative efforts for development of ALARA procedures:
- Radiation workers will be given opportunities to participate in formulating the procedures that they will be required to follow to maintain the ALARA philosophy.
- The RSO will be in close contact with the workers in order to develop ALARA procedures for working with radiation-producing equipment.
- The RSO will establish procedures for receiving and evaluating the suggestions of individual workers for improving health physics practices and will encourage the use of those programs.
- Workers will be instructed in recourses available if they feel that ALARA is not being promoted and supported on the job.

Reviewing instances of deviation from good ALARA practices:
- The RSO will investigate all known instances of deviation from good ALARA practices and, if possible, will determine the causes. When the cause is known, the RSO will implement changes in the program to maintain doses ALARA.

Registrant’s responsibility to supervised individuals:
- The registrant will explain the ALARA concept and the need to maintain exposures ALARA to all supervised individuals.
- The registrant will ensure that supervised individuals who are subject to occupational radiation exposure are trained and educated in health physics practices involving time, distance, shielding and appropriate techniques in maintaining exposures ALARA.
Addenda

1) Lead Protective Device Biennial Check
2) Article- “Biological Effects of Radiation from Dental Radiography”
3) Article- “The Use of Dental Radiographs”
4) Radiation Safety Officer- Delegation of Authority
5) Job description- Radiation Safety Officer
6) Declaration of Pregnancy Form
7) Training Log
8) Radiology Equipment Safety Check
9) Densitometry Quality Assurance Worksheet
10) Fog Test Semi- Annual Test Records
11) Speed Match Test
12) Screen Film Contact Test
13) CBCT Daily and Monthly Performance Evaluation
14) Annual Spot Check- CBCT
15) Article- Operational Principles for CBCT
16) Information on Incorporating Digital Radiology in Practice
Addendum 1

Lead Protective Device Biennial Check (Apron, Gloves, Etc.)

This test must be done at least once every 24 months.

1. Lay the lead protective apron flat out and make sure that there is no bunching up of the lead or protective material. Perform inspection on other devices also.
2. Look closely for any signs of wear to the devices. Any holes or seams that are unraveling, cracks, or even a discoloration should be evaluated for possible repair or replacement.
3. If there are any questionable findings please notify the Radiation Safety Officer.

<table>
<thead>
<tr>
<th>Date</th>
<th>Good Condition?</th>
<th>Device Needs Repair or Replacement (be specific)</th>
<th>RSO Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Addenda 2 and 3

Comprised of attached articles:


Placement in Radiation Manual: Addenda pages 25-31


Placement in Radiation Manual: Addenda pages 32-40
Biological effects of radiation from dental radiography

Council on Dental Materials, Instruments, and Equipment

The harmful nature of high doses of X rays has been known for many years. However, for low doses, such as those commonly employed in dental radiographic procedures, the magnitude of the risk (or even if there is a risk) remains uncertain. (The concept of high and low doses is very subjective. Within this report 0.20 Gy (20 rads) is arbitrarily considered the demarcation between high and low doses. Units are defined in the next section.)

The principal risks associated with low doses of X rays are cancers, mutations, and congenital abnormalities.1-3 A major problem in evaluating the risk of these effects is that there is no known method of distinguishing between those effects induced by radiation and those arising from other causes. Therefore, the only way to assess the magnitude of these risks is to look for excess incidence in irradiated populations. If this excess incidence is expected to be small, as from a diagnostic dose of X rays, then extremely large populations and long periods of observation are required. The latent period for radiation-induced cancer, even from high doses, is years to decades.4 For example, to evaluate by epidemiologic methods the well-publicized breast cancer risk of mammography, a population of 60 million women, followed from age 35 to death, would be required for a reasonable chance of accurate results.5 Half of the sample would receive mammographic examination at age 35; half would not. Obviously, such a study would require a massive international effort, would take at least 40 years to complete, and would be prohibitively expensive; thus it is not likely to be performed. Similar considerations apply to evaluations of risks of all cancers and mutations in human beings from other low X-ray doses including dental radiography. Therefore, observations from human and animal populations exposed to large doses must be used for
risk estimation, thus leading to significant problems in the quantitative estimation of risks to humans from low doses of radiation.

Several excellent reviews of available data, together with discussions and interpretations, have been published. The latest reports of the committee on Biological Effects of Ionizing Radiation (BEIR) of the National Academy of Sciences and of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) have considered the problem of radiation from all sources. A 1980 symposium from the American Association of Physicians in Medicine (AAPM) limited its consideration to exposures in the healing arts. All are recommended.

Radiation quantities and units

Three quantities are commonly used in discussions of radiation dosimetry: exposure, dose, and dose equivalent. Exposure refers to the quantity of radiation incident upon something and is generally measured in units called roentgens (R). However, when biological material is exposed to X rays, only a portion of the incident energy is absorbed; much of the energy is transmitted through the tissue without effect. The amount of energy absorbed is termed dose, and is traditionally measured in rads (1 rad is 100 ergs of energy absorbed per gram of absorber).

The relationship of dose to exposure depends on both X-ray energy and the nature of the absorber. For example, with a diagnostic-energy X-ray beam, one R of exposure will deposit about 0.9 rads to soft tissue and 3 to 4 rads to bone.

Different types of radiations (such as X rays, neutrons, and alpha-particles) differ in the magnitude of their effects per rad. Thus the term dose equivalent has been introduced to compensate for this difference; it is the dose multiplied by the relative biological effectiveness (RBE) of the type of radiation employed, and is measured in rems. The RBE of X rays is, by definition, one, so for X rays the dose in rads is numerically equal to the dose equivalent in rems.

Recently, new units for dose and dose equivalent were introduced into the metric system. The new unit of dose is the gray (Gy, 1 Gy = 100 rad) and that of dose equivalent is the sievert (Sv, 1 Sv = 100 rem). These new units are coming into widespread use and will be used in this report. In dental radiology, doses are quite small and are generally expressed in milirads (1 mrad = 0.001 rad) or micrograys (1 μGy = 0.000001 Gy). For conversion, 1 mrad is equal to 10 μGy. Similarly, 1 mrem is equal to 10 μSv.

For purposes of comparison with dental radiography, doses from environmental and various consumer product sources are given in Tables 1 and 2.

Table 1: Radiation doses to US population from environmental sources.

<table>
<thead>
<tr>
<th>Source</th>
<th>Average dose equivalent rate† [μSv/yr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td></td>
</tr>
<tr>
<td>Cosmic</td>
<td>280</td>
</tr>
<tr>
<td>Terrestrial</td>
<td>250</td>
</tr>
<tr>
<td>Internal</td>
<td>240 (mammal), 280 (gonads)</td>
</tr>
<tr>
<td>Artificial</td>
<td></td>
</tr>
<tr>
<td>Atmospheric weapons test</td>
<td>40-50</td>
</tr>
<tr>
<td>Nuclear power industry</td>
<td>1</td>
</tr>
<tr>
<td>Building materials</td>
<td>30-40</td>
</tr>
<tr>
<td>Total (rounded)</td>
<td>800</td>
</tr>
</tbody>
</table>

* Data from BEIR III †; excludes occupational exposure. ‡Average trip. †For conversion 10 μSv equal 1 mrem.

Table 2: User doses from selected consumer products.

<table>
<thead>
<tr>
<th>Product</th>
<th>Body portion considered</th>
<th>Average dose equivalent to user (μSv/yr)†‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminous wristwatch</td>
<td>Gonads</td>
<td>10-30</td>
</tr>
<tr>
<td>Television receiver</td>
<td>Gonads</td>
<td>3 (females), 10 (males)</td>
</tr>
<tr>
<td>Combustion of fossil fuels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>Lungs</td>
<td>2-40</td>
</tr>
<tr>
<td>Oil</td>
<td>Lungs</td>
<td>0.02-0.4</td>
</tr>
<tr>
<td>Natural gas</td>
<td>Lungs</td>
<td>65-220</td>
</tr>
<tr>
<td>Tobacco products</td>
<td>Lungs</td>
<td>80,000</td>
</tr>
<tr>
<td>Airline travel</td>
<td>Whole body</td>
<td>5</td>
</tr>
</tbody>
</table>

* Data from BEIR III †; excludes occupational exposure. ‡Average trip. †For conversion 10 μSv equal 1 mrem.

Table 3: Estimated genetic risk per million live births for average population that has been exposed to a dose equivalent of 0.01 Sv (1 rem) per generation.

<table>
<thead>
<tr>
<th>Disease classification</th>
<th>UNSCEAR*</th>
<th>BEIR III*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autosomal dominant and x-linked</td>
<td>Current incidence</td>
<td>F1*</td>
</tr>
<tr>
<td>Irregularly inherited</td>
<td>10,000</td>
<td>20</td>
</tr>
<tr>
<td>Recessive</td>
<td>96,000</td>
<td>5</td>
</tr>
<tr>
<td>Chromosomal aberrations</td>
<td>1.100</td>
<td>Slight</td>
</tr>
<tr>
<td>Total</td>
<td>6,000†‡</td>
<td>38</td>
</tr>
<tr>
<td>Percent of current incidence</td>
<td>107,100</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
</tr>
</tbody>
</table>

*First postirradiation generation. †Genetic equilibrium after several generations. ‡UNSCEAR suggested 4.00%
energy (kVp) and type of collimator. These doses are numerically small, but not necessarily insignificant. Using the data in Table 3 to estimate the genetic risk per unit dose, the gonadal doses from dental radiography should carry a very small risk of mutation—about one in a billion,10 that is, about one recognizable mutation of any kind in the progeny of one billion people who receive an average, but unspecified, dental radiographic examination.

The Bureau of Radiological Health of the US Public Health Service has estimated for 1970 the genetically significant dose of X rays from exposure of patients in the United States during medical and dental examinations. The genetically significant dose is the actual dose delivered to part of the population from medical and dental procedures, weighted by the probability in each exposed patient of conception of children, and then prorated for the entire population. The genetically significant dose is thus an estimate of the dose that, if administered uniformly to the total population, would be expected to carry the same genetic burden as the doses actually delivered to part of the population. In 1970, the estimated genetically significant dose was 200 μSv (20 mrem) from medical diagnostic procedures. From dental procedures, it was less than 1 μSv (0.1 mrem); thus, the dental contribution to the genetic radiation burden of the American population in 1970 was excluded from the calculation. From these data and Table 1, it can be estimated that medical radiology contributes about 20% of the genetic radiation burden of the American population, whereas dental radiology contributes less than 0.1%. Use of radiologic procedures in the healing arts is increasing; however, technological advances will presumably reduce the gonadal dose per procedure so that the genetically significant dose will not increase and may decrease.

### Cancer

A few retrospective epidemiologic studies have suggested an association between diagnostic (including dental) X-ray exposure and cancer, especially leukemia;12-15 however, such studies do not show cause and effect. They merely show an association. The association may be a case of X-ray exposure being the result of seeking medical care because of chronic illness associated with early undiagnosed leukemia, rather than a direct cause-and-effect relationship.

Cancer was not regarded as a major population risk from sublethal radiation doses until excess leukemia began to appear in the Japanese atomic-bomb survivors in the late forties. Since then, excess cancer has been identified in nearly all organs and tissues of the survivors.16 Latent periods (the time between radiation exposure and development of clinical cancer) have ranged from a few years (for leukemia) to several decades. In addition, excess cancer has appeared in many other populations. Uranium miners have been shown to get excess lung cancer from breathing radioactive radon gas; the risk appears greater in white than nonwhite miners.18 A large population in England, treated with therapeutic doses of X rays for ankylosing spondylitis, have developed excess leukemia.17 Tuberculosis patients in eastern Canada in the late forties were treated by repeated (up to 400 times) pneumothorax under fluoroscopic control. Excess breast cancer has been identified in the women in this study,19 and in women treated with therapeutic X rays for postpartum mastitis.20 Excess thyroid cancer has been found in a large population in the United States, who were treated years ago during childhood with therapeutic doses for tonsillitis, adenoids, and thymic enlargement. In this population, the risk in females was approximately twice that in males.20 In Israel, some 1,300 children were treated with X rays for tonsils; excess cancers of the brain, salivary glands, and thyroid have been identified in this group.21 The latest estimate of cancer risk in various organs, from BEIR III, is given in Table 4.

There are many problems in the estimation of the cancer risk from small radiation doses. There is much information for high doses, for both human beings and experimental animals;
Table 6 — Doses to organs in the head and neck from dental radiographic procedures (μGy per examination).

<table>
<thead>
<tr>
<th>No. of films</th>
<th>kVp</th>
<th>Source-subject distance (cm)</th>
<th>Shape</th>
<th>Thyroid gland</th>
<th>Bone marrow</th>
<th>Salivary gland</th>
<th>Brain</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intracanal radiography</td>
<td>14</td>
<td>85</td>
<td>20</td>
<td>Round</td>
<td>400</td>
<td>550</td>
<td>Richards and Webber²⁷</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>90</td>
<td>20</td>
<td>Round</td>
<td>480</td>
<td>530</td>
<td>Winkler²⁸</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>90</td>
<td>40</td>
<td>Round</td>
<td>920</td>
<td>3,500</td>
<td>Greer²⁹</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>90</td>
<td>40</td>
<td>Rect</td>
<td>100</td>
<td>950</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>60</td>
<td>20</td>
<td>R/Sl</td>
<td>200</td>
<td>4,100</td>
<td>470</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>60</td>
<td>20</td>
<td>RO/C</td>
<td>390</td>
<td>4,950</td>
<td>690</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>60</td>
<td>20</td>
<td>RF</td>
<td>410</td>
<td>3,500</td>
<td>1,590</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>80</td>
<td>20</td>
<td>R/Sl</td>
<td>330</td>
<td>2,500</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>80</td>
<td>20</td>
<td>RO/C</td>
<td>400</td>
<td>3,750</td>
<td>490</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>75</td>
<td>20</td>
<td>R/Sl</td>
<td>210</td>
<td>3,600</td>
<td>550</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>75</td>
<td>20</td>
<td>RO/C</td>
<td>390</td>
<td>4,800</td>
<td>790</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>75</td>
<td>20</td>
<td>RF</td>
<td>430</td>
<td>3,850</td>
<td>660</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>75</td>
<td>40</td>
<td>R/Sl</td>
<td>250</td>
<td>3,200</td>
<td>360</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>75</td>
<td>40</td>
<td>RO/C</td>
<td>1,100</td>
<td>4,100</td>
<td>570</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>50</td>
<td>20</td>
<td>R/Sl</td>
<td>330</td>
<td>4,100</td>
<td>940</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>50</td>
<td>20</td>
<td>RO/C</td>
<td>410</td>
<td>5,150</td>
<td>850</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>90</td>
<td>20</td>
<td>RF</td>
<td>510</td>
<td>4,200</td>
<td>950</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>90</td>
<td>20</td>
<td>R/Sl</td>
<td>330</td>
<td>4,100</td>
<td>940</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>50</td>
<td>40</td>
<td>R/Sl</td>
<td>170</td>
<td>3,850</td>
<td>360</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>50</td>
<td>40</td>
<td>RO/C</td>
<td>380</td>
<td>4,350</td>
<td>540</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>60</td>
<td>15</td>
<td>Round</td>
<td>4,200</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>60</td>
<td>40</td>
<td>Round</td>
<td>160</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>60</td>
<td>20</td>
<td>Rect</td>
<td>600</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>80</td>
<td>20</td>
<td>Rect</td>
<td>750</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>75</td>
<td>30</td>
<td>Rect</td>
<td>800</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>50</td>
<td>20</td>
<td>Rect</td>
<td>800</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-25</td>
<td>60</td>
<td>40</td>
<td>Round</td>
<td>500</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>50</td>
<td>20</td>
<td>Rect</td>
<td>600</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>75</td>
<td>40</td>
<td>Rect</td>
<td>390</td>
<td>600</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panoramic tomography</td>
<td>1</td>
<td>75</td>
<td>30</td>
<td>Rect</td>
<td>300</td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>85-90</td>
<td>450</td>
<td>Round</td>
<td>3,600</td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>85-90</td>
<td>300</td>
<td>Round</td>
<td>2,680</td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>85-90</td>
<td>100</td>
<td>Round</td>
<td>2,680</td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>65-90</td>
<td>50-100</td>
<td>Round</td>
<td>1,410-4,800</td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>75-80</td>
<td>100</td>
<td>Round</td>
<td>1,410-4,800</td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>80</td>
<td>20</td>
<td>Round</td>
<td>1,410-4,800</td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>75</td>
<td>40</td>
<td>Round</td>
<td>270</td>
<td>240</td>
<td>240</td>
<td></td>
</tr>
</tbody>
</table>

*For conversion, 10 μGy equal 1 mrad.
²Round, not further specified; Rect, rectangular; R/Sl, round beam; Open, lead-plated cylinder; RO/C, round beam, open unshielded cylinder; RF, round beam, pointed cone.
³Usually measured at pituitary gland.
⁴Representative estimate.
⁵Including.

However, as mentioned earlier, enormous study populations and long intervals of observation would be required to determine excess cancer incidence from small doses. Because there are no data for small doses, estimates of low-dose risk must be made by extrapolating from the effects of large doses—clearly a risky procedure. Until recently, most authorities have used a linear model for this extrapolation.² However, several lines of recent evidence suggest that so doing may overestimate the risk of small doses.²² Despite these problems, the UNSCEAR Committee has estimated the lifetime cancer risk in individual organs per unit dose (Table 5). These data are estimates of average lifetime cancer risks for a population of the same age distribution as that used by UNSCEAR. Further, both UNSCEAR and BEIR committees have warned that their risk estimates are valid only over the range of doses from which the data were obtained. Thus, these data may not be applied directly for estimation of individual risk.

Because leukemia was the first radiation-induced cancer observed in the Japanese, it has received the most attention in the radiobiological literature. A concept analogous to the genetically significant dose, called the caput marrow dose, has been introduced.²³ The caput marrow dose is the dose that, if administered uniformly to the total population, would be expected to carry the same risk of leukemia as the doses actually delivered to part of the population from diagnostic procedures. For 1970, the caput marrow dose in the United States for medical radiology was estimated as 1.000 μGy (100 mrad), and that for dental radiology as 30 μGy (3 mrad). Comparing these data with the population dose from background sources (Table 1), it appears that medical radiology contributed about 5% of the leukemogenic burden from radiation in 1970 to the American population, whereas dental radiology contributed about 1.5%. Obviously, this approach assumes that the total population bone marrow dose, 1.830 μGy (183 mrad), in 1970 was harmful.

The somatic or cancer risk from dental radiographic procedures has been estimated by use of the concept of detriment,²⁴ in which the total risk from exposure of part of the body is the sum of individual risks to each organ exposed.²⁵-²⁶ Use of this notion requires data detailing the dose to each sensitive organ in the body from each dental radiographic procedure. The risk to each organ is the product of the dose to that organ multiplied by the
Table 7 - Estimated cancer risk from dental radiology (cases per million examinations).

<table>
<thead>
<tr>
<th>Examination</th>
<th>No. of films</th>
<th>Beam shape</th>
<th>Bengtson</th>
<th>Danforth and Gibbas</th>
<th>Gregg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-mouth, periapical and blowing films</td>
<td>14-22</td>
<td>Round</td>
<td>12</td>
<td>6-17</td>
<td></td>
</tr>
<tr>
<td>Full-mouth, periapical and blowing films</td>
<td>21-22</td>
<td>Rectangular</td>
<td>4-6</td>
<td>3-7</td>
<td></td>
</tr>
<tr>
<td>Bitewing</td>
<td>2</td>
<td>Round</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dental, not further specified</td>
<td>4</td>
<td></td>
<td>4</td>
<td>2-7</td>
<td>3</td>
</tr>
<tr>
<td>Panoramic tomography</td>
<td>1</td>
<td></td>
<td>12-27</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Panoramic, intraoral source</td>
<td>2</td>
<td></td>
<td>1-5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Skull</td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are only risk estimates, not established facts, and thus provide only an approximation of the order of magnitude of the risk. They may be modified as additional data become available. Because they use compounded assumptions, particularly the linear dose-response model, they may be proved incorrect at some future date. The recent discovery of an apparent error in the dosimetry of the Hiroshima atomic bomb has cast some doubt on the validity of the Japanese data. Dose recalculations are as yet incomplete; preliminary results suggest that the low-dose X-ray risk estimates may not be significantly changed by the new data.

Embryo and fetus

The mammalian organism in utero is especially sensitive to the harmful effects of ionizing radiation. An embryo or fetus undergoes rapid growth. Its immune system is undeveloped, and almost all exposures to radiation involve the whole body. Many studies with experimental animals have shown that X rays in sufficient doses can lead to a variety of adverse effects. These effects are also known to occur in human beings as summarized in Table 6. For prenatal death and congenital abnormalities, most authors have suggested a threshold of about 0.1 Sv (10 rem). However, a few studies have shown minimal malformations from doses as low as 0.05 Sv (5 rem). Similarly, most authors have considered a threshold of 0.1 Sv (10 rem) to apply to growth and mental retardation; a few cases of microcephaly have been found in the Japanese atomic-bomb survivors irradiated in utero with doses in the 0.01 to 0.1 Sv (1 to 10 rem) range. These latter effects occur from exposure throughout pregnancy; the first trimester is most sensitive.

A large-scale retrospective epidemiologic study in England demonstrated a significant association between in utero exposure to diagnostic levels of X rays and childhood cancer, especially leukemia. Since then, the study has been extended; and many similar studies have been carried out in several countries, including the United States. Most of these studies found similar associations, although a few were negative. The weighted average results of all reported studies have indicated that the human embryo...
Table 9: Situations in which a person has a one in a million risk of dying.*

<table>
<thead>
<tr>
<th>Risk situation</th>
<th>Cause of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being a man, age 60, for 20 minutes</td>
<td>Cardiovascular disease, cancer</td>
</tr>
<tr>
<td>Living in New York for two days</td>
<td>Air pollution</td>
</tr>
<tr>
<td>Living in Denver for two months</td>
<td>Cosmic radiation</td>
</tr>
<tr>
<td>Living in a stone building for two months</td>
<td>Natural radioactivity</td>
</tr>
<tr>
<td>Drinking water in Miami for one year</td>
<td>Carcinogen</td>
</tr>
<tr>
<td>Living near a polyvinyl chloride plant for ten years</td>
<td>Carcinogen</td>
</tr>
<tr>
<td>Riding in a canoe for six minutes</td>
<td>Accident</td>
</tr>
<tr>
<td>Riding a bicycle for ten miles</td>
<td>Accident</td>
</tr>
<tr>
<td>Riding in a car for 300 miles</td>
<td>Accident</td>
</tr>
<tr>
<td>Traveling by airplane for 1,000 miles</td>
<td>Accident</td>
</tr>
<tr>
<td>Traveling by airplane for 6,000 miles</td>
<td>Cosmic radiation</td>
</tr>
<tr>
<td>Working in a coal mine for one hour</td>
<td>Black lung</td>
</tr>
<tr>
<td>Working in a coal mine for three hours</td>
<td>Accident</td>
</tr>
<tr>
<td>Working in a typical factory for ten days</td>
<td>Accident</td>
</tr>
<tr>
<td>Smoking cigarettes, 14</td>
<td>Cardiovascular disease, cancer</td>
</tr>
<tr>
<td>Drinking wine, 500 cc</td>
<td>Cirrhosis</td>
</tr>
<tr>
<td>Drinking diet sods, 30 cans</td>
<td>Carcinogen</td>
</tr>
</tbody>
</table>

*Data from Puchin and Wilson.*

may be exceptionally sensitive to the carcinogenic effects of radiation. However, no excess childhood cancers were found in the Japanese atomic bomb survivors irradiated in utero. Studies of a group of children who had received radiation in conjunction with routine pelvimetry at term found no excess childhood cancers. Although there is some disagreement in the data, the above studies, taken as a whole, suggest that every precaution should be taken to minimize exposure to the unborn child.

The significant sensitivity of the embryo to radiation has led several countries to implement the 10-day rule, which requires that diagnostic exposure to the pelvic region in female patients of childbearing age be limited to the ten-day period following the onset of menses—unless there is compelling evidence that the patient cannot be pregnant or compelling medical reason to proceed with exposure even if she is pregnant. This procedure has not been implemented in the United States. Further, it applies only to involvement of the pelvic region in the primary beam. Therefore, the 10-day rule is not applicable to dental radiography. Occasionally, a patient may have a dental radiographic examination and subsequently be determined to have been pregnant at the time. There are no data concerning dose to the embryo from dental radiographic procedures. However, gonadal doses may be used as an approximation. These indicate that the dose to an embryo would not exceed 20 μGy (2 mrad) from either a full-mouth intraoral or a panoramic examination. Current medical practice suggests that therapeutic abortion should be recommended on the basis of radiation exposure to the embryo only if the dose exceeded 0.1 Gy (10 rads). Obviously, doses from dental radiographic procedures should never approach that level.

Occupational exposure

The National Council on Radiation Protection and Measurements (NCRP) currently recommends a maximum permissible dose equivalent from occupational sources of 0.05 Sv (5 rem) per year. A mean exposure of 100 μSv (10 mrem), range 50 to 600 μSv (5 to 60 mrem), in a one-month period among 231 dental personnel in 72 private dental offices has been reported. In addition, the NCRP recommends an occupational limit of 0.005 Sv (500 mrem) to the embryo-fetus during the entire term of pregnancy. Monitoring of occupational exposure of dental office personnel may provide protection to a dentist in the event of an illness or injury to an employee that could have been caused by radiation.

Summary and conclusions

Clearly, there is ample evidence of adverse effects of radiation in sufficient doses. There is at present no proof of such effects from doses commonly employed in dental practice; however, it has not been possible to prove the absence of such effects. Most experts now agree that there may be a small difficult to quantify risk of cancer due to a genetic mutation from diagnostic exposure in patients and in personnel exposed during work. Prudence dictates acceptance of this position until proof to the contrary is available.

This report has presented recent attempts to quantify the risk to patients based on speculative calculations and extrapolations. Indices of population risks indicate that medical radiology is the largest source of humanmade genetic and leukemogenic radiation burden to the American public. Dental radiology contributes a small—but not necessarily insignificant—portion. Of major concern is the increasing use of radiation for diagnostic purposes in both medicine and dentistry. Technological advances have reduced exposure per examination; presumably, this trend will continue so that total exposure of populations to radiation in the healing arts will not increase.

Recent analyses suggest that the cancer risk to a patient from a dental radiographic examination is of the order of one in a million; the genetic risk is substantially less, about one in a billion. The risks appear to be essentially equal for full-mouth intraoral and panoramic examinations. These estimates are numerically quite small, but the effects are severe. Thus, these risks cannot be ignored. However, we currently accept risks of similar magnitude in our daily lives (Table 9). In addition, the risk of failure to make an accurate diagnosis may be greater than the risk from exposure to the radiation from a justified and properly conducted radiographic examination. It therefore appears reasonable that the information gained from a justified and properly conducted radiographic examination outweighs the risk.

The risk estimates presented in this report are not established fact, and thus provide only approximations of the order of magnitude of risks. The estimates are useful for the a priori assessment of the risk of a dental radiographic procedure. They are not sufficiently accurate to permit meaningful calculation of the frequency of adverse effects of dental radiography.

This report was prepared at the request of the Council on Dental Materials, Instruments, and Equipment by S. Julian Gibbs, DDS, PhD, associate professor, department of radiology and
radiological sciences, Vanderbilt University, School of Medicine. Nashville, Tenn 37232.

This informational report was approved by the Council in December 1981.


The use of dental radiographs
Update and recommendations

American Dental Association Council on Scientific Affairs

Dental radiographs are a useful and necessary tool in the diagnosis and treatment of oral diseases such as caries, periodontal diseases and oral pathologies. Although radiation doses in dental radiography are low, exposure to radiation should be minimized where practicable. Dentists should weigh the benefits of dental radiographs against the consequences of increasing a patient’s exposure to radiation, the effects of which accumulate from multiple sources over time. The “as low as reasonably achievable” (ALARA) principle should be followed to minimize exposure to radiation.

This report discusses implementation of proper radiographic practices. It addresses topics such as patient selection criteria, film selection for conventional radiographs, collimation, beam filtration, patient protective equipment, film holders, operator protection, film exposure and processing, infection control, quality assurance, image viewing, direct digital radiography and con-

Background and Overview. The National Council on Radiation Protection & Measurements updated its recommendations on radiation protection in dentistry in 2003, the Centers for Disease Control and Prevention published its Guidelines for Infection Control in Dental Health-Care Settings in 2003, and the U.S. Food and Drug Administration updated its selection criteria for dental radiographs in 2004. This report summarizes the recommendations presented in these documents and addresses additional topics such as patient selection criteria, film selection for conventional radiographs, collimation, beam filtration, patient protective equipment, film holders, operator protection, film exposure and processing, infection control, quality assurance, image viewing, direct digital radiography and continuing education of dental health care workers who expose radiographs.

Conclusions. This report discusses implementation of proper radiographic practices. In addition to these guidelines, dentists should be aware of, and comply with, applicable federal and state regulations.

Clinical Implications. Dentists should weigh the benefits of dental radiographs against the consequences of increasing a patient’s exposure to radiation and implement appropriate radiation control procedures.

Key Words. Radiographs; X-ray; radiographic examination; radiation exposure; digital radiography; quality assurance.

JADA 2006;137:1304-12.

Address reprint requests to American Dental Association Council on Scientific Affairs, 211 E. Chicago Ave., Chicago, Ill. 60611.
tioning education of dental health care workers who expose radiographs. This report also summarizes the updated recommendations of the National Council on Radiation Protection & Measurements (NCRP) on radiation protection in dentistry (available for purchase on the Web at www.ncrppublications.org/index.cfm?fm=Product.AddToCart&pid=1845765544" or by phone at 1-800-229-2652), the Centers for Disease Control and Prevention's Guidelines for Infection Control in Dental Health-Care Settings (www.cdc.gov/oralhealth/infectioncontrol/guidelines/index.htm) and the U.S. Food and Drug Administration (FDA) selection criteria for dental radiographs (www.ada.org/prof/resources/topics/radiography.asp).

In addition to these guidelines, dentists should be aware of, and comply with, applicable federal and state regulations. (The Web site of the Conference of Radiation Control Program Directors at www.crcc.org/Map/map.asp provides contact information for state radiation control and protection programs.)

PATIENT SELECTION CRITERIA

There is little evidence to support radiographic exposure of all dentulous areas of the oral cavity in search of occult pathoses in the asymptomatic patient. Studies have shown that basing selection criteria on clinical evaluations for asymptomatic patients, combined with selected periapical radiographs for symptomatic patients, can result in a 43 percent reduction in the number of radiographs without a clinically consequential increase in the rate of undiagnosed disease.

In collaboration with the ADA, the FDA has updated its guidelines for the selection of patients for dental radiographic examination (Table 1). These guidelines provide recommendations for radiographs with consideration given to a patient's caries risk, periodontal status, stage of growth and development, and other specific circumstances. The guidelines recommend that radiographs be limited to the areas required for adequate diagnosis and treatment on the basis of the sound exercise of professional judgment. Dentists should not prescribe routine dental radiographs at preset intervals for all patients. Instead, they should prescribe radiographs after an evaluation of the patient's needs that includes a health history review, a clinical dental history assessment, a clinical examination and an evaluation of susceptibility to dental diseases. For new or referred patients, clinicians should obtain recent dental radiographs from the patient's previous dental health care provider. They also should review early radiographs, if available, for comparative purposes.

Dental radiographs may be prescribed for pregnant patients with careful adherence to the FDA selection criteria guidelines. Dental disease left untreated during pregnancy can lead to problems for both the mother and the fetus, and dental radiographs may be required for proper diagnosis and management.

No special considerations apply to dental radiographs for patients undergoing radiation therapy to the head and neck. These patients are at a high risk of developing dental diseases, and the radiation exposure from dental radiographs is negligible when compared with the therapeutic exposure they already are receiving in their treatment.

Panoramic radiographs may reveal calcifications of the carotid artery through examination of the region 1.5 to 2.5 centimeters posterior and inferior to the angle of the mandible. It is not recommended that the clinician take dental panoramic radiographs specifically to evaluate for carotid artery calcification, but rather that he or she evaluate radiographs taken for dental purposes for this condition as well. If the dentist suspects this condition, he or she should refer the patient to a physician for evaluation.

FILM SELECTION FOR CONVENTIONAL RADIOGRAPHS

The American National Standards Institute and the International Organization for Standardization have established standards for film speed. Film speeds available for dental radiography are D-speed, E-speed and F-speed, with D-speed being the slowest and F-speed the fastest. The use of faster film speed can result in up to a 50 percent decrease in exposure to the patient without compromising diagnostic quality. Film of a speed slower than E-speed should not be used for dental radiographs.

Exposure of extraoral films such as panoramic radiographs requires intensifying screens to minimize radiation exposure to patients. The intensifying screen consists of layers of phosphor crystals that fluoresce when exposed to radiation. In addition to the radiation incident on the film, the film is exposed primarily to the light emitted from the intensifying screen. Previous generations of
## U.S. Food and Drug Administration guidelines for prescribing dental radiographs

The recommendations in this table are subject to clinical judgment and may not apply to every patient. They are to be used by dentists only after reviewing the patient's health history and completing a clinical examination. Because every precaution should be taken to minimize radiostim exposure, protective thyroid collars and aprons should be used whenever possible. This practice is strongly recommended for children, women of childbearing age and pregnant women.

<table>
<thead>
<tr>
<th>TYPE OF ENCOUNTER</th>
<th>PATIENT AGE AND DENTAL DEVELOPMENTAL STAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Child With Primary Dentition (Prior to Eruption of First Permanent Tooth)</td>
</tr>
<tr>
<td>New Patient* Being Evaluated for Dental Diseases and Dental Development</td>
<td>Individualized radiographic examination consisting of selected periapical/occlusal views and/or posterior bitewings if proximal surfaces cannot be visualized or probed; patients without evidence of disease and with open proximal contacts may not require a radiographic examination at this time</td>
</tr>
<tr>
<td>Recall Patient† With Clinical Caries or at Increased Risk of Developing Caries*</td>
<td>Posterior bitewing examination at six- to 12-month intervals if proximal surfaces cannot be examined visually or with a probe</td>
</tr>
<tr>
<td>Recall Patient† With No Clinical Caries and Not at Increased Risk of Developing Caries*</td>
<td>Posterior bitewing examination at 12- to 24-month intervals if proximal surfaces cannot be examined visually or with a probe</td>
</tr>
<tr>
<td>Recall Patient‡ With Periodontal Disease</td>
<td>Clinical judgment as to the need for and type of radiographic images for the evaluation of periodontal disease; imaging may consist of, but is not limited to, selected bitewing and/or periapical images of areas in which periodontal disease (other than nonspecific gingivitis) can be demonstrated clinically</td>
</tr>
<tr>
<td>Patient for Monitoring of Growth and Development</td>
<td>Clinical judgment as to need for and type of radiographic images for evaluation and/or monitoring of dentofacial growth and development.</td>
</tr>
<tr>
<td>Patient With Other Circumstances Including, but not Limited to, Proposed or Existing Implants, Pathology, Restorative/Endodontic Needs, Treated Periodontal Disease and Caries Remineralization</td>
<td>Clinical judgment as to need for and type of radiographic images for evaluation and/or monitoring of these conditions</td>
</tr>
</tbody>
</table>

---

* Reprinted from U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration; and American Dental Association, Council on Dental Benefit Programs, Council on Scientific Affairs.
† Clinical situations for which radiographs may be indicated include, but are not limited to, the following: Positive historical findings: Previous periodontal or endodontic treatment, history of pain or trauma, familial history of dental anomalies, postoperative evaluation of healing, remineralization monitoring, presence of implants or evaluation for implant placement. Positive clinical signs/symptoms: clinical evidence of periodontal disease, large or deep restorations, deep carious lesions, malposed or clinically impacted teeth, swelling, evidence of dental/facial trauma, mobility of teeth, sinus tract ("tulipa"), clinically suspected sinus pathology, growth abnormalities, oral involvement in known or suspected systemic diseases, positive neurologic findings in the head and neck, evidence of foreign bodies, pain and/or dysfunction of the temporomandibular joint, facial asymmetry, abutment teeth for fixed or removable partial prosthesis, unexplained bleeding, unexplained sensitivity of teeth, unusual eruption, spacing or migration of teeth, unusual tooth morphology, calcification or color, missing teeth with unknown reason, clinical erosion.
‡ Factors increasing risk for caries may include, but are not limited to, the following: high level of caries experience or demineralization, history of recurrent caries, high titers of cariogenic bacteria, existing restoration of poor quality, poor oral hygiene, inadequate fluoride exposure, prolonged nursing (bottle or breast), diet with high sucrose frequency, poor family dental health, developmental or acquired enamel defects, developmental or acquired amelogenesis, early tooth loss, genetic abnormality of teeth, many multisurface restorations, chemotherapeutic therapy, eating disorders, drug/alcohol abuse, irregular dental care.
intensifying screens were composed of phosphors such as calcium tungstate. However, rare-earth intensifying screens are recommended because they reduce a patient’s radiation exposure by 50 percent compared with calcium tungstate-intensifying screens. Rare-earth film systems, combined with a high-speed film of 400 or greater, can be used for conventional panoramic radiographs. Older panoramic equipment can be retrofitted to reduce the radiation exposure to accommodate the use of rare-earth high-speed systems.

COLLIMATION

Collimation limits the amount of radiation, both primary and scattered, to which the patient is exposed. The X-ray beam should not exceed the minimum coverage necessary, and each dimension of the beam should be collimated so that the beam does not exceed the receptor by more than 2 percent of the source-to-image receptor distance. Since a rectangular collimator decreases the radiation dose by up to fivefold as compared with a circular one, radiographic equipment should provide rectangular collimation for exposure of periapical and bitewing radiographs. The position-indicating device (PID) should be opened and have a metallic lining to restrict the primary beam and reduce the tissue volume exposed to radiation. Use of long source-to-skin distances of 40 cm, rather than short distances of 20 cm, decreases exposure by 10 to 25 percent. Distances between 20 cm and 40 cm are appropriate, but the longer distances are optimal.

BEAM FILTRATION

The operating potential of dental X-ray machines affects the radiation dose and backscatter radiation. Lower voltages produce higher-contrast images and higher entrance skin doses and lower deep-tissue doses and levels of backscatter radiation. However, higher voltages produce lower-contrast images that enable better separation of objects with differing densities. Thus, the diagnostic purposes of the radiograph should be used to determine the selection of kilovoltage.

The operating potential of dental X-ray machines must range between 50 and 100 kilovolt peak but should range between 60 and 80 kVp. Manufacturers of low-kVp (less than 60) dental radiographic equipment are required to install internal aluminum beam filters so that the mean beam energy will approach 60 kVp.

PATIENT PROTECTIVE EQUIPMENT

Leaded aprons and thyroid shields that contain lead or other materials are patient-protective equipment that minimize exposure to scattered radiation. If all of the NCRP recommendations are followed rigorously, the use of a leaded apron on patients is not required. However, if any of the recommendations is not implemented, then a leaded apron should be used.

Thyroid shielding with a leaded thyroid shield or collar is strongly recommended for children and pregnant women, as these patients may be especially susceptible to radiation effects. Thyroid shielding also is recommended for adults when it will not interfere with the exposure. To prevent cracks from occurring in the leaded shield, practitioners should ensure that leaded aprons and collars are hung and not folded.

FILM HOLDERS

Film holders that align the film precisely with the collimated beam are recommended for periapical and bitewing radiographs. Heat-sterilizable or disposable intraoral radiograph film-holding devices are recommended for optimal infection control. Dental professionals should not hold the film holder during exposure. Under extraordinary circumstances in which members of the patient’s family (or other caregiver) must provide restraint or hold a film holder in place during exposure, such a person should have appropriate shielding.

OPERATOR PROTECTION

Although dental professionals receive less exposure to X-radiation than do other health care workers, operator protection measures are essential to minimize occupational exposure to ionizing radiation. Operator protection measures include education, the implementation of a radiation protection program, annual and lifetime limits of exposure to ionizing radiation, recommendations for personal dosimeters and the use of barrier shielding.

The maximum permissible annual dose of ionizing radiation for health care workers is 50 millisieverts and the maximum permissible lifetime dose is 10 mSv multiplied by a person’s age in years. Personal dosimeters should be used by workers who may receive an annual dose greater than 1 mSv to monitor their exposure levels. Dental personnel who expose radiographs and are
pregnant also should use personal dosimeters, regardless of anticipated exposure levels.\textsuperscript{3}

Operators of radiographic equipment should use barrier protection when possible, and barriers should contain a leaded glass window to enable the operator to view the patient during exposure.\textsuperscript{3} When shielding is not possible, the operator should stand at least two meters from the tube head and out of the path of the primary beam.\textsuperscript{3} The NCRP report “Radiation Protection in Dentistry” offers detailed information on shielding and office design (in its Appendix F).\textsuperscript{3}

\textbf{FILM EXPOSURE AND PROCESSING}

Exposure settings and film processing procedures can affect the quality of the radiographic image. The operator should set the amperage and time settings for exposure of dental radiographs of optimal quality. Radiographs should not be over-exposed and then underdeveloped, because this practice results in greater exposure to the patient and dental health care worker and can produce images of poor diagnostic quality. Dental radiographs should not be processed by sight, and manufacturers’ instructions regarding time, temperature and chemistry should be followed.\textsuperscript{3}

Darkrooms should have adequate ventilation, and dental personnel should use protective procedures to avoid contact with the development chemicals.\textsuperscript{34} A darkroom is preferable to daylight-loading processors, as the latter makes infection control procedures difficult to follow.\textsuperscript{34} The length of time for which a film can be exposed to the safelight should be determined for the specific safelight/film combination used.\textsuperscript{34}

State regulations may provide instructions regarding disposal of film-processing solutions and lead foil from the film packet. Fixer solutions may be considered hazardous waste because of their silver content and should be placed in containers and transported for recycling or to disposal sites.\textsuperscript{35,36} The EPA recommends that lead foil be disposed of in accordance with local regulations.\textsuperscript{38,36}

\textbf{INFECTION CONTROL}

Each dental health care facility should use standard precautions when exposing dental radiographs.\textsuperscript{3} The personnel exposing the films should set out all necessary supplies and adjust the patient chair and head position before beginning the procedure. They should wear gloves when exposing the film and handling contami-
nated items, and they should always wash their hands before and after wearing gloves.\textsuperscript{3,4,11} They should wear additional personal protective equipment, such as eyewear and a mask or face shield, when exposure to body fluids is anticipated.\textsuperscript{3,57,38}

Heat-sterilizable or disposable intraoral radiograph film-holding devices are recommended, and barrier-protected film should be used whenever possible to prevent contamination and to minimize infection control procedures.\textsuperscript{4} Digital intraoral film receptors that cannot be heat-sterilized should be covered with FDA-cleared protective barriers.\textsuperscript{4} Because contamination of daylight-loading film processors is difficult to avoid, barrier-protected film also is recommended for use with these.

The film packet should be dried after a film is exposed.\textsuperscript{3,34,37} If a protective film barrier is used, it should be removed carefully to avoid contamination of the film packet.\textsuperscript{4} The uncontaminated contents then can be handled without gloves or other precautions. If the barrier is not used, gloves should be worn when the contaminated film packet is opened and the film allowed to fall out of the packet.\textsuperscript{34,37} After all of the films have been removed in this manner, the gloves are removed and hands washed.\textsuperscript{34,37,4} Once his or her hands are clean, the operator now can place the films in the processor as well as mount the processed radiographs.

All extraoral devices that will be contacted during the procedure should be either disinfected between patients or protected by a barrier and changed between patients.\textsuperscript{3,4,37,38} An EPA-registered hospital-level disinfectant with low-to-intermediate activity should be used to treat any surfaces that become contaminated.\textsuperscript{3,4,38}

\textbf{QUALITY ASSURANCE}

Quality assurance protocols for the X-ray machine, imaging receptor, film processing, dark room, and leaded aprons and thyroid collars should be developed and implemented for each dental health care setting.\textsuperscript{3} All quality assurance procedures, including date, procedure, results and corrective action, should be logged for documentation purposes.\textsuperscript{3}

A qualified expert should survey all X-ray machines on their placement and should resurvey the equipment every four years or if there are any changes made to it during this interval.\textsuperscript{3} Surveys typically are performed by state agencies, and individual state regulations should be consulted.
regarding specific survey intervals. The film processor should be evaluated at its initial installation and on a monthly basis afterward. The processing chemistry should be evaluated daily, and each type of film should be evaluated monthly or when a new box or batch of film is opened. Lead aprons and thyroid collars should be inspected visually for damage on a monthly basis and examined fluoroscopically on an annual basis. Lead aprons and collars in poor condition should be disposed of using a recycler licensed to handle lead waste. Table 2 lists specific methods of quality assurance procedures, covering not only inspection of the X-ray machine itself but also the film processor, the image receptor devices, the darkroom and leaded aprons and collars. (Figure, page 1311).

**IMAGE VIEWING**

The dentist should view radiographs under appropriate conditions for analysis and diagnosis. An illuminated viewer, preferably with variable intensity to allow for optimization of high- and low-density areas, should be used. Minimum room light will reduce reflections, and an opaque film holder will help to prevent glare and loss of visual acuity. Magnification should be used as needed.

**DIGITAL RADIOGRAPHY**

A high-quality image can be obtained through the use of direct digital radiography while minimizing exposure to both patient and health care provider. Advantages of digital radiography include a decrease in radiation exposure for intraoral radiographs, speed in obtaining the image, ease of digital storage and electronic transmission of the image, and discontinued need for darkroom equipment. A digital radiographic image can be adjusted for optimal diagnostic quality, including alterations in contrast, density, magnification and color. Radiographic images can be printed on photo-quality paper or transparent sheets using any of a number of standard printers.

Widely available forms of direct digital radiography include photo-stimulable storage phosphor (PSP) sensors (also known simply as "storage phosphor sensors"), solid-state electronic sensors such as charged-coupled devices (CCD) and complementary metal-oxide semiconductor active pixel sensors (CMOS-APS). The image receptor used by the PSP format is similar in size, shape and flexibility to that of a conventional radiographic film. On exposure, the image is converted into stored energy on the image receptor. The exposed image receptors are placed in a processor and scanned by a laser. The image is converted into a digital format in one to two minutes. The image receptor can be reused after proper infection control procedures are carried out, and after erasure of the residual image by exposure to a strong light source for one minute. Because of the time required to obtain an image in this processing format, a PSP system is suited for instances in which an immediately available image is not essential.

The CCD and CMOS-APS formats use a reusable intraoral image receptor that is sensitive to X-rays and visible light and is connected by a cable directly to a computer. The receptor is the size of intraoral films, but the image's active area may be smaller than this size. Upon exposure, the image is immediately converted to a digital format. The speed of obtaining an image makes these systems desirable when instant images are essential (such as oral surgery procedures, endodontics and implant placement).

Although technological advances in direct digital radiography have made the diagnostic quality of digital images comparable to that of conventional films, there are some concerns about direct digital radiographs. These include the small receptor area that may require multiple exposures per area, the thickness and rigidity of some receptors that may make positioning difficult, and decreased resolution. FDA-cleared protective barriers are necessary for adequate infection control due to the lack of heat-tolerant intraoral equipment. Finally, proprietary formats for image-viewing may limit electronic transfer and accessibility of the digital image.

The Digital Imaging and Communications in Medicine (DICOM) standard, developed by the American College of Radiology and the National Electrical Manufacturers Association, aims to facilitate a common method of transmission for medical radiographic images. The ADA supports the use of DICOM. To further adapt the DICOM standards for the exchange of digital radiographic images used in dentistry, the ADA Standards Committee on Dental Informatics (SCDI) developed a report, Technical Report (TR) No 1023: Implementation Requirements for DICOM in Dentistry. The DICOM requirements presented in the Technical Report enable exchange of digital
### TABLE 2

**Quality assurance procedures for assessment of radiographic equipment.**

The following procedures for periodic assessment of the performance of radiographic equipment, film processing equipment, image receptor devices, dark room integrity, and leaded apron and thyroid collar are adapted from the National Council for Radiation Protection & Measurements report, "Radiation Protection in Dentistry." Please refer to state guidelines for specific regulations.

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>FREQUENCY</th>
<th>METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X-ray Machine</strong></td>
<td>On installation, At regular intervals as recommended by state regulations, Whenever there are any changes in installation, workload or operating conditions</td>
<td>Inspection by qualified expert (as specified by state regulations)</td>
</tr>
<tr>
<td><strong>Film Processor</strong></td>
<td>On installation, Daily</td>
<td><strong>Method 1: Sensitometry and Densitometry</strong>&lt;sup&gt;5&lt;/sup&gt;  &lt;br&gt;A sensitometer is used to expose a film, followed by standard processing of the film &lt;br&gt;The processed film will have a defined pattern of optical densities &lt;br&gt;The densities are measured with a densitometer &lt;br&gt;The densitometer measurements are compared to the densities of films exposed and processed under ideal conditions &lt;br&gt;A change in densitometer values indicates a problem with either the development time, temperature or the developer solutions  &lt;br&gt;<strong>Advantages</strong> &lt;br&gt;Speed &lt;br&gt;<strong>Disadvantages</strong> &lt;br&gt;Expense of additional equipment</td>
</tr>
<tr>
<td></td>
<td>On installation, Daily</td>
<td><strong>Method 2: Stepwedge (See Figure)</strong>  &lt;br&gt;An aluminum stepwedge may be purchased or fabricated to resemble stairs, with each step of the aluminum stepwedge at 1 millimeter thick and 3 to 4 mm wide, with at least six steps &lt;br&gt;A film is exposed through the stepwedge with the same machine settings, film placement and step wedge placement used for each daily exposure &lt;br&gt;The processed film is compared visually with a reference film &lt;br&gt;A change in density of one or more steps indicates a problem with either the development time, temperature or the developer solutions &lt;br&gt;<strong>Advantages</strong> &lt;br&gt;Cost effectiveness &lt;br&gt;<strong>Disadvantages</strong> &lt;br&gt;Loss of precision</td>
</tr>
<tr>
<td><strong>Image Receptor Devices</strong></td>
<td>Monthly</td>
<td><strong>Method 3: Reference Film</strong>&lt;sup&gt;6&lt;/sup&gt;  &lt;br&gt;A film exposed and processed under ideal conditions is attached to the corner of a view box as a reference film  &lt;br&gt;Subsequent films are compared with the reference film  &lt;br&gt;<strong>Advantages</strong> &lt;br&gt;Cost effectiveness &lt;br&gt;<strong>Disadvantages</strong> &lt;br&gt;Least sensitivity</td>
</tr>
<tr>
<td><strong>Film</strong></td>
<td>With each new batch of film</td>
<td>Method 1: Sensitometry and Densitometry (as described above)</td>
</tr>
<tr>
<td><strong>Intensifying Screen and Extraoral Cassettes</strong></td>
<td>Every six months</td>
<td>Method 3: Reference Film (as described above)</td>
</tr>
<tr>
<td><strong>Darkroom Integrity</strong></td>
<td>On installation, Monthly</td>
<td>Visual inspection of cassette integrity  &lt;br&gt;Examination of intensifying screen for scratches  &lt;br&gt;Development of an exposed film that has been in the cassette exposed to normal lighting for one hour or more</td>
</tr>
<tr>
<td></td>
<td>After a change in the lighting filter or lamp</td>
<td>While in a darkroom with the safelight on, place a metal object (such as a coin) on unwrapped film for a period that is equivalent to the time required for a typical darkroom procedure  &lt;br&gt;Develop the film  &lt;br&gt;Detection of the object indicates a problem with the safelight or light leaks in the darkroom</td>
</tr>
<tr>
<td><strong>Loaded Apron and Collar</strong></td>
<td>Monthly (visual), Annual (fluoroscopic)</td>
<td>Visual: inspection of the apron and collar for obvious tears, rips, cuts, etc.  &lt;br&gt;Fluoroscopic: performed by a qualified professional&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>5</sup> There are three options for evaluating a film processor.  
<sup>6</sup> As indicated in Lambert and McKern<sup>42</sup> and Michel and Zern<sup>43</sup>.  

---

JADA, Vol. 137  
http://jada.ada.org  
September 2006  
Copyright ©2006 American Dental Association. All rights reserved.
radiographic images between dental providers regardless of operating systems. Dental digital imaging system vendors that follow the requirements should certify that they are in compliance with ADA SCDI TR 1023.

**TRAINING AND EDUCATION**

Where permitted by law, auxiliary dental personnel can perform intraoral and extraoral film exposure. Personnel certified to expose dental radiographs should receive appropriate education. They also should receive training in infection control procedures because radiographic operators are subjected to occupational exposure to bloodborne pathogens. Practitioners should remain informed about safety updates and the availability of new equipment, supplies and techniques that could further improve the diagnostic quality of radiographs and decrease radiation exposure. The ADA’s Web site provides access to a continuing education course list in topics of dental radiographs, radiation safety and infection control (“www.ada.org/prof/edce/index.asp”).

**CONCLUSION**

Dentists should consider developing and implementing a radiation protection program in their offices. In addition, practitioners should remain informed about safety updates and the availability of new equipment, supplies and techniques that could further improve the diagnostic ability of radiographs and decrease exposure.

This report makes recommendations to dentists on implementation of radiographic practice. It is not intended to establish a legal standard of care for the practice of dentistry. In reviewing these recommendations and in making treatment decisions, the dentist’s own professional judgment must remain paramount. In addition, the recommendations set forth here are general. Practitioners must consult their state laws for specific requirements. State law may address who may perform radiographic exposures, the level of supervision and training required, equipment inspection and maintenance, waste disposal, operator protection and other issues.


![Figure](image-url) An aluminum step wedge, which may be purchased or fabricated, can aid in the quality assessment of a radiographic film processor.

Addendum 4

Radiation Safety Officer
Delegation of Authority

Dental Practice
Practice Manager
Contact information

The purpose of this form is to state that you have been appointed Radiation Safety Officer for the X-ray department. You are responsible for ensuring the safe use of radiation. Your responsibilities include managing the radiation protection program, identifying x-ray radiation protection problems, ensuring quality control tests are completed and documented, recommending, or providing corrective actions; verifying implementation of corrective actions; stopping unsafe activities; and ensuring compliance with state regulations.

You are delegated the time and authority necessary to meet those responsibilities, including prohibiting the use of radiation-producing equipment by employees who do not meet the necessary requirements and shutting down operations where radiation safety is compromised. You are required to notify management if staff do not cooperate and do not address radiation safety issues. In addition, you are free to raise issues with the Minnesota Department of Health at any time.

Your signature below indicates acceptance of the above responsibilities.

<table>
<thead>
<tr>
<th>Year</th>
<th>RSO Signature</th>
<th>Practice Mgr. Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Addendum 5  

Job Description for RSO

<table>
<thead>
<tr>
<th>Title:</th>
<th>Radiation Safety Officer (RSO)</th>
</tr>
</thead>
</table>
| Description: | Manage responsibilities (as noted below) and maintain records related to Radiation Safety.  
Attend annual continuing education within the dental radiology field and provide training and updates to staff members.  
Train staff within the practice as needed for assigned tasks.  
Officer will perform quarterly radiation program inspections that include assessment of unsafe practices, evaluation of products that can enhance the safety and efficacy of dental radiology and providing updates to policies and procedures as needed.  
All other items as related to Radiation Safety. |
| Reports To: |  |
| Supervises: | N/A |
| Responsibilities: | Radiation Safety Officer Minimum Training requirements  
The individual designated as a radiation safety officer must be either a licensed practitioner of the healing arts; or an individual who has completed training in the following items:  
(1) fundamentals of radiation safety;  
(2) familiarization with facility's x-ray equipment;  
(3) film processing, if applicable;  
(4) digital imaging, if applicable;  
(5) quality assurance program;  
(6) audits of the quality assurance program;  
(7) emergency procedures for x-ray equipment failures;  
(8) proper use of personal dosimetry, if applicable;  
(9) requirements of pertinent state rules; and  
(10) the registrant's written operating and emergency procedures. |
Radiation Safety Officer Responsibilities

Understand and support the Radiation Safety program as outlined in the manual.

Radiation Delegation of Authority- included in the RSO section of radiology manual

**Quality assurance** tests as noted in the Radiation manual

- Crabtree test
- Step Wedge test
- Quick developer
- Processor cleaning
- Fog test

**Biennial checks:**
- Lead apron
- Screen Contact testing of cassettes
- Speed Match testing of cassettes
- Performance evaluations of x-ray equipment

- Maintain technique charts

Maintain “Site Specific for Radiation” for the practice

**DDS standing order of X-rays**

Provide x-ray unit information for annual registration as directed

Maintain new equipment & repair records and informing practice manager of new x-ray installations for state registration

**Training Records**

- Training records
  - New employee, flex staff, fill-in staff, temporary agency staff and extern training (sign-off sheets)
  - Provide site specific training in practice for new employees as related to Radiation Safety

**Annual RSO audit-** standard audit template provided with manual

- Shielding records if required

Be available for MDH inspections
Declaration of Pregnancy Form

In accordance with the MDH rule 4732:0415, the pregnancy must be declared in writing.

**Declaration of Pregnancy**

Upon declaration of pregnancy, I agree to utilize safe operation standards and commit to ALARA when performing x-ray duties.

As always, staff members must stand at a distance of 6 ft from the beam.
An x-ray apron is required if staff must remain in the room and within 6 feet of the x-ray beam or patient
Fetal monitoring is not required unless the declared pregnant worker is likely to receive during the pregnancy a dose in excess of 0.1 Rem (100 millirem).

I ________________________ (print name) declare that I am pregnant.

Signature: __________________ Date: ________________

Last 4 digits of employee’s Social Security #: ________________

**Revoking my Declaration of Pregnancy**

I ________________________ (print name) choose to revoke my Declaration of Pregnancy.

Signature: __________________ Date: ________________

Submit form to Practice Manager ____________________________________________

Name of the individual who was trained: ________________________________
Addendum 7

**Training Log**- To be used when there is a new hire, new procedure or new equipment

<table>
<thead>
<tr>
<th>Date</th>
<th>Details</th>
<th>RSO Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(New employee, new equipment, new procedure)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Radiology Equipment Safety Check**

<table>
<thead>
<tr>
<th>Date</th>
<th>Equipment Checked</th>
<th>RSO Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note any deficiencies/corrections needed
*Note WNL if check reveals no problems/corrections needed
DAILY DENTAL EXPOSURE & DENSITOMETRY
QUALITY ASSURANCE WORKSHEET
SEE SUGGESTED INFORMATION PROVIDED BY MDH.

<table>
<thead>
<tr>
<th>Date</th>
<th>Step Reading</th>
<th>Is reading within the Range (3-5)?</th>
<th>Developer temp.</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual reading</td>
<td>Y or N</td>
<td>If no, how many steps is it off?</td>
<td>Temp</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Addendum 10

**Fog Test Semi-Annual Test Records**

Be certain to date all test films using a black sharpie pen. Films can be taped to the back side of this form.

**Clinic:** _________________________ **Type of processor:** _________________________

Darkroom or Daylight processor: ___________________________________________________

Technique Used for Extra-oral Fog Test: ____________________________________________

<table>
<thead>
<tr>
<th>Two minute test:</th>
<th>TAPE FILM HERE!</th>
<th>Pass or Fail (circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Exposed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performed by:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Two minute test:</th>
<th>TAPE FILM HERE!</th>
<th>Pass or Fail (circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Exposed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performed by:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Two minute test:</th>
<th>TAPE FILM HERE!</th>
<th>Pass or Fail (circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Exposed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performed by:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Two minute test:</th>
<th>TAPE FILM HERE!</th>
<th>Pass or Fail (circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Exposed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performed by:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Two minute test:</th>
<th>TAPE FILM HERE!</th>
<th>Pass or Fail (circle one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Exposed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performed by:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

48
Addendum 11

Speed Match Test (not to exceed 24 months)

This test is ONLY performed if the office has 2 or more panorex or ceph cassettes.
This test should be done “not to exceed 24 months” on the panorex or ceph cassette. Recommend to have this test performed at the same time as the x-ray unit calibrations. This test is to be performed when cassettes are put into place as well as when a screen is replaced.

The Radiation Safety person will schedule the testing with their dental radiography service provider. This can generally be arranged with your local dental vendor. Paperwork from the service provider will show that this has been complete. The service provider will also leave the test films for each cassette. The films should be 3-hole punched and placed in this section of the manual.

Patterson Dental or another vendor will perform this test.
- Both panorex or ceph films will be exposed at the same time.
- Films are processed.
- Processed films are individually placed into the densitometer for a optical density reading.
- Passing tests are + or – 0.10 OD (10%) 
- This test determines the effectiveness of the intensifying screen.
- If test falls outside of the + or – 0.10 (10%)-cassette is removed from usage until the screen has been replaced and retested.

<table>
<thead>
<tr>
<th>Date</th>
<th>Test Results (pass)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Addendum 12

Screen Film Contact Test
(Not to exceed 24 months)

This test, like calibration tests, should be done “Not to exceed 24 months” on the Panorex/Ceph cassette. Recommend to have this test performed at the same time as the x-ray unit calibrations. This test is also to be performed when cassettes are put into use as well as when a screen is replaced.

Your service provider will perform this test. The Radiation Safety Officer will schedule the testing. Upon completion of test, your service provider will leave the “test” film and the films can be placed in Radiology Manual.

This test is performed on all flexible and flat cassettes only, not the metal curved cassettes that are present with some Panorex units. There will be a test film for each cassette in the practice.

<table>
<thead>
<tr>
<th>Date</th>
<th>Test Results (pass)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CBCT DAILY AND MONTHLY PERFORMANCE EVALUATIONS

<table>
<thead>
<tr>
<th>Sun</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Include Employee Initials and Date
- Note any deficiencies/ corrections needed
- Note WNL if check reveals no problems/ corrections needed
### Addendum 14

**Annual Spot Check- CBCT Equipment Performance Evaluation**

<table>
<thead>
<tr>
<th>Date</th>
<th>Equipment Checked and Found Safe</th>
<th>RSO Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Addendum 15

**Comprised of attached article:** Hatcher, D. (2010). Operational Principles for Cone Beam Computed Tomography. JADA, 141, 3S-6S.

Many of the diagnostic challenges that routinely arise in clinical practices can benefit from imaging investigations. Until recently, dentists were limited to using two-dimensional radiographs to assess three-dimensional (3-D) anatomy. Cone-beam computed tomography (CBCT) was introduced into the European market in 1998. In May 2001, QR (Verona, Italy) introduced CBCT, a 3-D digital imaging technology, into the U.S. market. It has been estimated that more than 3,000 CBCT units consisting of more than 30 different machines have been installed in the United States (oral communication, Chris Scharff, vice president of sales, Imaging Sciences International, Hatfield, Pa., July 2010).

During a CBCT scan, the scanner (x-ray source and a rigidly coupled sensor) rotates, usually 360 degrees, around the head to obtain multiple images (ranging from approximately 150 to 599 unique radiographic views). The scanning software collects the raw image data and reconstructs them into viewable formats. The scan time can range between five and 40 seconds, depending on the unit and protocol setting. The x-ray source emits a low milliampere and a shaped or divergent beam. The beam size is constrained by a circular or rectangular collimator to match the sensor size, but in some cases it can be constrained (collimated) further to match the anatomical region of interest. After the scan, the resultant image set or raw data are subjected to a reconstruction process that results in the production of a digital volume (a cylindrical or spherical shape that is composed of volume elements called “voxels” that are stacked in rows and columns) of anatomical

**ABSTRACT**

**Background.** Cone-beam computed tomography (CBCT) was introduced into the U.S. market in 2001. Today, there are more than 3,000 installed units in the United States. There are numerous CBCT manufacturers and types of units. To produce the best imaging results, clinicians need to be knowledgeable about the CBCT unit, the clinical issue being investigated and how to optimize the unit’s operational parameters. The author identifies the variables that should be considered for each imaging session and addresses the building blocks required to design the appropriate imaging strategy. The remaining articles in this supplement address imaging for orthodontics, the investigation and localization of impacted teeth and implant planning, and customized imaging protocols designed to solve the clinical issues being presented.

**Methods.** The author addresses CBCT from an operational point of view. An ideal imaging examination answers the clinical question while maintaining an acceptable radiation dose and cost. The quality and value of each imaging study is proportional to the protocol being used. The author also addresses imaging protocol variables (raw data frames, scan time, voxel size, field of view and milliampere settings) and their effects on the final image quality and radiation dose, as well as CBCT accuracy and the radiation dose.

**Results.** CBCT can provide image volumes of the maxillofacial region and can be useful in clinical dentistry.

**Conclusion.** CBCT has been shown to be a precise imaging modality and is a valuable tool for use in dental applications.

**Clinical Implications.** CBCT can be used for diagnosis and treatment planning for all of the dental specialties.

**Key Words.** Cone-beam computed tomography; cone-beam imaging; radiation risk.

JADA 2010;141(10 suppl):3S-6S.

Dr. Hatcher is a clinical professor, College of Dental Medicine, University of Southern Nevada, Henderson, and an adjunct associate clinical professor, Arthur A. Dugoni School of Dentistry, University of the Pacific, San Francisco, and he maintains a private practice in oral and maxillofacial radiology. Address reprint requests to Dr. Hatcher at 99 Scripps Drive, Suite 101, Sacramento, Calif. 95826, e-mail “David@ddicenters.com”.

Copyright © 2010 American Dental Association. All rights reserved. Reprinted by permission.
data that can be visualized with specialized software. Voxels are the smallest subunit of a digital volume. CBCT voxels generally are isotropic (that is, X, Y and Z dimensions are equal) and range in size from approximately 0.07 to 0.40 millimeters per side. Each voxel is assigned a gray-scale value that approximates the attenuation value of the represented tissue or space. The latest generation of CBCT units produces 12- or 14-bit images in which 12 bits is $2^{12}$ (4,096) shades of gray and 14 bits is $2^{14}$ (16,384) shades of gray. Computer monitors used to visualize the 12- or 14-bit digital or voxel volume can display only eight bits (256 shades) of gray at a time. The software uses a technique called “windowing and leveling” that allows the operator to access and visualize all of the data. Windowing allows the data to be scrolled through, thus visualizing eight bits at a time with air and soft tissues (low-attenuation structures) at one end of the spectrum and bone and teeth (high-attenuation structures) at the other end of the spectrum. Once the optimum window level has been achieved, the contrast and brightness (leveling) are adjusted by the clinician for optimal viewing. The small isotropic voxel size along with the large number of gray levels have contributed to accuracy and precision when clinicians measure the dimensions of anatomical structures and visualize anatomical form.

The diagnostic value of an imaging study needs to be balanced against the risk to the patient and the cost of service. The trend for CBCT use has been to apply it clinically and then validate its utility scientifically. CBCT technology has several beneficial applications in the clinical setting. The articles in this supplement address the benefits of using CBCT for investigations in orthodontics, impactions and implants. The authors of these articles discuss the coordinated effort required by clinicians in the investigative process to achieve successful imaging outcomes that meet the clinical objectives. The authors also define clinical objectives and associated imaging goals, imaging protocols, diagnostic portfolios and value proposition. When possible, the authors attempt to blend clinical applications using CBCT technology with the appropriate scholarly validation.

CBCT imaging sessions are based on a process designed to answer specific clinical questions. This design process results in the development of imaging goals, a customized or case-specific imaging protocol and an imaging portfolio. It may require input from several people, including the clinician ordering the scan, the radiology technologist and the reviewing radiologist. An ideal imaging session provides answers to the clinical question via a precise display of relevant anatomical information that can aid the clinician, the radiologist and the patient. An illustration of the levels of decision making in the imaging process are provided as online supplemental data to this article (available at “http://jada.ada.org”).

Imaging protocol variables include field of view (FOV), voxel size, scan time, mA setting and patient immobilization. Clinicians select imaging protocol variables to investigate a patient’s condition on the basis of their knowledge about image sensor responses or conversion of the analog signal to a digital signal. There are many options clinicians can use to visualize the digital volume. The diagnostic portfolio includes the visualization options clinicians can use to provide a customized image set that is relevant to the clinical issue being addressed.

**IMAGE QUALITY**

Images acquired by CBCT are converted to a voxel volume and stored digitally on computers. The image quality or feature detection ability can be related to physical characteristics of digital images represented by Nyquist-Shannon sampling theorem, volume averaging, dynamic range, modulation transfer function and signal-to-noise ratio. The effects of these variables are provided as online supplemental data to this article (available at “http://jada.ada.org”).

**Data visualization.** The reconstructed volumes can be viewed using specialized software. The smallest subunit in a CBCT volume is the voxel. The voxels created from a CBCT generally are isotropic. The voxels are stacked in rows and columns. Information (for example, dimension, 3-D location and value) for each voxel is stored in the computer.

The voxel volume can be retrieved and viewed by using a range of viewing options. Visualization options include multiplanar or orthogonal (that is, coronal, axial, sagittal) viewing angles. The data can be sliced into a single row or column of voxels. Multiple voxel layers can be combined to create a slab. Clinicians can produce and visualize oblique and curved slices or slabs, and they can render and visualize the entire volume from any angle.

There are several techniques for visualizing a volume, including shaded surface display and volume rendering (Figure). Illustrations of additional visualization options are provided as online supplemental data to this article (available at “http://jada.ada.org”). Shaded surface display is a software technique that allows the user to set a threshold range for the data on the basis of an attenuation value. The data with an attenuation value outside the selected range will not be visible. The shaded surface display creates a 3-D object of the anatomy that can be visualized from any selected angle. It is common to use shaded surface display technique to visualize soft tissue or bone surfaces. Volume rendering is a method that uses all of the voxels but allows the operator to assign transparency values to voxels on the basis of their attenuation values. For example, if the superficial

![Effective dose for i-CAT Classic cone-beam computed tomography.††](http://jada.ada.org)

<table>
<thead>
<tr>
<th>CONE-BEAM COMPUTED TOMOGRAPHY</th>
<th>Standard</th>
<th>High Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 cm FOV</td>
<td>92.8 μSv</td>
<td>NA**</td>
</tr>
<tr>
<td>13 cm FOV</td>
<td>39.5 μSv</td>
<td>NA</td>
</tr>
<tr>
<td>6 cm FOV mand††</td>
<td>23.9 μSv</td>
<td>47.2 μSv</td>
</tr>
<tr>
<td>6 cm FOV max†‡</td>
<td>9.7 μSv</td>
<td>18.5 μSv</td>
</tr>
</tbody>
</table>

* I-CAT Classic is manufactured by Imaging Sciences International (Hatfield, Pa.).
†† FOV mand: 6-centimeter field of view, mandible.
‡‡ FOV Max: 6-cm field of view, maxilla.
† The data shown in this table are calculations of the effective dose using the 2007 International Commission on Radiological Protection tissue-weighting factors for the i-CAT Classic cone-beam computed tomography machine with a flat panel sensor (amorphous silicon) using a field of view (FOV) of 22, 13 and 6 centimeters and time settings of 20 and 40 seconds. This unit captures angular images (raw data) at 15 images per second. A 20-second rotation around the head (standard resolution) creates 300 images. High-resolution scans are produced by increasing scan time to 40 seconds at 15 images per second for 599 or 600 images. The 22-cm scan requires two 20-second rotations. The effective dose for Next Generation i-CAT (Imaging Sciences International) in landscape mode (standard resolution) was 87 microsieverts.4
‡ E 1990: Effective dose calculations using 1990 tissue-weighting factors.
†† FOV mand: 6-centimeter field of view, mandible.
‡‡ FOV Max: 6-cm field of view, maxilla.

**Effective dose for two-dimensional techniques.**

<table>
<thead>
<tr>
<th>TWO-DIMENSIONAL IMAGING</th>
<th>ROUND COLLIMATION</th>
<th>RECTANGULAR COLLIMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PSP/ F-Speed Film</td>
<td>D-Speed Film</td>
</tr>
<tr>
<td>Complete Series of Radiographs</td>
<td>170.7 μSv†</td>
<td>388.0 μSv</td>
</tr>
<tr>
<td></td>
<td>PSP/ F-Speed Film</td>
<td></td>
</tr>
</tbody>
</table>

* Source: Ludlow and colleagues.9
† The data shown in this table are calculations of the effective dose using the 2007 International Commission on Radiological Protection tissue-weighting factors for common two-dimensional maxillofacial intraoral and extraoral techniques. For intraoral imaging, the sensors were F- and D-speed film and photostimulable phosphor (PSP) storage using round or rectangular collimation.
†† PSP: Photostimulable phosphor.
§ Source: Ludlow and colleagues.9
††µSv: Microsieverts.
TABLE 3

<table>
<thead>
<tr>
<th>TWO-DIMENSIONAL IMAGING</th>
<th>EFFECTIVE DOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panoramic (Charge-Coupled Device)</td>
<td>14.2-24.3 µSv</td>
</tr>
<tr>
<td>Cephalometric (Photostimulable Phosphor)</td>
<td>5.1-5.6 µSv</td>
</tr>
</tbody>
</table>

* Source: Ludlow and colleagues. 9
† µSv: Microsieverts.

To the area of interest can optimize the effective dose. Having shorter scan times, reducing the mA setting or both can reduce the dose, but doing so also can decrease the signal and therefore image quality (Tables 1, 2 and 3).

CONCLUSIONS

Diagnostic imaging investigations are processes that begin with designing an imaging protocol to address specific individual clinical goals. Selecting the optimum technique begins by determining the imaging goals. Clinicians need to determine precisely what information needs to be revealed during the imaging study; this will allow them to determine what imaging modalities can fulfill the imaging goals. The optimum imaging modality fulfills the imaging goals, has the lowest radiation dose and has an acceptable cost.

The articles in this supplement outline the utility of CBCT for specific clinical investigations. The authors discuss specific clinical objectives, imaging goals, imaging protocols and appropriate image portfolios.

Disclosure. Dr. Hatcher did not report any disclosures.

REFERENCES

Addendum 16

PROCEDURES FOR ADDING OR CONVERTING TO PSP OR DIGITAL IMAGING SYSTEM TO A DENTAL OFFICE

What is it?
PSP imaging and Digital imaging are the manner in which the x-rays are received and processed to provide for a diagnostic image. Many registrants converting intraoral x-ray units to a PSP or Digital imaging system may only replace the film with a sensor. Panoramic, Cephalometric and Cone Beam CT units are generally replaced as a whole unit.
Regardless of the imaging system an x-ray tube is necessary and the patient must receive radiation in order to generate the image.
PSP is a photostimulable storage phosphor: After the exposure, the imaging sensor must be or placed within a image reader to obtain the x-ray image.
Digital imaging: The x-ray image is obtained directly from the sensor and received on the computer monitor without the need for an image reader.

Why is it important?
PSP and Digital imaging do not require processing of the image in the same manner as film. This may reduce the patient dose from ½ to ¼ of conventional film imaging depending on the film speed in use.

What you must do?
Submit a letter or email to the X-ray unit stating that you have gone digital whether it is be intraoral, extraoral or a combination of both.
Retain this letter your records.
When installing new x-ray equipment in your digital conversion, The service provider must complete an installation calibration.
When replacing only the image receptor (Film to PSP or Digital), new maximum posterior bitewing techniques must be developed.
The maximum posterior bitewing doses must be at or below the following::
  o Digital imaging with a maximum dose below 120 mR
  o PSP imaging with a maximum dose below 170 mR
Work closely with the service provider to give you the best image quality and maintain the patient dose as low as possible and adjust your technique charts accordingly.
The service provider or registrant must adjust the preprogrammed techniques if they are to be used.
Review your PSP and Digital technical manuals very carefully. Maintenance and quality control testing of the image receptors must be performed according to manufacturer’s specifications.

Training will need to be done at the time of conversion and documented for all those who attend training to ensure staff is aware of new exposure techniques, proper equipment usage (including use of holders) and equipment maintenance and quality control requirements. All employees must have training documented.

Update your Radiation Safety/Quality Assurance Manual to include procedures for the use of PSP or Digital imaging.
Additional Resources for Video

Provided by MDH

1. Dental Intra-Oral Fog Test
2. Dental Extra-Oral Fog Test
3. Procedures for Extra-oral Daily Processor Quality Control (Step Wedge)
4. Procedures for Dental Extra-oral Screen Contact Test

We would like to extend a special thank you to Craig Verke, Radiation Specialist from the Minnesota Department of Health X-ray Unit for agreeing to provide instruction for the video. We would also like to thank Barbara Butts-Williams, wife of the late Dr. John Williams DDS and staff members; Tracie Donnell-Walker and Carla McMorris for allowing us to utilize clinic space and providing materials for the video.

Clarification: In the video, the term “glove box” refers to a daylight loader glove box that may be used in some clinics for processing in lieu of processor within a dark room.
1. Dental Intraoral Fog Test

What is it?
The darkroom/glove box (daylight processor) fog test is meant to determine and minimize the amount of unwanted light within the darkroom or glove box.

Why is it important?
Improper safelights and unwanted light in the darkroom or glove box can compromise the quality of your radiographs by reducing contrast and darkening the image. This can jeopardize image quality to the point of repeating the image or misdiagnosis.

Items Needed:
- Timer
- Coin
- Unexposed Intraoral Film Packet (Fastest film in use)

What is the requirement?
- Chapter 4732.0555 requires the darkroom/glove box test be performed
  - Initially and at intervals not to exceed six (6) months.
  - Anytime fog is suspected;
  - Anytime there is a filter or bulb change; and
  - Any other change in darkroom conditions.
  - The amount of fog for a two-minute test must not allow visualization of the outline of a coin on the intraoral film.
- Chapter 4732.0330 requires records be maintained for review by the X-ray unit

Procedure
- Set the timer for two minutes.
- Place all of the items needed for this test in the darkroom or glove box.
- Ensure the darkroom or glove box is performed using the same processing conditions that are used for processing patient films. (i.e. safelight on/off, cracks under door covered/uncovered, glove box filters open/closed, etc.)
- Under the conditions addressed above unwrap the film from the film packet and place the film in the typical work area of the darkroom or glove box. (See Figure 1 for the glove box).
- Place the coin on the film.
- Start the 2 minute timer.
- In the darkroom, stand back from the film to ensure your body is not shadowing it. Take the time to look around the darkroom for any potential light leaks or sources of unwanted light.
- In a glove box, keep your hands in the cuffs and lean from the viewing window to ensure your body is not shadowing it. Evaluate the condition of the cuffs and any seals for potential light leaks.
When the timer goes off, process the film as usual. Review the film to ensure it passes.

- Figure 2 shows a passing fog test.
- Figure 3 shows a failing fog test. If any difference between the covered and uncovered portions is seen, it may indicate the presence of darkroom fog. See corrective actions on the next page.

If the fog test fails, corrective action must be taken and another fog test must performed to verify the corrective action was acceptable.

Record the date, the results of the test (pass/fail), and save the film for state inspection.

Figure 1 – Intraoral Fog Test Set-up in a Glove box

Figure 2 – Passing Fog Test       Figure 3 – Failing Fog Test

Helpful Hints:

Common conditions why the fog test may fail:

- Glove box:
  - Placed under direct fluorescent lights.
  - Glove box cuffs are worn and fit loosely around the wrists.
  - Filter cover may be damaged or is not compatible with film used.
  - Seal between the glove box and processor are bad.
Darkroom:
- Safelight/filter:
  - Not compatible with the film being used.
  - Bulb in the safelight is too high a wattage.
  - Cracks
  - Filter emulsion flaking off.
- Electronic equipment indicator lights.
- Glow in the dark stickers or toothbrushes.
- Ceiling tiles that are not installed correctly.
- Light leaks around ceiling fixtures.
- Light leaks around the door.

Corrective Actions:
Glove boxes:
If a daylight processor glove box fog test fails, try covering the viewing window filter when redoing the fog test to see if this is the source of fog. If that is the case, moving the processor to a different location or changing surrounding lighting conditions may help to remove the fogging conditions. Replace cuffs that are loose fitting.
Glove boxes attached to table top processors may not seal properly. Place a flashlight in the glove box, close the cover and see if any light is coming out through the seal between the glove box and processor. If there is, light is also getting in during film processing.

Darkroom:
Repeating a fog test without the safelight on and the fog is removed, the safelight may need to be replaced or moved further away from the processor.
Any light other than that from the safelight can potentially fog your patient films. Remove or completely cover any of these sources of unwanted light.
  - Close cupboards or place items behind a curtain.
  - Place a curtain covering the entire darkroom door entrance and use a curtain rod or hooks to move the curtain out of the way when film processing is not being performed.
  - Tape around light leaks in the ceiling.
  - Attach weather stripping around the darkroom door.

2. Dental Extraoral Fog Testing Instruction and Information
What is it?
The darkroom/glove box (daylight processor) fog test is meant to determine and minimize the amount of unwanted light within the darkroom or glove box.

Why is it important?
Improper safelights and unwanted light in the darkroom or glove box can compromise the quality of your radiographs by reducing contrast and darkening the image. This can jeopardize image quality to the point of repeating the image or misdiagnosis.
Items needed:

- Aluminum medical step wedge with at least 11 steps.
- Loaded pan/ceph cassette
- A currently calibrated intraoral operatory
- Establish technique factors for the step wedge test (in the range of a posterior bite wing).
- Tape measure or yard stick
- Timer

Procedure:

1. Load a pan or cephalometric cassette under your normal Darkroom/glove box conditions.
2. Take the loaded pan or cephalometric cassette into an intraoral room that is used routinely.
3. Place the cassette on the floor.
4. Place step wedge on top of the cassette. Make sure you know which direction the step wedge is placed, along the long or short axis of the cassette. This will be important in the next steps.
5. The cassette should be placed on the floor with the tube at a distance of at least 40” (this will provide enough distance from the tube to the cassette to allow the x-ray field to cover the entire step wedge).
6. Note the orientation of the step wedge to the film and expose the step wedge and cassette using your established setting.
7. Take the cassette into the darkroom or place in the glove box and use the same conditions that would be used for processing patient films.
8. Remove the film from the cassette and cover half of the film lengthwise on the step wedge image with something that is light opaque.
9. Start the 2 minute timer.
10. In the darkroom: Stand back from the film to ensure your body is not shadowing the fog test film. Take the time to look around the darkroom for any potential light leaks or sources of unwanted light.
11. In the glove box test keep your hands in the cuffs and lean from the viewing window to ensure your body is not shadowing the viewing window. Evaluate the condition of the cuffs and any seals for potential light leaks.
12. When the timer goes off, process the film as usual.
13. Take the processed film and place a newspaper behind the step wedge image. Using the step you have established as your standard for the step wedge evaluation, review the density on the side of the film that was covered with the density on the side of the film that was uncovered. The difference in densities between the covered and uncovered side must be less than a one-step density difference.
14. If the density is greater than one-step your fog test fails corrective action must be taken and another fog test must performed to verify the corrective action was acceptable.
15. Record the date, the results of the test (pass/fail), and save the film for state inspection.
Helpful Hints:

Common conditions why the fog test may fail:
- Glove box:
  - Placed under direct fluorescent lights.
  - Glove box cuffs are worn and fit loosely around the wrists.
  - Filter cover may be damaged or is not compatible with film used.
  - Seal between the glove box and processor are bad.
- Darkroom:
  - Safelight/filter:
    - Not compatible with the film being used.
    - Bulb in the safelight is too high a wattage.
    - Cracks
    - Filter emulsion flaking off.
  - Electronic equipment indicator lights.
  - Glow in the dark stickers or toothbrushes.
  - Ceiling tiles that are not installed correctly.
  - Light leaks around ceiling fixtures.
  - Light leaks around the door.

Corrective Actions:

Glove boxes:
If a daylight processor glove box fog test fails, try covering the viewing window filter when redoing the fog test to see if this is the source of fog. If that is the case, moving the processor to a different location or changing surrounding lighting conditions may help to remove the fogging conditions.
Replace cuffs that are loose fitting.
Glove boxes attached to table top processors may not seal properly. Place a flashlight in the glove box, close the cover and see if any light is coming out through the seal between the glove box and processor. If there is, light is also getting in during film processing.

Darkroom:
Repeating a fog test without the safelight on and the fog is removed, the safelight may need to be replaced or moved further away from the processor.
Any light other than that from the safelight can potentially fog your patient films.
Remove or completely cover any of these sources of unwanted light.
  - Close cupboards or place items behind a curtain.
  - Place a curtain covering the entire darkroom door entrance and use a curtain rod or hooks to move the curtain out of the way when film processing is not being performed.
  - Tape around light leaks in the ceiling.
  - Attach weather stripping around the darkroom door.
3. Procedures for Extraoral Daily Processor Quality Control (Step Wedge)

What is it?
The step wedge test, along with a check of your developer temperature, is simple quality control test which can be used to evaluate the stability of your x-ray film processing conditions.

Why is it important?
The stability of your processor is very important to the diagnostic quality and reproducibility of your patient films. Many registrants do not know they are under developing their patient films because they are adjusting the technique factors on the x-ray equipment to compensate for under development. This practice sacrifices the film quality and may increase an unnecessary radiation dose to your patients from under developing or having to repeat films.

Items needed:
- Aluminum medical step wedge with at least 11 steps.
- Loaded pan/ceph cassette
- A currently calibrated intraoral operatory
- Establish technique factors for the step wedge test (in the range of a posterior bite wing).
- Tape measure or yard stick
- Thermometer (ready light).

Procedure:
1. Load a pan or cephalometric cassette under your normal Darkroom/glove box conditions.
2. Take the loaded pan or cephalometric cassette into an intraoral room that is used routinely.
3. Place the cassette on the floor.
4. Place step wedge on top of the cassette. Make sure you know which direction the step wedge is placed, along the long or short axis of the cassette. This will be important in the next steps.
5. The cassette should be placed on the floor with the tube at a distance of at least 40” (this will provide enough distance from the tube to the cassette to allow the x-ray field to cover the entire step wedge).
6. Expose the step wedge and cassette using your established setting.
7. Take the cassette into the darkroom and process the film under your normal processing conditions including the developer temperature.
8. Take the processed film and place a newspaper behind the step wedge image on the film. The darkest step at which you can see the newspaper print clearly will be your “standard density and step” to use for your evaluation. Tape a paper clip or other marker on this step. This will be your standard step on your step wedge film to compare with each of the daily step wedge films. Do not dispose of this film. This film is your “standard” film which you compare your daily step wedge film to.
9. Compare the marked step on your standard with the same step on your daily step test film. The density of the marked step on your daily film must be within ± 1 step of the marked step of your standard.
10. Each day’s step wedge film must be evaluated and documented prior to processing any patient films. Evaluation results must be saved until the next inspection by the State. The daily step wedge films must be saved for 60 days.

If the daily test result is greater than ± 1 step from the standard step, your processing is not within the range of stability and you must not process any patient films until corrective actions are taken.

When performing this test it is very important that as many variables that may affect the results of this testing are removed. For this reason, once you have established a “standard film” using the procedures above, document the room #, technique setting used, the distance at which you performed the test and make sure these are used each time you perform the step wedge test. A change in any of these conditions will affect the results of your testing.

**Helpful hints:**
If your daily step wedge test fails, repeat the test, confirming that all the procedures are followed.

- Same operatory
- Same technique setting (kVp, mA and time)
- Same distance
- Developer at the correct temperature
- Use the same view box or viewing conditions

If the second test fails you must perform corrective action and repeat the step wedge test to verify your corrective actions have brought your processing within range of the established standard.

You may need to establish a new standard when:

- The x-ray unit used has been calibrated or replaced with a new x-ray unit.
- New brand of film or chemistry
- New processor
- Using a different operatory for the step wedge testing
- Film used as the standard has degraded or lost.

For any of these reasons you would need to follow the procedures above to establish a new standard film. Adding fresh chemistry or purchasing a new box of the same brand of film would not require you to establish a new standard. Remove the excess film around the standard film and the daily test film. This will make it easier to perform a visual comparison of the density steps.
4. Procedures for Dental Extraoral Screen Contact Test

What is it?
The screen contact test is used to confirm there is good contact between the screens and the film inside of the x-ray cassette and must be performed on all x-ray cassettes used clinically. Repeated exposure to x-rays does not cause x-ray screens to wear out. Typically, the causes for poor contact which requires replacement are due to improper maintenance and handling. Be sure and follow the manufacturer’s recommendations for cleaning and care.

*Note: The metal curved cassettes are exempt from the screen contact evaluation.*

Why is it important?
Poor contact between the screen and the film inside of an x-ray cassette can cause an x-ray image to look blurred, fluctuations in the density throughout the film, and artifacts which may reduce the diagnostic quality of your patient films and add unnecessary radiation dose to your patients if the films must be repeated.

The screen contact test is required to be performed at the same frequency as the calibration/performance evaluations of your x-ray equipment and it may be of value to have the service provider perform this test for you.

What is the requirement?
Chapter 4732.1100 requires that an extraoral screen contact test be performed on new cassettes and at intervals not to exceed 24 months.
Chapter 4732.0330 requires records be maintained for review by the X-ray unit.

Items needed:
- 8 wire/inch mesh test tool; or
- 7 hole per inch test tool
- All pan/cephalometric cassettes (Each cassette must be identified along with the test film)
- Intraoral x-ray unit
- View box

Procedure:
1. Load with film each pan and cephalometric cassette under your normal Darkroom/glove box conditions allowing them to sit for at least 15 minutes after loading. This will give any air trapped in the cassettes to dissipate.
2. Take the loaded pan or cephalometric cassette into an intraoral room that is used routinely.
3. Place the cassette on the floor.
4. Place the screen contact test tool on top of the cassette.
5. The cassette should be placed on the floor with the tube at a distance of at least 40” (this will provide enough distance from the tube to the cassette to allow the x-ray field to cover the entire cassette).
6. Expose the test tool and cassette using half the timer setting used for your daily step wedge testing.
7. Take each cassette into the darkroom and process the film under your normal processing conditions.
8. View each film on a view box in a dimly lit room from a distance of approximately six feet or more.
9. Look for areas that are darker and/or more blurry than the rest of the film. This indicates poor contact.
10. If there is an area of poor contact and it may be located in an area of interest on a film, remove the cassette from service.

**Helpful hints:**

Some common causes of poor screen-film contact:

- Worn felt behind the screen(s)
- Loose, bent or broken hinges
- Loose, bent or broken latches
- Warped screens
- Warped cassette front
- Sprung or cracked cassette frame
- Foreign matter under the screen

X-ray cassettes and screen will last indefinitely when they are properly handled and maintained following the manufacturer’s recommendations.