An overview of the TG-175’s recommendations on intraoral, panoramic and cephalometric dental units

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Disclaimer

The appearance of any commercial products is for illustration purposes only, and should NOT be interpreted as an endorsement.
**TG-175’s Charge**

The purpose of the task group is to investigate the factors that affect image quality and dose in dental units. The task group will make recommendations for specific parameter evaluation, such as collimation, spatial resolution, uniformity, SNR and dose measurement, and will define practical procedures in which medical physicists can evaluate these parameters on x-ray systems associated with dental facilities.

**Testing Methods**

The testing methods mentioned are intended to provide guidance on how to perform these medical physics tests, but they are not intended to be the sole methods for performing any particular evaluation.
Learning Objectives

- Overview of the TG-175 recommendations.
- The acceptance testing and quality control (QC) recommendations for intraoral dental units.
- Recommendations intended for panoramic dental units.
- Recommendations made for cephalometric dental units.

What about Cone-Beam CT?

AAPM COMMITTEE TREE

Task Group No. 261 - Quality control methodology for low-dose dental and maxillofacial CBCT systems

- To establish a methodology for assessment, evaluation and quality control of dental and maxillofacial CBCT imaging systems. The methodology will include detail procedures and techniques for:
  - facility shielding design requirements;
  - image quality testing;
  - dose estimate measurements like “CTDI-like” or other dose index and;
  - radiation safety of these systems.

- This TG will work on homogenizing the variety of individualized tests that are available for each different system in the market.
- This TG will establish a set of consistent image quality and dose estimate tolerances and guidelines for these systems.
- Development of routine QC program for these systems.
Learning Objectives

• Overview of the TG-175 recommendations.

• The acceptance testing and quality control (QC) recommendations for intraoral dental units.

• Recommendations made for panoramic dental units.

• The recommendations intended for cephalometric dental units.

Intraoral Image Receptor Recommendation

TG-175 recommends the exclusive use of:
  – E-, E/F-, or F-speed film
  – PSP receptors, or
  – CCD/CMOS receptors

D-speed film should NOT be used.
NCRP Report No. 172

Recommended Diagnostic Reference Levels and Achievable Doses for Intraoral Examinations. NCRP recommends adopting the NEXT E-speed film 75th percentile entrance skin dose of 1.6 mGy as the DRL for dental intraoral periapical and bitewing radiography. The NEXT survey demonstrated that a decade ago this goal was readily achievable with proper radiographic technique. This value (1.6 mGy) is also well above the mean value of 1.3 mGy for users of E-F-speed film and the median value of 0.8 mGy for users of digital systems in the Michigan surveys (MDCH, 2012a; 2012b). Recommendation of a single DRL for all intraoral imaging is consistent with the principle that patient dose should follow the ALARA principle.

The use of dental radiographs

Update and recommendations

American Dental Association Council on Scientific Affairs

The American National Standards Institute and the International Organization for Standardization have established standards for film speed.20,21

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.22 Film of a speed slower than E-speed should not be used for dental radiographs.22,23

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
Digital Receptors

Table II. Overview of evaluated parameters from digital systems

<table>
<thead>
<tr>
<th>Direct digital system</th>
<th>Sensor type</th>
<th>Image enhancement types</th>
<th>Latitude (highest exposure/lowest exposure)</th>
<th>Optimal exposure (mGy)</th>
<th>μm (SR)</th>
<th>Δ Dia. wells*</th>
<th>Δ Dose wells*</th>
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</thead>
<tbody>
<tr>
<td>RVG 6000</td>
<td>CMOS</td>
<td>Perio Mode</td>
<td>6.38</td>
<td>0.74</td>
<td>14</td>
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<td>2</td>
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<td></td>
<td></td>
<td>Endo Mode</td>
<td>5.07</td>
<td>0.49</td>
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<td>2</td>
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<tr>
<td></td>
<td></td>
<td>DEI Mode</td>
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<tr>
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<td></td>
<td>Endo Mode</td>
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<tr>
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<td></td>
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<table>
<thead>
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<th>Indirect digital system</th>
<th>Sensor type</th>
<th>Image enhancement types</th>
<th>Latitude (highest exposure/lowest exposure)</th>
<th>Optimal exposure (mGy)</th>
<th>μm</th>
<th>Δ Dia. wells*</th>
<th>Δ Dose wells*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan-X</td>
<td>PSP Plate</td>
<td>Normal Resolution (NR)</td>
<td>24.80</td>
<td>1.47</td>
<td>7</td>
<td>5</td>
<td>3</td>
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<tr>
<td>Digi Optim X</td>
<td>PSP Plate</td>
<td>High Resolution (HR)</td>
<td>12.58</td>
<td>0.74</td>
<td>6</td>
<td>5</td>
<td>2</td>
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<td></td>
<td></td>
<td>Super High Resolution (SHR)</td>
<td>12.58</td>
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<tr>
<td>Den Optix QST</td>
<td>PSP Plate</td>
<td>Normal Resolution (NR)</td>
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<td></td>
<td></td>
<td>High Resolution (HR)</td>
<td>63.79</td>
<td>1.19</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>
**Digital Receptors - Continue**

- CMOS receptors require 50% to 80% of the dose required for F-speed film.

- CCD receptors typically require less than half the radiation of F-speed film.

- PSP receptors require radiation dose similar to F-speed film.

**kVp Recommendation**

TG-175 recommends tube voltages less than 60 kVp **NOT be used** for intraoral dental imaging as this may result in higher-than-necessary patient radiation doses.
Learning Objectives

• Overview of the TG-175 recommendations.

• The acceptance testing and quality control (QC) recommendations for intraoral dental units.

• Recommendations made for panoramic dental units.

• The recommendations intended for cephalometric dental units.

Intraoral Dental Units

3. Acceptance Testing and Quality Control (QC) Recommendations for Intraoral Dental Units

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**Tube Head Stability & Positioning**

From NCRP Report 145:

The tube head shall achieve a stable position, free of drift and oscillation, within 1 s after its release at the desired operating position. Drift during that 1 s shall be no greater than 0.5 cm. The operator shall not hold the tube head during exposure.

Not applicable to handheld units - confirm if there are any additional requirements in state and local regulations.

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**Leakage**

- Start with a visual inspection.

- Suspicions of compromised shielding:
  - Perform a leakage measurement
  - Place an intraoral film or a digital sensor over the suspect area
  - Use a larger CR plate
Collimation & Minimum SSD

For units operating above 50 kVp:
- SSD ≥ 18 cm (21 CFR 1020.31)

• Circular collimation:
  - Diameter < 7 cm (21 CFR 1020.31)

• Rectangular collimation:
  - Linear dimensions of the beam in each axis “should not exceed the dimension of the image receptor by more than two percent of the source-to-image receptor distance.” (NCRP report 145)

Beam Quality

Table 1: Minimum HVL Requirement for Introral Dental Units

<table>
<thead>
<tr>
<th>X-ray Tube Potential (kVp)</th>
<th>Minimum HVL (mm of Aluminum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Specified Dental Systema</td>
</tr>
<tr>
<td>60</td>
<td>1.3</td>
</tr>
<tr>
<td>70</td>
<td>1.3</td>
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<tr>
<td>80</td>
<td>2.3</td>
</tr>
<tr>
<td>90</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*a Dental x-ray systems designed for use with introral image receptors and manufactured after December 1, 1980.
b* Panoramic and cephalometric systems manufactured on or after June 30, 2006.

* 21 CFR 1020.30
**kVp Accuracy**

- Sensors are completely exposed.
- Measures across the useful range of kVp.
- The deviation must not exceed the manufacturer’s specifications.
- In absence of a manufacturer’s specifications, the deviation should not exceed 10%.

**Timer Accuracy (Optional)**

- Preheat period → exposure time may be difficult to determine.
- The deviation from the nominal timer value must not exceed the manufacturer’s specifications.
- In the absence of a manufacturer’s specifications, the deviation should not exceed 10% for settings greater than 10 milliseconds.
**Exposure Reproducibility**

- Ensure the detector is fully irradiated.
- For QC testing, use typical technique.
- For acceptance testing, do more?
- COV must not exceeded manufacturer’s specifications (or 0.05 if specifications is not available).

**Linearity (if applicable)**

Intended **only** for x-ray units that have more than one mA or mAs station available at the same kVp setting.

\[ |X_1 - X_2| \leq 0.10 (X_1 + X_2) \]

where \( X = \text{air kerma (mGy) / milliampere-second (mAs)} \)
**Technique Factors & Entrance Skin Air Kerma**

- NCRP Report No. 172 recommends a DRL of 1.6 mGy.
- The exposure settings used should be consistent with the manufacturer’s recommendations.
- A technique chart should be posted next to the operator control panel.

**Scattered Radiation Survey**

- During the acceptance testing.
- Scatter source:
  - Head phantom
  - One-gallon milk jug?
- Location:
  - Control panel
  - Standing location?
- Very small amount of radiation
Darkroom & Film Processing QC

• Darkroom:
  – Checking for exposure to unwanted light to avoid film fog.

• Film Processing:
  – Commercial device.
  – Sensitometer & Densitometer.*

* For panoramic or cephalometric unit, the film processing QC must be performed using a sensitometer & densitometer.

Mid-Density Level

Figure 13.3, The essential physics of medical imaging
Evaluation of Site’s QC Program

### Digital Intraoral Image Receptors QC

- Uniformity, artifact, contrast resolution, & spatial resolution evaluations:
  - Manufacturer’s method (phantom)
  - Commercially available QC tools

- Establish baseline values (technique)

- Periodic quality control testing
Learning Objectives

• Overview of the TG-175 recommendations.
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Similar to Intraoral?

- Leakage

- Beam Quality:
  - Different column

- Darkroom QC:
  - Expose a panoramic film to an OD of ~1.00

- Digital Panoramic Image Receptors QC:
  - Uniformity & artifact evaluations

- Evaluation of Site’s QC Program

- Scattered Radiation Survey

$kVp$ Accuracy (Recommended)
**Beam Slit Length and Width Coincidence**

No standard criteria.

Suggested criteria:
- The X-ray field should be contained within the beam slit:
  - 2% of the SID total error in the vertical direction
  - within the beam slit in the width direction
- The x-ray field should not exceed the sensitive area of the image receptor along the long dimension.
Exposure Reproducibility

- The entire sensitive volume of the radiation detector is generally **NOT** irradiated by the primary beam.

- Motion could affect the measurements.

Exposure Reproducibility - Continue
Technique Factors

NCRP Report No. 172 recommends a DRL of 100 mGy·cm\(^2\) for the air kerma-area product, and achievable dose-area product of 76 mGy·cm\(^2\).
Learning Objectives

• Overview of the TG-175 recommendations.

• The acceptance testing and quality control (QC) recommendations for intraoral dental units.

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Cephalometric Dental Units

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**Similar?**

- Leakage
- Beam Quality:
  - Different column
- kVp Accuracy:
  - Make sure nothing is in the beam path
- Linearity (if applicable)
- Timer Accuracy (if applicable)

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**Similar? - Continue**

- Darkroom QC:
  - Expose a cephalometric film to an OD of ~1.00
- Digital Cephalometric Image Receptors QC:
  - Uniformity & artifact evaluations
- Evaluation of Site’s QC Program
- Scattered Radiation Survey
Collimation

- Scanning slit systems → panoramic units
- For broad-beam units:
  - Absolute sum of the discrepancies of opposing light and radiation field edges must not exceed 2% of the SID.
  - Each dimension (width and height) of the radiation field must agree with the corresponding indicator setting to within 2% of the SID.
  - Distance between the centers of the radiation field and image receptor must be no more than 2% of the SID.

Exposure Reproducibility & Technique Factors

- Exposure reproducibility:
  - Ensure the entire sensitive volume of the radiation detector is irradiated by the primary beam.

- NCRP Report No. 172 recommends:
  - Adopting the Michigan 85th percentile entrance skin dose (0.14 mGy) as the DRL
  - The median dose (0.09 mGy) as the achievable dose.
Typical Entrance Air Kerma

The Michigan’s cephalometric radiography survey is similar to the 1999 NEXT dental survey for cephalometric imaging procedure:

$$ESA_K = K_a \times \left[ \frac{SDD}{SID - 17.5 \text{ cm}} \right]^2$$

TG-175

AAPM REPORT NO. 175

Acceptance Testing and Quality Control of Dental Imaging Equipment

The Report of AAPM Task Group 175

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Questions?