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.

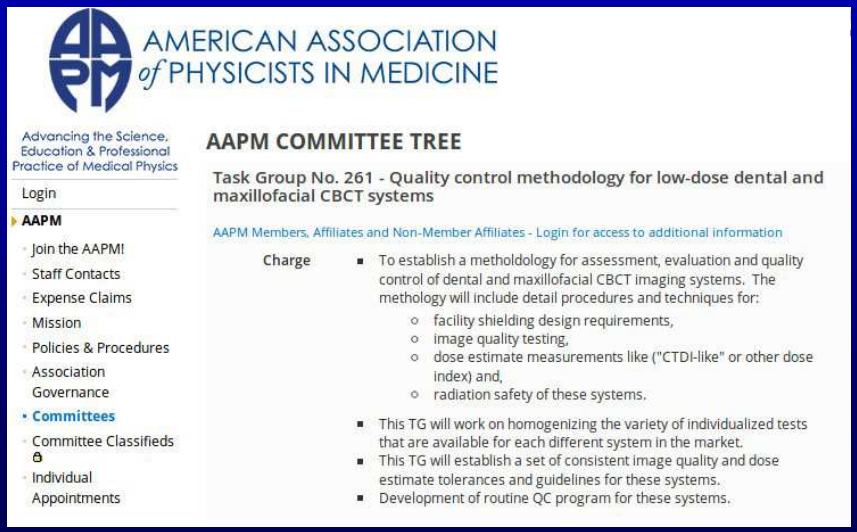
Testing Methods

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?



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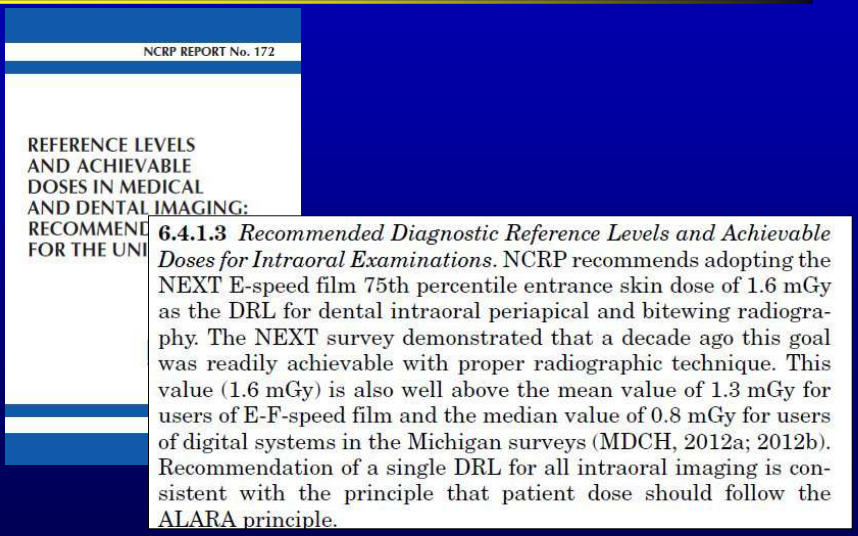
Intraoral Image Receptor Recommendation

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

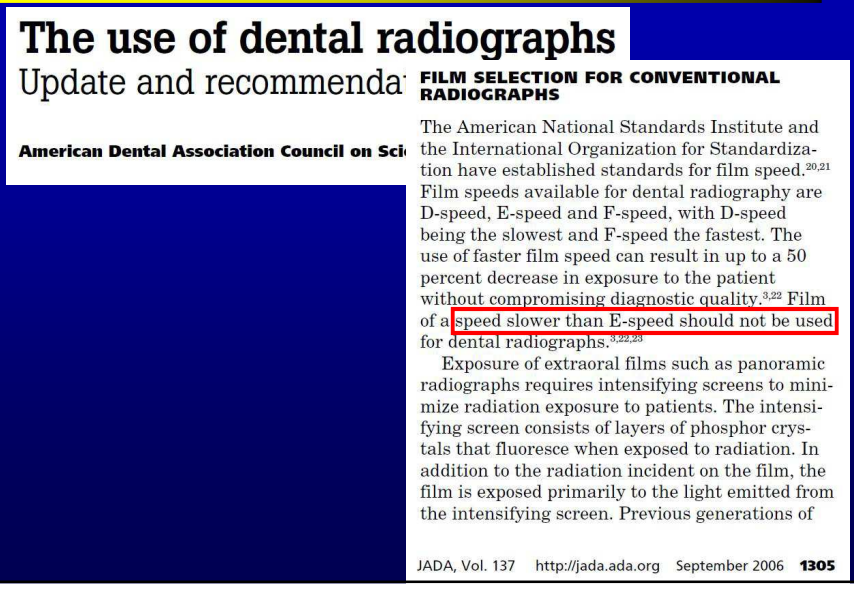


NCRP REPORT No. 172

REFERENCE LEVELS AND ACHIEVABLE DOSES IN MEDICAL AND DENTAL IMAGING: RECOMMEND FOR THE UNI

6.4.1.3 *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.

JADA 2006



The use of dental radiographs

Update and recommenda

American Dental Association Council on Sci

FILM SELECTION FOR CONVENTIONAL RADIOGRAPHS

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.[3,22] Film of a speed slower than E-speed should not be used for dental radiographs.[3,22,23]

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

JADA, Vol. 137 http://jada.ada.org September 2006 **1305**

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Digital Receptors

Table II. Overview of evaluated parameters from digital systems

Direct digital system	*Sensor type*	*Image enhancement types*	*Latitude (highest exposure/ lowest exposure)*	*Optimal exposure (mGy)*	*lp/mm (SR)*	*Δ Dia. wells**	*ΔDep. wells†*
RVG 6000	CMOS	Perio Mode	6.38	0.74	14	5	2
		Endo Mode	5.07	0.95	13	6	2
		DEJ Mode	2.02	0.48	12	5	1
RVG 6100	CMOS	Perio Mode	5.07	1.19	13	5	4
		Endo Mode	5.07	0.48	10	5	2
		DEJ Mode	1.00	0.74	11	5	3
RVG 6500	CMOS	Perio Mode	3.18	0.95	15	6	4
Dr. Suni Plus sensor	CCD		10.00	0.74	8	4	0
Dixi 3 Sensor	CCD	Normal Resolution (NR)	12.84	0.48	7	4	2
		High Resolution (HR)	6.22	0.48	12	5	3
Accent Barrier Sensor	CCD	Low Resolution (LR)	1.26	0.38	7	5	2
		High Resolution (HR)	1.27	0.38	8	5	2
Indirect digital system	*Sensor type*	*Image enhancement types*	*Latitude (highest exposure/ lowest exposure)*	*Optimal exposure*	*lp/mm*	*Δ Dia. Wells**	*ΔDepth wells†*
Scan-X	PSP Plate	———	24.80	1.47	7	5	3
Digora Optime	PSP Plate	High Resolution (HR)	12.58	0.74	6	5	2
		Super High Resolution (SHR)	12.58	1.19	8	5	2
Den Optix QST	PSP Plate	Normal Resolution (NR)	63.79	1.19	7	5	3
		High Resolution (HR)	63.79	1.19	8	6	3

OOOO 2013; 116: 774-83

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.

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- Overview of the TG-175 recommendations.
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Intraoral Dental Units

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.

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 Intraoral Dental Units*

X-ray Tube Potential (kVp)	Minimum HVL (mm of Aluminum)	
	Specified Dental System[a]	Other X-ray System[b]
60	1.5	1.5
70	1.5	1.8
71	2.1	2.5
80	2.3	2.9
90	2.5	3.2

[a] Dental x-ray systems designed for use with intraoral image receptors and manufactured after December 1, 1980
[b] Panoramic and cephalometric systems manufactured on or after June 10, 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 = 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.

X-Ray Machine: (Brand name)
Location: (Room)
mA: 15
kVP: 70
Sensor: (Brand name)

Projection	Exposure time Seconds	Impulses
Adult periapicals		
Incisors	0.25	15
Premolars	0.30	18
Molars	0.35	21
Occlusal	0.40	24
Adult bitewings		
Premolar	0.30	18
Molar	0.35	21
Edentulous periapicals		
Incisors	0.20	12
Premolars	0.25	15
Molars	0.30	18
Occlusal	0.35	21
Children		
Anterior periapicals	0.25	15
Posterior periapicals	0.25	15
Bitewing	0.25	15
Occlusal	0.30	18

Fig 15-2, Oral Radiology: Principles and Interpretation, Ed. 7

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

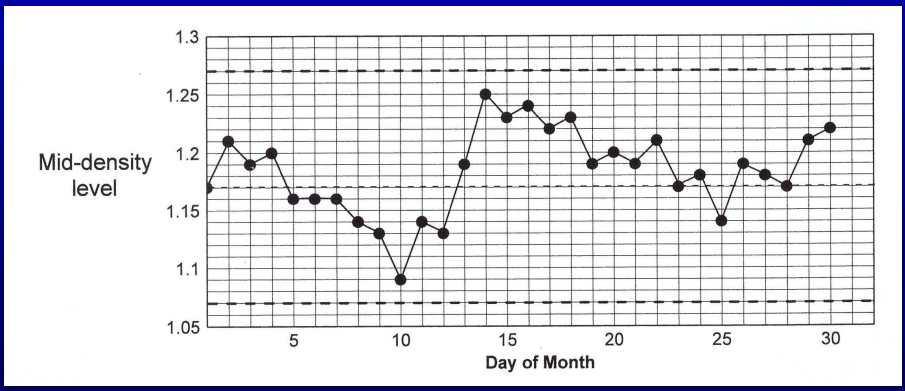

Figure 13.3, The essential physics of medical imaging

Evaluation of Site's QC Program

Table 2: Acceptance and QC Recommendations for Intraoral, Panoramic, and Cephalometric Dental Units

Recommended Tests	Device(s)	Frequency	Tolerance
Tube head stability and positioning	Intraoral unit only	Annually	≤0.5 cm drift after 1 second
Leakage radiation and visual inspection	All (Intraoral, panoramic, and cephalometric) units	Annually	No leakage
Minimum SSD	Intraoral units only	Refer to Section 3.3	≥18 cm (above 50 kVp)
Circular collimation	Intraoral units only	Refer to Section 3.3	≤7 cm
Rectangular collimation	Intraoral units only	Refer to Section 3.3	≤2% of SID in each axis
X-ray beam slit length and width	Panoramic units only	Annually	Refer to Section 4.2
Cephalometric collimation	Cephalometric units only	Annually	≤2% of SID in each axis
Beam quality	All units	Annually	Refer to Table 1
kVp accuracy	All units	Annually	Manufacturer specs, ≤10% without specs
Timer accuracy	Intraoral and cephalometric units	Annually	Manufacturer specs, ≤10% without specs
Exposure reproducibility	All units	Annually	Manufacturer specs, COV ≤0.05
Technique factors	All units	Annually	Published DRLs and Achievable Doses
mA or mAs linearity	Intraoral and cephalometric units	Annually if selection is available	Ratio ≤10%
Scattered radiation survey	All units	Acceptance testing	Refer to Section 3.14, 4.10, or 5.11
QC for digital receptor – uniformity and artifact	All units	Monthly to quarterly by site's personnel, reviewed by QMP annually	No significant non-uniformity or artifact is observed.
QC for digital receptor – phantom image	Intraoral units	Quarterly to semi-annually by site's personnel, reviewed by QMP annually	No deviation from baseline
Darkroom fog test	If darkroom is used	Annually	No visible difference
Film processing QC	If film processor is used.	Daily by site's personnel, reviewed by QMP annually	No deviation from baseline

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

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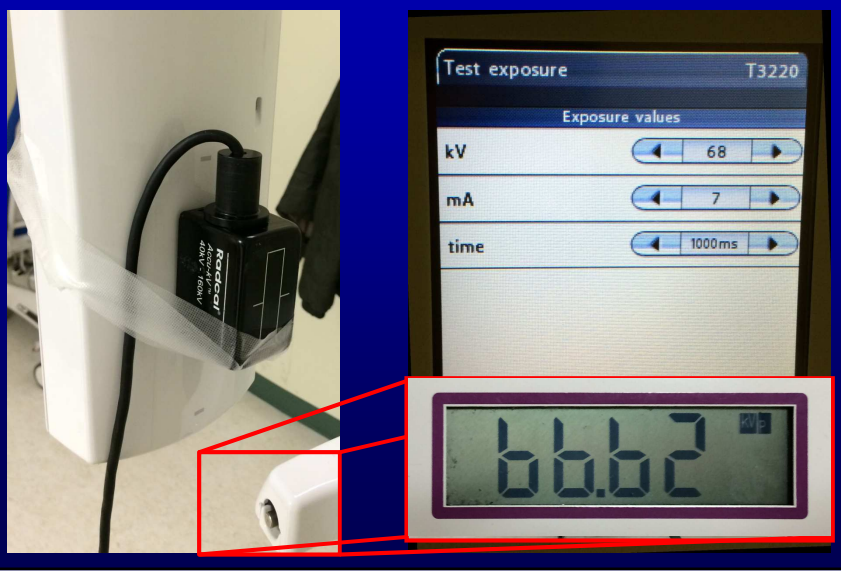
Panoramic Dental Units

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:

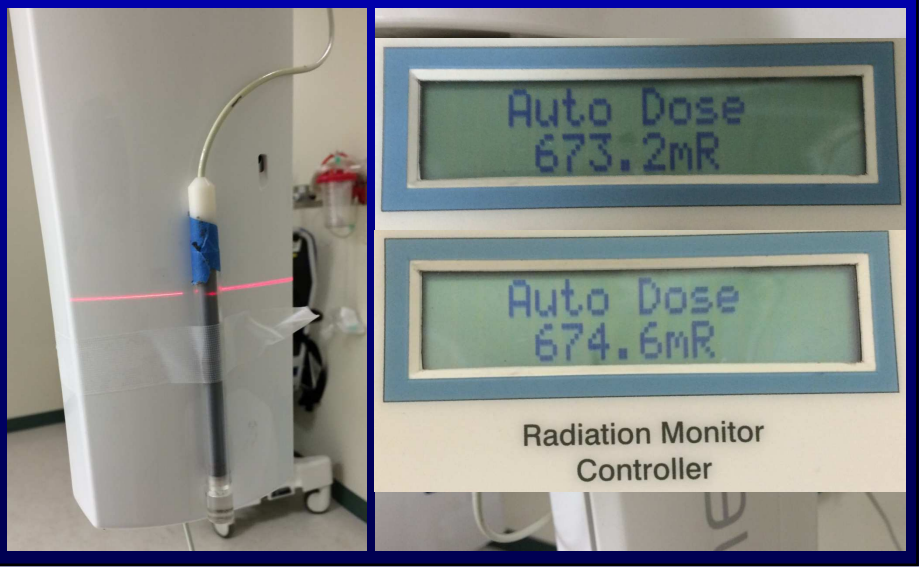
- The X-ray field should be contained within the beam slit:
  - 2% of the SID total error in the vertical direction
  - within the beam slit in the width direction
- The x-ray field should not exceed the sensitive area of the image receptor along the long dimension.

Beam Slit Length and Width Coincidence

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

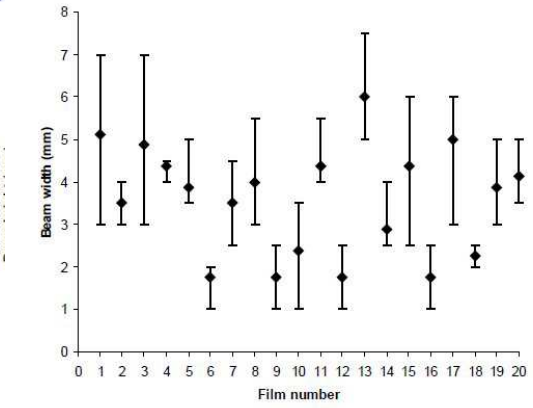


Technique Factors

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.

HPA-CRCE-032

Figure 3 Mean and range of beam width measurements made using a ruler.



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Cephalometric Dental Units

Similar?

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

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

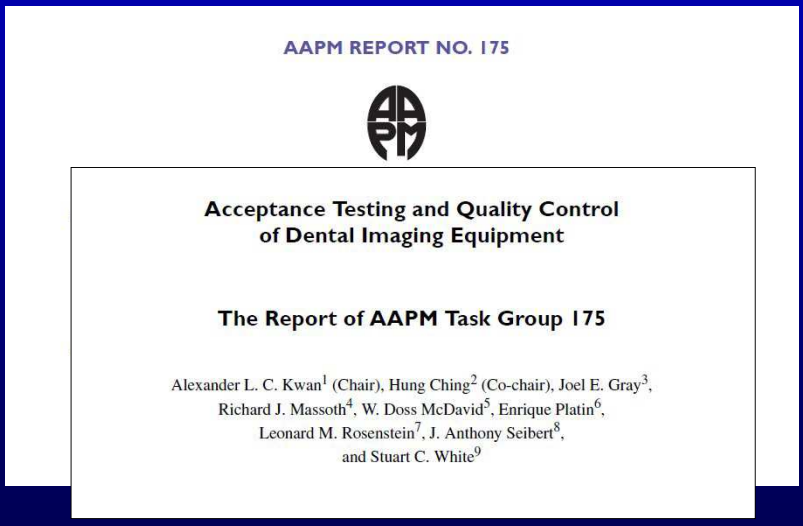
- Exposure reproducibility:
  - Ensure the entire sensitive volume of the radiation detector is irradiated by the primary beam.
- NCRP Report No. 172 recommends:
  - Adopting the Michigan 85th percentile entrance skin dose (0.14 mGy) as the DRL
  - The median dose (0.09 mGy) as the achievable dose.

Typical Entrance Air Kerma

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

$$ESAK = \overline{K}_a \times [SDD / (SID - 17.5\ cm)]^2$$

TG-175


AAPM REPORT NO. 175

Acceptance Testing and Quality Control of Dental Imaging Equipment

The Report of AAPM Task Group 175

Alexander L. C. Kwan[1] (Chair), Hung Ching[2] (Co-chair), Joel E. Gray[3], Richard J. Massoth[4], W. Doss McDavid[5], Enrique Platin[6], Leonard M. Rosenstein[7], J. Anthony Seibert[8], and Stuart C. White[9]

https://www.aapm.org/pubs/reports/detail.asp?docid=160

Questions?

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