

REPORT DOCUMENTATION PAGE				<i>Form Approved</i> <i>OMB No. 0704-0188</i>	
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1. REPORT DATE (DD-MM-YYYY) 24 Aug 2012		2. REPORT TYPE Consultative Letter		3. DATES COVERED (From – To) 19 Jun 2012 – 13 Jul 2012	
4. TITLE AND SUBTITLE Calculation of Dental Exam Room X-Ray Shielding in Walls and Entrances				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Andrew McUmber				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USAF School of Aerospace Medicine Occupational and Environmental Health Dept/OEC 2510 Fifth St. Wright-Patterson AFB, OH 45433-7913				8. PERFORMING ORGANIZATION REPORT NUMBER AFRL-SA-WP-CL-2012-0061	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSORING/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Distribution A: Approved for public release; distribution is unlimited. Case Number: 88ABW-2012-4565, 24 Aug 2012					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The U.S. Air Force School of Aerospace Medicine, Radiation Health Consulting Branch (USAFSAM/OEC), performed an assessment of the x-ray shielding design of a newly designated dental exam room at the 113 WG/MDG. In accordance with AFI 48-148, <i>Ionizing Radiation Protection</i> , and NCRP-116, <i>Limitation of Exposure to Ionizing Radiation</i> , persons in uncontrolled areas should not receive a dose in excess of 100 mrem/yr. USAFSAM/OEC recommends using specialty shielding on all walls that includes 3.0-mm lead. The door and window should both be replaced with specialty fixtures that incorporate shielding materials equivalent to 3.0-mm lead. If these are used, the primary barrier design is sufficient to prevent personnel from exceeding the 100 mrem/yr limit (based on the supplied information and stated assumptions).					
15. SUBJECT TERMS x-ray shielding, ionizing radiation, radiation assessment					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			Capt Andrew McUmber
			SAR	5	19b. TELEPHONE NUMBER (include area code)



DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OHIO 45433

24 August 2012

MEMORANDUM FOR 113 WG/MDG
ATTN: MSGT THOMAS KATT
JOINT BASE ANDREWS, MD 20762

FROM: USAFSAM/OEC
2510 Fifth Street, Building 840
Wright-Patterson AFB, OH 45433-7913

SUBJECT: Consultative Letter AFRL-SA-WP-CL-2012-0061, Calculation of Dental Exam Room X-Ray Shielding in Walls and Entrances

1. The U.S. Air Force School of Aerospace Medicine (USAFSAM), Radiation Health Consulting Branch (OEC), performed an assessment of the x-ray shielding design of a newly designated dental exam room at the request of MSgt Thomas Katt and A1C Kimya Richardson, 113 WG/MDG. The request was to calculate needed shielding materials for the walls of the room, one door, and one window. "Panoramic" and "bitewing" modes were considered, per discussions with dental staff. The Planmeca ProMax x-ray unit uses panoramic, linear tomographic, cone beam volumetric tomographic, and cephalometric techniques to produce x-ray images for the diagnosis of dentomaxillofacial anatomy.

2. The evaluation was based on the following information provided by 113 WG/MDG.

a. The dental exam room is located inside Building 3282, a clinical medical facility. Room A06 will serve as the future exam room. Dimensions of this rectangular room are 10 ft by 13 ft. There is one window on the north wall that faces an outside parking lot. The door is located on the south wall and joins an outside hallway. Office spaces adjacent to this room are located by the west and east walls. There is another building floor above the exam room, but no workspace below the exam room. The ProMax unit will be installed near the east wall. Exams will be conducted in the east portion of the room, closest to the east wall.

b. The office spaces, hallway, and parking lot will be occupied by members of the public and, thus, must meet unrestricted area requirements. Patient exposures will be directed on a horizontal plane. Therefore, the walls, door, and window require shielding as primary barriers. The ceiling must be assessed as a secondary barrier due to scatter radiation.

c. The x-ray device to be used is a Planmeca ProMax unit.

(1) Technique settings

(a) 50-100 patients/mo $\approx$ 25 patients/wk (assume 100 patients/mo)

(b) 1 exposure/patient

(c) 2.5 to 16 s/exposure = 0.04 to 0.27 min/exposure (assume 0.27 min/exposure)

(d) 54 to 84 kVp @ 1 to 16 mA (assume 100 kVp @ 16 mA)

(2) Projected maximum (worst-case) workload

$$(a) W = \left[mA \left(\frac{patients}{wk} \right) \left(\frac{exposures}{patient} \right) \left(\frac{min}{exposure} \right) \right] \quad (1)$$

$$(b) W = [16(25)(1)(0.27)] = 108 \frac{mA \cdot min}{wk}$$

d. The tube head will not be in a fixed position, but the distance between the tube head and east wall will be a minimum of 2 ft (0.610 m). The elevation of the tube will vary between 5 ft and 8 ft. An exposure angle of 90° relative to the floor will be used.

e. The dental exam room currently uses $\frac{5}{16}$ in drywall on all walls. No specialty shielding products (e.g., lead) are currently being used on any walls.

f. The window and door are not composed of specialty shielding materials.

3. Findings

a. In accordance with AFI 48-148, *Ionizing Radiation Protection*, and NCRP-116, *Limitation of Exposure to Ionizing Radiation*, persons in uncontrolled areas should not receive a dose in excess of 100 mrem/yr. Therefore, the weekly dose limit is 2 mrem/wk for a 50-wk working year. Additionally, the dose shall not exceed 2 mrem in any one hour.

b. All shielding calculations were done using several assumptions. First, the tube head will be oriented on a horizontal plane (maximum use factor) with a minimum distance of 2 ft from adjacent rooms. Second, there will be full-time occupancy outside the exam room (maximum occupancy factor), including the southern corridor where controls will be placed. Third, there will be long exposure times (maximum workload, see Eq. 1). Finally, the highest kV-peak setting was selected, as a conservative measure.

c. Design of NDI primary barrier (exam room walls, door, and window)

$$(1) Q = 0.114 \frac{Pd^2}{WUT} = 0.114 \frac{(0.02)(0.610)^2}{(108)(1)(1)} = 7.9 \times 10^{-6} \frac{R}{mA \cdot min} \quad (2)$$

where the following factors are:

Q = exposure of lead-attenuated radiation

P = Air-Kerma shielding design goal (unrestricted)

d = minimum distance

W = workload

U = use factor
T = occupancy factor

(2) Figure 15.9 of *Atoms, Radiation and Radiation Protection (3rd Edition)* gives 3.0 mm lead (0.118 in) as needed for Q (Eq. 2). This calculation assumes the use of a 100-kVp beam.

(3) With the use of $^{5/16}$ in drywall, no radiation shielding properties are assumed.

4. Recommendations

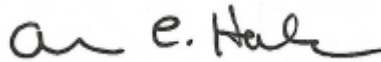
a. USAFSAM/OEC recommends using specialty shielding on all walls that includes 3.0-mm lead. The door and window should both be replaced with specialty fixtures that incorporate shielding materials equivalent to 3.0-mm lead. If these are used, the primary barrier design is sufficient to prevent personnel from exceeding the 100 mrem/yr limit (based on the supplied information and stated assumptions).

b. There was no information provided concerning the design of the secondary barrier (ceiling). However, the reference in 3.c.2 above gives the approximate lead shielding thickness of 2.0 mm for scatter radiation from dental exams at 2.0 ft. Materials such as concrete will reduce this value.

c. The facility should have a radiation scatter survey performed and documented prior to initial operations per AFI 48-148 §5.2.

d. This evaluation was based on the assumption that the x-ray exam room would have a maximum usage of 25 exposures per week. These calculations are only valid with the ProMax unit. Usage of the facility in means other than described above would require further evaluation from USAFSAM/OEC or the Installation Radiation Safety Officer.

e. Any questions or comments regarding this consultation may be directed to Capt Andrew McUmbert at (937) 938-3317 (DSN 798-3317), or andrew.mcumber@wpafb.af.mil.



ALAN C. HALE, Maj, USAF, BSC
Chief, Radiation Health Consulting

Attachment:
Room Diagram, MSgt Thomas Katt, 6 July 2012

Attachment

Room Diagram

Window

DENTAL EXAM ROOM

10' x 13' - NOT to scale

Exposure button will be placed outside the doorway entry to the room.

PANO
Equip

Both sides of the room contain offices, single sheet of 5/16" drywall on each side of each wall to combine for the 2 sheet requirement recommendation.

Doorway