IAEA Standard syllabus course on Radiation Protection in diagnostic and interventional radiology

RADIATION PROTECTION IN DIAGNOSTIC RADIOLOGY

Part 10: Patient dose assessment

IAEA Post Graduate Educational Course Radiation Protection and Safe Use of Radiation Sources

Introduction

A review is made of:

- The different parameters influencing the patient exposure
- The problems related to instrument calibration
- The existing dosimetric methods applicable to diagnostic radiology

Part 10: Patient dose assessment 2

Contents

- Parameters influencing patient exposure
- Dosimetry methods
- Instrument calibration
- Dose measurements

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Overview

- To become familiar with the patient dose assessment and dosimetry instrument characteristics.

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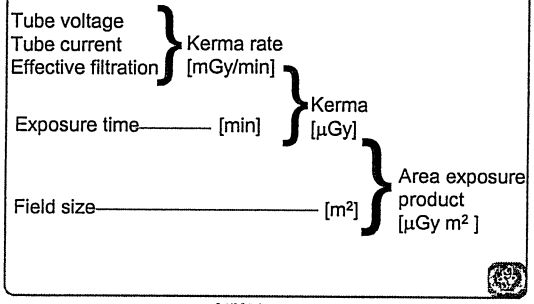
Part 10 : Patient dose assessment

Topic 1 : Parameters influencing the patient exposure

Essential parameters influencing patient exposure



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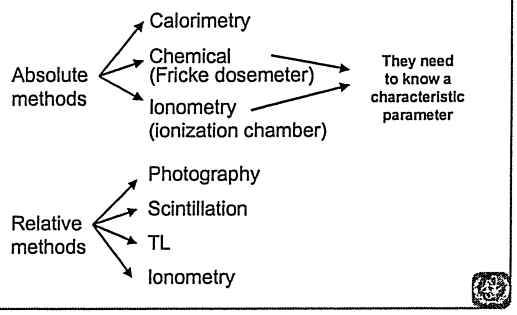
What we want to measure

- The radiation output of X-Ray tubes
- The dose-area product
- The computed-tomography dose index (CTDI)
- Entrance surface dose

How to measure doses



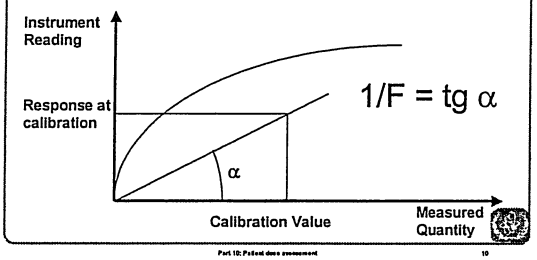
Calibration of an instrument

- ☆ Establish Calibration Reference Conditions (CRC) [type and energy of radiation, SDD, rate, ...]
- Compare response of your instrument with that of another instrument (absolute or calibrated)
- Get the calibration factor

$$F = \frac{\textit{Response of the reference instrument}}{\textit{Response of the instrument to be calibrated}} \quad \textit{[appropriate unit]}$$

Range of use

Hypothesis: the instrument reading is a known monotonic function of the measured quantity (usually linear within a specified range)



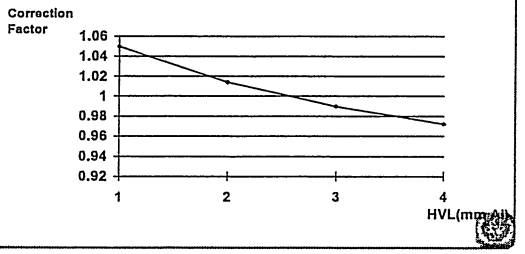
Use of a calibrated instrument

- Under the same conditions as the CRC
- Within the range of use

Q (dosimetric quantity) = **F** x **R** (reading of the instrument)

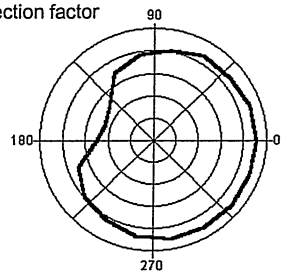
Correction factors for use other than under the CRC

A. Energy correction factor



Correction factors for use other than under the CRC

B. Directional correction factor



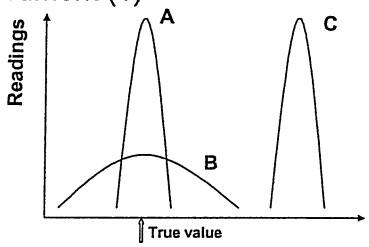
Correction factors for use other than under the CRC

C. Air density correction factor
(for ionization chambers)

$$K_D = \frac{p_0(t+273)}{p(t_0+273)}$$

p_0, t_0 calibration values

Accuracy and precision of a calibrated instrument (1)



Curve A: Instrument both accurate and precise
Curve B: Instrument accurate but not precise
Curve C: Instrument precise but not accurate

Accuracy and precision of a calibrated instrument (2)

Traceability: Primary standard (absolute measurement) —Calibration→ Secondary standard —Calibration→ Field instrument

Accuracy: decreases →

Relative uncertainty associated to the dosimetric quantity Q :

$$r_q \geq 2r_{R_C}^2 + r_{R_R}^2$$

Where :

r_{RC} is the relative uncertainty of the reading of the calibrated instrument

r_{RR} is the relative uncertainty of the reading of the reading instrument

Requirements on Diagnostic Dosemeters

Traceability

Well defined reference X-ray spectra not available

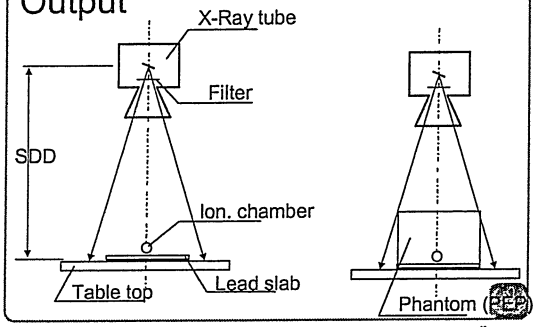
Accuracy

At least 10 - 30 %

Limits of error in the response of diagnostic dosemeters

Parameter	Range of values	Reference condition	Deviation (%)
Radiation quality	According to manufacturer	70 kV	5-8
Dose rate	According to manufacturer	–	4
Direction of radiation incidence	±5°	Preference direction	3
Atmospheric pressure	80-106 hPa	101.3 hPa	3
Ambient temperature	15-30°	20° C	3

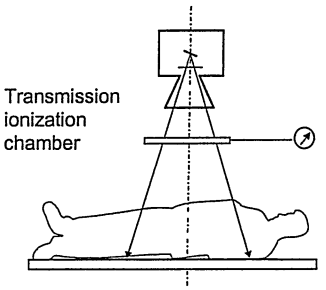
Measurements of Radiation Output



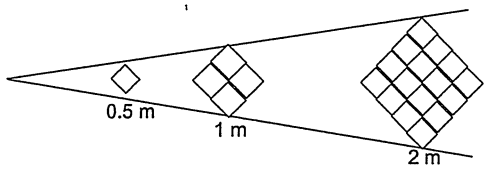
Measurements of Radiation Output

- Operating conditions
- Consistency check
- The output as a function of kVp
- The output as a function of mA
- The output as a function of exposure time

Dose Area Product (DAP)

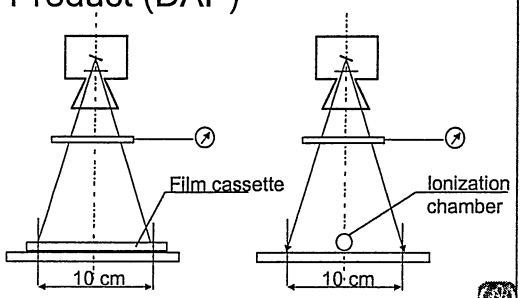


Dose Area Product (DAP)

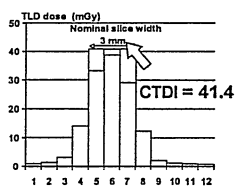


Air Kerma :	$40*10^3$ µGy	$10*10^3$ µGy	$2.5*10^3$ µGy
Area :	$2.5*10^{-3}$ m²	$10*10^{-3}$ m²	$40*10^{-3}$ m²
Area exposure product	100 µGy m²	100 µGy m²	100 µGy m²

Calibration of a Dose Area Product (DAP)



Computed Tomography Dose Index (CTDI)



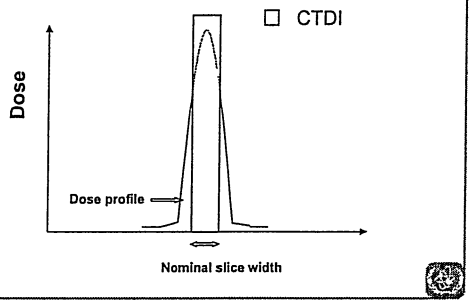
$$CTDI = \frac{\Sigma (e_l \, d_l)}{En}$$

En : nominal slice width
e_l : TLD thickness

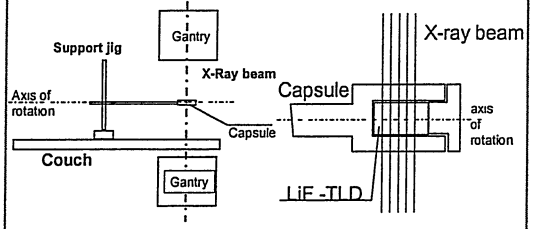
Normalized CTDI :

$$CTDI_n = \frac{CTDI}{mAs}$$

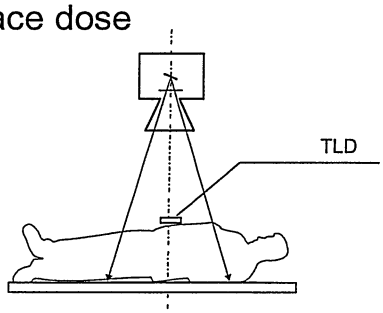
Computed Tomography Dose Index (CTDI)



TLD arrangement for CTDI measurements



Measurement of entrance surface dose



Where to Get More Information

- Equipment for diagnostic radiology, E. Forster, MTP Press, 1993
- The Essential Physics of Medical Imaging, Williams and Wilkins. Baltimore:1994
- Leitz, W., Axiesson, B., Szendro, G. Computed tomography dose assessment - a practical approach. Nuclear Technology 37 1-4 1993) 377_80