Product Note

RTI From Radiation to Information

Evaluation of Effective Length of CT Ionization Chambers

1. Background

It has been observed that the length of 10 cm CT ion chambers varies between brands. The effective length matters for different reasons.

a. When the CT chamber is calibrated fully irradiated the effective length must be used in calculation of CTDI parameters.
b. Measurement on wide beams where the chamber is moved in consecutive steps.

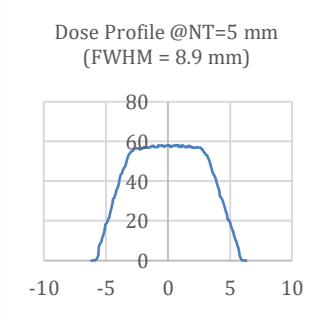
In both cases described above the measurement error is proportional to the difference in effective length, and nominal length.

Example #1:

An example is a measurement free in air of a 140 mm collimated beam. The CTDI free in air is then measured by taking two exposures. The chamber is moved 100 mm between the two exposures. Then 70 mm of the chamber is irradiated in each exposure.
A chamber that has an effective length of 90 mm (5 mm "short" in each end) will in this case underestimate the dose by 5/70 = -7%
A chamber that has an effective length of 110 mm will over-estimate the dose by 7%.

2. Sensitivity profile

The graph below shows the result when the chambers has been axially scanned in a CT scanner, in "step and shoot" sequence. Each dot in the graph represents a 1 sec, 360 deg rotation. The collimation is 5 mm (FWHM is 8.9 mm). The figure to the right shows the dose profile at 5 mm collimation.
In the center region of the chambers, exposures were made with 5 mm increment. At the edges, the increment was1 mm.
Due to the relatively wide beam used, and the fact that neither the beam, nor the sensitivity profile are perfect square functions, it is hard to make an accurate judgement on the effective length of the chambers. However, the differences between chamber models are obvious.



Three chambers were evaluated:

Radcal CT chamber
Standard Imaging 10 cm Prototype chamber
RTI DCT10 CT chamber

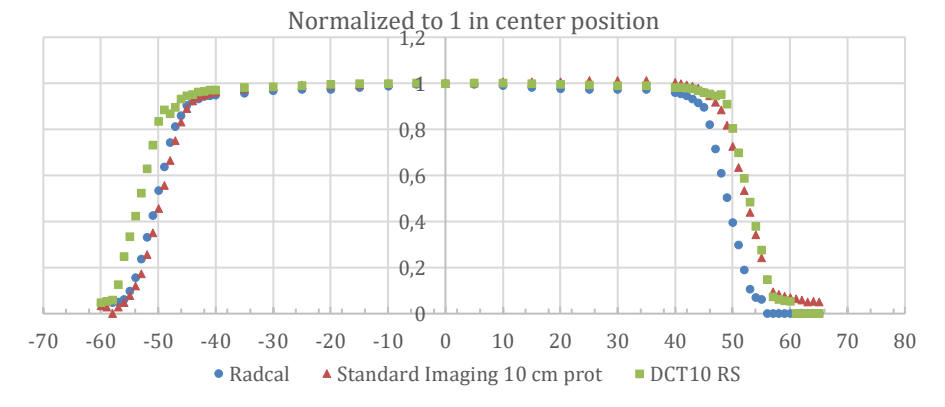


Figure 1. Sensitivity profile for 3 CT chambers. The x-axis shows mm from center, where (-) is the end side, and (+) is the cable/connection.

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3. Effective length

Knowing from above that the sensitivity profile is flat in the range ±40 mm, the sensitivity per unit length can be estimated.
This was done using a standard radiographic x-ray unit, and a well-defined lead collimation close to the CT ionization chamber. Based on a 40 mm and a 80 mm collimation the average sensitivity per mm was calculated.

$$N_{(UL)} = \frac{M_{(i)}}{Coll_{(i)}}$$

Where
$N_{(UL)}$ = Sensitivity per unit length
$M_{(i)}$ = Measured value at collimation (i)
$Coll_{(i)}$ = Collimation (i mm)

Then the entire chamber was irradiated.
The effective length is then

$$L_{(eff)} = \frac{M_{(full)}}{N_{(UL)}}$$

where
$L_{(eff)}$ = Effective Length
$N_{(UL)}$ = Sensitivity per unit lenght
$M_{(full)}$ = Measured value when fully irradiated

This method gives the following results.
In this test also the Standard imaging A101 commercially available chamber was included.

Radcal:	97 mm
St Im (prototype):	99 mm
DCT 10:	102 mm
St Im A101:	117 mm

The uncertainty is estimated to ±1 mm

The results compare well with the rough estimate that can be done from the sensitivity profiles above.

Taking these numbers to example #1 above means that:

a. The DCT 10 will over-estimate the dose with 1/70 = 1.5%
b. The difference between Radcal and DCT 10 will be -1.5/70 – 1/70 = -3.5%
c. On a narrower collimation, the error will increase since the divider (70) will decrease.

*** END ***

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