CT Scanner Dose Survey

Measurement Protocol

Version 5.0 July 1997

Co-ordinated by ImPACT and The Medical Physics Department,

St George's Healthcare, London SW17, UK. 0181-725-3366

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S Edyvean, M A Lewis and A J Britten.

Address for Correspondence:

ImPACT, Department of Medical Physics,
St George's Hospital,
Blackshaw Road,
London SW17 OQT.

Tel: 0181-725-3366
Fax: 0181-725-3969

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Measurement Protocol for CT Dose Survey: Version 5.0 July 1997

Contents

Primary Aim of Survey

The primary aim of this survey is to determine the radiation dose characteristics of CT scanners in current clinical use. This will enable the matching of newer scanners to scanners which are represented in the NRPB Monte Carlo data sets, in order to be able to use these datasets for the calculation of patient dose from the newer scanners.

In order to compare scanners, two aspects of the scanner need to be matched:

1. The beam quality.
2. The beam filter(s).

Ideally one would obtain this information from the Manufacturers, but this is very difficult to obtain, and is not always easily verified for the particular model installed. Hence the need for measurements which are aimed at providing the information relating to the beam quality and the beam shaping or flat filters.

Additional Benefits from this Survey

The main aim of this survey is as given above, but there are two other purposes for which collected data will be useful and important.

(i) The forthcoming CEC publication on reference doses in CT makes use of the phantom CTDI measurements.

(ii) Beyond matching the scanners for the NRPB datasets, comparative data for Axial scans and SPR ("Scan Projection Radiographs") scans can be very helpful. Whilst not providing effective doses it can give a good guide to the relative doses between scanners in their various modes of operation. Some of this sort of data has been excluded from the main protocol, though a protocol is included and the data will be gratefully received (See Section 6).

Overview of Measurements

The measurements, using a 10cm 3cc "CTDI" pencil ion chamber, are separated into those with the tube stationary and axial scan measurements. They consist of the following:

A. Stationary Tube Measurements

The stationary tube is obtained by engineer control to allow a "stationary tube axial scan", or by use of the SPR scan, 'scoutview', 'topgram' etc.

i. Beam filter(s): On axis and off-axis exposures.

ii. HVL: 1st HVL.

B. Axial Scan Measurements (CTDI)

iii. CTDI in air: On axis

iv. CTDI in perspex phantoms: Phantom centre and periphery

16cm, and 32cm diameter phantoms used, measurements in each phantom

These measurements fulfil the aims of the survey in the following way.

Measurement		To characterise:
i	in air dose (stat. tube): on and off axis	shaping/flat filter(s)
ii	HVL	beam quality
iii	CTDI: in air	tube output
iv	CTDI perspex phantoms	CEC reference doses
iii,iv	Ratios axial doses: head and body to air	beam quality
iv	Ratios periphery to centre phantom	shaping/flat filter(s)

We recommend the following order to carry out the measurements, although this may be changed for local convenience. The measurements can be carried out at different times, though to check constancy it is preferable if one measurement, the CTDI in air and on axis, is carried out each time. The measurements are referred to by these numbers throughout the rest of the protocol:

1. CTDI in air.
2. Dose in-air to characterise beam-shaping or flat filters.
3. HVL.
4. CTDI in phantoms.

The following table is presented as a guide to the time involved in carrying out the measurements. To some extent the time taken for each task will depend on the scanner. For example, some scanners take longer to reset from any change in parameter, whereas others are slower in other respects.

Measurement		~Time taken
1	CTDI: in air	¼-½ hr
2	in air dose (stat. tube): on and off axis	½-2 hrs
3	HVL	2 hrs
4	CTDI perspex phantoms	2-3 hrs

Introduction to the Protocol

Since the protocol covers a wide range of different scanners which operate in different ways, and will be carried out by people with different equipment, the protocol cannot specify the procedures in detail. We have therefore included a discussion of the issues involved in an attempt to provide the measurers with information to allow them to take decisions on-site.

Each measurement procedure is therefore introduced by a discussion section covering the measurement methods which may be used. This discussion is then followed by a one page summary headed with the measurement number and title, for example "1.2 MEASUREMENTS: CTDI in-air". This page briefly summarises the measurement conditions, chamber and phantom positions and measurements required. Where there is a choice of methods we indicate a "Recommended" procedure, and an "Acceptable" procedure.

A section headed "Additional Equipment" lists some of the equipment which may be needed in addition to your standard CT survey equipment. A full list of equipment is not provided.

Alterations to the protocol are required for some scanners, and these specific alterations are noted in the "Scanner Notes" issued by ImPACT. Please consult these notes for each model of scanner you investigate.

Data sheets: When looking at the protocol reference to the Data Sheets (provided separately for data collection, and bound in here as an appendix) may be helpful.

Partial Data: This is not an "all-or-nothing" protocol. We will be pleased to receive data from *any* part of the protocol, so please do whatever time allows and return that information to us. (If only phantom data is collected one in-air CTDI measurement is helpful for cross-referencing output).

General Measurements Information

At the beginning of the measurements take 3 exposure readings; if the readings are consistent (< 3% variation) it may be possible to save time by making only one exposure for subsequent studies. However, since the majority of the time spent in these measurements is usually the setting up time of the chamber and phantoms, we would prefer 3 exposures for each measurement unless time is very pressing.

Three readings are definitely required for the off-axis CTDI in-phantom measurements, in order to obtain some information related to scan start position. SPR scans have also been noted to be more variable in output than axial scans, and so three readings are desirable for SPR scans unless you find good stability on your system(s).

On the data sheets please record the meter readings, without any correction factors or calibration factors applied. It would be good if you could also measure and record temperature and pressure, but we will still accept measurements without these since the error is relatively small.

If conditions vary so that you are not able to exactly follow the protocol, please note this on the data sheets and still submit the data - it will be useful as long as the conditions are noted.

The main measurements should be made at the nominal 120kV setting *or the closest clinically used kV to 120.* In this protocol nominal kV settings are noted in inverted commas, for example "120"kV. Please record the actual value used if different. Any data on actual measured kV (from scanner diagnostics or other source) is useful but not essential.

Some Comments on Beam Filters

We wish to collect data on scan modes used in clinical practice. Some scanners have one fixed filter (flat or shaped), whilst others have more than one selectable filter. By selecting a scan mode (eg HEAD, BODY, SPINE, PAEDIATRIC) the appropriate filter combination will be positioned for scanners with selectable filters.

We do not want you to set up any non-clinically used filter configurations.

As long as the mode and field of view are recorded on the data sheets, knowing the exact filter combination when you are doing the measurements is not important.

With HVL measurements for different filters, the on-axis filter thickness may be the same for different filters, and so there will be no need to repeat HVL measurements for all filters. A simple comparison of on-axis dose will determine whether the filters differ on-axis.

In principle the filter characterisation measurements (off-axis stationary tube and HVL) may be carried out with SPR scans. However, it may not be possible to carry out SPR scans with the range of filters on the scanner, and so stationary tube axial scanning ("engineer mode") may be required to measure filters not used in SPR mode.

When beam shaping filters are used there is a need to find the position corresponding to the centre (thinnest part) of the shaped filter, both for the filter shape measurements and the HVL measurements. A method is given in section 2.5 "Finding the Centre of a Beam Shaping Filter" page 14.

See the scanner notes from ImPACT for specific details of filters used on scanner models.

Phantom and Chamber Positioning and Alignment

For chamber and phantom alignment there are both rotational and translational errors. A lot of time can be spent trying to get precise alignment. Fortunately, the measurements are not very sensitive to over precise alignment, and quite generous tolerances on set-up are given below.

It is usually best to use the lights for approximate positioning (the use of a spirit level can also be helpful) with the final positioning being checked by SPR and transaxial imaging. The protocol describes an image based set-up confirmation procedure which does not rely on precise accuracy of the alignment lights.

Alignment Lights

The most useful lights are those defining the scan plane, with the other lights (sagittal and coronal planes) assisting in centering the phantom or chamber in the scan plane, see Figure 1. Light positioning accuracy can alter with the off-axis (off-isocentre) distance, or, where two or more lights are used to identify the same plane they may only match at one specified position, or they may not be properly set up.

Therefore in order for the lights to be used as the primary means of alignment for the phantom or chamber positioning they would need to be checked for both on-axis (for in air measurements), and at 8cm and 16cm off-axis (for phantom measurements).

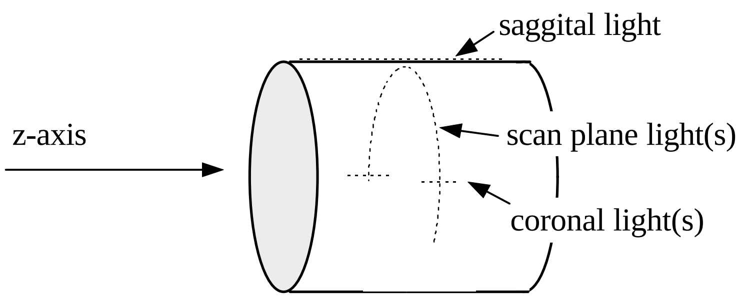


Figure 1. Scanner lights defining planes, as seen on a phantom.

Swivel and Tilt Alignment

The 'swivel' and 'tilt' alignment errors describe the misalignment of the axis of the phantom or chamber along the scanner axis (conventionally the z-axis). 'Swivel' refers to the chamber or phantom swivelling left to right through the vertical plane, and 'tilt' is the movement from the horizontal. This is illustrated in Appendix B.

Misalignment due to swivel and tilt can be roughly assessed from the lights, but more accurately measured from SPR images (swivel from AP/PA SPRs and tilt from lateral SPRs). The extent of the misalignment is measured either as an angle or as a divergence of the phantom or chamber ends from the orthogonal image axes, illustrated in figures 2 and 3. In both instances the alignment accuracy required is 2 degrees.

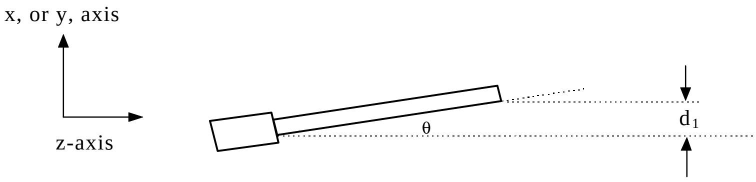


Figure 2. Chamber swivel and tilt. SPR view.
Tolerance: with θ = 2 degrees, d_1 = 3.5mm.

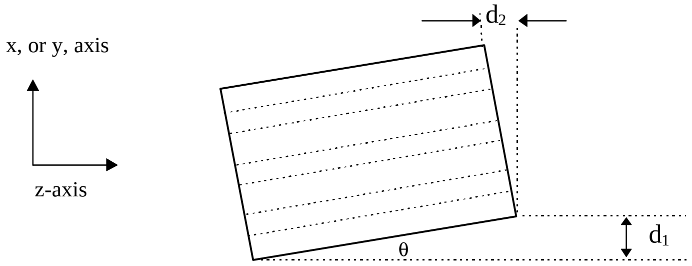


Figure 3. Phantom swivel and tilt. SPR view.
Tolerance: with θ = 2 degrees, d_1= 5mm for both phantoms and d_2 = 5mm (head phantom) and 11 mm (body phantom).

Rotation Alignment

In additon to swivel and tilt there is the 'rotation' alignment in the scan plane. This only applies to the phantom measuremements. The phantoms have chamber hole positions which should lie at 0, 90, 180 and 270 degrees (with the 90 to-270 degree line being horizontal), figure 4. (These positions are referred to as N,E,S and W. See Appendix A.)

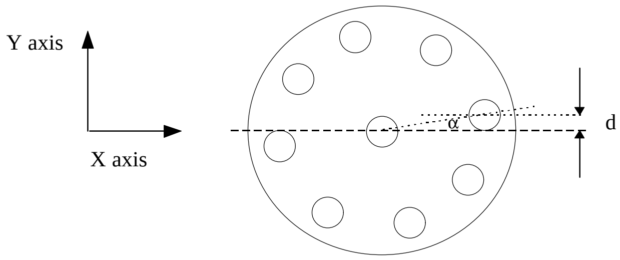


Figure 4. Phantom rotation. Axial view

Tolerance: with α = 2 degrees,
d=2.5mm (head phantom), or 5.5mm (body phantom).

Lateral and Vertical Displacement

The translational tolerances are given in terms of displacement from the X and Y axes in the scan plane, more simply described as 'up and down', and 'left and right' by an observer looking into the gantry along the scanner axis. Figure 5.

The centre phantom measurements are not unduly affected by the phantom being positioned away from the iso-centre. The periphery phantom measurements are more affected, but by taking the mean value around the phantom any effects are cancelled out. A tolerance of 5mm is allowed.

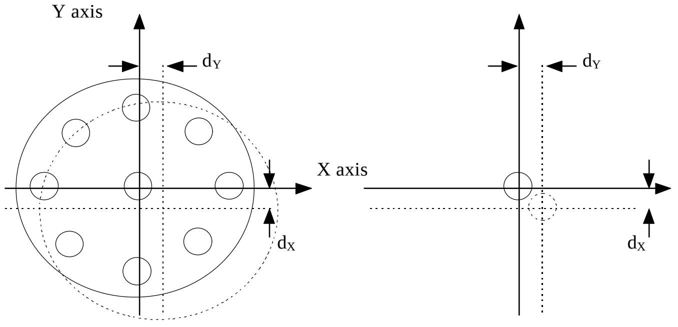


Figure 5. Phantom or chamber lateral or vertical displacement. Axial view.
Tolerance : d_x and d_y = 5mm.

Scan Plane Determination

The desired scan plane can be specified from an SPR, figure 6, or if the accuracy is known , from alignment lights.

From an SPR a table position for the required scanning position can be obtained. This is sufficient in itself, but it can also be used to identify any difference from the plane identified by the lights. (However the accuracy will be limited by the extent one can clearly view the chamber on the SPR unless a marker wire, as described below, has been used).

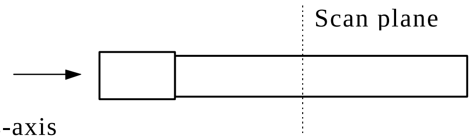


Figure 6. Chamber (and phantom) scan plane determination. SPR view.
Tolerance = 5mm between chamber/phantom centre and scan plane.

The scan plane lights can be checked by using a piece of wire, an unbent paperclip for example, and scanning using either a combination of an SPR and a transaxial scan, or a series of transaxial scans.

Place a piece of wire, aligned with the scan plane, across the middle of the chamber, or centre line of the surface of the phantom. Then either:

a) Carry out an AP/PA SPR. Setup as though preparing to carry out an axial scan at the wire position. Move couch to required position. Carry out thin axial scan to confirm. Check difference with lights, note for reference. Take wire off.

or,

b) Carry out a series of thin slices covering either side of the setup position (spiral or axial). Note the couch position of the slice with the best image of the wire. Check difference with lights, note for reference. Take wire off.

Both approaches are easy to carry out and can be done as part of the measurement set-up procedure.

Suggested Procedure for Alignment

This is a suggested alignment procedure. It can be followed for both the chamber in air, or for setting up the CTDI phantoms. Other methods may be more applicable for your phantom (eg if it has alignment aids).

You may wish to check the scan plane lights according to the methods described on page 8. This can be incorporated into steps 1 or 2.

1. Set the phantom/chamber up roughly using lights and by eye and spirit level with scan plane through centre of chamber.
2. AP/PA SPR to check for swivel. Adjust. *Tolerance = 2°.*
3. Lateral SPR to check for tilt. Adjust. *Tolerance = 2°.*
4. Move to axial scan position as determined from SPR or knowledge of lights.

   Tolerance = 5mm.

(If the SPR was used, note any difference of couch position determined by the set scan plane and that determined by the lights. Note for future reference)

5. Axial scan to check for lateral or vertical translation. Adjust. *Tolerance = 5mm.*
6. For phantom measurements check also for rotation. Adjust. *Tolerance = 2°.*
7. Visually check the set-up. (To ensure that there has not been any gross error due to, for example redefining of co-ordinates by the software, or re-setting of table position)
8. Carry out measurements.

1. CTDI in air

1.1 Methods

We will compare the on-axis in-air CTDI measurements with the later in-phantom CTDI measurements (sections 4 and 5), and it will avoid possible timing errors if the same scan time is used for all sets of measurements. A scan time of around 2s may be appropriate.

1.2 Chamber Positioning

Fix the chamber so that it extends beyond the couch end (ie couch attenuation is not included). The chamber must be on the isocentre. Some chambers may be used with a thin perspex sleeve. Since the difference in readings with sleeve on or off is less than 2%, measurements may be made with the sleeve on or off, but please record if the sleeve is used.

1.3 Chamber Alignment

A suggested alignment procedure is given on page 9.

The chamber should be aligned within the tolerances given in the alignment section, pages 6-9, also given below. The distance, d_1, is illustrated in figure 2 on page 7.

1. Swivel and tilt	*Tolerance* = 2^o (d_1 = 3.5mm)
2. Axial scan position	*Tolerance = 5mm.*
3. Lateral or vertical translation.	*Tolerance = 5mm.*

It is important not to forget the visual check just prior to the measurements.

1.4 MEASUREMENTS: CTDI in-air

Additional Equipment:

Spirit level.

Phantom:

None

Chamber:

10cm 3cc CTDI chamber.

Position: In-air, free of couch, on-axis.

Alignment: pages 9 and 10.

Scan Parameters:

Axial Scans

Scan time: ~ 2s (The same time as will be used in the CTDI phantom measurements)

<u>HEAD scans</u>

- If overscan is selectable, switch it OFF.
- Fix mA Vary slice width "120" kV
- Vary mA 10mm slice width "120" kV
- Fix mA 10mm slice width Vary kV
- If overscan is selectable, repeat just one reading with overscan ON.

<u>Other Scan modes if Selectable Filters Available</u>

- Fix mA 10mm slice width For all clincally used kVs

Measurements:

On-axis in-air exposure readings.

2. Dose in Air from a stationary tube: (Beam Filter Characterisation)

2.1 Methods

The tube can be made stationary in an engineer control mode ("stationary tube axial scan"), or the scanner can simply be operated in the SPR mode. If the scanner is operated in the SPR mode, the chamber can either be attached to the table top (figure 7) and the whole chamber irradiated, or the chamber can be fixed independently of the couch using a floor stand. A microphone stand can be helpful here. In this instance, as with the "stationary tube axial scan", only the centre of the chamber length will be irradiated.

a) SPR mode

If the SPR mode is used, perform SPR using minimum couch speed, maximum mA and slice width. This is to ensure that there is a sufficiently large chamber readings. Sometimes typical SPR settings give too low a dose.

If the moving chamber set-up is used, figure 7, the chamber should be irradiated beyond its length, without irradiating too much of the cable. Typically do an SPR over a length of 15 cm for example, making sure the extra scan length is over the air end as opposed to the cable end.

It does not really matter whether the SPR is lateral (R or L) or AP (or PA), provided the chamber is in air, but with lateral SPR check the vertical movement range available (section 2.2).

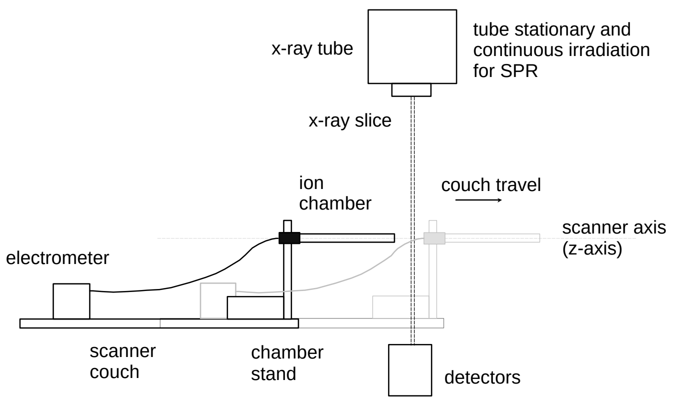


Figure 7. SPR : couch top direction of motion.

Using the SPR mode no specialist control is needed, however with some of the older scanners it can take quite a long time to repeat scans since they usually only expect one SPR per patient and may require you to enter details as though another patient were about to be scanned. If the scanner has selectable filters, SPR mode may not be suitable for measuring all filters since there may only be one default filter used in SPR mode - you will have to check for your scanner.

A disadvantage of SPR mode is that the moving couch can interfere with stands holding the chamber, or the actual irradiation region (there is a little more flexibility if any head extensions on the couch are taken off), or lead to movement of the chamber if it is held on the moving couch. SPR mode also seems to be of more variable output, probably due to variation in exposure time.

b) Stationary tube axial scan (Engineer Mode)

There are, therefore, some advantages to having the tube and couch stationary for an irradiation ("stationary tube axial scan"). The irradiations can be carried out quickly, with delays only due to changing the position of the chamber. The site engineer may show you how to operate in this "enginner control" mode.

If the stationary tube mode is used, fix the tube at either 0, 90, 180, 270 degrees.

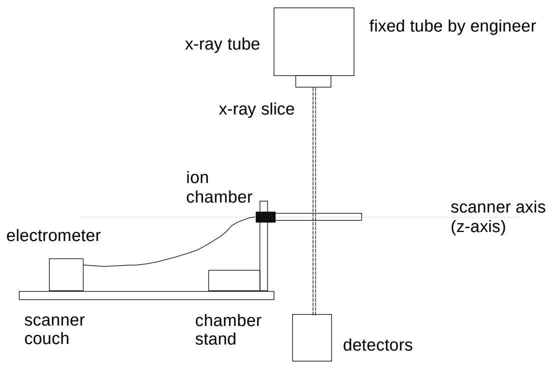


Figure 8. Chamber overhanging the table end.

2.2 Chamber Positioning

The chamber needs to be positioned on axis, and then off-axis (laterally or vertically) to measure the irrradiation from the thicker part of the beam shaping filter (figure 9).

To move the chamber laterally in its holder we recommend placing a board across the couch top. We have had a perspex jig made up to do this, though a flat board with a ruler taped to it can suffice. The same can be achieved with the chamber clamped independently of the couch, but it is much harder to maintain positional accuracy and alignment as the chamber is repositioned. To move the chamber up and down can be an easy option as it can be achieved using the couch movement, however couch movement is often limited so it is best to check the required range beforehand. A range of about 25cm off-axis is required for body fields of view.

The off-axis measurements are at set intervals - please report actual distances from axis, aiming to get within +/- 5mm of the nominal position - ie 4.5cm reported is just as acceptable as 5cm.

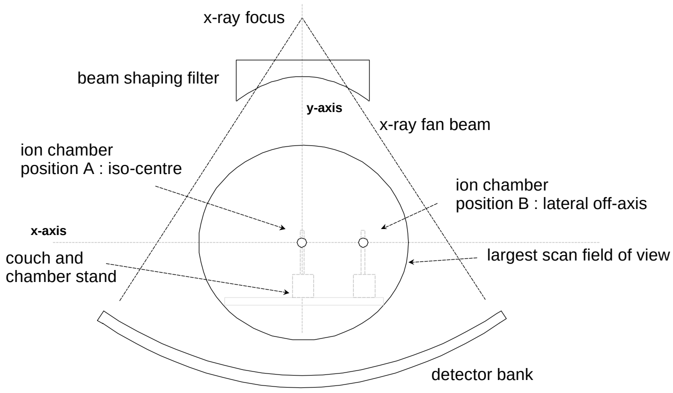


Figure 9. Showing transaxial off-axis positioning of the chamber.

2.3 Chamber Alignment

Follow the same procedure as for the CTDI in air, see page 10 (and pages 6-9).

- Mark the axis position, for example with masking tape on the board surface, for reference.

2.4 Finding the Centre of a Beam Shaping Filter

Where there is a beam shaping filter, measurements need to be obtained either side of the centre of the filter. This is to ensure that the maximum output, through the thinnest part of the beam shaping filter, has been measured, or can be estimated, to enable subsequent location of the centre of the beam shaping filter.

- Make exposure readings at the following positions from the estimated scanner axis: -2, -1, 0, 1, 2 cm (to enable the peak to be identified).
- Is the peak in the +/- 2cm range?

If not, then there may be a problem, so stop and investigate.

- Note that the zero "on-axis" position for all measurements is the on-axis position defined by the light alignment and imaging procedures as given above in section 2.3. All off-axis positions are to be referenced relative to this zero position.

  The exact centre position will be confirmed or estimated when the data is analysed, and the true off-axis positions will be recalculated at this stage.

2.5 MEASUREMENTS: In-air beam filter characterisation

Additional Equipment:

Board to span couch and position chamber off-axis, and ruler/tape measure.

Masking tape for position marking.

Phantom:

None

Chamber:

10cm 3cc CTDI chamber.

Position: In-air, free of couch (ie couch not irradiated), on and off-axis.

Alignment: See page 9.

Recommended: On flat board firmly fixed on couch.

Acceptable: Clamped independent of couch.

Acceptable: Clamped on couch, using vertical couch motion for positioning, if sufficient range available.

Scan Parameters:

All clinical scans with different beam shaping or flat filters.

Nominal "120"kV

Recommended Mode: Stationary tube axial scan

Acceptable Mode: SPR

If SPR: low speed, high mA, wide slice width.

If SPR: Scan length ~ 15cm, avoiding cable.

Measurements:

<u>No filter or flat filter:</u>

On-axis and at 5cm intervals , up to half maximum FOV off-axis.

<u>For Shaping Filters:</u>

-2, -1, On-axis, 1, 2, 5, and at 5cm intervals up to half maximum FOV off-axis.

Note: distances off-axis are nominal - please report actual distances, aiming to be within 5mm of nominal.

<u>For Asymmetric Beams.</u>

After finding the position for the chamber on-axis, measure exposure at half the maximum body field of view off-axis in order to find which side the beam extends furthest.

3. Half Value Layer

3.1 Methods and Position

The tube should be fixed at the bottom position as in Figure 10. This can be achieved with a stationary tube axial scan, or scanning with a PA SPR. The relative merits of the two modes are discussed in section 2.2. The chamber should extend beyond the couch top end, as in figure 8 page 13.

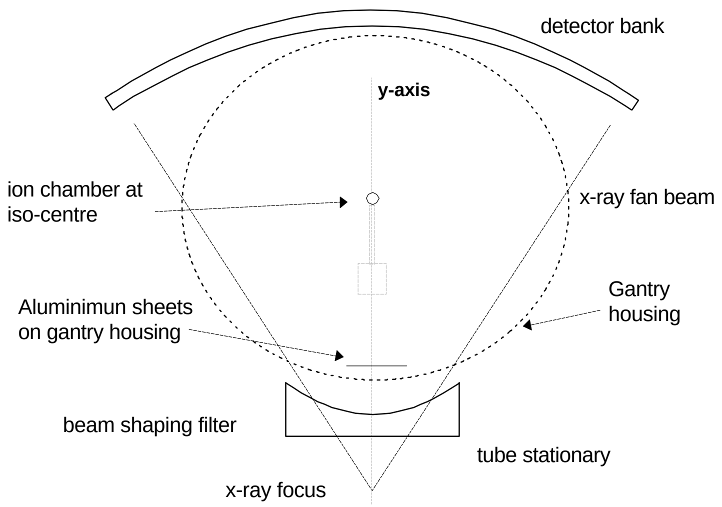


Figure 10. Schematic diagram for HVL measurement.

The 10cm CTDI chamber should be used, on axis.

If the SPR method is used then *the chamber must be clamped stationary* during the exposure - movement has the disadvantages of possible misalignment, but also introduces errors due to scatter once the SPR goes beyond the end of the chamber.

The 20 mm by 20 mm (2mm, 1mm and 0.5mm nominal thickness) Aluminium filters (99.5% pure) provided by ImPACT should be used, placed on the gantry over the exit beam.

Some scanners may not allow a PA SPR, so the Al must be positioned appropriately at the gantry top or sides for AP or lateral SPRs.

Record exposures as for standard HVL measurement, with one measurement each side of the HVL, and one final measurement at 20mm Al thickness.

At 120 kV we expect HVLs between 5 and 10mm.

3.2 Alignment Verification for HVL Measurements

The alignment procedure is slightly different than for the previous measurements (sections 1 and 2). The chamber is centred on the isocentre by use of the alignment lights and confirmation is given with axial scans. Using the fixed chamber mode as required above, the stationary chamber tilt and swivel are of little consequence here, so there is no need for a full SPR set up of the chamber as for the CTDI on-axis scan.

If there is a beam shaping filter then the alignment procedures described in section 2.4 (page 14, "Finding the Centre of a Beam Shaping Filter") should be followed to ensure that the HVL is being measured over the thinnest part of the filter - estimate the centre from the -2cm to +2cm off-axis measurements. If you have carried out the filter shape measurements already (section 2) you can use the filter centre position estimated there - as long as you use the same mode ie SPR or Stationary tube axial scan.

The chamber and aluminium must be aligned so that the chamber is over the centre of the projected shadow of the 20mm aluminium plates (or at most a few mm off-centre). In SPR mode this must be verified by imaging - change the display window to see the chamber and aluminium. If the tube is "engineer fixed" then alignment verification may be difficult - the alignment lights may not indicate the anterior-posterior line along which the tube has stopped. Alignment can be carried out with two sheets of lead to cut down the beam's transaxial spread and therefore find the focus-Al-chamber line by trial-and-error.

It may be useful to stick masking tape to the gantry to allow marking of the final position and subsequent repositioning of the Al sheets.

3.3 MEASUREMENTS: HVL

Additional Equipment:

Aluminium sheets (20 by 20mm), nominal thickness 2mm, 1mm, 0.5mm, 99.5% pure.

Two lead sheets may be required to verify positioning in the stationary tube.

axial scan mode.

Masking tape.

Phantom:

None. In-air.

Al sheets placed on the top surface of the bottom of the gantry over the exit beam.

Chamber:

10cm 3cc CTDI chamber.

Position: In-air, free of couch (ie couch not irradiated), on-axis.

Alignment: Page 17

Recommended: If SPR, clamped independent of couch.

It is Not Acceptable to have a moving chamber SPR mode (see methods above).

Scan Parameters:

Recommended Mode: Stationary tube axial scan.

Acceptable Mode: SPR

If SPR: low speed, high mA, wide slice width.

<u>BODY scans</u>

- "120" kV
- All other clinically used kVs

<u>Other Scan modes if Selectable Filters Available</u>

- "120" kV
- All other clinically used kVs

Measurements:

If beam shaping filters are used, find beam centre (see page 17), and position at maximum beam intensity.

On-axis in-air exposure readings, standard HVL procedures with measurements close either side of the HVL, and with a final measurement at 20mm Al thickness.

4. CTDI in Head Phantom

4.1 Methods

A 16cm diameter perspex CTDI head phantom is used (see Appendix A for schematic diagrams).

Place the phantom on the head rest.

We will compare the on-axis in-phantom CTDI measurements with the earlier in-air CTDI measurements (section 1), and it will avoid possible timing errors if the same scan time is used for all sets of measurements. A scan time of around 2s may be appropriate - check the scan times you used earlier.

Having positioned the phantom (see below) carry out single slice axial scans with the chamber in the positions in the head phantom as indicated in section 4.4. If the scanner has a Paediatric mode with a different beam shaping filter, it is appropriate to use the 16cm CTDI Head phantom as a paediatric body equivalent.

Some scanners have a small amount of overscan, others a significant amount which can be switched off. If overscan is selectable then do all measurements with overscan OFF. However this should not be a feature on head scans (except for one manufacturer). The large overscan is mainly used by three manufacturers and is usually for body scanning modes - see the scanner specific notes issued as additional information. If in doubt ask engineer about overscan on the model under investigation.

If you have a pair of in-air CTDI measurements with overscan ON and OFF then we will be able to simply calculate the CTDI in-phantom with overscan ON. If you have not recorded such a pair of measurements in-air, please repeat the phantom measurements to obtain a pair with overscan ON/OFF.

4.2 Head Phantom Positioning

The head phantom is positioned in the head rest used for normal scanning. This is the preferable approach. If the set-up is different (eg head phantom on couch or using a coronal head rest) please note on the data sheets.

4.3 Alignment of Head Phantom

A suggested alignment procedure is given on page 9.

The phantom should be aligned within the tolerances given in the alignment section, pages 6-9, and also given below. The distances, d_1 and d_2, are illustrated in figure 3 on page 7.

1. Swivel and tilt — *Tolerance = 2^o (d_1=5mm, d_2=5mm)*
2. Axial scan position — *Tolerance = 5mm.*
3. Lateral or vertical translation. — *Tolerance = 5mm.*
4. Phantom rotation. — *Tolerance = 2^o.*

It is important not to forget the visual check just prior to the measurements.

4.4 MEASUREMENTS: CTDI in HEAD Phantom

Additional Equipment:

Spirit level.

Phantom:

16cm diameter CTDI HEAD phantom.

Position the phantom in the usual head rest. Note if different set-up is used.

For alignment see methods 4.1

Chamber:

10cm 3cc CTDI chamber.

Position: In CTDI phantom, at Centre, and peripheral N, E, S, W positions.

Scan Parameters:

Axial scans Slice Width 10mm

Scan time: ~ 2s - Ideally same as CTDI in-air measurements, see section 1.

Scan Modes: HEAD, and any other scan modes with different filters applicable for Head field of view.

If there is a paediatric mode with a different filter, then use the 16cm CTDI Head phantom for measurements in this mode.

<u>HEAD scans</u>

- If overscan is selectable, switch OFF.
- Vary kV Chamber Centre Position
- "120"kV Chamber N, E, S & W positions
- Other kVs Chamber W only

Measurements:

Exposure readings from 10cm CTDI chamber under conditions set out above.

5. CTDI in Body Phantom

5.1 Methods

A 32cm diameter CTDI body phantom is used. See Appendix A for schematic diagram.

We will compare the on-axis in-phantom CTDI measurements with the earlier in-air CTDI measurements (section 1), and it will avoid possible timing errors if the same scan time is used for all sets of measurements. A scan time of around 2s may be appropriate - check the scan times you used earlier.

Place phantom on the couch.

Having positioned the phantom (see below) carry out single slice axial scans for chamber in slot positions in the body phantom, as indicated in 5.4.

Some scanners have a small amount of overscan, others a significant amount which can be switched off. If overscan is selectable then do all measurements with overscan OFF. The large overscan is mainly used by three manufacturers and is usually for body scanning modes - see the scanner specific notes issued as additional information. If in doubt ask engineer about overscan on the model under investigation.

If you have a pair of in-air CTDI measurements with overscan ON and OFF then we will be able to simply calculate the CTDI in-phantom with overscan ON. If you have not recorded such a pair of measurements in-air, please repeat the phantom measurements to obtain a pair with overscan ON/OFF.

5.2 Body Phantom Positioning

The body phantom is positioned on the couch. This is the preferable approach. It can be tricky sometimes to balance on the couch mattress so if the set-up is different (eg different, or no, mattress) please note on the data sheets.

5.3 Alignment of Body Phantom

A suggested alignment procedure is given on page 9.

The phantom should be aligned within the tolerances given in the alignment section, pages 6-9, and also given below. The distances, d_1 and d_2, are illustrated in figure 3 on page 7.

1. Swivel and tilt — *Tolerance = 2^o (d_1=5mm, d_2=11mm)*
2. Axial scan position — *Tolerance = 5mm.*
3. Lateral or vertical translation. — *Tolerance = 5mm.*
4. Phantom rotation. — *Tolerance = 2^o.*

It is important not to forget the visual check just prior to the measurements.

5.4 MEASUREMENTS: CTDI in BODY Phantom

Additional Equipment:

Spirit level.

Phantom:

32cm diameter CTDI BODY phantom.

Position the phantom on the couch.
(Note any differences from clincial situation (eg different, or no mattress).

For alignment see methods 5.1

Chamber:

10cm 3cc CTDI chamber.

Position: In CTDI phantom, at Centre, and peripheral N, E, S, W positions.

Scan Parameters:

Axial scans: Slice Width 10mm

Scan time: ~ 2s Ideally same as for CTDI in-air measurements (section 1).

Scan Modes: BODY, and any other scan modes with different filters applicable for Body field of view.

<u>BODY scans</u>

- If overscan is selectable, switch OFF.
- Vary kV   Chamber Centre Position
- "120"kV   Chamber N, E, S & W positions
- Other kVs   Chamber W only

Measurements:

Exposure readings from 10cm CTDI chamber under conditions set out above.

6. Additional Measurements

These SPR measurements would be of use for comparing protocols for pelvimetry examinations, whilst the CTDI measurements free of couch or over couch will characterise the range of couch effects on CTDI.

6.1 SPR Measurements in 16cm CTDI Head Phantom

Phantom Position

Phantom centred on-axis.

Measurements:

(i)entrance dose for PA SPR, measured with chamber in top peripheral (N) position nearest entry beam (or W/E position if L/R lateral SPR):

Typical couch speed and slice width using different kV's.

(ii)centre : chamber in centre position, and chamber on axis.

Same set-up conditions as for entrance measurements.

6.2 SPR Measurements in 32cm CTDI Body Phantom

Phantom Position

Phantom centred on-axis.

Measurements:

(i)entrance dose for PA SPR, measured with chamber in top peripheral (N) position nearest entry beam (or W/E position if L/R lateral SPR):

Typical couch speed and slice width, using different kV's

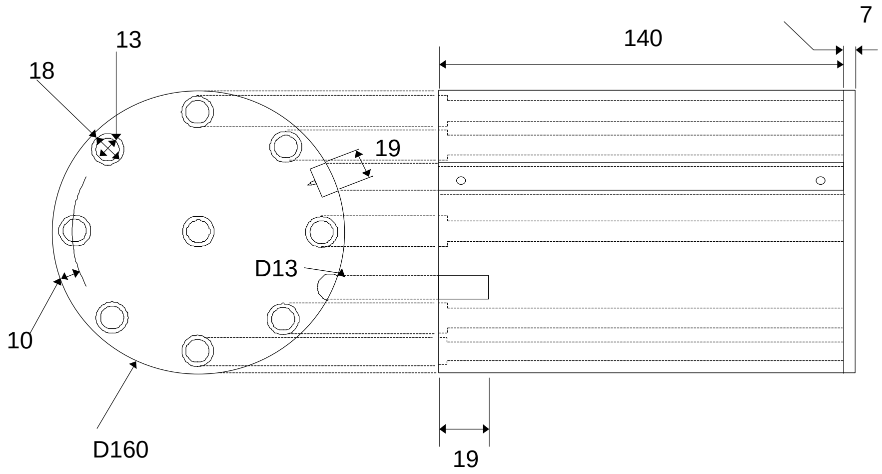
(ii)centre : chamber in centre position, and on-axis.

Same set-up conditions as for entrance measurements.

6.3 CTDI Measurements In-Air: over the couch and away from the couch

The effect of the couch on CTDI in-air values is of interest. Please measure CTDI in-air free of the couch as in section 1 of this protocol, and then repeat with the chamber over the couch. Please position the couch 8cm below the on-axis chamber

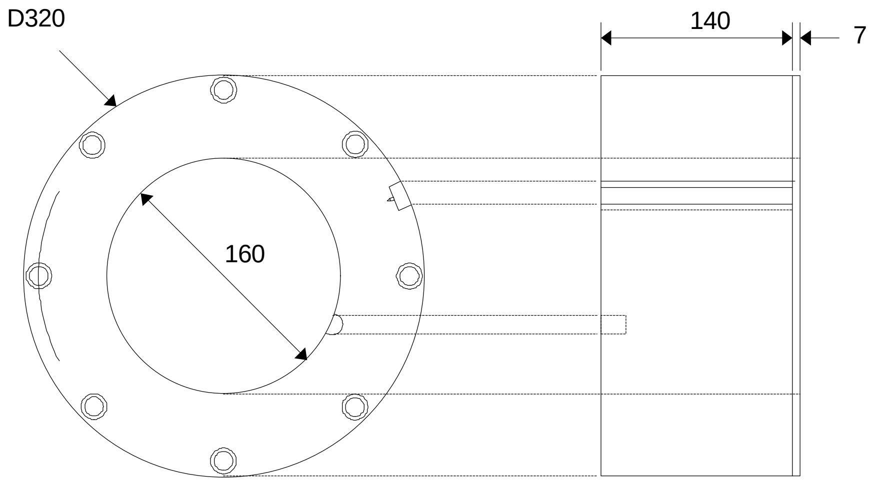
APPENDIX A: CTDI Head and Body Phantoms (with Inserts)



All measurements in mm

Key: D - Diameter

Figure 11. Perspex Head Phantom for CTDI$_{CDRH}$ Measurements.
Based on CDRH (FDA) definitions with modifications.



All measurements in mm

Key: D = diameter

Figure 12. Perspex Body Phantom for CTDI$_{CDRH}$ measurements. (Annulus that fits over head phantom.)
Based on CDRH (FDA) definitions with modifications.

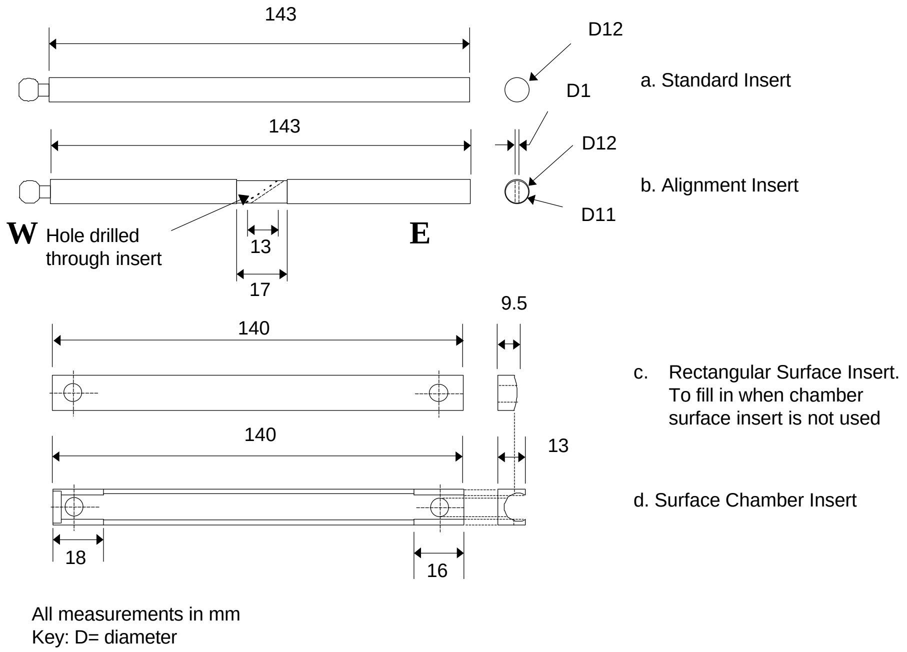


Figure 13. Inserts for Perspex Phantoms for CTDI Measurements.
Based on CDRH (FDA) definitions with additional modifications
(Alignment inserts from ImPACT's phantom set).

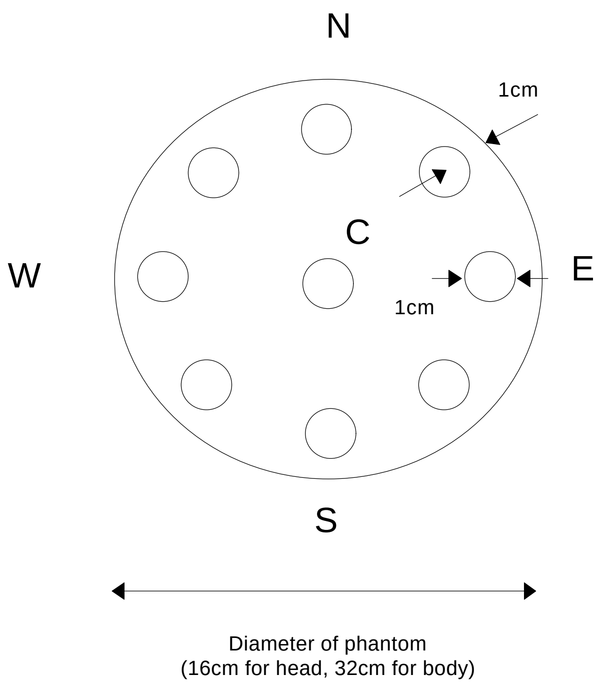


Figure 14. Chamber Positions in the CTDI phantoms.
As viewed into gantry from console, or table foot.

APPENDIX B: Alignment: 'Tilt' and 'Swivel'

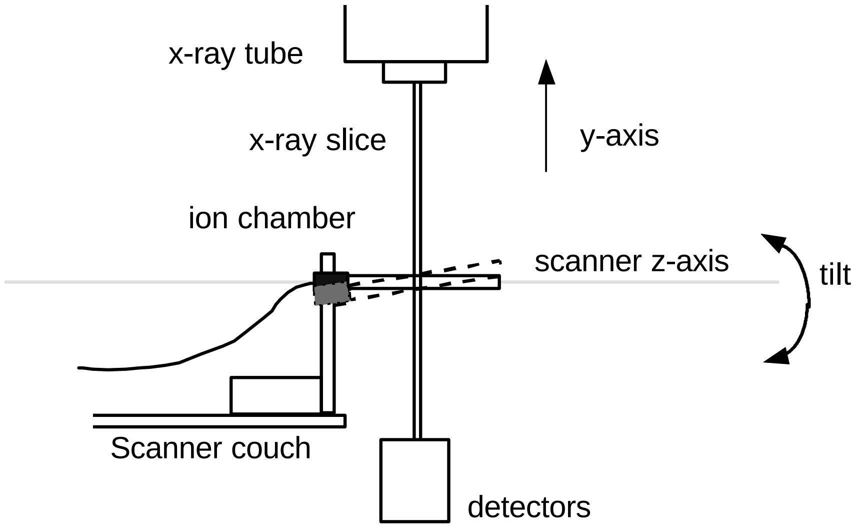


Figure 15. Chamber Tilt, Lateral View.

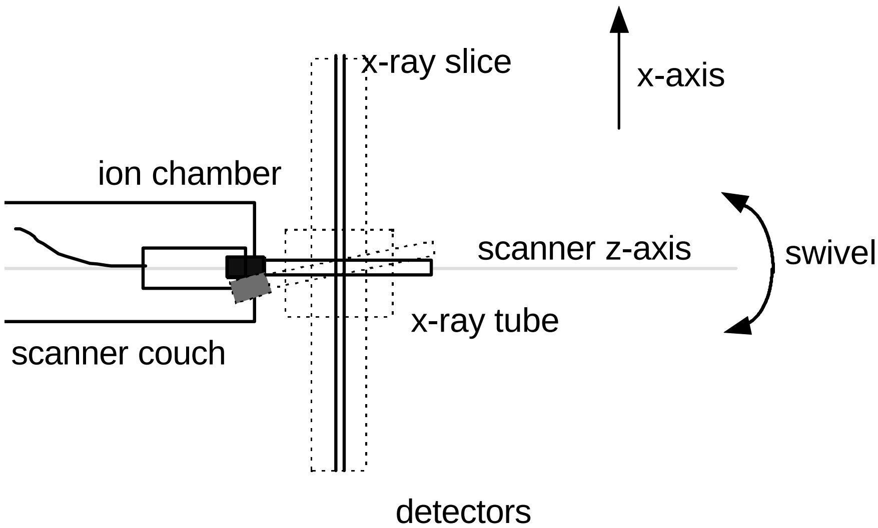


Figure 16. Chamber Swivel, Plan View.