Explanatory Notes for Version 14 of the target CNR calculator

Target CNR Calculator Version 14

Changes to all of the calculated values of the equivalent attenuation coefficient for gold. The tube voltage range has been extended for several anode/filter combinations. The modelling of the processing has been improved.

The x-ray spectra have been taken from Hernandez et al.[6], rather than IPEM Spectra generator

HVL data from NHSBSP reports. The calculated spectra is adjusted to give this nominal HVL by adjusting thickness of filter, previously aluminium had been added or ‘subtracted’.

The thickness of the objects assumed to be in the beam:

* Paddle: 2.4 mm thick polycarbonate
* Breast support: 1.2 mm thick carbon fibre
* Air: 600mm thick
* 0.5 mm thick Beryllium in addition to that stated in Hernandez
* 40 mm thick PMMA
* CDMAM phantom: 3 mm PMMA and 0.5 mm Al

Quantum detection efficiency and energy absorption efficiency has been estimated Oliver Diaz using Monte Carlo for a-Se and CsI detectors for Mackenzie et al [**7**]. Previously a simpler version of estimating absorption was used and only for CsI.

The calculations were undertaken in matlab rather than excel, so it was simple to extend the calculations to other tube voltages.

Expanded kV range for W/Rh and W/Ag.

Some of the percentage differences between V13 and V14 are above 10%, but the reality is that the final results are only slightly affected.

**Updated by Alistair Mackenzie, 31st May 2022**

Target CNR Calculator Version 13

Only formatting changes were made.

Target CNR Calculator Version 12

The only change to version 12 from Version 11 is that effective attenuation coefficients for gold discs in the CDMAM are now provided for the target/filter combination of Rh/Ag from 25 to 34 kV as used in the GE Pristina system.

Target CNR Calculator Version 11

In order to apply the standards in the European protocol1,2, it is necessary to relate the image quality measured using the CDMAM for an equivalent breast thickness of 60mm, to that for other breast thicknesses using contrast-to-noise (CNR) measurements. CNR is sometimes referred to as signal difference to noise ratio (SDNR). The method of measuring CNR in the NHSBSP protocol3 is the same as that described in the European protocol. The European protocol gives the relationship between threshold contrast and CNR measurements. This enables the calculation of a target CNR value for a particular level of image quality on a particular mammography system, which can be compared to CNR measurements made at other breast thicknesses. A spreadsheet is provided here to enable this task. The contrast for a particular gold thickness is calculated using Equation 1, and the target CNR is calculated using Equation 2.

$Contrast=1-e^{-μt}$ (1)

where µ is the effective attenuation coefficient for gold, and t is the gold thickness.

$CNR\_{target}=\frac{CNR\_{measured} × TC\_{measured}}{TC\_{target}}$ (2)

where *CNRmeasured* is the CNR for a 60 mm equivalent breast (simulated using a 50 mm thickness of PMMA), *TCmeasured* is the threshold contrast calculated using the threshold gold thickness for a 0.1 mm diameter detail, as measured using the CDMAM at the same dose as used for *CNRmeasured*, and *TCtarget* is the calculated threshold contrast corresponding to the threshold gold thickness required to meet either the minimum acceptable or achievable level of image quality as defined in the UK standard.

This calculation is carried out using the 0.1mm detail threshold gold thickness because this detail size is generally regarded as the most critical of the detail diameters for which performance standards are set.

The effective attenuation coefficient for gold used in Equation 1 depends on the beam quality used for the exposure, and is selected from a table of values in the spreadsheet. These values were calculated by DR Dance and KC Young with 3mm PMMA representing the compression paddle, using spectra from Boone et al4 and attenuation coefficients for materials in the test objects (aluminium, gold, PMMA) from Berger et al5.

***Dose correction***

In version 11 of this spreadsheet I have added a modification to provide a dose correction should the mAs used to expose the PMMA slabs for the CNR measurement be different from that used for the CDMAM exposures. This typically arises if one exposure is manually selected and the other is selected by the AEC. In this case the CNR measured is corrected to what it would have been at the exposure used for the CDMAM using equation 3. This assumes that the CNR is proportional to the square root of the dose and this will be approximately true where quantum noise dominates and for moderate dose differences. Thus equation 2 now becomes equation 4.

$CNR\_{corrected}=CNR\_{measured} x \left(\frac{mAs\_{CDMAM}}{mAs\_{PMMA}}\right)^{0.5}$ (3)

$CNR\_{target}=\frac{CNR\_{corrected} × TC\_{measured}}{TC\_{target}}$ (4)

**Prepared by Ken Young at NCCPM on 28th March 2017.**

REFERENCES

1. Van Engen R, Young KC, Bosmans H, et al. The European protocol for the quality control of the physical and technical aspects of mammography screening. In: *European Guidelines for Quality Assurance in Breast Cancer Screening and Diagnosis*, 4th Edition, Luxembourg: European Commission, 2006.
2. van Engen R, Bosmans H, Dance D et al. Digital mammography update: European protocol for the quality control of the physical and technical aspects of mammography screening. In: *European guidelines for quality assurance in breast cancer screening and diagnosis,* Fourth edition – Supplements. Luxembourg: European Commission, 2013.
3. Workman A, Castellano I, Kulama E et al. *Commissioning and Routine Testing of Full Field Digital Mammography Systems* (NHSBSP Equipment Report 0604)*.* Sheffield: NHS Cancer Screening Programmes, 2006.
4. Boone JM, Fewell TR and Jennings RJ. Molybdenum, rhodium and tungsten anode spectral models using interpolating polynomials with application to mammography *Medical Physics,* 1997, 24: 1863-1974.
5. Berger MJ, Hubbell JH, Seltzer SM Chang et al. XCOM: Photon Cross Section Database (version 1.3) <http://physics.nist.gov/xcom> (Gaithersburg, MD, National Institute of Standards and Technology), 2005.
6. Hernandez AM, Seibert JA, Nosratieh A, Boone JM. Generation and analysis of clinically relevant breast imaging x-ray spectra. Medical Physics. 2017 Jun;44(6):2148–60.
7. Mackenzie A, Dance DR, Diaz O, Young KC. Image simulation and a model of noise power spectra across a range of mammographic beam qualities. Medical physics. 2014;41(12):121901.