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LETTER TO THE EDITOR

Reply to 'On the p_{dis} correction factor for cylindrical chambers'

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Abstract
In this letter we reply to the letter by Professor Andreo (Andreo 2010 *Phys. Med. Biol.* **55** L9–16) regarding the values of the replacement correction factor for cylindrical chambers, which in turn commented on our recent paper on this (Wang and Rogers 2009 *Phys. Med. Biol.* **54** 1609–20).

We thank Professor Andreo for drawing attention (Andreo 2010) to the implications of the results in our recent paper regarding the values of the replacement correction factor (Wang and Rogers 2009c). We are particularly pleased that he uses our calculated values and has created two figures based on them, thereby suggesting acceptance of these values (although he later appears to question them). We suggest, however, that he has misrepresented our statement that 'the difference in the replacement correction factors can lead to a calibration deviation of more than 0.5% for Farmer-like chambers in high-energy photon beams', since he quotes it twice without the qualifying 'in high-energy photon beams' which in context of our figure 5 was clearly referring to beams with $\%dd(10)_x$ values more than 80% or TPR_{10}^{20} values more than 0.77. We grant that one might misinterpret this in the sense that, in other contexts, we use the phrase to mean all accelerator photon beams, but in the context of our figure 5, there can be no ambiguity about our meaning. We encourage the interested reader to review the text of our actual paper when considering Andreo's comments. In particular, his two graphs confirm our statement (when quoted in full) except that he finds that the deviation for Farmer chambers is only 0.4% at high energies. The 0.4% value is based on using fits to the raw data which (a) are fits with a stated uncertainty of 0.1% (Wang and Rogers 2009c) and (b) utilize a conversion from $\%dd(10)_x$ to TPR_{10}^{20} (Kalach and Rogers 2003). In contrast the 0.5% value comes from the more accurate raw data in the original figure 5.

In addition to requesting interested parties to read our original paper while considering Andreo's criticisms, there are three issues we wish to discuss.

Andreo faults our work for not modelling the full chamber in detail. However, the experiments of Johansson *et al* (1978) were done with very simple ion chambers and in our

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paper we clearly pointed out that we had considered the effect of the 50 μm graphite coating, which corresponds to a detailed model in this case, and using this detailed model had a negligible effect on our results. In general, it is correct to state that one must model an ion chamber in detail when making direct comparisons to experiment. Our group has made this point elsewhere (see, e.g., figure 9 of La Russa *et al* (2007)). This is also true when comparing calculated and measured values of the effective point of measurement and we have explicitly done so for NE2571 and NACP chambers in Wang and Rogers (2009b). However, when calculating correction factors for use in the TG-51 protocol or TRS-398 Code of Practice, this is not the case since the replacement correction factor (P_{repl} or $p_{\mathrm{dis}}\,p_{\mathrm{cav}}$ in IAEA terminology) refers to the effects of only the ion chamber's air cavity. The effects of the walls, insulators and central electrodes are taken care of separately. The corrections are not independent and the definitions must be internally consistent as discussed regarding figure 5-1 in Seuntjens and Rogers (2009). Thus, Andreo's concern that we were only modelling the air cavity is beside the point since modelling just the air cavity corresponds to how the replacement correction is defined and used by both TG-51 and TRS-398.

Andreo points out the consistency between doses determined in electron beams by either direct calibrations using primary standards for electron beams or based on calibration of cylindrical chambers in a ^{60}Co beam followed by application of TRS-398. He then argues that the P_{repl} value for ^{60}Co 'is not likely to be in error by 1%' because it is one of the corrections used in achieving the observed agreement. This argument is negated by two important factors. The first is that in their experiment, the calibration coefficients in ^{60}Co and electron beams have been obtained from two different primary standards laboratories, and thus the ratio of calibration coefficients based on the primary standards in two such different beam qualities may well be uncertain by a large fraction of 1% (there was no uncertainty analysis in the extended abstract quoted by Andreo and a full paper was not in the published proceedings). More critically, to make the comparison Andreo refers to also requires the value of the P_{fl} component of P_{repl} for cylindrical chambers in electron beams (p_{cav} in the IAEA's notation). In a recent paper we have shown that the P_{fl} values for a Farmer-like chamber are low in both TG-51 and TRS-398 by roughly 1% (see figure 7 in Wang and Rogers (2009a)). In other words, Andreo's argument that a change in the ^{60}Co value of P_{repl} would be inconsistent with the observed agreement is incorrect because the change in P_{fl} in the electron beam will compensate for the change in the ^{60}Co value of P_{repl} and leave the observed agreement. Thus, if one could ignore the uncertainty due to the calibration coefficients, the observed agreement is a further confirmation of our calculations.

Although there are many other issues we disagree with in Andreo's letter we would like to clarify just one other point. We did not mean to imply that the seminal work of Johansson *et al* (1978) was anything less than a masterpiece. Much of modern dosimetry can be traced to the many exquisite experiments and ideas presented in that paper, and the fact that one assumption, which has survived unchallenged for 32 years, has now been shown to be invalid, does not reduce one's appreciation for that paper. We do however apologize for mistakenly giving the year of publication (1978) as the year of the meeting (1977).

We thank PMB for requesting that we provide a response to Professor Andreo's comments so we could clarify various issues. In particular, it allows us to point out that, contrary to what Andreo has suggested, the change in P_{repl} in ^{60}Co beams will not affect electron beam dosimetry dramatically because of the compensating changes required for P_{repl} in electron beams. We do agree with Andreo that our new values of P_{repl}, despite being substantially different from the values used in TRS-398, will have little effect on the final dose values produced using TRS-398 for photon beams, except for the highest energy beams, and figure 5 in our paper made exactly that point.

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