# Status report on the NMi portable water calorimeter

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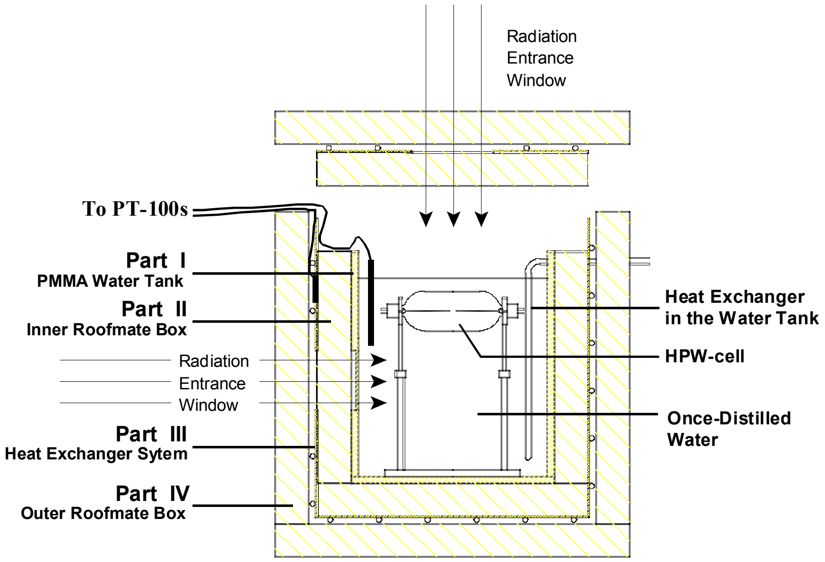
The design of the water calorimeter is based on the sealed-water calorimeter of Domen (NIST). The water calorimeter consists of a computer-controlled water-cooled thermostat surrounding a high-purity water cell, which contains two thermistor probes. The temperature rise due to irradiation by high-energy photons is measured inside a volume of water enclosed by a sealed, thin-walled glass vessel. The quality of the water is carefully controlled by preparing the water before filling the glass vessel. This is achieved by purifying the water, and by saturating it with selected gasses.The water calorimeter is compact and transportable, weighing 60 kg when empty, and having outer dimensions of only 60x60x70 $cm^3$. The dimensions of the water phantom are standard 30x30x30 $cm^3$. A small spacing between the inner and outer polystyrene foam insulation boxes encloses a copper heat exchange system. The six copper walls are connected in a parallel manner, which helps to reduce temperature gradients inside the water phantom. Cooling is performed by a computer-controlled Lauda RC6 CP water-cooling thermostat, which uses two PT100 thermometers (one mounted on one of the copper walls and one mounted inside the water phantom) to control and monitor the calorimeter temperature. A built-in magnetic stirrer enables a reduction of temperature drifts due to conduction in between irradiation runs. A cold finger placed inside the water phantom can be switched into the cooling circuit to reduce the time needed to cool down from room temperature to 4 $^{o}$C.
The NMi water calorimeter can be used in both horizontal and vertical beams. A schematic drawing of the NMi water calorimeter is given in the figure below.

The calorimeter is equipped with an electrical measurement assembly comprising of two AC-Wheatstone bridges in combination with two lock-in amplifiers. The calorimeter has extensively been tested in the $^{60}$Co gamma



beam of NMi, in clinical photon beams of the Dutch Cancer Institute (NKI) and in the high energy photon beams of the Saturne 43 linear accelerator of BNM-LNHB. Various correction factors of the water calorimeter as a function of photon energy have been determined experimentally and with the use of a computer program to simulate heat transport. Further test measurements were carried out in clinical photon beams in several Belgian hospitals and at NKI with the water calorimeter using high precision digital multimeters (DMM) as read-out devices for the determination of the resistance changes of the thermistors during irradiation. The DMM method has several advantages compared to the Wheatstone circuit. The results of these measurements will be reported at a forthcoming workshop on absorbed dose standards (Absdos 2003) later this year. In December 2002 the water calorimeter has been compared with the graphite calorimeter of NMi for $^{60}$Co gamma radiation. To convert the dose to graphite measured with the graphite calorimeter to dose to water the fluence scaling theorem is used. The preliminary result expressed as the ratio of absorbed dose to water determined with the water calorimeter and with the graphite calorimeter respectively is 1.0003 +/- 0.44%. The portable water calorimeter is part of an extensive measurement program to determine $k_Q$ factors in representative clinical high-energy photon beams of different medical linear accelerators at 9 selected radiotherapy institutes in Belgium and The Netherlands (REDORA project). The results will be used to tabulate measured $k_Q$ factors for photon radiation in the new NCS Codes of Practice for the determination af absorbed dose to water in high-energy photon and electron beams, which are currently being drafted.

## References

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[2] A.H.L. Aalbers et al., Clinical Reference Dosimetry for High-Energy Photon and Electron Beams: Revision of the NCS Codes of Practice, Klinische Fysica 2002 vol. 2+3, pp. 6-9

[3] M.W.H. Pieksma, L.A. de Prez, E. van Dijk, A.H.L. Aalbers, Measurements of $k_Q$ beam quality correction factors for the NE2611A chamber in high-energy photon beams using the NMi water calorimeter IAEA-CN-96-7 (2002)