

**SPECIFICATION for 3D Scanning Water Phantom for Radiotherapy Dosimetry
compatible with a Varian TrueBeam and Halcyon****1. Scope**

- 1.1. This specification describes the requirements for a 3D scanning water phantom (hereinafter referred to as “the System”) to be installed at Ocean Road Cancer Institute (ORCI), Tanzania (hereinafter referred to as “the End-User”).
- 1.2. The procurement of this equipment is related to the IAEA TC project URT6034 “Expanding and Improving Radiotherapy and Nuclear Medicine Services Phase II.”

2. Applicable Documents

The following documents shall be applicable for this Specification to the extent specified hereinafter:

- 2.1. International Atomic Energy Agency. (2004). Commissioning and quality assurance of computerized planning systems for radiation treatment of cancer (IAEA Technical Reports Series No. 430). IAEA.
- 2.2. International Atomic Energy Agency. (2007). Specification and acceptance testing of radiotherapy treatment planning systems (IAEA TECDOC-1540). IAEA.
- 2.3. International Atomic Energy Agency. (2008). Commissioning of radiotherapy treatment planning systems: Testing for typical external beam treatment techniques (IAEA TECDOC-1583). IAEA.
- 2.4. International Atomic Energy Agency. (2017). Dosimetry of small static fields used in external beam radiotherapy (IAEA Technical Reports Series No. 483). IAEA.
- 2.5. International Atomic Energy Agency. (2024). Absorbed dose determination in external beam radiotherapy: An international code of practice for dosimetry based on standards of absorbed dose to water (IAEA Technical Reports Series No. 398, Rev. 1). IAEA.
- 2.6. International Electrotechnical Commission. (2011). Radiotherapy equipment - Coordinates, movements and scales (IEC 61217:2011, 2nd ed.). IEC.
- 2.7. International Electrotechnical Commission. (2016). Medical electrical equipment - Dosimeters with ionization chambers as used in radiotherapy (IEC 60731:2011 + AMD1:2016, Ed. 3.1). IEC.
- 2.8. International Organization for Standardization. (2017). Health informatics - Digital imaging and communication in medicine (DICOM) including workflow and data management (ISO 12052:2017, 2nd ed.). ISO.

In the event of conflict between the documents listed above and the content of this Specification, the content of this Specification shall take precedence to the extent of the conflict.

3. Definitions, Acronyms, and Abbreviations

The following definitions, acronyms, and abbreviations shall apply throughout this Specification unless defined otherwise hereinafter:

- 3.1. PDD: Percent Depth Dose
- 3.2. TMR: Tissue Maximum



3.3. Ratio TPR: Tissue Phantom

3.4. Ratio SSD: Source Surface Distance

4. Requirements

4.1. Functional and Performance Requirements

The System shall include the following equipment and functionality:

- 4.1.1. A portable water tank, reservoir, lift table, controller, dual-channel electrometer, detectors, software and computer capable of automated measurement of relative beam dosimetry, suitable for Varian TrueBeam and Halcyon linacs.
- 4.1.2. The relevant software and license for the generation of beam data file, suitable for export to the defined treatment planning system.

4.2. Technical Requirements

The System shall meet the following technical requirements:

- 4.2.1. Acrylic scanning water phantom providing a minimum effective scanning volume of 480 mm × 480 mm × 400 mm (X, Y and Z axes). The complete phantom assembly shall be compatible with Varian TrueBeam and Halcyon linear accelerators and shall permit acquisition of percentage depth dose (PDD), beam profiles, output factor and beam quality measurements over the specified scanning volume.
- 4.2.2. Detector position accuracy shall be ± 0.1 mm or better and detector position reproducibility shall be ± 0.1 mm or better in all axes. Position resolution shall be 0.1 mm or better. The system shall support both continuous and stepwise acquisition modes.
- 4.2.3. Water tank with motorized three-dimensional scanning capability allowing automated acquisition of depth-dose curves, in-plane profiles, cross-plane profiles, diagonal profiles and user-defined scan trajectories. The system shall support simultaneous use of scanning and reference detectors.
- 4.2.4. Automated acquisition, calculation and analysis of PDD, TPR_{20/10}, TPR and TMR measurements.
- 4.2.5. Computer-controlled reservoir pump, water level sensor and lift table with a minimum vertical travel range of 500 mm for automated TPR/TMR measurements. The lift table shall safely support the fully filled scanning tank and associated accessories.
- 4.2.6. Provision for levelling and alignment of the scanning mechanism, including suitable adjustment devices and alignment procedures to ensure detector positioning accuracy within the specified tolerance.
- 4.2.7. The control unit that controls the movement of the ion chambers in XYZ direction and acquires detector data from the electrometer.
- 4.2.8. A transportable water reservoir with a minimum storage volume of 100 litres and equipped with bidirectional pump and hose assembly. Filling and draining of the scanning tank shall be controlled through the system software.
- 4.2.9. In case of 80 cm SAD Co-60 unit, reservoir shall be separate from water tank for easy positioning.
- 4.2.10. One portable laptop computer with Windows operating system with connectivity to the control unit.
- 4.2.11. Connector cable(s) (Minimum 20 m) between the computer (with required interface and software driver) and the controller and water tank.
- 4.2.12. Equipment for dosimetry
 - 4.2.12.1. A dual electrometer and control unit with bias range: 0 through ± 400 V,



minimum resolution of 10 fA, and leakage current < 250 fA; with TNC connector;

- 4.2.12.2. Two (2) waterproof type calibrated (NDW Co-60) ionization chambers (Active volume approximately 0.13 cm³) for relative dosimetry with holders for scanning and reference chambers.
- 4.2.12.3. Two (2) cables compatible with ionization chamber detectors and dual electrometer; and
- 4.2.12.4. One (1) spare cable equivalent to the above.
- 4.2.13. Software with one perpetual license for beam data acquisition, scan optimization, detector correction, data analysis and beam modelling support. The software shall provide variable scan speed and resolution settings, profile analysis, beam quality analysis, symmetry and flatness analysis, scan merging, smoothing and reporting functions.
- 4.2.14. The software shall allow export of beam profile data, depth-dose data and processed beam data in text and spreadsheet-compatible formats suitable for Microsoft Excel or equivalent applications;
- 4.2.15. The software shall support export of beam data in formats accepted by Varian Eclipse Treatment Planning System and other compatible treatment planning systems. The vendor shall demonstrate successful export of representative commissioning data during acceptance testing;
- 4.2.16. The software shall support beam data analysis and reporting according to internationally recognized dosimetry protocols and recommendations, including:
 - 4.2.16.1. IAEA TRS398;
 - 4.2.16.2. AEA TRS-483, where applicable;
 - 4.2.16.3. AAPM-TG51;
 - 4.2.16.4. IEC 60976;
 - 4.2.16.5. Relevant IPEM recommendations, where applicable.
- 4.2.17. Software shall include:
 - 4.2.17.1. Generation of TMR and TPR data from measured PDD data;
 - 4.2.17.2. Data processing, visualization, analysis and report generation tools for beam commissioning measurements;
 - 4.2.17.3. Film calibration and analysis functionality, if available.

5. Marking

The System shall have all safety markings in English.

6. Packing

The System, for shipment to the User, shall be packed in accordance with international standards that are applicable for the shipment by air/road of this kind of equipment.

7. Quality Requirements

- 7.1. The System shall be manufactured, packed and installed in accordance with the Contractor's ISO quality assurance system or an equivalent quality assurance system.
- 7.2. The Contractor shall document the compliance with this quality assurance system.

8. Acceptance Testing

- 8.1. The System, prior to shipment, shall be tested for conformance of the System with manufacturer's performance specifications and the minimum requirements specified herein.
- 8.2. The System, after installation, shall be tested by the Contractor together with the End-User to demonstrate that the performance meets the manufacturer's performance specifications

and the minimum requirements specified herein.

8.3. The acceptance test shall demonstrate compliance with the following minimum performance requirements:

- 8.3.1. Detector positioning accuracy: ± 0.1 mm or better.
- 8.3.2. Detector positioning reproducibility: ± 0.1 mm or better;
- 8.3.3. Electrometer leakage current: less than 250 fA;
- 8.3.4. Successful operation of automated filling and draining functions;
- 8.3.5. Successful acquisition of PDD, profile and TPR/TMR measurements;
- 8.3.6. Successful export of commissioning data to Treatment Planning System;
- 8.3.7. Demonstrated capability to acquire PDD, profile and beam quality measurements on the installed treatment unit in accordance with the manufacturer's specifications.

8.4. The results of the testing shall be documented by the Contractor in an acceptance protocol that shall be signed by the End-User.

9. Installation and Training

9.1. The Contractor shall install the System at the End-User's location

9.2. The Contractor shall provide a minimum of two (2) days of on-site application training for up to three (3) End-User staff. Training shall include system setup, detector installation, beam data acquisition, beam data analysis, TPS export and routine maintenance procedures.

10. Warranty

The Contractor shall provide a minimum warranty period of twenty-four (24) months commencing upon acceptance of the System. The warranty shall include replacement of defective parts, labour, software updates necessary for operation of the System and technical support.

11. Deliverable Data Items

The Contractor shall provide two (2) complete sets of operation manuals in English.
