Efficacy Analysis of 1-Dimensional Water Tank for Clinical Physicist Practice

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ABSTRACT

Purpose: One-dimensional (1D) water tanks are widely used in clinical practice due to their efficiency and reduced setup complexity; however, measurement accuracy can be influenced by operational parameters selected during data acquisition. This study presents an efficacy-focused process analysis of a 1D water tank system, emphasizing the clinical impact of parameter selection on workflow efficiency and dosimetric accuracy.
Methods: A Sun Nuclear 1D water tank system was evaluated with emphasis on tank setup, water filling workflow, and PDD measurement procedures. Water filling was performed using a Venturi-effect-based apparatus derived from Bernoulli's principle, designed to minimize physical effort and setup time. Following tank filling to approximately 30 cm depth, automated water surface detection was used to establish a 100 cm source-to-surface distance. A measurement chamber and reference chamber were connected to a PC Electrometer, with motion and data acquisition controlled via the manufacturer's software. PDD scans were acquired for a 10 × 10 cm^2 Field while varying chamber motion speeds and data Filtering parameters.
Results: Procedure demonstrated that the Venturi-based filling approach reduced operator travel and physical workload by approximately an order of magnitude, improving procedural efficiency and safety. During PDD acquisition, chamber motion speed was identified as a critical parameter affecting dosimetric accuracy. Variations in scan speed from 0.1 mm/s to 2.0 mm/s produced shifts of up to 4 mm in the depth of maximum dose, highlighting the sensitivity of PDD measurements to temporal acquisition settings.
Conclusion: The 1D water tank provides an efficient and clinically practical solution for routine QA when appropriate scan parameters are selected. Optimization of chamber motion speed is essential to balance measurement efficiency and dosimetric precision. Future investigations should incorporate chamber volume effects, reference signal noise, and additional system variables to further standardize operational procedures and support robust clinical QA implementation.

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INTRODUCTION

Modern radiotherapy treatment planning relies on accurate dosimetric measurements, including percent depth dose (PDD), beam profiles, and output factors. These measurements are typically obtained during commissioning and verified periodically to ensure the consistency and stability of beam generation.
While three-dimensional water tank systems remain the gold standard for comprehensive beam data acquisition, one-dimensional (1D) water tank systems offer practical advantages for routine quality assurance (QA), including reduced setup complexity, improved workflow efficiency, and lower physical demand on operators.
However, the accuracy of measurements obtained using 1D systems depends strongly on the selection of acquisition parameters. In particular, scan speed and temporal sampling characteristics can influence the fidelity of measured PDD curves. The finite temporal response of ionization chambers introduces potential distortion during dynamic acquisition, especially in regions with steep dose gradients such as the buildup region.
Despite its clinical relevance, the relationship between scan speed and dosimetric accuracy has not been fully quantified in routine QA workflows. This study aims to evaluate the efficacy of a 1D water tank system and to establish a data-driven framework for selecting acquisition parameters, enabling the development of standardized operating procedures (SOPs) for clinical implementation.

METHODS AND MATERIALS

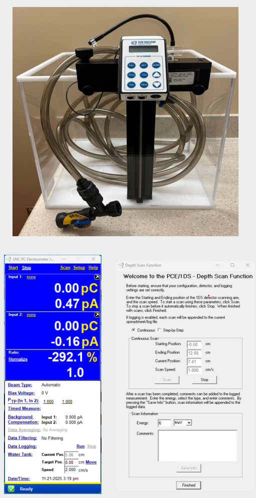

Figure 1 1D tank from Sun Nuclear Company with control panel..

METHODS AND MATERIALS

System Configuration
A 1D water tank system (Sun Nuclear Corporation) was used for this study. The tank was filled using a water delivery system based on the Venturi effect, derived from the Bernoulli principle, allowing efficient filling with minimal physical effort. The tank was filled to approximately 30 cm depth, after which an automatic detector system identified the water surface.
The measurement setup included:
Source-to-surface distance (SSD): 100 cm
Field size: 10 × 10 cm²
Measurement chamber positioned at water surface
Reference chamber connected to a PC electrometer
Motion control and data acquisition performed via PCE/1DS software. (figure 1)
These procedures follow standard clinical practices and system guidelines .

Measurement Procedure
Percent depth dose (PDD) curves were acquired for a 9 MeV electron beam using continuous scanning. Multiple scan speeds were evaluated to assess their effect on measurement accuracy.
Key acquisition parameters included:
Chamber motion speed
Data filtering settings
Sampling resolution

Data Analysis
The effect of scan speed was evaluated by comparing PDD curves acquired under different conditions.
a. Spatial Analysis
Depth of maximum dose (dmax) was identified for each scan
Shift in dmax relative to baseline was measured
b.Dosimetric Analysis
Relative dose variation was assessed across depths
Particular attention was given to high-gradient regions

Temporal Response Interpretation
The observed distortion was interpreted using a first-order detector response model:

$$S_{measured}(t) = S_{true}(t) * e^{-t/\tau}$$

where τ represents the detector time constant. This model explains lag and smoothing effects observed at higher scan speeds.

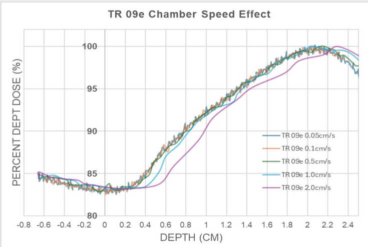

Figure 2 Scanning Result for 9MeV beam at different chamber motion speeds.

RESULTS

The Venturi-based filling mechanism significantly improved workflow efficiency, reducing setup time and physical effort compared to conventional filling methods.
Analysis of PDD curves demonstrated that scan speed is a critical determinant of measurement accuracy. At lower scan speeds, PDD curves were consistent and reproducible. As scan speed increased, distortion became apparent, particularly in the buildup region.
Key findings include:
Spatial shift in dmax of up to **4 mm** at higher scan speeds
Localized dose deviations in high-gradient regions
Increasing distortion with increasing scan speed
These results indicate that high scan speeds introduce measurable inaccuracies due to detector temporal response limitations.(figure 2)

DISCUSSION

Efficiency and Practical Implementation
The 1D water tank system provides a practical solution for routine QA, particularly when combined with an optimized water filling system that reduces operator workload.

Parameter Sensitivity
Scan speed was identified as the most influential parameter affecting measurement accuracy. The observed distortion is consistent with the expected behavior of a detector with finite temporal response.

Clinical Implications
Improper parameter selection may lead to:
Inaccurate beam data
Errors in commissioning
Reduced QA reliability
A data-driven approach allows for the definition of acceptable parameter ranges and supports the development of standardized procedures.

SOP Development
The findings of this study support the creation of a standard operating procedure (SOP) that:
Defines acceptable scan speeds
Establishes tolerance criteria
Provides decision-making guidelines

Limitations and Future Work
Only one beam energy was evaluated
Detector-specific effects were not fully characterized
Further study should include:
Chamber volume effects
Reference signal noise
Multi-energy validation
Moving target dosimetry accuracy.

CONCLUSIONS

The 1D water tank system is an effective tool for clinical QA when appropriate acquisition parameters are selected. Scan speed has a significant impact on both spatial and dosimetric accuracy due to detector temporal response. A data-driven framework enables the development of robust SOPs that ensure measurement reliability and clinical consistency.

REFERENCES

Das IJ, et al. AAPM Task Group 155 report. *Med Phys*. 2021.
Geurts MW, et al. AAPM Practice Guideline 5.b. *J Appl Clin Med Phys*. 2022.
Sun Nuclear Corp. 1D Scanner Reference Guide. 2024.
Li K. Stakeholder model for SOP development. ASTRO. 2023.

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