

European Forearm Phantom

The standard for quality control in peripheral bone mineral densitometry by peripheral quantitative CT (pqCT).

QRM-EFP, a phantom consisting of water- and bone-equivalent solid materials was devised to test peripheral bone densitometry systems. A prime design consideration of the forearm phantom was to use the same material as is used for the European Spine Phantom QRM-ESP. This not only allows for the comparison of trabecular bone examinations at different locations and different machines, but also to compare axial with peripheral bone measurements.

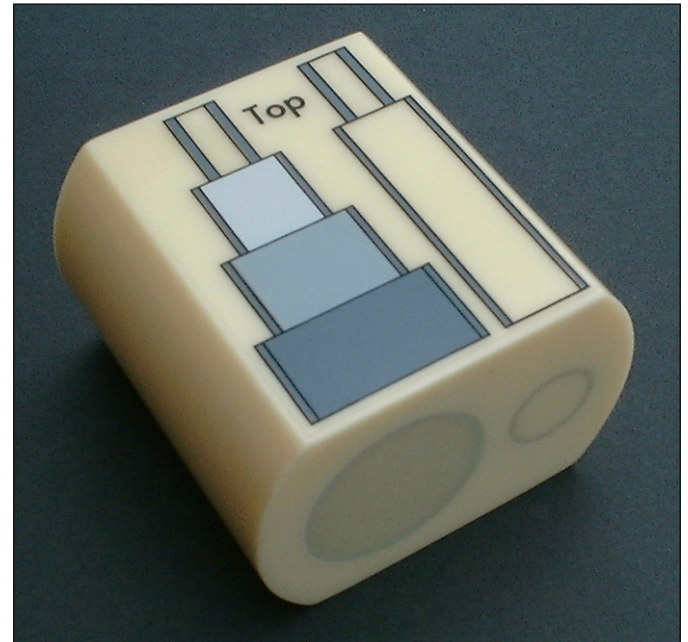
A circular cross section with a diameter of 60 mm was chosen, with the sides flattened by 10 mm to model the forearm. The inserts simulate trabecular bone and provide the basis for linearity checks in quantitative computed tomography (qCT)

The phantom provides the opportunity to test reproducibility and accuracy of machines, both in clinical installations and at manufacturers' sites.

The following quantities are to be determined:

- (I) bone area in cm^2 ,
- (ii) thickness of cortical bone in mm,
- (iii) trabecular and cortical mineral density in g/cm^3 ,
- (iv) bone mineral content (BMC) in g/cm ,
- (v) bone mineral area density (BMD) in g/cm^2 .

The three inserts of the phantom simulating large, medium and small bone have diameters of 28 mm, 21 mm and 14 mm, respectively. The calcium hydroxyapatite (HA) density of the

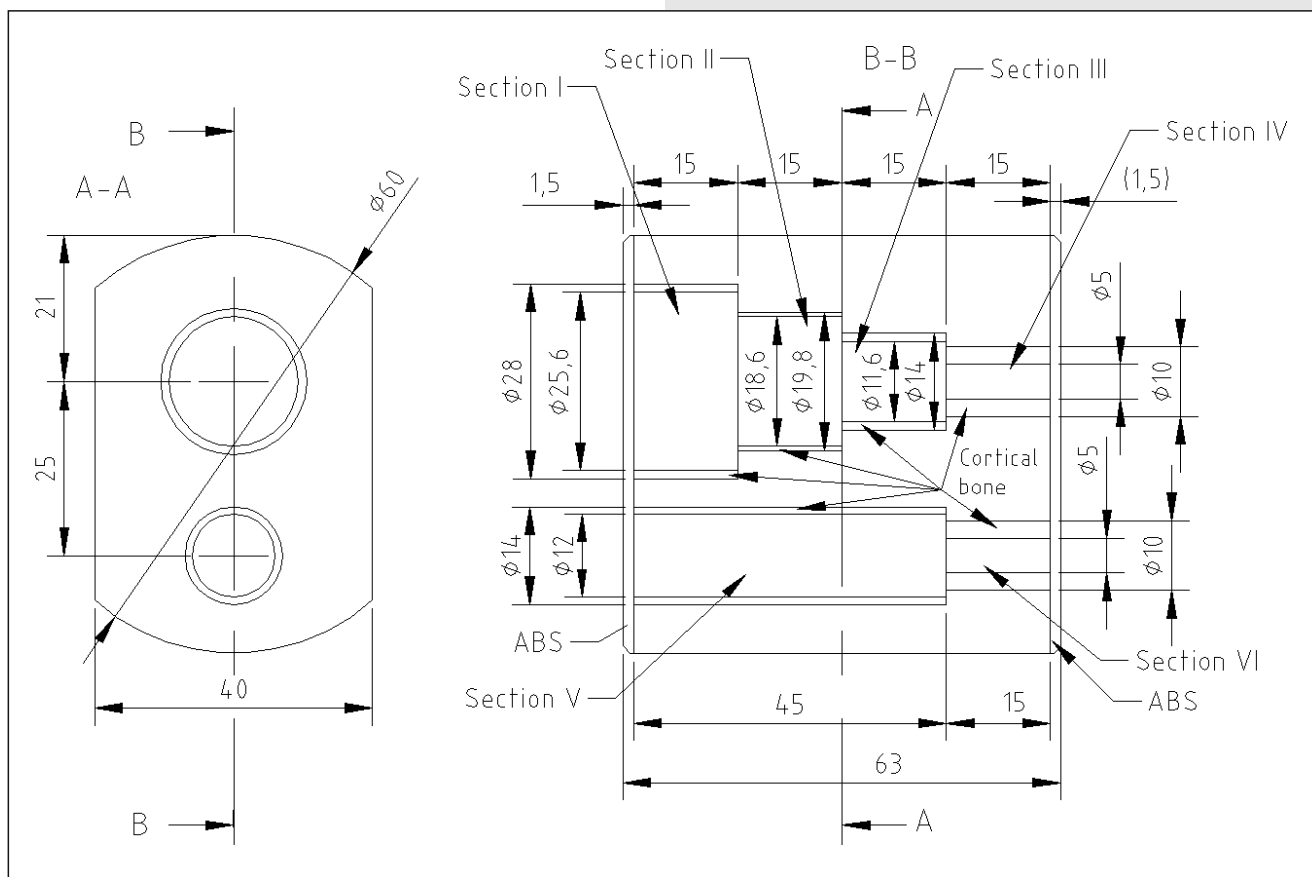


trabecular bone was selected according to the densities used in the European Spine Phantom QRM-ESP, namely 200, 100 and 50 mg HA/cm^3 . 1.2 mm was selected as the thickness of the cortical bone, its HA density was chosen as 800 mg HA/cm^3 .

Quality control with CT guarantees a homogeneously distributed trabecular bone density with an average that deviates less than 1 mg/cm^3 from linearity.

The manufacturing tolerances were set to ± 0.1 mm for the geometric measures and at $\pm 0.5\%$ (at best 0.5 mg) for the calcium hydroxyapatite concentrations. Routine quality control of phantom production is carried out by CT.

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Area measured with CT

	Nominal area (cm ²)	Mean (cm ²)	Range (cm ²)
Section I	6.158 ±0.044	6.091	6.066-6.119
Section II	3.464 ±0.033	3.425	3.400-3.447
Section III	1.539 ±0.022	1.515	1.501-1.534

Density measured with CT

	Nominal density (cm ⁻¹)	Mean (cm ⁻¹)	Range (cm ⁻¹)
Section I	0.4153 ±0.0008	0.4154	0.4148-0.4160
Section II	0.3393 ±0.0004	0.3391	0.3382-0.3400
Section III	0.3013 ±0.0004	0.3015	0.3006-0.3022

Specifications

Base material water-equivalent resin
 Phantom cross section 60 mm x 40 mm
 Phantom length 60 mm
 Phantom weight 140 g
 Cortical bone 800 mg HA/cm³
 Section I 200 mg HA/cm³
 Section II 100 mg HA/cm³
 Section III 50 mg HA/cm³
 Section IV to VI water-equivalent resin

References: [1] Rügsegger, P., Kalender, W.A.: A phantom for standardization and quality control in peripheral bone measurements by PQCT and DXA. Phys. Med. Biol. (1993) 1963-1970