Quantitative X-ray CT of Geopolymer Wasteforms: Development of a Spatial Resolution Target to Improve Wasteform Defect Metrology Measurement Confidence

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Geopolymers show promise as intermediate- and low-level waste wasteform candidates for the immobilization of a variety of radioisotopes destined for final disposal in a geological disposal repository. Inspection of any wasteform is imperative to ensure correct formulation and suitability for disposal. The presence of fractures and defects (e.g. air gaps, porosity, voids, and heterogeneous particle distributions) in a wasteform leads to an increased risk of radioisotope release. It is therefore important to understand the internal structures of the hazardous waste and final wasteform as part of inspection and validation to ensure correct wasteform manufacture and to help predict failure. X-ray Computed Tomography (CT) Non-Destructive Evaluation (NDE) allows for these imperfections to be identified. Further, X-ray CT NDE allows for the quantification of internal features such as cracks, defects, deformation, and voids as part of object metrology. However, X-ray CT NDE alone lacks measurement confidence, an important consideration for resolving defect detection limits and performing defect metrology. In this study, a bespoke X-ray CT spatial resolution target (Representative Quality Indicator, RQI) has been developed enabling defect metrology of geopolymer wasteforms. Implementing spatial resolution targets, the dimensions of which are known and certified independently, will allow for rapid dimensional calibration of X-ray CT systems for object defect metrology, allow for the quality of the X-ray CT scans to be assessed, determine what is the smallest defect that is detectable, and will lead to overall improvements in measurement confidence. A Nano Dimension Tera 250 micro-additive manufacturing system was used to generate a low-cost 3D printed RQI with the required dimensional accuracy and repeatability of the features. The RQI was then applied for the selection of promising geopolymer candidate wasteforms based on X-ray CT NDE. Further, this work, while initially designed for academia, could be scaled up for the assessment of radioactive waste containers destined for final disposal to ensure there is no internal damage, with the developed RQIs enabling standardization of the inspection process.