



Standard Guide for Nondestructive Evaluation of Nuclear Grade Graphite¹

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1. Scope

1.1 This guide provides general tutorial information regarding the application of conventional nondestructive evaluation technologies (NDE) to nuclear grade graphite. An introduction will be provided to the characteristics of graphite that defines the inspection technologies that can be applied and the limitations imposed by the microstructure. This guide does not provide specific techniques or acceptance criteria for end-user examinations but is intended to provide information that will assist in identifying and developing suitable approaches.

1.2 The values stated in SI units are to be regarded as the standard.

1.2.1 *Exception*—Alternative units provided in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

C709 Terminology Relating to Manufactured Carbon and Graphite

D7219 Specification for Isotropic and Near-isotropic Nuclear Graphites

E94 Guide for Radiographic Examination

E1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology

E1441 Guide for Computed Tomography (CT) Imaging

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3. Summary of Guide

3.1 This guide describes the impact specific material properties have on the application of three nondestructive evaluation technologies: Eddy current/electromagnetic testing (ET) (surface/near surface interrogation), ultrasonic testing (UT) (volumetric interrogation), radiographic (X-ray) testing (RT) (volumetric interrogation), to nuclear grade graphite.

4. Significance and Use

4.1 Nuclear grade graphite is a composite material made from petroleum or a coal-tar-based coke and a pitch binder. Manufacturing graphite is an iterative process of baking and pitch impregnation of a formed billet prior to final graphitization, which occurs at temperatures greater than 2500 °C. The impregnation and rebake step is repeated several times until the desired product density is obtained. Integral to this process is the use of isotropic cokes and a forming process (that is, isostatically molded, vibrationally molded, or extruded) that is intended to obtain an isotropic or near isotropic material. However, the source, size, and blend of the starting materials as well as the forming process of the green billet will impart unique material properties as well as variations within the final product. There will be density variations from the billet surface inward and different physical properties with and transverse the grain direction. Material variations are expected within individual billets as well as billet-to-billet and lot-to-lot. Other manufacturing defects of interest include large pores, inclusions, and cracks. In addition to the material variation inherent to the manufacturing process, graphite will experience changes in volume, mechanical strength, and thermal properties while in service in a nuclear reactor along with the possibility of cracking due to stress and oxidation resulting from constituents in the gas coolant or oxygen ingress. Therefore, there is the recognized need to be able to nondestructively characterize a variety of material attributes such as uniformity, isotropy, and porosity distributions as a means to assure consistent stock material. This need also includes the ability to detect isolated defects such as cracks, large pores and inclusions, or distributed material damage such as material loss due to oxidation. The use of this guide is to acquire a basic understanding of the unique attributes of nuclear grade graphite