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Standard Guide for Investigating the Effects of Helium in Irradiated Metals¹

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1. Scope

1.1 This guide provides advice for conducting experiments to investigate the effects of helium on the properties of metals where the technique for introducing the helium differs in some way from the actual mechanism of introduction of helium in service. Techniques considered for introducing helium may include charged particle implantation, exposure to α -emitting radioisotopes, and tritium decay techniques. Procedures for the analysis of helium content and helium distribution within the specimen are also recommended.

1.2 Three other methods for introducing helium into irradiated materials are not covered in this guide. They are: (1) the enhancement of helium production in nickel-bearing alloys by spectral tailoring in mixed-spectrum fission reactors, (2) a related technique that uses a thin layer of NiAl on the specimen surface to inject helium, and (3) isotopic tailoring in both fast and mixed-spectrum fission reactors. These techniques are described in Refs (1-6).² Dual ion beam techniques (7) for simultaneously implanting helium and generating displacement damage are also not included here. This latter method is discussed in Practice E521.

1.3 In addition to helium, hydrogen is also produced in many materials by nuclear transmutation. In some cases it appears to act synergistically with helium (8-10). The specific impact of hydrogen is not addressed in this guide.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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.*

¹ This guide is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.08 on Procedures for Neutron Radiation Damage Simulation.

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² The boldface numbers in parentheses refer to a list of references at the end of this guide.

2. Referenced Documents

2.1 ASTM Standards:³

C859 Terminology Relating to Nuclear Materials

E170 Terminology Relating to Radiation Measurements and Dosimetry

E521 Practice for Investigating the Effects of Neutron Radiation Damage Using Charged-Particle Irradiation

E706 Master Matrix for Light-Water Reactor Pressure Vessel Surveillance Standards, E 706(0) (Withdrawn 2011)⁴

E910 Test Method for Application and Analysis of Helium Accumulation Fluence Monitors for Reactor Vessel Surveillance, E706 (IIIC)

3. Terminology

3.1 Descriptions of relevant terms are found in Terminology C859 and Terminology E170.

4. Significance and Use

4.1 Helium is introduced into metals as a consequence of nuclear reactions, such as (n, α), or by the injection of helium into metals from the plasma in fusion reactors. The characterization of the effect of helium on the properties of metals using direct irradiation methods may be impractical because of the time required to perform the irradiation or the lack of a radiation facility, as in the case of the fusion reactor. Simulation techniques can accelerate the research by identifying and isolating major effects caused by the presence of helium. The word ‘simulation’ is used here in a broad sense to imply an approximation of the relevant irradiation environment. There are many complex interactions between the helium produced during irradiation and other irradiation effects, so care must be exercised to ensure that the effects being studied are a suitable approximation of the real effect. By way of illustration, details of helium introduction, especially the implantation temperature, may determine the subsequent distribution of the helium (that is, dispersed atomistically, in small clusters in bubbles, etc.).

³ 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.

⁴ The last approved version of this historical standard is referenced on www.astm.org.