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# Irradiation Damage in Graphite due to Fast Neutrons in Fission and Fusion Systems

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# FOREWORD

Gas cooled reactors have been in operation for the production of electricity for over forty years, encompassing a total of 56 units operated in seven countries. The predominant experience has been with carbon dioxide cooled reactors (52 units), with the majority operated in the United Kingdom. In addition, four prototype helium cooled power plants were operated in the United States and Germany. The United Kingdom has no plans for further construction of carbon dioxide units, and the last helium cooled unit was shutdown in 1990. However, there has been an increasing interest in modular helium cooled reactors during the 1990s as a possible future nuclear option.

Graphite is a primary material for the construction of gas cooled reactor cores, serving as a low absorption neutron moderator and providing a high temperature, high strength structure. Commercial gas cooled reactor cores (both carbon dioxide cooled and helium cooled) utilise large quantities of graphite. The structural behaviour of graphite (strength, dimensional stability, susceptibility to cracking, etc.) is a complex function of the source material, manufacturing process, chemical environment, and temperature and irradiation history.

A large body of data on graphite structural performance has accumulated from operation of commercial gas cooled reactors, beginning in the 1950s and continuing to the present. The IAEA is supporting a project to collect graphite data and archive it in a retrievable form as an International Database on Irradiated Nuclear Graphite Properties, with limited general access and more detailed access by participating Member States. Because of the large size of the database, the complexity of the phenomena and the number of variables involved, a general understanding of graphite behaviour is essential to the understanding and use of the data.

Research into the subject of radiation damage in graphite began in the early 1940s as a part of the development of nuclear weapons and nuclear power. Since that time many graphite moderated nuclear fission reactors have been built and many varieties of graphite developed. In recent years the scale of research on the effects of fission neutrons has been much reduced and many of the active researchers have retired. However, new programmes are being formulated related to the use of graphite, particularly in the form of carbon-carbon composites in fusion systems and of modular helium cooled reactors, and these developments should be assisted by the existing fission related database. It is possible to engineer the properties of graphite to a remarkable degree, and also the response to neutron irradiation. The objective of this report is to summarise the vast amount of information that has been accumulated and the understanding that has been gained for the use of those concerned with such materials in the future.

The primary contributor to the technical information contained in this report was Mr. B.T. Kelly of the United Kingdom Atomic Energy Authority (UKAEA). Additional material was produced by B. J. Marsden, K. Hall, D. G. Martin, A. Harper and A. Blanchard, also of the UKAEA. Mr. Marsden was also responsible for assembling the total report.

***EDITORIAL NOTE***

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