07 August 2008

CARBOWASTE - An Integrated Approach to Irradiated Graphite

AW Banford[a], H Eccles[b], MJ Graves[c] , W von Lensa[d] & S Norris[e]

a UK National Nuclear Laboratory, Risley
b UK National Nuclear Laboratory, Preston Laboratory;
c Doosan Babcock, Baltic Business Centre, Gateshead, UK
d Forschungzentrum Juelich GmbH, Germany
e Nuclear Decommissioning Authority, UK

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Introduction

A four year collaborative European Project 'Treatment and Disposal of Irradiated Graphite and other Carbonaceous Waste (CARBOWASTE)' was launched in April 2008 under the 7th EURATOM Framework Programme. The aim of the project is to develop best practices in the retrieval, treatment and disposal of irradiated graphite, addressing both existing legacy waste as well as waste from graphite-based nuclear fuel resulting from a new generation of nuclear reactors (e.g. V/HTR). The consortium is led by Forschungszentrum, Juelich (FZJ) in Germany and involves 28 partners from Belgium, France, Germany, Italy, Lithuania, Netherlands, Romania, South Africa, Spain, Sweden and the United Kingdom. Six organisations form the UK are involved in this collaboration; AMEC, Bradtec Decon Technologies Ltd, Doosan Babcock, the National Nuclear Laboratory, the Nuclear Decommissioning Authority, and the University of Manchester. This paper gives an overview of the project focussing predominantly on legacy graphite.

The graphite legacy

The UK has a large legacy of irradiated graphite as a result of its predominant use of graphite moderated gas cooled reactors, such as Magnox and AGR. Various European countries and others around the world also have legacy irradiated graphite. The reactors vary in size and type across Europe and include research/test reactors as well as larger baseload reactors; such as the RBMK, such as at Ignalina in Lithuania, and the French gas cooled reactors. Whilst some graphite has already been removed and packaged as in the case of GLEEP and WAGR in the UK, on other sites the graphite remains in the reactor building. The major challenge is related to the presence of long lived isotopes such as radiocarbon (^{14}C) and chlorine (^{36}Cl) and shorter lived ones such as cobalt (^{60}Co). The wide range of activities and quantities of graphite means that the recovery, treatment and end point may vary from country to country and potentially from site to site. The challenge for the Carbowaste project is to build a harmonised 'tool box' of techniques, methodologies and best practices for decommissioning and waste management of irradiated graphite, that can be applied to the specific needs and conditions within a country and site.

The Carbowaste project will consider the lifecycle of irradiated graphite from its in reactor state through to ultimate disposal or reuse. To cover such a broad subject, the project is sub divided into six technical work packages (WPs);

- integrated waste management approach (WP 1)
- retrieval and segregation (WP 2)
- characterisation and modelling (WP 3)
- treatment and purification (WP 4)
- recycling and new products (WP 5)
- disposal behaviour (WP 6)

In order to develop a coherent lifecycle waste management solution, the relationships between work packages (figure 1) must be considered. For example, the nature of the graphite (WP 3) and disposal behaviour (WP 6) affect the requirements for any treatment process (WP 4).

Integrated Waste Management Approach (WP1)

This work package will commence with a review of the current knowledge and practices internationally, recognising that much work has already been carried out, some of which was summarised in an International Atomic Energy Authority Tecdoc [1] and at an IAEA conference at the University of Manchester [2]. This review will focus on understanding the condition and nature of irradiated graphite, experience of decommissioning (retrieval and segregation), treatment options and disposal issues.

A key element of the integrated approach to irradiated graphite waste management is the development of an irradiated graphite road map. This will identify all the key stages/decision and end points necessary to allow appropriate waste management strategies to be developed. Together, the review and the roadmap will be used to identify the key factors and information that will influence any waste management strategy for irradiated graphite and to identify key gaps in knowledge that will be researched in subsequent work packages.

Indeed this work package, which is being led by the UK National Nuclear Laboratory, is also instrumental in integrating the outputs of the other work packages, utilising a multi criteria decision analysis (MCDA) approach to assess waste management options.

Retrieval and Segregation (WP2)

In considering the current disposition of irradiated graphite, work package 2 will address the difficulties of retrieving the graphite waste. In most cases the irradiated graphite will be associated with other materials; many metallic but others ceramic. An additional burden for reactors, such as the UK's Magnox and AGRs, is the size, shape and weight of the graphite blocks/bricks. They are of intricate design many with a self locking mechanism and any retrieval solution will have to overcome these issues while operating within the confines of the pressure vessel interior and associated interior furniture. The UK has experience of decommissioning early graphite moderated reactors e.g. GLEEP and WAGR. Doosan Babcock has a key role to play here, from their experience as the principal contractor in the stage three decommissioning of the graphite pile reactor GLEEP at Harwell [3]. This package will also consider the specific case of V/HTR segregation.

Characterisation and Modelling (WP 3) and Treatment and Purification (WP4)

Prior to selecting any treatment option for irradiated graphite, a comprehensive understanding of its characteristics is needed. Physical properties such as density and material condition, will affect the selection of retrieval technology, while detailed composition is needed because graphite contains impurities these undergo neutron activation during operation. Whilst there is a wealth of graphite data and information in existence, mostly gathered in support of the continued safe operation of reactors, further information is required to underpin retrieval, treatment, disposal and/or potential re-use (WP3). Understanding the precise location of the radionuclides in the irradiated graphite lattice will allow the selection of appropriate treatment options. The characterisation of irradiated graphite samples will be undertaken by a variety of laboratories in Member State countries. A variety of treatment options will be assessed at laboratory scale in (work package 4) supported by technical feasibility assessment and economic evaluation.

Recycling and New Products (WP5)

An attractive option for irradiated graphite is re-use/recycle. This approach is not new in the nuclear industry, with uranium being recycled and also decontaminated metals such as aluminium being free-released into the metal market. In all cases risk assessments of any residual radioactivity associated with these materials are a pre-requirement to ensure the environment, work force and the public are protected. Opportunities for the recycle of irradiated graphite within the nuclear industry will be assessed and the size of the market opportunity will be influential in the option studies.

Disposal Behaviour (WP6)

The disposal of graphite is complicated by the presence of long lived isotopes. Work package 6 will examine disposal behaviour of irradiated graphite and of other carbonaceous materials. This work package will also consider improving disposal behaviour by waste packaging and assess the performance of the waste in the longer term.

Summary

The new 7th EURATOM Framework Carbowaste project will develop an integrated approach to waste management, through investigation of the nature of graphite and other carbonaceous wastes, potential treatment options, the potential for recycling/re-use and disposal behaviour. When complete the project will provide a toolbox of techniques for assessing the most appropriate retrieval, treatment, re-use and disposal options for a range of situations.

References

[1] Technologies for gas cooled reactor decommissioning, fuel storage and waste disposal . Proc IAEA Technical Committee meeting. IAEA-TECDOC—1043, Juelich, 8-10 Sep 1997

[2] Nuclear Graphite Waste Management. Proc IAEA Technical Committee Meeting. Manchester 12-20 October 1999

[3] Grave, M.J., Buffery, J. et al IBC International Conference, Decommissioning Experience, Nov 2004, London, Removal and Handling of Graphite from the GLEEP Reactor.

ACKNOWLEDGEMENT

The authors would like to acknowledge the financial support of European Commission (European Atomic Energy Community [EURATOM]) for funding project 211333 in the Seventh Framework Programme for nuclear research and training, and their fellow partners in this research consortium.

The NNL would also like to acknowledge the support of the NDA in this project.

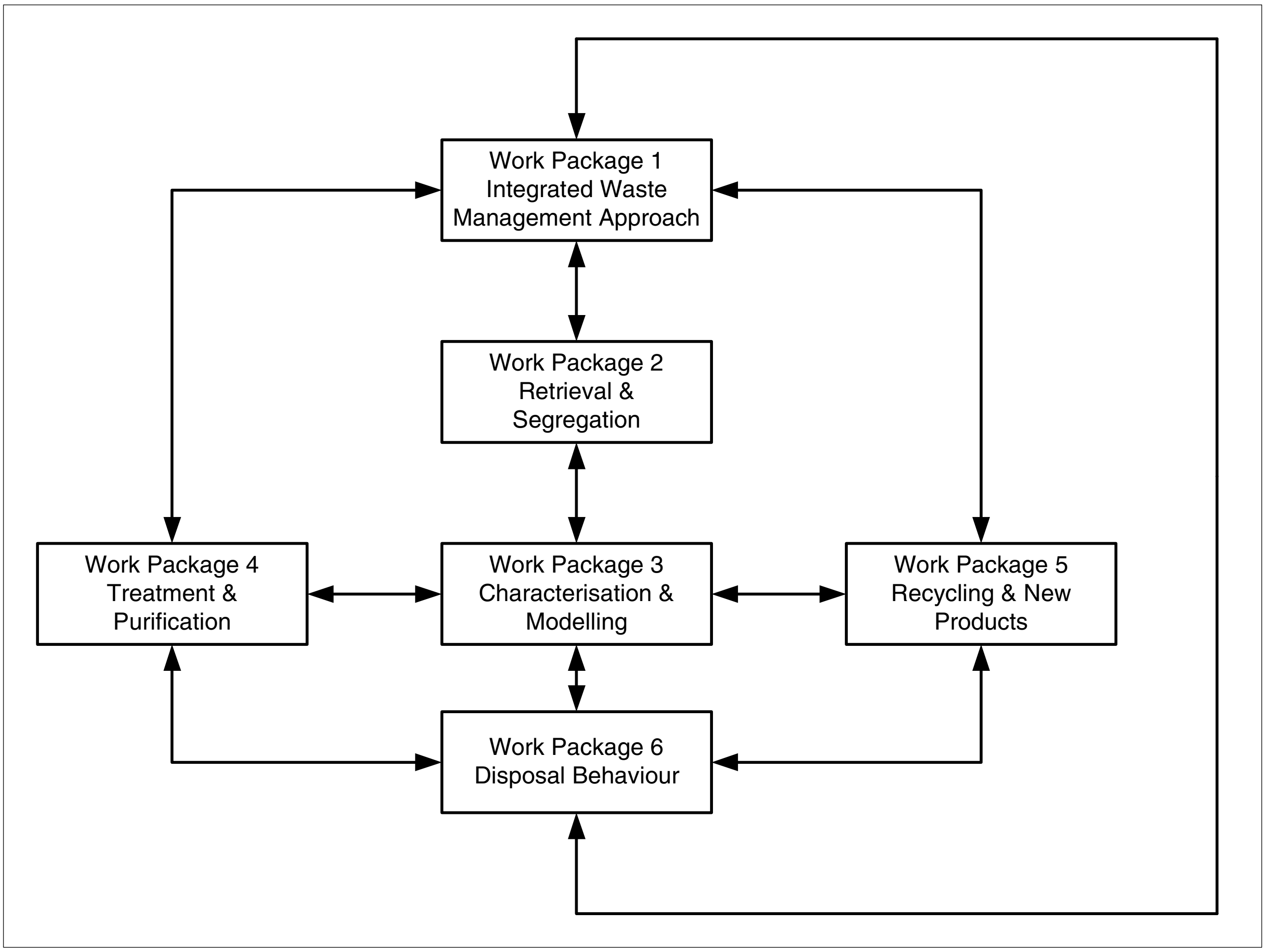

Figure 1 Carbowaste project work packages