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Updating irradiated graphite disposal: Project 'GRAPA' and the international decommissioning network

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ABSTRACT

Demonstrating competence in planning and executing the disposal of radioactive wastes is a key factor in the public perception of the nuclear power industry and must be demonstrated when making the case for new nuclear build. This work addresses the particular waste stream of irradiated graphite, mostly derived from reactor moderators and amounting to more than 250,000 tonnes world-wide. Use may be made of its unique chemical and physical properties to consider possible processing and disposal options outside the normal simple classifications and repository options for mixed low or intermediate-level wastes. The IAEA has an obvious involvement in radioactive waste disposal and has established a new project 'GRAPA' – Irradiated Graphite Processing Approaches – to encourage an international debate and collaborative work aimed at optimising and facilitating the treatment of irradiated graphite.

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1. Introduction

There exists more than 250,000 tonnes of irradiated (and therefore radioactive) nuclear graphite in the world, primarily as a result of the development of graphite-moderated power-reactor systems, initially for defence and subsequently for commercial purposes (Fig. 1). Only a very small number of such plants have been dismantled and, for most cases, the final destiny of the irradiated graphite ("*i*-graphite") remains unresolved. Future high-temperature reactor programmes, such as the Chinese HTR-PM development, will produce more graphite and carbonaceous wastes from both structural components and the fuel pebbles (which are approximately 96% carbonaceous), the latter producing a continuous stream of so-called 'operational waste'.

The problem of dismantling irradiated graphite reactor stacks, possibly distorted through neutron damage, with a variable content of 'stored' Wigner energy and in some cases degraded further by radiation-chemical attack by gaseous coolants, and then finding the appropriate treatments and final destiny of the material, has exercised the International Atomic Energy Agency, along with separate initiatives by the European Union, the OECD Nuclear Energy Agency, and the USA Electric Power Research Institute, for more than 25 years, seeking to address the different issues and available disposal solutions in different IAEA Member States. Fig. 2 indicates some of the decisions and evaluations which need to be made ahead of commencing dismantling.

An IAEA collaborative research program on treatment options has recently been completed, and it has been decided to establish an active group of international specialists in this area as part of the IAEA International Decommissioning Network under the envelope of Project 'GRAPA' (Irradiated **Gra**phite **P**rocessing **A**pproaches). The scope of work being undertaken during the planned two-year duration of the project is discussed in this paper.

2. History of irradiated-graphite disposal investigations

The IAEA has been instrumental since 1995 in promoting various consultancies and technical meetings in respect of *i*-graphite issues, commencing with a discussion at a Technical Meeting "Graphite Moderator Lifecycle Behaviour" at The University of Bath, UK [IAEA, 1996], where it was proposed that an international database on nuclear graphite properties (later to become a full knowledge base) should be established in order to preserve knowledge relevant to both continuing development of graphite-moderated reactors and also their subsequent dismantling and disposal of the graphite. Further consultancies specifically

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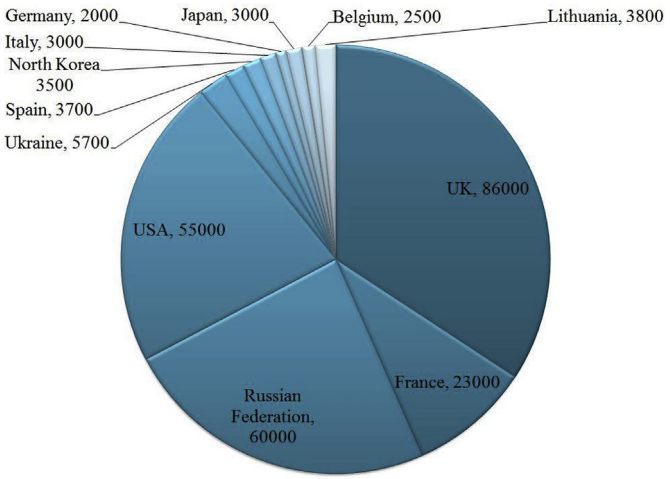

Fig. 1. Distribution of irradiated graphite waste world-wide (quantities in tonnes).

related to *i*-graphite characterisation and disposal followed [IAEA, 2001, 2010], along with an IAEA Technical Document (TECDOC) specifically addressing issues of characterisation, potential treatments and conditioning of *i*-graphite, intended to represent the 'state of the art' manual and available to assist all involved Member States with addressing the graphite-waste question [IAEA, 2006].

At the time of the publication of that TECDOC in 2006, all UNGG reactors in France and a majority of the Magnox reactors in the United Kingdom had closed, and two major graphite reactor cores had been dismantled – Fort St Vrain in the United States of America [Fisher, 1998], and the Windscale Prototype Advanced Gas-Cooled Reactor in the UK [Marsden and Wickham, 1998]. Work was commencing on the dismantling of the 700-tonne graphite core of the Brookhaven Research Reactor in the USA (completed 2010). Two major initiatives outside of IAEA – a series of reports and workshops on graphite-decommissioning issues commissioned by the Electric Power Research Institute (USA) on behalf of its members [Bradbury and Wickham, 2006, 2007, 2008; Bradbury and Mason, 2008; Wickham, 2010, 2012; Bradbury and Goodwin 2010] and the EU, which had commissioned a very early study based upon Magnox-reactor graphite in the 1980s [White et al., 1984] initiated a major new study under FP7 - CARBOWASTE [Grambow et al., 2013] involving more than 30 participating organisations with the objective "to develop an integrated waste management concept as well as innovative processes for treatment and recycling of purified material".

These activities served to underline the increasing importance of this topic, the last in particular addressing the very significant amounts of carbonaceous wastes which will accrue from an increasing number of high-temperature reactors world-wide in addition to the existing *i*-graphite.

In consequence, the IAEA established in 2010 a Coordinated Research Programme (CRP) to address 'Treatment Options [of *i*-graphite] to Meet Waste-Acceptance Criteria'. A new TECDOC reporting the work undertaken under this CRP, and updating a great deal of the additional data and information from [IAEA, 2006], was published recently [Ojovan and Wickham, 2014, 2016; IAEA 2016].

3. The scope of 'GRAPA'

The IAEA has now decided to support Member States in resolving *i*-graphite management up to industrial implementation of processing technologies by launching an International Project on Irradiated Graphite Processing Approaches (GRAPA). This reflects a developing concern among some specialists that the ability to successfully recover, treat, and dispose of *i*-graphite from a commercial reactor after a full operational lifetime may not be as straightforward as is hoped, and the involvement of the active membership of the International Decommissioning Network would be beneficial in widening the perspective of the activities. Two consultancy meetings were convened during 2015 to define the basic 'shape' of the programme, followed by a Technical Meeting in February 2016 at which IAEA Member States were invited to endorse the proposal and to indicate their levels of interest and participation.

In drawing up the detail of the proposed GRAPA project, specialists from the following Member States have participated:

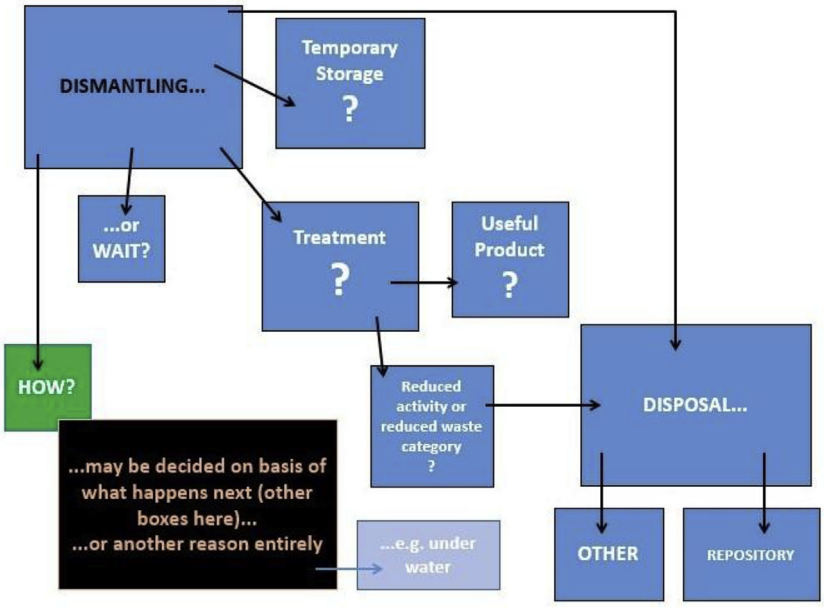

Fig. 2. Decision tree for the removal of irradiated graphite ahead of commencing core removal.

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