The New International Project on Irradiated Graphite Processing Approaches (GRAPA) -16559

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ABSTRACT

Developing of strategies and methods for the management of spent nuclear (irradiated) graphite is one of the major task in decommissioning internationaly. More than 250.000 Mg of i-graphite have been accumulated worldwide.

Having completed in 2014 a comprehensive collaborative research programme on the treatment options for the disposal of i-graphite wastes to meet disposal criteria, the IAEA decided to maintain an active group of international specialists in this area as part of the International Decommissioning Network (IDN). To foster further development in R&D and steps towards industrial applications in i-graphite management this group was requested to propose the terms of reference and work programme for a new IAEA project. The basic concept for this future programme has been formulated by the German Forschungszentrum (Research Centre) Juelich, Institute IEK-6.

The initiative has expanded to include representation from UK, USA, France, Italy, Russia, Ukraine and Lithuania. Additional Member States of the IAEA are expected to join the project. The concept presented by the IEK-6 was discussed among the experts and extended on an international meeting at IAEA in Vienna in February 2015. In addition to the development of the terms of reference a number of individual tasks have been identified. The project will combine a comprehensive state-of-the-art study with concerted actions as well as cross-cutting subprojects. This will include a practical demonstration of the removal, treatment and disposal of highly-irradiated graphite from a decommissioned reactor. Prior to official implementation of this project preparatory work has been started on topic areas where weaknesses in the scientific knowledge or the technology have been identified.

The scope of the international project ("Irradiated Graphite Processing Approaches, GRAPA") and its expected development as well as the possible impact of GRAPA on the future international i-graphite research activities will be described in this presentation. The project will be performed jointly by both the IAEA International Decommissioning Network and the new IAEA Pretreatment Network (IMM, under development).

INTRODUCTION

The European Commission's 'CarboWaste' project, which began in 2008, assembled for the first time partners from research, industry and waste management organizations, in order to describe good practice and to provide a 'toolbox' of sustainable and economic options for the future management of irradiated graphite. Non-European partners were subsequently also introduced by IAEA as partners in its Coordinated Research Project (CRP) 'Treatment of Irradiated Graphite to meet Acceptance Criteria for Waste Disposal'.

The impact on certain decommissioning projects of the lack of treatment solutions for irradiated graphite make it is necessary to pursue further efforts to assemble national perspectives on i-graphite management with the aim of identifying potential near-term industrial solutions, at least at pilot scale. A European follow-up project has been discussed, under the working title 'CarboSolutions', with the aim of developing innovative waste management solutions and launching systematic multi-scale investigations and technical demonstrations. But the timeframe for launching this or other projects at European level is currently unclear.

In light of the potentially very high costs of future decommissioning of graphite reactors worldwide and for the disposal of the resulting irradiated graphite, the development of sustainable and economic solutions that address the needs and conditions that exist in the relevant countries remains a priority issue. This IAEA project will therefore facilitate ongoing exchange of current thinking, as well as updating knowledge and experience in relevant international specialist circles.

Addressing the open R&D issues remaining from the CarboWaste and IAEA CRP projects, and reflecting latest findings, the project will identify the specific areas where efforts need to be strengthened or expanded to provide application-oriented solutions for the management of irradiated graphite on an industrial scale. The project will aim to progress the design of modular full-scale process lines which may be flexibly adapted to different framework conditions and/or special local requirements. To minimize both the waste volume and the efforts and costs of disposal particular attention will be devoted to characterization, treatment (including sorting), and decontamination and conditioning techniques. For these purposes the project will be performed under the joint auspices of the IAEA's IDN[a] and IMM[b] networks.

OBJECTIVES

The objective of the project is to learn from and build on the experiences gained from previous national and international projects. Recognizing that considerable work already has been done, this project will review, check and analyze existing knowledge, results and experience in order to provide information and guidance through establishing a scientific-technical roadmap for implementation of graphite management processes at an industrial scale.

[a] International Decommissioning Network
[b] International Pre-Disposal Network

The project also aims to foster the exchange of knowledge and experience as well as promoting the establishment of joint/shared activities; and to promote the sharing of cross-cutting views and new perspectives through comprehensive collaboration.

Although the project is focused on the management of irradiated graphite on a large scale, physical and chemical fundamentals are still essential, together with consideration of relevant treatment and process technologies. For example, recent findings that the release of C-14 under certain conditions may be dominated by organic species may indicate that the benefit of concrete (trapping) barriers or cementation may be limited.

PROJECT APPROACH AND STRUCTURE

A particular focus of this project will be application-oriented considerations, proposing both general guidelines as well as modular solutions, applicable to different Member States, for the management of irradiated graphite at an industrial level. For this purpose all relevant topics, whether at scientific, technical, governmental or any other levels, have to be considered and checked or examined in a systematic, holistic, way.

For the design and realization of nuclear decommissioning projects appropriate technical strategies have to be established. These strategies need to include and match several different considerations and to describe the planned activities as precisely as possible. In this respect legal frameworks and regulations also need to be considered. In addition, uncertainties, alternatives, resources as well as unfinished and open tasks or questions need to be considered. This applies in particular to the decommissioning of graphite moderated reactors and management of irradiated graphite. Technical decommissioning concepts include waste disposition strategies which—for individual waste streams such as irradiated graphite—may be subdivided into modules (Fig. 1). Each of these is connected with (basic or specific) scientific, technical and institutional demands or questions – see the example provided in Fig. 2.

The central consideration of this project is the development of a global schedule addressing the design of modular full process lines which may flexibly be adapted to different framework conditions or special local requirements. Taking into account the historic data of the already-completed projects (CarboWaste, IAEA CRP, and others) as well as new perspectives, this will help to identify the gaps necessary to achieve this in the different relevant fields. Accordingly, the project will be split into the three thematic areas: (1) scientific considerations, (2) technological and industrial considerations and (3) institutional frameworks and implementation strategies. Appropriate working groups will be established, cross-linked by a coordinator or coordinating working group. The project may require that participants temporarily contribute to more than one thematic area. Once the working groups are formed, each will develop its own approach and goals, scanning each disposal module (Fig. 1) in terms of relevance, cross connections, state of the art, ‘gaps’ or open questions as well as points that need further work or should be investigated in more detail during the project.

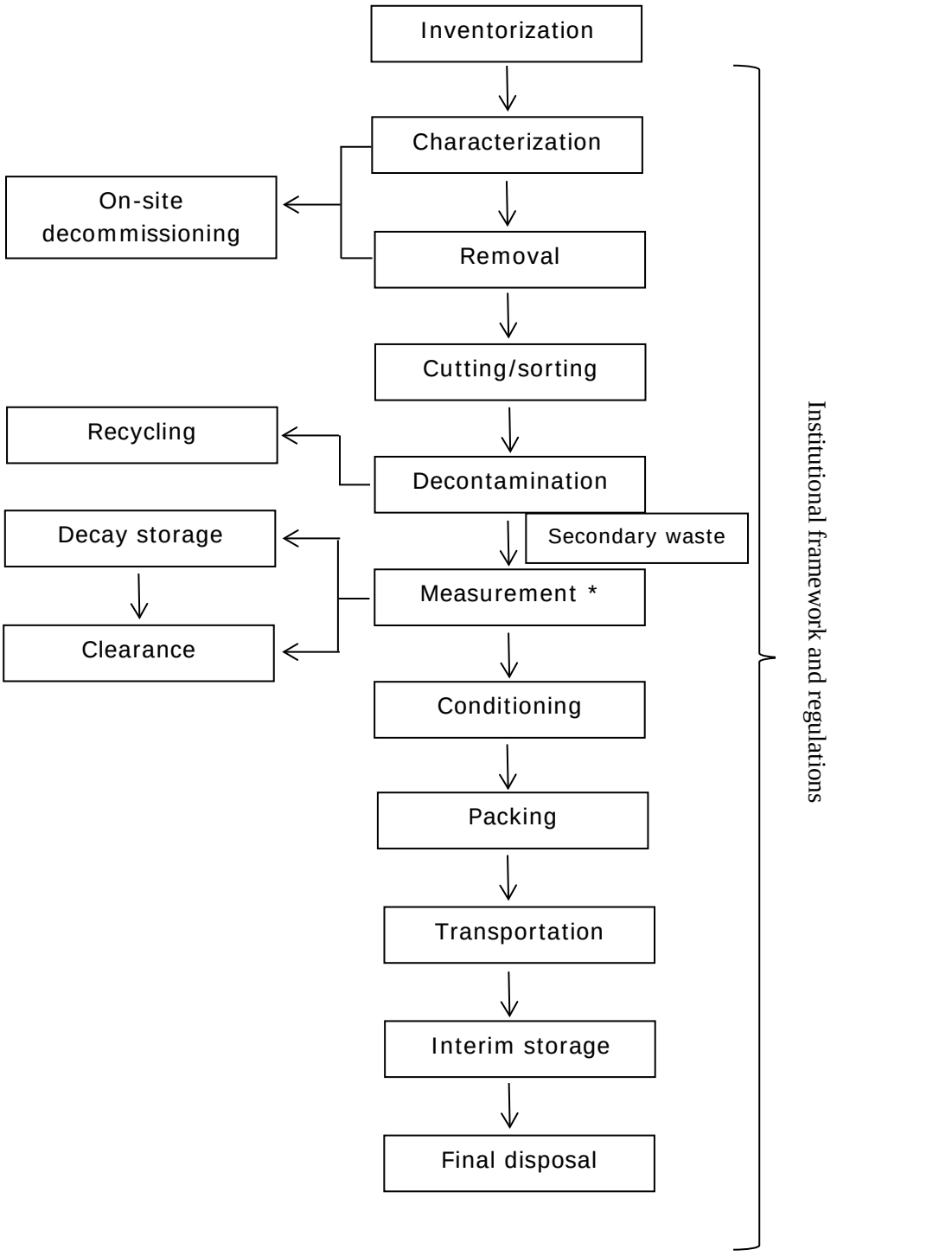

Fig. 1 Modular Disposal or Waste Management Concept

Towards a scientific-technical roadmap

Disposal concept		Scientific & technological tasks
• Characterization release	-	model system(s) i-graphite, graphite structure, mechanisms of activation.
• Removal		Stack removal in gas or underwater Containment and filtration of gas versus water during dismantling of graphite stack.
• Cutting / crushing	-	Distribution and binding of volatile radionuclides. Different solutions for wire removal, influence of wet and dry i-graphite (underwater decommissioning).
• Treatment & Decontamination releases,	-	Techniques and model system(s) for thermal treatment, kinetics of surface reactions, global mass balance, secondary waste created by the process and ways to condition it, mobile device for treatment.
• Clearance	-	Nuclide correlations, qualification of techniques, Measurements before and after treatment on industrial scale (e.g. dealing with inhomogeneities in bulk measurements)
• Conditioning	-	Immobilization, model system i-graphite/matrix, i-graphite as matrix (also for other radionuclides), sealing (thermal treatment), coating, volume reduction.
• Packaging & Transport	-	Design of packages, types and transport of i-graphite casks.
• Interim storage & Final disposal	-	model systems for i-graphite waste products, release rates under various conditions, system(s) waste products or package/environment (including corrosion, radiolysis, leaching), waste acceptance criteria

Fig. 2 Possible approach for linking of practice, theory and R&D

The working groups will meet regularly to present and compare their results and to reflect topical overlaps, interdependences and comprehensive issues. This process will serve also to identify tasks and expedient approaches for future R&D. Specific challenges in the Member States and/or specific tasks at individual decommissioning sites will also be determined and compared using a modular approach.

ACTIVITIES AND ROLES

The terms of reference were developed, at least in an outline, during an expert meeting at IAEA in Vienna in May 2015, the final structure will be fixed at the beginning of the project which is scheduled to be in February 2016. In order to prepare and update draft sections of this project report the participants will need to review the state of the art in science and technology as well as the current status and state of development of the institutional framework. The project report will be completed during the third year of the project. The coordinating working group will continuously gather deliverables and feedback, compiling a draft document that will be reviewed and discussed during a final plenary meeting to which several Member States will be invited to send representatives.

The final document will include (among others) especially the topics:

- National and international projects and activities
  Description of projects undertaken to date, overview of goals and achievements, cross-checking, identification of 'gaps' relating to application-oriented (industrial) goals.
- State-of-the art (including newest findings)
  Basic considerations, national and international situations, scientific-technical survey (addressed to the individual modules of the waste management concept).
- International competency levels
  Description of national institutions and working groups, focal areas & work priorities, participation and role in projects, competency networks & collaborations, R&D opportunities at various sites.
- Recommendations
  Analysis and discussions, development needs, proposals and roadmaps, proposal of further R&D and reference projects.

In addition the planning for GRAPA includes 3 envelope projects and an open list of subprojects on special tasks. Envelope projects are

- A Chernobyl study (graphite: from reactor to disposal within exclusion zone, evaluating options/benefits for treatment etc.);
- Implementing a framework for future pilot plant(s);
- Plugging 'gaps' in the scientific and technological basis of *i*-graphite disposal

Thematic areas of the subprojects so far are (1) packaging, (2) microwave heating, (3) classification of samples, (4) removal of blocks, (5) shallow disposal, (6) large scale classification and classification of mass streams, (7) nibble & vacuum, (8)

surface chemistry and modeling, (9) leaching information, (10) wigner energy and (11) isotope ratio(s). Each will be coordinated by individual sub-coordinators.

CONCLUSIONS

The new IAEA project GRAPA will link scientists, operators and practical engineers in a goal oriented way preparing the next steps towards i-Graphite processing. GRAPA also aims at the harmonization of procedures and the devolpment of practical methods and processes.

The main outcome of the project will be a report that describes the state of the art in science and technology in relation both to general and site specific situations and challenges. The report will include up-to-date information concerning regulatory frameworks, country-specific and common priorities, scientific/technical challenges and open questions, specific experiences, know-how and lessons learned in condensed form. It will include analysis, summary and comparison of the range of views and perspectives of scientists and graphite technical experts, decommissioning specialists, site managers as well as regulatory bodies. The report will also list relevant plans and activities in the individual Member States. Recommendations and possibilities for future targeted (application-oriented) joint initiatives or projects as well as for international tasks sharing will also be provided as an outcome. This will include a survey on opportunities and available resources for study and work at specific sites.

The report will be applicable to the scientific community, operators, regulators, government officials, policy makers, strategic planners and other stakeholders.