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Dismantling of the graphite pile of Latina NPP: Characterization and handling/removal equipment for single brick or multi-bricks

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ABSTRACT

This work describes the issues related the dismantling of graphite piles of the 1st generation gas cooled reactor of Latina NPP (Italy).

The retrieval of the graphite is a strategic matter for the decommissioning of this type of plant: in this study were described and analysed the current approaches used to access the core and to perform the remote and dry extraction of graphite bricks from the top.

Based on these data, the removal of the graphite of Latina NPP will be planned; the extraction of the graphite will be carried out layer by layer by means of a dedicated remote controlled handling systems. This equipment will be duly designed according to the nuclear, physical and mechanical constraints of the graphite piles in core. In doing that the issues regarding the irradiated graphite have been also analysed by FEM code, especially those related to the core geometry and to the proposed technique of hooking the graphite bricks by a 'gripper' tool inside the axial channel.

Data on fresh nuclear grade and irradiated graphite, used for the numerical simulations, were obtained by means of experimental tests, which were carried out on samples extracted from the reactor, and from theoretical models.

The results obtained could support the final design of proper lifting and gripper tools and handling equipment, for single brick or multi-bricks, and to implement waste management strategy for the graphite.

1. Introduction

When dealing with the decommissioning of gas-cooled graphite-moderated reactors, it has to face the large amount of radwaste, in the form of graphite stack fragments, that was generated during the lifetime of reactor (on average 1500–2000 tons per reactor, as evaluated by the IAEA).

With more than 250,000 tonnes of material (including graphite moderators and reflectors) existing world-wide, the graphite represents a major waste stream in decommissioning of reactors (EPRI, 2006; IAEA, 2010) to be dealt with (Fig. 1).

The major concerns of graphite arise because of the large volumes requiring disposal, the long half-lives of the main radionuclides involved and the specific properties of graphite, such as stored Wigner energy (this is directly related to the irradiation temperature of the graphite, being extremely significant in old plant operated with the graphite near or just above ambient temperature), graphite dust explosiveness, and the potential for radioactive gases to be released.

The most obvious source of irradiated graphite is from reactor moderators and reflectors.

The highest potential activation of impurity isotopes will be found in the former, although local movement of contaminants, such as metal oxides from component corrosion may result in additional deposition of activity in all regions.

Radioactivity of graphite stacks is generally caused by:

- Activation of graphite and impurities containing therein by neutron irradiation;
- Graphite contamination with the activation products of purging gas circulated in the stack;
- Graphite contamination with radionuclides in case of coolant leaks into the stack;

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List of acronym

E	Young modulus
^{14}C	^{14}Carbon
^{3}H	^{3}Hydrogen
^{6}Li	^{6}Lithium
EFPD	Equivalent Full Power Days
FEM	Finite Element Model
G	Shear modulus
HEPA	High Efficiency Particulate Air filter
IAEA	International Atomic Energy Agency
IGW	Inventory of irradiated graphite
ν	Poisson modulus
NPP	Nuclear Power Plant
PGA	Pile Grade A
PGB	Pile Grade B

- Graphite contamination with non-radioactive products in case of coolant-to-stack leaks and subsequent activation of these products with neutrons;
- Graphite contamination with fuel composition and fission products in case of fuel damage;
- Graphite contamination with radioactive products of corrosion and erosion of the structures in case of contact between graphite and structural elements such as, supports, tubes, etc.

As indicated in (IAEA, 2010), ^{14}C is the radionuclide of greatest concern in nuclear graphite principally arising through the neutron-nitrogen interactions (the nitrogen is present in graphite as an impurity or in the reactor coolant or in the cover gas); ^{3}H is from the reactions of neutrons with ^{6}Li impurities in graphite as well as from fuel fission. ^{36}Cl is instead generated thanks to the neutron activation of chlorine impurities in graphite. In consideration of these radioactivity inventories it is not possible in general to provide reliable predictions of reactor graphite radioactivity after its long-time irradiation during the reactor operation. That is why, there is a large effort in investigating dismantling and treatment procedures as well as various options for the management of radioactive graphite have been studied. However, a general accepted approach for conditioning and disposal graphite does not yet exist.

Indeed, it is worthy to highlight that different solutions may be appropriate in different cases and that there are no specific safety standards on the subject of graphite waste management.

In this study it will be described and analysed the current approach for the management of radioactive graphite, and specifically the procedure to be adopted for the remote and dry extraction of graphite from the Latina reactor. Moreover a proper experimental device designed for gripping, lifting and remote handling of single or multiple graphite bricks will be described along with numerical analyses carried out.

Finally a simplified model for graphite Pile Grade A (PGA) has been implemented in order to simulate (3D model by COMSOL Multiphysics®) stress distribution in a 'cold' irradiated graphite component subject to all loads arisen during the extraction from the stack.

2. Description of Latina NPP

The Latina plant is a Magnox reactor type, built by SIMEA S.p.A. (75% owned by Agip Nucleare and 25% by IRI), and definitively shut down in November 1986. During its 23 years of operation, the plant actually produced 4200 Equivalent Full Power Days (EFPD). Fig. 2 shows an overview and its vertical section with the indication of

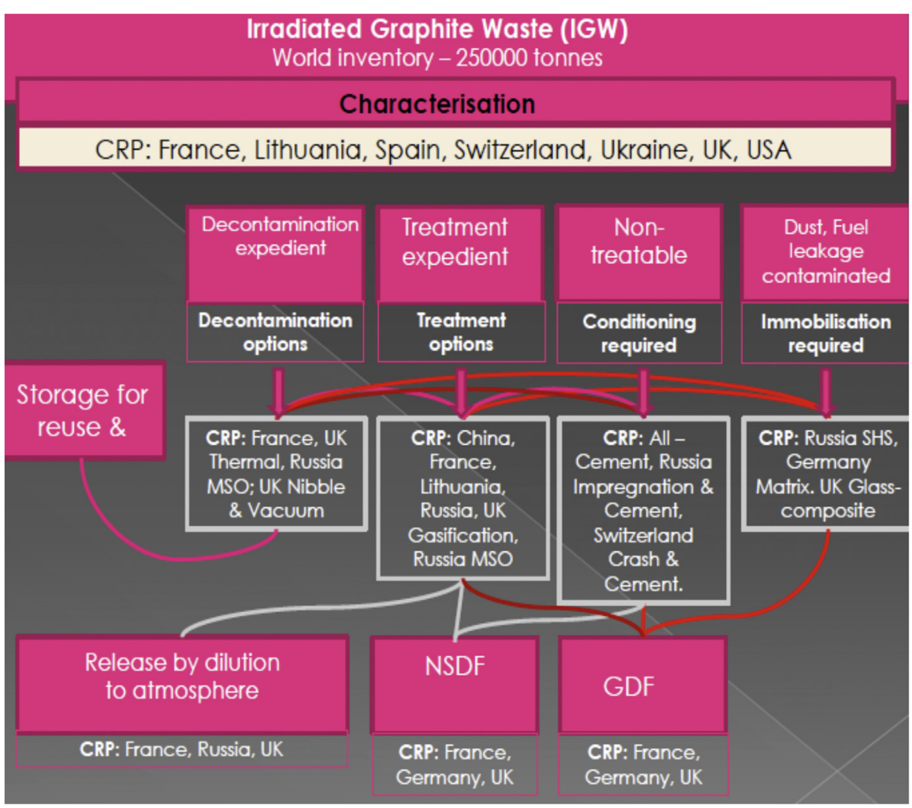

Fig. 1. Inventory of irradiated graphite (IGW) (courtesy of CRP IAEA).