Assessment of the Suitability of the planned Graphite Electrode Plant in Ardakan / Iran for the Production of Nuclear Graphite

1. Preamble

An Article has been published in Strategic Policy Consulting Inc and launched on Google "**Iran Smuggles Ceramic Matrix Composite, a Key Material for Building a Nuclear Bomb"** by Mr. Jafarzadeh that seems is alteration of the truth and presentation of fake information.

An example is his statement about a project which is under construction and could be used for production of nuclear bomb.

Quotation from the Article;

"Iran is building a large Graphite Electrode Plant, which by small changes in production line, can be used to produce Ceramic Matrix Composite.

In May 2004 Iran made a contract and started the construction of a large graphite electrode plant.

The plant has the capacity of producing 30,000 MTPA of UHP (Ultra High Power) grade Electrodes.

This plant will allow Iran to master the graphite technology including the technology to produce C.M.C. and other needed products of graphite for a nuclear bomb. Minor changes in the line of production of this plant would enable the Iranian regime to produce graphite products needed for a nuclear bomb."

Counterfeit of the provided data caused we provide the some technical fact to illuminate the mind of those who have read this Article.

In our reply we refer to the Contract, Resolution of UN Security Council 1737 (2006) and related Documents, and basic design criteria.

Firstly we point out that this plant is not under construction or operation.

The Contract was signed on May 2004 and the Contract period was predicted 49 months after contract coming into force. The enforcement of the contract was pending till 2007 and finally it was terminated

2. Definition

Ref; ***Resolution of UN Security Council 1737 (2006)***

In INFCIRC/254/Rev.8/Part 1, Annex A, the term in the public domain is defined as:
*"**In the public domain**"* means technology that has been made available without restrictions upon its further dissemination.

3. Abstract

The document in hand provides information about the question, whether or not the Ardakan Graphite Electrode Plant, to be located in Iran near the city of Ardakan in province Yazd, needs to be prevented based on the UN Security Council Resolution 1737(2006).
As the graphite products meet the specification of nuclear graphite set by the UN Security Council and the IAEA, the transfer of technology (including services) directly associated with nuclear graphite are subject to as great a degree of scrutiny and control as the nuclear graphite itself to the extent permitted by national law. Not covered is technology that is available "***in the public domain***" and "***basic research***".
The equipment is not specially designed to produce nuclear graphite and is only intended for the production of graphite electrodes and nipples for use in electric arc furnaces in steel making.
Some parts of the equipment and installations are so general that they could be used in many ways including the production of nuclear graphite (mechanical raw material treatment i.e. storage, grinding, sieving, conveying, mixing).
But this equipment can be considered to be ***in the public domain*** anyway and is therefore not prohibited.
The following major differences exist between the production of graphite electrodes and nipples for electric arc furnaces in the steel industry and the production of nuclear graphite parts.
Main production equipment like pressing/extrusion, impregnation, graphitization and machining is not suitable for the production of nuclear graphite due to technical constraints. The state of the art production of nuclear graphite parts would include isostatic molding for shaping to receive isotropic properties instead of extrusion in case of shaping electrodes and nipple rods. The impregnation would have to be adjusted by means of geometry and pressure. To reach the demanded properties, graphitization of nuclear graphite can not be carried out in a lengthwise graphitization furnace (***Castner***

furnace) as planned for Ardakan project. Usually, nuclear graphite is graphitized by use of an ***Acheson furnace*** or inductive graphitization

Additionally, equipment needed for the production of nuclear graphite, like surface treatment of finished products by chemical vapor deposition or treatment for purification, either by the chemical leaching and washing of raw material or by halogen treatment in an oven, are missing.

The plant is designed to use calcined petroleum coke as raw material, which results in an anisotropic structure of the final electrode product. For nuclear graphite products, special raw material with isotropic properties and isostatic pressing in combination with Acheson furnaces or inductive graphitization would have to be used in order to achieve an isotropic structure without cracks as well as necessary pureness of the final nuclear graphite product.

4. Assessment of the Existing Main Equipment

The main equipment of the production assessed whether or not it can possibly be used for the production of nuclear graphite.

- ***Green electrode preparation*** (coke preparation and mixing), ***baking and re-baking*** are ***in public domain*** and buyable by free trading.
- ***Extrusion of electrodes and nipple rods***

  Modern nuclear graphite production involves a quality control choice of low boron equivalent content coke materials, fine particle sizes, isostatic pressing/molding in rubber bags in order to graphite with the desired properties. Compared to extrusion, for molding the amount of binder pitch can be reduced to a wide extent. The shrinkage of the molded bodies is less compared to extruded bodies. This adds to the differences in properties of graphite electrodes and nuclear graphite.

  Therefore for forming purposes of high quality nuclear graphite, the method extrusion ***is not suitable***.
- ***Impregnation***

  The principal system of this type of impregnation is well known in the electrodes/nipples producing industry. For other pre-baked bodies with dimensions differing from the electrodes and nipples, ***the equipment would have***

to be specially designed. Additionally, the ***design would differ in*** order to reach the higher density of nuclear graphite in the impregnation process.

- ***Graphitization***

  For the preparation of nuclear graphite, ***the lengthwise graphitization is not feasible***. Firstly due to the geometric constraints, and secondly due to the behavior of the nuclear graphite material (isotropic) which does not allow the fast heating needed to reach the electric current and resistance in the material for heating and graphitization. Additionally, parameters (coefficient of thermal expansion, specific electric resistance, etc.) differ to a great extent.

- ***Machining***

  The machining facilities for electrodes and nipples are especially designed for these purposes.

  For the machining of more complex geometries, a specially designed machining shop would be needed. ***It is not possible to machine complex nuclear graphite parts with the planned machining equipment***.

- ***Packing / Dispatch***

  The equipment for packaging and dispatch are ***in public domain*** and is freely available.

5. <u>Missing Processes and Equipment</u>

The following Processes and Equipment are not existed in Ardakan project while they are required for a nuclear graphite production

- ***Leaching***

  For nuclear graphite products, leaching (e.g. with HCl) is used to treat and purify the raw material.

- ***Pressing***

  For nuclear graphite, the isotropic crystalline form is necessary resulting in the desired physical properties. This is reached by molding rather that extrusion. Specially designed molding and pressing equipment is required.

- ***Acheson Furnace***

  The Acheson furnace is the common furnace to graphitize any molded shape of graphite.

The electric current flows through the coke bulk surrounding the graphite bodies heating up the coke, from which the heat is transmitted to the graphite bodies. Due to indirect heating, the anisotropic or isotropic structure of the graphite bodies is not changed. ***Such a furnace would be needed for nuclear graphite*** production.

- ***Purification***

  In order to purify the resulting, graphite it is heated up to 3,100°C. Additionally, forming stable compounds of heteroatom using halogens can be performed at 3,000°C in order to reduce the content of impurities below200 ppm. ***Specially designed facilities would be needed***.

- ***Surface Treatment***

  Chemical vapor deposition of silane (SiH4) or methane (CH4) is used to build abrasion protection layers around the graphite or in order to reach higher densities by layers of pyrolitic, almost hexagonal graphite. ***Specially designed facilities would be needed.***

- ***Summary Table***

The following table summarized the suitability of the production steps of ***Ardakan graphite electrodes*** for the production of nuclear graphite.

Suitability of Graphite Electrode Production to produce Nuclear Graphite

No	Raw Mat./ Production Step	Suitable for Nuclear graphite	Remarks
1	Raw material CPC, needle coke	**no**	anisotropic
2	Raw material binder pitch principally	yes	depends on quality and softening point
3	Raw material impregnation pitch principally	yes	depends on quality and softening point
4	Coke preparation (crushing, sieving, storage bins)	principally yes	depends on recipe
5	Chemical raw material treatment, leaching	**missing**	
6	Mixing	principally yes	depends on raw materials,

			recipe, temperature, viscosity, technical adjustment of mixture
7	Extrusion press	**no**	different technology
8	Baking / Re-baking	principally yes	
9	Impregnation	**no**	different design
10	Graphitization (LWG furnace)	**no**	different technology
11	Purification (thermo-chemical)	**missing**	
12	Surface treatment (CVD)	**missing**	
13	Machining	**no**	different dimensions and geometry
14	Packing / Dispatch	principally yes	

6. Assessment Results

The UN Security Council Resolution 1737 (2006) forbids the export of nuclear graphite and of technology for internals of heavy water nuclear reactors. The Resolution attached documents further define the technology, services and parts not to be exported in a very general way.

As summarized in table 1, only the general unit systems which are used in a wide variety of industrial processes and production are usable for the production of nuclear graphite. Anyway, those units are not to be covered by control mechanisms as they are in the public domain. Some equipment would need a different design to be able to process nuclear graphite parts. ***Vital equipment for the production of nuclear graphite is missing***.

From the documents (Contract, basic design), the graphite electrode plant in Ardakan project is not technologically able to produce state of the art nuclear graphite parts.