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Tungsten Use in Nuclear Weapon Simulation Tests

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In November 2011, the International Atomic Energy Agency (IAEA) published an annex to its report on the implementation of safeguards in Iran that listed possible military dimensions (PMD) to Iran's nuclear programme, based on intelligence information provided to the Agency by certain Member States.[1] Among these was information that Iran was using the element tungsten in nuclear weapon development related experiments.

> *"Information which the Agency has been provided by Member States, some of which the Agency has been able to examine directly, indicates that Iran has manufactured simulated nuclear explosive components using high density materials such as tungsten. These components were said to have incorporated small central cavities suitable for the insertion of capsules such as those described in Section C.9 below."*

This once again is a case where the IAEA chose to include information in its November 2011 annex on PMD in Iran that was suspicious from the beginning and should never have been published without proper analysis. The notion that tungsten is a good simulant for uranium in nuclear weapon development based solely on its density is what may be referred to politely as "junk science" and does not reflect any expertise or experience in knowledge about the development and testing of nuclear weapons. The parts described in the quotation above from the IAEA annex simulate the actual fissioning uranium core of a nuclear weapon and

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[1] Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran, *Report by the Director General, IAEA* GOV/2011/65, 8 November 2011

the cavities mentioned are the void for the neutron initiator. If the core is not properly constructed, the behavior of the initiator will not be correct. What is missing in the quote above is what other high density materials might be used.

Tungsten is an extremely hard and brittle material. It has the second highest melting point of any element in the periodic table, at 3422˚C. It cannot be cast into workable shapes because no crucible can hold it. Instead, tungsten metal parts are made using a powder metallurgy process that requires making fine tungsten *powder* and then pressing the powder in moulds in very specialized industrial presses at extreme pressures and temperatures. The resulting tungsten metal parts will not be precise enough to substitute for uranium parts for internal implosion in uranium-based nuclear weapons. Tungsten is virtually impossible to machine using conventional methods because it is harder than most cutting tools. More expensive grinding technology needs to be used. By the time precision simulated uranium parts made out of tungsten are produced, a State choosing this route will have invested a huge amount of effort into a dead-end process development.

It is a dead end because the material properties of tungsten are very different from those of uranium. Uranium melts at a much lower temperature, 1132˚C, and is relatively easy to cast and machine. It is a ductile not brittle metal. The most obvious choice for testing uranium parts is to make them out of the right material, uranium, in the first place. A few kilogrammes of uranium metal could easily be produced clandestinely and would be the right material with the right properties that would give the right experimental data without the expense of creating a very expensive infrastructure to produce tungsten surrogate weapon parts, and get the wrong results.

The purported purpose of the experiments using tungsten in place of uranium is to measure the mechanical behaviour of uranium and the internal initiator as it is compressed by high explosives, as in the core of a nuclear bomb. Because the properties of tungsten are completely different from uranium, with the trivial coincidence of density, the experiments will give ambiguous results that will not answer any relevant questions related to the properties of nuclear explosives. This could be avoided simply by using the right material in the first place: uranium! To test the compression behaviour of uranium, uranium itself must be used, not tungsten. The differences between the melting point, hardness and equation of state of the two metals mean that they are not the same and cannot be used interchangeably for testing purposes.

Unfortunately the similarity in density between tungsten and uranium captures the attention of non-technical analysts and observers leading them to leap to the conclusion that the claim in the PMD annex is correct and significant. In reality, it is neither; because as noted above tungsten is not a suitable substitute for uranium in simulated nuclear weapon tests. The only exception might be a State with no access to either natural or depleted uranium – such a State is unlikely to be developing nuclear weapons.

The problem becomes even more obvious when environmental sampling for presence of uranium versus tungsten is introduced to the argument. The IAEA and its Network of Analytical Laboratories analyze cloths wiped over surfaces for evidence of tiny particles of uranium. Uranium is relatively easy to detect by this method because it is radioactive, it fissions in a nuclear reactor, and its presence in the swipes can be detected by chemical analysis in the laboratory. Very precise measurement technologies take advantage of these properties to allow environmental sample chemists to detect tiny particles of uranium from the wipe samples and subject them to further analysis.[2] Tungsten is neither radioactive nor fissionable. The techniques used to identify tiny uranium particles on wipe samples do not work for tungsten. In a wipe sample of thousands of particles, the analytical scientist can make the uranium particles "light up" and identify themselves for further analysis. In fact, finding particles of non-fissile elements such as tungsten, graphite or stainless steel, borders on impossible. It can only be done by painstakingly evaluating every particle of dirt or debris under a microscope one at a time and the sensitivity is poor as well.

The bottom lines:

- Pure tungsten metal cannot be melted or cast;
- Sophisticated powder metallurgy techniques and expensive grinding are required for fabrication of precision simulated nuclear weapons parts made from tungsten;
- Uranium is the best and simplest simulant for uranium;

[2] Environmental Sampling in Iran, Tariq Rauf, http://www.sipri.org/research/disarmament/nuclear/environmental-sampling-in-iran.

- Results of explosive tests using tungsten in place of uranium will give ambiguous results that do not answer the experimenter's questions; and
- Searching for tungsten particles in debris from explosive testing is an impractical and misguided errand using IAEA environmental wipe sampling techniques.

A final note. This topic has been discussed before and Twitter Intelligence Analysts have tried to counter that *tungsten carbide* components were used in the first nuclear weapon, Little Boy, a gun-type weapon dropped on Hiroshima in 1945. The first point is simple: *tungsten carbide* is not *tungsten* although most of the poor simulation physical arguments above still apply. Secondly, the tungsten carbide was wrapped outside the Hiroshima bomb to give it strength and hold it together for a brief period longer prior to detonation; it was not used for any purpose other than for being a tamper. The parts did not have to be as precise as internal parts in an implosion weapon and there can be no comparison between the two cases.

To conclude, the references to the use by Iran of tungsten as a substitute element for uranium in nuclear weapons development work as stated in the 2011 annex on PMD are incorrect, based on a lack of relevant expertise in nuclear weapons development and simulated testing.