CARAMEL: THE 7.5% SOLUTION TO IRAN'S 60% URANIUM ENRICHMENT THREAT

PressTV yesterday carried a threat from an Iranian lawmaker (and Reuters also reports the threat) that should the current round of P5+1 talks on Iran's nuclear technology break down, Iran would begin enriching uranium to 60% in order to produce fuel for a nuclear-powered submarine. The state of Iran's submarine technology suggests that this is mostly an idle threat, but there is a very easy route for the P5+1 group to diffuse the threat before it becomes a "red line" issue. France, a member of the P5+1 group, has a new generation of nuclear reactors for submarines that relies on a fuel known as "caramel", which is only enriched to 7.5% uranium. Providing one of these reactors to Iran would allow them to power a submarine with nuclear fuel without having to enrich to weapons grade or near weapons grade.

The US Office of Naval Intelligence tells us (pdf) that Iran is the only nation near the Persian Gulf possessing submarines. However, the submarine fleet is meager and mostly composed of very small vessels. From the Nuclear Threat Initiative:

> Iran's submarine force currently consists of three Russian Kilo-class diesel-electric submarines (Tareq 901, Noor 902, Yunes 903), one 350-400-ton Nahang and an expanding force of roughly a dozen 120-ton Ghadir-class midget submarines.
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> The three Kilo-class diesel-electric submarines, called Tareq-class in Iran, were commissioned from 1992 to 1996. Iran allegedly paid USD600 million for

> each boat and they are all based at Bandar Abbas in the Straits of Hormuz (Tehran is reportedly contemplating the relocation of its submarines from the shallow waters of Bandar Abbas to naval facilities in deeper waters at Chah Bahar in the Gulf of Oman). [12] Two of the Kilo-class submarines are operational at any one time and they are occasionally deployed in the eastern mouth of the Straits, the Gulf of Oman or the Arabian Sea.[13] Their utility in the Persian Gulf is, however, somewhat limited as Kilo-class boats require a depth of at least 164 feet and can therefore only access about one third of the Gulf.[14] Unique water conditions (water salinity and strong currents) in the Gulf further limit the boats' operational use unless the submarines are deployed to deeper waters in the Gulf of Oman or the Arabian Sea.[15]

Only the kilo-class submarines, which Iran does not manufacture, are large enough to be powered by a nuclear reactor. And NTI tells us that a retrofit of one of the Russian kilo-class vessels would be the likely home of a nuclear reactor, but Iran does not have the technology for the reactor itself:

> In June 2012, an Iranian official asserted that scientists were "at the initial phases of manufacturing atomic submarines."[24] He claimed Iran's success in retrofitting one of the imported Kilo-class submarines (after Russia had declined to do so), as evidence of the country's advancing submarine development capability, despite delays.[25] However, outside analysts stressed that manufacturing a nuclear reactor for use in submarines would be beyond Iran's current capabilities, suggesting that the announcement may be meant as leverage in

> negotiations with the P5+1, or as an excuse to continue enriching uranium.[26]

It would appear, then, that Iran is threatening to enrich uranium to a level appropriate for a nuclear submarine at a time when the only submarine it could put the reactor into is one purchased from Russia and then retrofitted. However, Iran also does not yet have the technology to build the reactor itself.

The suggestion that they would enrich to 60% uranium for a submarine reactor is a very strange target level for enrichment, as 60% doesn't line up with any of the known reactors used in submarines. The World Nuclear Organization describes the various submarine reactor technologies now in use:

> they deliver a lot of power from a very small volume and therefore run on highly-enriched uranium (>20% U-235, originally c 97% but apparently now 93% in latest US submarines, c 20-25% in some western vessels, 20% in the first and second generation Russian reactors (1957-81)*, then 21% to 45% in 3rd generation Russian units, 40% in India's *Arihant*).

Iran's stated target of 60% enrichment is higher than the Russian technologies that would use 20% or 40% enriched uranium and much lower than the US technologies that rely on weapons grade uranium enriched to over 90%. How did Iran choose the 60% number?

Setting aside the mysterious target of 60%, there is further information from the World Nuclear Organization that suggests a way around the issue of further enrichment if Iran really wants a nuclear-powered submarine:

> However, the enrichment level for newer French naval fuel has been dropped to 7.5% U-235, the fuel being known as

> ‘caramel’, which needs to be changed every ten years or so. This avoids the need for a specific military enrichment line, and some reactors will be smaller versions of those on the *Charles de Gaulle*.

Since France is a member of the P5+1 group, it seems that they could offer a reactor that runs on caramel to Iran so that they can power a submarine with fuel enriched only to 7.5%, removing the reason to enrich beyond their current maximum 20% level for production of medical isotopes. Alternatively, Russia (also a P5+1 member) could provide access to their submarine reactor technology that relies on 20% enrichment, which is also within Iran’s current enrichment capability.