Online Series

Implications of Iran's Success in Developing Fourth-Generation Centrifuge Technology

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Online Series CO 12-07

Iran has announced that it has developed a cutting-edge uranium enrichment facility that will dramatically increase its enrichment speed and production capacity. In a February 15th broadcast, Iran's government-operated television network quoted the Iranian Atomic Energy Organization (IAEO) as saying that fourth-generation centrifuges with improved processing speed had been successfully developed at the Natanz uranium enrichment site in central Iran, and that this was a significant advance for the nuclear development program.

The IAEO also announced that nuclear fuel rods developed using Iran's own domestic technology had been installed that day for the first time in the reactor at Tehran's nuclear research facility. Iranian President Mahmoud Ahmadinejad participated in the fuel rod installation ceremony, where he remarked, "With the addition of 3000 new fourth-generation centrifuges the number of centrifuges currently operating in Iran has reached approximately 9000." Already on the first of last month Iran announced that it had started to produce its own nuclear fuel rods and begun running tests.

At these facilities it is possible to produce 2.5%, 4%, and 20% enriched uranium. 20% is on the borderline between low and high enrichment and suggests a goal of nuclear weapons production capacity; this degree of enrichment is considered a "red line" by the IAEA. Iran's claim to have attained the ability to produce 20% enriched uranium signifies that they have been able to advance their nuclear program without external assistance. Fereidoun Abbasi Davani, the head of the IAEO, claimed that "This achievement is a strong response to the ruthless interference by external forces." Iran's intention to accelerate its nuclear weapons development has now been exposed.

Capacity of the Fourth-Generation Centrifuge

Figure 1: Specs of Iran's Current Centrifuges in Operation

Type	Original Model	Tubing Material	Gauge	Enrichment Capacity
P-1	S(C)NOR	Aluminum	Diameter: 10㎝ Length: 2m	3 SWU/yr
P-2	G-2	Maraging steel	Diameter: 15㎝ Length: 1m	6 SWU/yr
P-3	4-M	Maraging steel	Diameter: 20㎝ Length: 2m	12 SWU/yr
P-4	SLM(TC-10)	Maraging steel	Diameter: 15㎝ Length: 3.2m	21 SWU/yr
	TC-12	Carbon fiber	Diameter: 20㎝ Length: 3m	40 SWU/yr
	AC100	Carbon fiber	Diameter: 60㎝ Length: 12m	330 SWU/yr

As the above figure shows, Iran has continuously developed the capacity of its centrifuges from type P-1 to P-4.[1] Centrifuge capacity is determined by the

1) As the figure shows, centrifuge technology has repeatedly evolved. The first person to devise a centrifuge to enrich uranium was the German mechanical engineer Gernot Zippe (1917~2008). At URENCO, a multi-national corporation (jointly operated by German, Dutch, British and American industries) that manufactured uranium fuel rods, Dr. Zippe created tubular centrifuges. He installed various types of orbital rotors inside the circular tubes, causing gaseous uranium hexafluoride (UF6) to pass from the top to the bottom. Mined uranium, or "yellow cake," consists of 0.7% U-235 and 99.3% U-238. Because U-238 is 3 neutrons heavier than U-235, when spun at a high speed (20,000-100,000 rpms) the heavier U-238 is pushed out of the tube by centrifugal forces.

The amount of natural uranium that a single centrifuge can separate into U-235 and U-238 in one year is referred to as a separative work unit (SWU). This unit is an expression of the amount of work required for enrichment. For example, to enrich 1kg of natural 0.72% uranium material and size of the circular tubing and the rotation speed. The material has improved from aluminum (P-1) to maraging steel (P-2), and finally carbon fiber (P-4), while the circular tube size has increased (216 times by volume) as well as the rotation speed (5 times), indicating breathtaking advances. This has enabled the mass production of highly enriched uranium. Iran's improved centrifuge technology and production ability are thought to have been provided by the neighboring Muslim country of Pakistan.

In terms of separating capacity, the fourth-generation centrifuge developed by Iran apparently performs at nearly the same standard as the AC (American Centrifuge) type which the USEC (United States Enrichment Corporation) has been operating since 2002. Compared to the 15kg of highly enriched uranium that can be produced by 2000 P-1 and P-2 machines operating for one year, 3000 P-4 centrifuges of the AC100 type could theoretically produce 1255kg in a year. In addition, if they can obtain the technology and know-how, they may become capable of mass-producing nuclear missiles.

In general, uranium enriched by 3.5% to 20% is referred to as lightly enriched uranium (LEU) and is used for reactor power plants and medical procedures. Highly enriched uranium has been enriched by 90% or more and can be used to manufacture nuclear weapons. The problem is that it is not too difficult to make weapons-grade HEU out of 20% enriched uranium. The amount of time it takes to get from 20% to 90% varies according to the number of centrifuges and their capacity (SWU), but in general about one year should be sufficient. This means that, if they have indeed succeeded in producing 20% enriched uranium, then weapons-grade HEU is not far off.

The highest grade 90% enriched HEU can reach critical mass at merely 2.5kg, and low-grade uranium can do so at 16kg. Critical mass is the amount of HEU that can be used to make one nuclear warhead.

On the 8th of last month, in a CBS broadcast, US Secretary of Defense Leon Panetta stated that Iran has still not produced a single nuclear bomb. However if Panetta's statement is true that the Iranian authorities have begun enriching

into 4% uranium requires a SWU of 5.834 kg SWU. The SWU measure varies according to the uranium's level of enrichment and tails assay. Thus the higher uranium is enriched and the lower the tails assay is, the greater the SWU becomes. During enrichment because the enrichment ratio for a single centrifuge is so low, many centrifuges must operate together in direct and parallel connections. This is called a cascade, and the unit is usually expressed in kg SWU and tons SWU.

uranium in the underground nuclear facility in the North at Fordo and that they are capable of producing 3.5% and 20% enriched uranium, then it appears Iran is getting close to the stage where nuclear weapons production would be possible.

The Iran-North Korea Connection and Influence on the Middle East

Meanwhile Iran has continued working to develop its medium-range Shahab-3 missile with a 1930km range and the capacity to carry a nuclear warhead. If nuclear-equipped, this missile could pose a serious threat not only for Israel, the life-or-death issue in US foreign policy, but also the entire Middle East. This would demolish the existing Middle Eastern security order built by the US and cause the balance of power to abruptly collapse. In addition, the Shahab-4 and more advanced missiles could put all of Europe within range. Since the 1980s North Korea and Iran have enjoyed military cooperation and technology exchange, mainly focused on missiles; North Korea's Taepodong-2 missile and Iran's Shahab-5 missile are already overtly acknowledged as byproducts of this cooperation.

As is well-known, Iran and North Korea have a cooperative relationship in the fields of nuclear and missile development. Several hundred core technicians who participated in North Korea's nuclear or missile development programs are now known to be working in Iran's nuclear and missile facilities. This substantiates the suspicions of a North Korea-Iran connection in nuclear and missile technologies and has repercussions for the further development of nuclear technology in both countries and the international community's response. A diplomatic source familiar with North Korean nuclear issues has remarked that "It has been confirmed that there are hundreds of North Korean engineers and scientists working at about ten different nuclear and missile facilities inside Iran," adding, "This has continued for years." These technicians come from "Room 99" which is attached to the KWP's Department of Military Industry, and are dispatched for 3- or 6-month shifts abroad. They enter Iran via a third country and are dispersed to some ten different nuclear or missile facilities inside the country such as Natanz and Qom. By directly aiding Iran's nuclear and missile development, North Korea poses a threat to the current order in the Middle East.

Meanwhile, international attention is focused on the possibility of Israel launching an attack against Iran's nuclear facilities. Israel bombed Iraq's reactor at Osirak in 1981 and the secret nuclear reactor under construction at Al Kibar in Syria in 2007, thus neutralizing those facilities. As Iran has accelerated its nuclear development program, Israel has made it clear that it considers the program to be "an existential threat" and that it will take any necessary measures to stop it from proceeding. However, unlike the case in places like Syria, Iran's nuclear facilities are scattered in underground fortresses, and attacking them will not be easy. Even if Israel opts to take military action, they may do no more than halt the program for a few years.

The Threat to South Korea's National Security

North Korea's HEU program, which the world began to be aware of in October 2002, was fully exposed on November 12th, 2010. Dr. Siegfried Hecker, the director of Stanford's Center for International Security and Cooperation, directly witnessed centrifuges in operation at a North Korean facility. Ironically the enrichment work was being done at the Yongbyon nuclear facility, a site that had been under continuous surveillance by the US for twenty years, since the early 1990s. Following his trip to the North, Dr. Hecker published a report on Stanford's website describing in detail the state of the uranium enrichment facility, including descriptions of the centrifuges. In his report, Dr. Hecker wrote, "Instead of seeing a few small cascades of centrifuges, which I believed to exist in North Korea, we saw a modern, clean centrifuge plant of more than a thousand centrifuges all neatly aligned and plumbed below us." He added, "The high-bay areas were two stories high and we were told 50 meters long each… There were three lines of centrifuge pairs, closely spaced, the entire length of each hall. We were told that they began construction in April 2009 and completed the operations a few days ago."

As Dr. Hecker has also explained, North Korea claims that these are not the same as the P-1 centrifuges developed by Pakistan and in use by Iran, but rather they were developed by North Korea based on German and Japanese models. Dr. Hecker writes that the centrifuges were cylindrical with a diameter of 20cm and a length of 1.82m. This size corresponds to that of the P-1, P-2, and P-3 models, but in this author's opinion if they used the 120 tons of aluminum previously purchased from Russia then this probably fits the P-2 model.

Considering the speed at which North Korea has installed this uranium enrichment facility, it is clear that they have had cooperation from Pakistan and/or Iran. Also, North Korean missile technicians are being dispatched to sites in Iran. North Korea has a closer relationship to Iran than any other country in the world. If Iran transferred one of its P-4 type centrifuges to North Korea, it is almost certain that the North will begin direct mass-production through reverse engineering based on over 10 years of experience developing centrifuges. This could lead to a system of mass-production of HEU-based nuclear warheads in North Korea. No matter what it takes we must sever this link. This is our urgent task.