INSTITUTE FOR SCIENCE AND INTERNATIONAL SECURITY

IMAGERY BRIEF REPORT

North Korea's IRT Reactor: Has it Restarted? Is it Safe?

By David Albright and Serena Kelleher Vergantini

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The Institute for Science and International Security has learned from two different sources that North Korea has operated the IRT Reactor at Yongbyon using indigenously produced enriched uranium, possibly highly enriched uranium (HEU). North Korea has used this reactor to produce medical isotopes. However, now it may also use it to make tritium for its nuclear weapons program. In addition, two fuel elements made by North Korea reportedly failed and melted. This raises safety concerns and the question of whether South Korea should provide nuclear safety assistance to North Korea.

IRT Reactor

The small Soviet-supplied research reactor known as the IRT reactor, at the Yongbyon nuclear center, requires enriched uranium fuel. North Korea's original source of fuel for the reactor was the Soviet Union, which stopped supplying fuel more than two decades ago. The reactor was originally under International Atomic Energy Agency (IAEA) safeguards but is not safeguarded today. The reactor produces medical isotopes, although it may be used now to make tritium for North Korea's nuclear weapons program. In the past, North Korea separated isotopes produced in this reactor at the nearby Isotope Production Laboratory. Figure 1 shows this facility and the reactor.

The IRT reactor was originally a 2 megawatt-thermal (MWth) light water research reactor provided by the Soviet Union that first went critical in 1965. Its power was upgraded to 4 MWth in 1974 and then to 8 MWth by the late 1980s. The reactor was originally fueled with 10 percent low-enriched uranium (LEU), but started using highly-enriched uranium (HEU) with the upgrades, first HEU enriched to 36 percent and finally HEU enriched to 80 percent.[1]

Until 1990, Russia provided a total of 42 kilograms (kg) of HEU for the IRT reactor.[2] Afterward, North Korea was unable to procure additional fuel for the IRT reactor from Russia, due to lack of funds and then because of Pyongyang's stated intention in 1993 to withdraw from the Nuclear Non-Proliferation Treaty. Therefore, since then, North Korea operated the reactor intermittently as it gradually expended its imported HEU inventory. By 2007, it still operated the IRT albeit less frequently, reflecting its lack of fuel. In light of this fuel shortage, the director of the Yongbyon Nuclear Research Center said, "The fuel rods are precious."[3] It is widely believed that by 2011 the Soviet-supplied fuel was completely utilized, or "burned up," and North Korea did not have any more fuel to run the IRT reactor.

[1] See David Albright and Kevin O'Neil, *Solving the North Korean Nuclear Puzzle* (Washington, D.C.: Institute for Science and International Security, 2000).
[2] Ibid.
[3] Interview of Ri Song Hop, Director of Yongbyon Nuclear Research Center, by Albright, Pyongyang, North Korea, February 1, 2007.

However, two independent sources have stated that North Korea may be operating this reactor using indigenously produced fuel. Unfortunately, analysis of commercial satellite imagery could not confirm this since there are no external signatures indicating that the small reactor is operational. This task is complicated further by the fact that the reactor may not have operated steadily. In addition, we do not know the enrichment level of this domestically produced fuel, but it is reasonable to assume that the new fuel uses 80 percent enriched uranium, the enrichment level of the latest Russian-supplied fuel. North Korea is capable of making HEU for this reactor. Enriched uranium could be produced indigenously either at the Yongbyon centrifuge plant or at another unknown location.

There is also a possibility that North Korea has produced about 20 percent enriched uranium, or what is called low enriched uranium, to fuel this reactor. There were numerous discussions starting in the mid-2000s between NGO experts and North Korean nuclear and foreign ministry officials about converting the IRT reactor to LEU fuel, which would eliminate the need to import HEU fuel which Russia would no longer supply and allow the reactor to operate for making medical isotopes. North Korean nuclear and foreign ministry officials expressed interest in converting the reactor to operate on near 20 percent LEU fuel. In an interview by one of the authors of this report with the director of the Yongbyon Nuclear Research Center in 2007, he said he was unaware of the international LEU conversion programs but expressed interest in the idea of converting the IRT, as long as North Korea could buy the fuel.[4] He noted that the use of LEU fuel would require some changes in the fuel design and the activation area where isotopes are produced from neutrons produced in the core. In subsequent meetings, North Korean officials, including the director of Yongbyon, expressed on-going interest in converting the reactor. At the time of these discussions, which mostly pre-dated the 2010 revelation of a centrifuge plant at Yongbyon, any conversion was assumed to involve importing new LEU fuels that could replace the HEU fuel and exporting all the irradiated HEU fuel imported earlier from Russia.

The annual enrichment requirements to make this fuel, whether using LEU or HEU, are relatively small. Assuming that the reactor operates at full power 60-70 percent of the year, it would require about 6 kg of uranium 235 in enriched uranium fuel per year. If the enrichment is 80 percent, then the annual amount of enriched uranium would be 7.5 kg; if enrichment is 20 percent, then the annual amount is 30 kg. Assuming the enriched uranium is produced in an ideal cascade, with a tails assay of 0.4 percent, this amount of enriched uranium would require about 1,000 separative work units (swu) per year. The actual value would be greater, reflecting the lack of ideal conditions expected in North Korea's centrifuge plant(s). How much greater is difficult to predict, but it is likely no more than double this value. The nominal enrichment output of the Yongbyon centrifuge plant was about 8,000 swu per year until about 2015, when it increased to an estimated 16,000 swu per year. In addition, North Korea may have another centrifuge plant of similar size. Thus, the production of enriched uranium for the IRT is feasible, whether it is LEU or HEU, especially since the IRT would likely operate far less than 60-70 percent of the year at full power.

North Korean efforts to produce indigenous fuel for the IRT appear to have started several years ago. One sign was North Korea's 2012 procurement in China of a considerable amount of foreign equipment—in fact a complete production line—for making this fuel, according to a source knowledgeable about North Korea's nuclear programs. According to this official, this equipment was placed in a small facility north of the 5 megawatt-electric reactor that had been engaged in pilot fuel

[4] Interview of Ri Song Hop, Director of Yongbyon Nuclear Research Center, op. cit. See also Report of Visit to the Democratic People's Republic of North Korea (DPRK). Pyongyang and the Nuclear Center at Yongbyon, Feb. 12 - 16, 2008. Prof. Siegfried S. Hecker, Center for International Security and Cooperation, Stanford University, March 14, 2008, where Hecker also discussed IRT conversion one year later.

fabrication activities many years earlier and satellite imagery shows was being renovated in 2010 (see figure 2).

North Korea, however, has reportedly experienced problems making the new fuel. We have received a report that two of the new fuel elements failed and melted sometime between about 2012 and 2014, requiring a complicated cleanup. Commercial satellite imagery could not confirm the fuel accidents. However, we do not have access to sufficient commercial satellite imagery of Yongbyon to do a more thorough analysis.

The report of fuel melting raises serious reactor safety concerns and should stimulate a conversation, possibly initiated by South Korea, about nuclear safety cooperation with North Korea. Although the current atmosphere may not be conducive to such contacts today, this is an objective worth striving for in the next year. Nuclear accidents are not in anyone's interest.

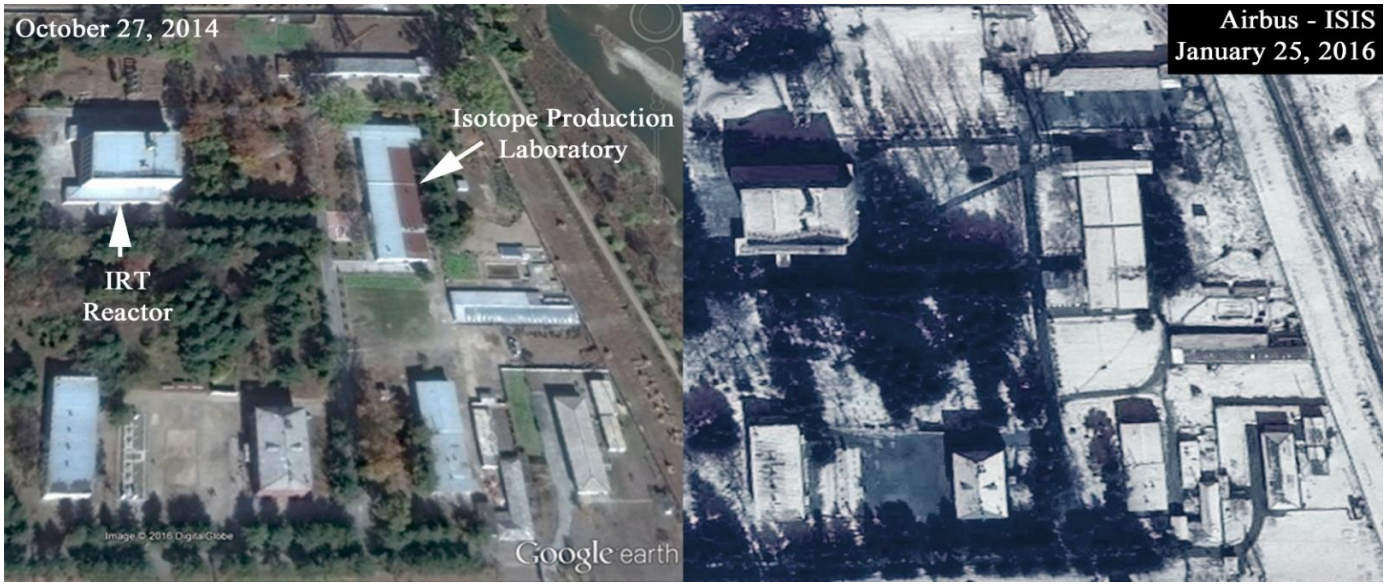

Figure 1. Google Earth and Airbus imagery showing the status of North Korea's IRT reactor in October 2014 and January 2016.

Figure 2. Progression of the Pilot Fuel Fabrication Plant near the 5 megawatt-electric reactor at Yongbyon.