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North Korea's Nuclear Weapons: How Soon an Arsenal?

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Summary

North Korea ended the eight-year freeze on its nuclear program in late 2002, expelling international inspectors and restarting plutonium production facilities. Before then, the CIA estimated that North Korea might have enough plutonium (Pu) for 1 or 2 weapons. Since then, North Korea may have reprocessed the 8000 spent fuel rods previously under seal at Yongbyon, yielding enough Pu for 6 or 8 weapons. In 2005, North Korea announced it had nuclear weapons and was building more. It restarted construction on two larger reactors, and shut down its small reactor, possibly to extract plutonium. In July 2005, North Korea rejoined the Six Party talks after a 13-month hiatus. Two unknowns in estimating the size of North Korea's arsenal are the status of its uranium enrichment efforts and whether Pakistani scientist A.Q. Khan gave North Korea a weapons design, as he did to Libya. This report will be updated as needed.

Background

In the early1980s, U.S. satellites tracked a growing indigenous nuclear program in North Korea. A small nuclear reactor at Yongbyon (5MWe), capable of producing about 6kg of plutonium per year, began operating in 1986.[1] Later that year, U.S. satellites detected high explosives testing and a new plant to separate plutonium. In addition, construction of two larger reactors (50MWe at Yongbyon and 200MWe at Taechon) added to the mounting evidence of a serious clandestine effort. Although North Korea had joined the Nuclear Nonproliferation Treaty in 1985, the safeguards inspections that began only in 1992 raised questions about how much plutonium North Korea had produced covertly that still have not been resolved. In 1994, North Korea pledged, under the Agreed Framework with the United States, to freeze its plutonium programs and eventually dismantle them in return for several kinds of assistance.[2] At that time, Western

[1] 5MWe is a power rating for the reactor, indicating that it produces 5 million watts of electricity per day (very small). Reactors are also described in terms of million watts of heat (MW thermal).

[2] See CRS Issue Brief IB91141, *North Korea's Nuclear Weapons Program.*

intelligence agencies estimated that North Korea had separated enough plutonium for one to two bombs; other sources claimed it was enough for 4-5 bombs.

Weapons Production Milestones

Acquiring fissile material — plutonium-239 or highly enriched uranium (HEU) — is the key hurdle in nuclear weapons development.[3] Producing these two materials is technically challenging; in comparison, many experts believe weaponization to be relatively easy.[4] North Korea has industrial-scale uranium mining, and plants for milling, refining, and converting uranium; it also has a fuel fabrication plant, a nuclear reactor, and a reprocessing plant — in short, everything needed to produce Pu-239. In its nuclear reactor, North Korea uses magnox fuel — natural uranium (>99%U-238) metal, wrapped in magnesium-alloy cladding. About 8000 fuel rods constitute a fuel core for the reactor.

When irradiated in a reactor, natural uranium fuel absorbs a neutron and then decays into plutonium (Pu-239). Fuel that remains in the reactor for a long time begins to become contaminated by the isotope Pu-240, which can "poison" the functioning of a nuclear weapon.[5] Spent or irradiated fuel, which poses radiological hazards, must cool after removal from the reactor. The cooling phase, estimated by some at five months, is proportional to the fuel burn-up. Reprocessing to separate plutonium from waste products and uranium is the next step. North Korea uses a PUREX separation process, like the United States. After shearing off the fuel cladding, the fuel is dissolved in nitric acid. Components (plutonium, uranium, waste) of the fuel are separated into different streams using organic solvents. In small quantities, separation can be done in hot cells, but larger quantities require significant shielding to prevent deadly exposure to radiation.[6]

Most experts agree that North Korea has mastered the engineering requirements of plutonium production. Its 5MWe nuclear reactor operated from 1986 to 1994, restarting in January 2003. North Korean officials claimed to have separated plutonium in hot cells and tested the reprocessing plant in 1990, and to have reprocessed all 8000 fuel rods from the 5MWe reactor between January and June 2003. Some analysts have reported that the 5MWe reactor operated at low efficiencies. The January 2004 unofficial U.S. delegation reported that "All indications from the display in the control room are that the reactor is operating smoothly now.... However, we have no way of assessing independently how well the reactor has operated during the past year."[7] The same delegation reported that the reprocessing "facility appeared in good repair," in contrast to a 1992 IAEA assessment of the reprocessing plant as "extremely primitive." In the end, however, North Korea's

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[3] Highly enriched uranium (HEU) has 20% or more U-235 isotope; weapons-grade uranium is 90% or more U-235.

[4] While the physical principles of weaponization are well-known, producing a weapon with high reliability, effectiveness and efficiency without testing holds significant challenges.

[5] Plutonium that stays in a reactor for a long time (reactor-grade, with high "burn-up") contains about 20% Pu-240; weapons-grade plutonium contains less than 7% Pu-240.

[6] Hot cells are heavily shielded rooms with remote handling equipment for working with irradiated materials.

[7] Siegfried Hecker, Jan. 21, 2004, testimony before Senate Foreign Relations Committee.

potential for developing a large nuclear arsenal depends on the completion of the two larger reactors and progress in the reported uranium enrichment program.

There is virtually no information on North Korean nuclear weapons design. The simplest, gun-type design requires no testing, but can only be made with HEU, not plutonium. Implosion devices, which use sophisticated lenses of high explosives to compress plutonium, are more likely to require testing. Some observers believe that North Korean testing of high explosives with particular compression patterns in the 1980s indicates the ability to manufacture an implosion device.[8] In April 2005, media reported that North Korea was readying a nuclear test site near Kilju, but the evidence did not seem conclusive.[9] A nuclear test by North Korea could provide more information on whether it has a workable nuclear weapon and what kind of design it is — simple or more complex (i.e., a boosted fission or composite pit design). It is unknown whether Pakistani scientist A.Q. Khan provided North Korea with the same Chinese-origin nuclear weapon design he provided to Libya.[10] If so, North Korea might develop a reliable warhead for ballistic missiles without testing. Such a warhead needs to be small, light and robust enough to tolerate the extreme conditions encountered through a ballistic trajectory. DIA Director Admiral Jacoby, in a hearing before the Senate Armed Services Committee on April 28, 2005, stated that North Korea had the capability to arm a missile with a nuclear device.

In January 2004, North Korean officials showed an unofficial U.S. delegation alloyed "scrap" from a plutonium (Pu) casting operation. Alloying plutonium with other materials is "common in plutonium metallurgy to retain the delta-phase of plutonium, which makes it easier to cast and shape" (two steps in weapons production).[11] Dr. Siegfried Hecker, a delegation member, assessed that the stated density of the material was consistent with plutonium alloyed with gallium or aluminum. If so, this could indicate a certain sophistication in North Korea's handling of Pu metal, but Hecker could not confirm that the metal was indeed plutonium, that it was alloyed, or that it was from the most recent reprocessing campaign, without conducting actual tests of the material.

Estimating Nuclear Material Production

Most estimates of nuclear weapon stockpiles are based on estimated fissile material production. Factors in plutonium production include the average power level of the reactor; days of operation; how much of the fuel is reprocessed and how quickly, and how much plutonium is lost in production processes. According to North Korea, the 5MWe reactor performed poorly early on, unevenly irradiating the rods. There is no data on the reactor's current performance or the reprocessing facility's efficiency. North Korea told the IAEA that during the 1990 "hot test," it lost almost 30% of the plutonium in the waste

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[8] Don Oberdorfer, *The Two Koreas,* (MA: Addison-Wesley, 1997), p. 250.

[9] First reported by the *Wall Street Journal* in the Seoul, on-line edition, Apr. 22, 2005. See also "What Are Koreans Up To? U.S. Agencies Can't Agree," *New York Times,* May 12, 2005.

[10] See also CRS Report RL32745, *Pakistan's Nuclear Proliferation Activities and the Recommendations of the 9/11 Commission: U.S. Policy Constraints and Options.*

[11] Hecker, Jan. 21, 2004 testimony before SFRC.

streams.[12] A key consideration is whether or not the reprocessing plant can successfully run continuously, since frequent shutdowns can lead to plutonium losses. According to North Korean officials in January 2004, the plant throughput is 110 tons of spent fuel annually, about twice the amount of fuel in the 5MWe reactor. A final factor in assessing how many weapons North Korea can produce is whether North Korea's technical sophistication enables it to use more or less material than the international standards of 8kg of Pu and 25kg for HEU per weapon. North Korea's abilities here are unknown.

What Does North Korea Have Now?

Secretary of State Powell stated in December 2002 that "We now believe they [North Koreans] have a couple of nuclear weapons and have had them for years."[13] On February 10, 2005, North Korea announced that it had manufactured "nukes" for self-defense and that it would bolster its nuclear weapons arsenal.[14] In June 2005, Vice Foreign Minister Kim Gye Gwan told ABC News that "We have enough nuclear bombs to defend against a U.S. attack. As for specifically how many we have, that is a secret." Kim also said North Korea was building more bombs and when asked about delivery systems, said "our scientists have the knowledge, comparable to other scientists around the world."[15] Some observers interpreted this to mean that North Korea can mate nuclear warheads to missiles. Some Members of Congress interpreted CIA Director Porter Goss's statements in mid-March on a "range" of nuclear weapon estimates to confirm that North Korea's arsenal has multiplied.[16]

Has North Korea reprocessed the existing spent fuel?. On July 13, 2003, North Korean officials told U.S. officials in New York that they had completed reprocessing the 8000 fuel rods on June 30.[17] On January 8, 2004, North Korean officials told the unofficial U.S. delegation that the reprocessing campaign began in mid-January 2003 and ended at the end of June 2003. In all, they reportedly reprocessed 50 tons of spent fuel in less than six months, which tracks with earlier estimates that North Korea could reprocess about 11 tons/month, roughly enough plutonium for 1 bomb per month.

The unofficial U.S. delegation visiting in January 2004 concluded that the spent fuel pond no longer held the 8000 fuel rods and surmised that those fuel rods could have been moved to a different storage location, but not without significant health and safety risks. The delegation was not allowed to visit the Dry Storage Building, where the fuel rods likely would have been stored before reprocessing. If the 8000 fuel rods from the 5MWe

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[12] David Albright and Kevin O'Neill, editors, *Solving the North Korean Nuclear Puzzle*, ISIS Report, ISIS Press, 2000, p. 88.

[13] Transcript of Dec. 29, 2002 *Meet the Press*.

[14] "North Korea Says It Has Nuclear Weapons and Rejects Talks," *New York Times*, Feb. 10, 2005.

[15] "N. Korea Building Bombs, Its Envoy Says," *Los Angeles Times*, June 9, 2005.

[16] Carl Levin and Hillary Clinton, "North Korea's Rising Urgency," *Washington Post*, July 5, 2005.

[17] "North Korea Says It Has Made Fuel For Atom Bombs," *New York Times*, July 15, 2003.

reactor have been reprocessed, they would yield, according to one estimate, between 25 and 30kg of plutonium, enough for 5 or 6 weapons.

The exact amount of plutonium that might have been reprocessed is not known. The January 2004 U.S. visitors to the plant were not allowed to visit waste facilities, and North Korean officials did not reveal any operating difficulties with the plant, stating that the reprocessing campaign was conducted continuously (4 six-hour shifts). U.S. efforts to detect Krypton-85 (a by-product of reprocessing) reportedly suggested that some reprocessing had taken place, but were largely inconclusive.

Adding to the Arsenal

Make New Plutonium in 5MWe Reactor. On February 6, 2003, North Korean officials announced that the 5MWe reactor was operating, and commercial satellite photography confirmed activity in March. In January 2004, North Korean officials told the unofficial U.S. delegation that the reactor was now operating smoothly at 100% of its rated power. The U.S. visitors noted that the display in the reactor control room and steam plumes from the cooling towers confirmed operation, but that there was no way of knowing how it had operated over the last year. In April 2005, the reactor was shut down, and on May 11, 2005, North Korean officials stated they harvested fuel rods for weapons.[18]

A common estimate is that the reactor generates 6kg of Pu per year, roughly 1 bomb per year, but the reactor would likely be operated for several years before fuel is withdrawn. Assuming a six-month cooling period for plutonium, North Korea would be ready to reprocess about 12 kg of Pu by October 2005 and convert into metal by April 2006, adding potentially another two nuclear weapons to the stockpile.

Bring New Reactors On-Line. The reactors at Yongbyon (50MWe) and Taechon (200MWe) are likely several years from completion. U.S. visitors in January 2004 saw heavy corrosion and cracks in concrete building structures at Yongbyon, reporting that the reactor building "looks in a terrible state of repair," but they did not visit the Taechon site.[19] The CIA estimates that the two reactors could generate about 275kg of plutonium per year.[20] In January 2004, North Korean officials told the unofficial U.S. delegation that they were evaluating what to do with both reactors. However, according to Japanese media, North Korean officials announced in May 2005 that it would prepare to restart construction, and that spy satellites corroborated the resumed construction in June 2005.[21]

Produce Highly Enriched Uranium for Weapons. A 2002 unclassified CIA working paper on North Korea's nuclear weapons and uranium enrichment estimated that

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[18] "North Koreans Claim to Extract Fuel for Nuclear Weapons," *New York Times*, May 12, 2005.

[19] Hecker Jan. 21, 2004 testimony before SRFC.

[20] CIA unclassified point paper distributed to Congressional staff on Nov. 19, 2002.

[21] "N. Korea Reportedly Resumes Work on 2 Nuclear Reactors," *Los Angeles Times*, July 1, 2005. The Japanese paper was the daily Nihon Keizai.

North Korea "is constructing a plant that could produce enough weapons-grade uranium for two or more nuclear weapons per year when fully operational — which could be as soon as mid-decade."[22] Such a plant would need to produce more than 50kg of HEU per year, requiring cascades of thousands of centrifuges. The paper noted that in 2001, North Korea "began seeking centrifuge-related materials in large quantities." Although not much is known about the program or facilities, Pakistan's A.Q. Khan probably offered the same P-2-design centrifuges to North Korea as he did to Libya and Iran.

For North Korea, a centrifuge enrichment program offers three advantages: such plants are difficult to locate and target, making them less vulnerable to military strikes than reactors or reprocessing plants. HEU also could give the North Koreans the option of producing either simpler weapons (gun-assembly type) or more sophisticated weapons (using composite pits or boosted fission techniques). Third, an HEU program is a bargaining chip to use with the United States. However, a centrifuge enrichment plant requires considerable industrial sophistication.

How to Verify North Korean Claims?

Information about North Korea's nuclear weapons production has depended largely on remote monitoring and defector information, with mixed results. Satellite images correctly indicated the start-up of the 5MWe reactor, but gave no detailed information about its operations. Satellites also detected trucks at Yongbyon in late January 2003, but could not confirm the movement of spent fuel to the reprocessing plant;[23] imagery reportedly detected activity at the reprocessing plant in April 2003, but could not confirm large-scale reprocessing;[24] and, satellite imagery could not peer into an empty spent fuel pond, which was shown to U.S. visitors in January 2004. Even U.S. scientists visiting Pyongyang in January 2004 could not confirm North Korean claims of having reprocessed the spent fuel or that the material shown was in fact plutonium. Verification of those claims would require greater access to the material and North Korean cooperation. This is particularly true in the case of uranium enrichment; U.S. intelligence officials have said they do not know where the uranium program is. According to one senior Administration official, the North Koreans have "got to give it up. That's how the Libyans did it."[25] This would also be true of other verification challenges, like confirming the existence of North Korean warheads and their dismantlement. There are precedents for bilateral verification (U.S. and Soviet) as well as international verification (IAEA verification of South African nuclear disarmament and the dismantlement of Iraqi nuclear weapon program following the 1991 Gulf war).

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[22] CIA unclassified point paper.

[23] "Reactor Restarted, North Korea Says," *Washington Post*, Feb. 6, 2003.

[24] "US Suspects North Korea Moved Ahead on Weapons," *New York Times*, May 6, 2003.

[25] "U.S. Offers North Korea Evidence That Nuclear Secrets Came From Pakistani's Network," *New York Times*, July 29, 2005.