

Special Report on the Shutdown of North Korea's 5MW(e) Nuclear Reactor

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On April 18, 2005, press reports indicated that North Korea's nuclear reactor in Yŏngbyŏn-kun, about 90 km north of Pyongyang, had been shut down. U.S. and South Korean officials, as well as non-governmental organizations, later confirmed that the reactor had been shut down for at least one week and possibly as early as April 7. According to Han Sŏng Ryŏl, North Korean deputy ambassador to the United Nations, North Korea plans to discharge the spent fuel and extract plutonium for bombs in order to increase the country's "nuclear deterrent."²

When Selig Harrison, director of the Asia Program at the Center of International Policy, visited Pyongyang on April 5-9, 2005, North Korean government officials warned him that North Korea planned to discharge the spent fuel over the next three months and reprocess the plutonium for nuclear bombs.³ On April 22, Kim Yŏng Nam, Chairman of the Presidium of the Supreme People's Assembly, and nominally the second ranking North Korean official, blamed the United States for having "conducted large scale nuclear war exercises," and claimed that North Korea's "nuclear deterrent" is for "legitimate self defense." Kim added that North Korea is committed to the peaceful resolution of the nuclear issue, but only if the "United States respects the DPRK's sovereignty...and replaces its hostile policy with one for a peaceful coexistence."⁴

North Korean media have not mentioned the reactor shutdown, but on April 21, the *Rodong Sinmun*, the official daily of the Central Committee of the Korean Workers Party, published a lengthy article criticizing the United States for "obstructing the denuclearization of the Korean Peninsula, and its strategy of preemptive nuclear attacks."⁵ The article also claims that North Korea was compelled to acquire nuclear

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² Barbara Slavin, "N. Korea Arsenal May Be Growing," *USA Today*, April 19, 2005, p. 1A.

³ Selig S. Harrison, article written for the *Hankryoreh Shinmun*, April 19, 2005, <http://ciponline.org/asia/articles/NorthKoreaTripArticleApril05.htm>; Yonhap News Agency, "北 '폐연료봉 재처리 계획' [North 'Spent Fuel Rod Reprocessing Plan']," *조선일보 [Chosun Ilbo]*, April 19, 2005, <http://nk.chosun.com>.

⁴ Jack Kim, "Senior South, North Koreans Meet; No Nuclear Talk," Reuters, April 22, 2005; Chris Brummitt, "N. Korea Says Nukes Needed for Defense," Associated Press, April 22, 2005.

⁵ "True Colors of U.S. as Arch Nuclear Criminal Disclosed," Korean Central News Agency, April 21, 2005, <http://www.kcna.co.jp>; "세계최대의 핵범인의 침략적정체 [The Aggressive Character of the World's

weapons because of the “U.S. policy of preemptive nuclear strikes” and “continuous efforts to stifle the DPRK.” The Korean version of the article is a much longer critique of the United States that includes references to U.S. nuclear forces, sub-critical nuclear tests, experiments to develop new miniature “bunker-buster” nuclear weapons, combined military exercises in South Korea, the U.S. withdrawal from the Anti-Ballistic Missile Treaty, and the U.S. weaponization of outer space.⁶

In a similar vein, on April 24, Vice Marshall Kim Yŏng Ch’un, Chief of the General Staff of the Korean People’s Army, accused the United States of “shipping ultra-modern war equipment and a nuclear strike group into South Korea in a bid to ‘bring down’ the North Korean system.” Kim warned that if the United States were to start a “war of aggression,” North Korea would “mobilize the military deterrent force built up for years and wipe out the invaders to the last man and win a final victory in the stand-off with the United States.”⁷

On April 25, a spokesman for the North Korean Foreign Ministry said “it is our consistent ultimate goal to denuclearize the Korean Peninsula and there is no change in our principled stand to attain it through negotiation.” However, the spokesman criticized U.S. Secretary of State Condoleezza Rice for her “threatening remarks against the DPRK” during an interview on Fox Television. The spokesman added that North Korea “can never return to the talks nor can we have any form of dealing with the U.S. unless the ill fame of an ‘outpost of tyranny’ is shaken off.” He reiterated Pyongyang’s view that United Nations Security Council sanctions would be considered a declaration of war.⁸

U.S. Response

In response to the reactor shutdown, White House spokesman Scott McClellan voiced continued U.S. government support for the Six-Party Talks, “calling on North Korea to come back to the talks so that we can talk about how we move forward in a substantive way.” McClellan said that North Korea’s “provocative words and actions only further isolate it.” When asked if the United States was contemplating referring a plan to the United Nations Security Council that would endorse the interdiction of suspected nuclear shipments to and from Pyongyang, McClellan said that “if North Korea refuses to come back to the six-party talks, then I fully expect we would consult with our partners in the region about the next steps, and that’s certainly one possibility.”⁹

Greatest Nuclear Criminal],” *로동신문* [Rodong Sinmun], April 21, 2005, <http://www.kcna.co.jp/today-rodong/rodong.htm>.

⁶ Ibid.

⁷ “DPRK to Steadily Bolster Its Nuclear Deterrent for Self-Defence,” Korean Central News Agency, April 24, 2005, <http://www.kcna.co.jp>; “김영춘총참모장 자위적인 핵억제력을 계속 늘어나갈것이라고 언명 [Chief of the General Staff Kim Yŏng Ch’un Declares the Self-defensive Nuclear Deterrent Will Continue to Be Increased],” Korean Central News Agency, April 24, 2005, <http://www.kcna.co.jp>.

⁸ “Spokesman for DPRK Foreign Ministry Assails Rice’s Reckless Remarks,” Korean Central News Agency, April 25, 2005, <http://www.kcna.co.jp>; “조선외무성대변인 제재를 곧 선전포고로 간주할것 [Korean Foreign Ministry Spokesman: Sanctions Will be Regarded as Immediate Declaration of War],” Korean Central News Agency, April 25, 2005, <http://www.kcna.co.jp>.

⁹ Scott McClellan, “Press Gaggle aboard Air Force One,” April 18, 2005, <http://www.whitehouse.gov>.

U.S. State Department spokesman Richard Boucher echoed McClellan's theme, stating that "running reactors or not running reactors, reprocessing or not reprocessing, is not going to get North Korea a solution to its troubles." He continued by saying that "whatever is going on in North Korea—and I can't get into the details, but I do say we follow developments at Yŏngbyŏn very closely—it's important to remember that they need to come back to [the] talks if they're going to solve their problems, and that's where our focus remains."¹⁰

While stressing that the framework of the Six-Party Talks was still in place and is the best forum in which to deal with the North Korean nuclear issue, Secretary of State Condoleezza Rice stated on April 21, 2005 that the United States is "absolutely willing, when the time is right, when we believe that we've exhausted the possibilities of the framework that we're in, to go to the Security Council."¹¹

Chinese Response

On April 21, Chinese Foreign Ministry spokesman Qin Gang stated that China has "taken note of the relevant reports, but we do not know the specific situation." He further emphasized China's continued view that "the Six-Party Talks are a practical and effective way of resolving the [Korean] peninsula nuclear issue" and urged "all the parties concerned, especially those mainly involved" to show "flexibility and sincerity" to resume negotiations as soon as possible.¹² Chinese Ambassador to South Korea Li Bin further articulated Beijing's position, stating on April 22 that "what China desires is that the U.S. and North Korea would come out to the table with more flexibility."¹³ He reiterated China's objection to referring North Korea to the U.N. Security Council by saying, "I don't think this is the time to discuss adopting a resolution on North Korea at the Security Council."¹⁴ Wang Guangya, China's ambassador to the United Nations, also said that efforts to adopt a UN Security Council resolution condemning North Korea "would destroy the whole process and push a solution to this issue even farther away."¹⁵

Recent press reports have suggested that Beijing had convinced Pyongyang to return to the Six-Party Talks in exchange for an official visit by Chinese President Hu Jintao to North Korea as early as April or May 2005.¹⁶ However, on April 21, Foreign Ministry

¹⁰ Richard Boucher, State Department Daily Press Briefing, April 18, 2005, <http://www.state.gov>.

¹¹ Condoleezza Rice, Interview with James Rosen of Fox News, Vilnius, Lithuania, April 21, 2005, http://usinfo.state.gov/eap/east_asia_pacific/north_korea/wosjuly6.html.

¹² Qin Gang, transcript of Chinese Foreign Ministry news conference on April 21, 2005, in "Transcript of PRC FM Spokesman News Conference on 21 Apr 05," FBIS Document ID: CPP20050421000199.

¹³ Yonhap News Agency, April 22, 2005 in "China Calls for 'More Flexibility' to Resume Six-Way Nuke Talks," FBIS Document ID: KPP20050422000299.

¹⁴ Choe Sang-hun, "China Calls for 6-Party Korea Talks," *International Herald Tribune*, April 23, 2005, p. 3, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>.

¹⁵ "China Raps Security Council Threat to N.Korea," *Chosun Ilbo*, April 27, 2005, <http://english.chosun.com/w21data/html/news/200504/200504270005.html>.

¹⁶ "Chinese Leader Tipped to Visit NK This Month," *Korea Times*, April 10, 2005, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>; Jong-heon Lee, "Analysis: N. Korea Plays New Card," UPI, March 31, 2005, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>; Yonhap News

spokesman Qin stated that that he “cannot confirm” such a visit. Since becoming president in March 2003, President Hu has yet to travel to North Korea.¹⁷

South Korean Response

South Korean government officials at first reacted to the reactor shutdown with skepticism; some initially believed the step was taken for technical reasons.¹⁸ On April 19, Minister of Foreign Affairs and Trade Ban Ki Mun told the National Assembly’s Unification-Foreign Affairs and Trade Committee, “For now, it is difficult to confirm whether the North halted the reactor to unload spent fuel rods or for technical reasons.”¹⁹ The following day Ban said, “We cannot but express serious concern if the North’s suspension of the 5-megawatt reactor is aimed at reprocessing.” Ban added, “This kind of act by North Korea runs counter to the expectations of the international community for a peaceful and diplomatic resolution of the nuclear issue, and it also does not conform to North Korea’s interests.”²⁰

Despite South Korean concerns, there is no government consensus on the use of more coercive measures against North Korea. On April 20, Unification Minister Chŏng Dong Yŏng, senior presidential advisors, and ruling Uri Party leaders met to discuss the situation but agreed that they would not support a referral to the UN Security Council or economic sanctions against Pyongyang.²¹ On April 21, Song Min Sun, Deputy Minister of Foreign Affairs and chief of the South Korean delegation to the Six-Party Talks, said that referring the North Korean nuclear problem to the UN Security Council is “no cure-all, and depending on the situation, it can be an added burden.”²² The government position has brought criticism from the opposition Grand National Party, which threatened to demand hearings on the government’s management of the North Korean nuclear issue.²³

Russian Response

In meetings with his South Korean counterpart April 22, Russian Defense Minister Sergey Ivanov stated that Russia “unequivocally favors [the] nuclear-free status of the

Agency, April 10, 2005, in “ROK’s Yonhap: Chinese President to Visit North Korea This Month,” FBIS Document ID: KPP20050410000011; Yonhap News Agency, April 20, 2005, in “ROK News Agency Cites Xinhua: PRC President ‘Likely’ to Visit DPRK 2 May,” FBIS Document ID:KPP20050420000011.

¹⁷ Qin Gang, transcript of Chinese Foreign Ministry news conference on April 21, 2005, in “Transcript of PRC FM Spokesman News Conference on 21 Apr 05,” FBIS Document ID: CPP20050421000199.

¹⁸ Yonhap News Agency, April 18, 2005, in “ROK ‘Senior’ Official Says DPRK Suspended Nuclear Reactor for ‘Technical Reasons’,” FBIS Document ID: KPP20050418000130.

¹⁹ “Purpose of NK Reactor Shutdown Unclear: FM,” *Korea Times*, April 20, 2005, in Lexis-Nexis.

²⁰ Yonhap News Agency, April 20, 2005, in “ROK Foreign Minister Expresses ‘Serious Concern’ Over Possible DPRK Reprocessing,” FBIS Document ID: KPP20050420000027.

²¹ “Seoul Opposes Sanction on N. Korea,” *Korea Times*, April 21, 2005, in Lexis-Nexis; Lee Joo-hee, “Government, Uri Opposed to U.N. Option on N.K.,” *Korea Herald*, April 21, 2005, in Lexis-Nexis.

²² “UNSC Is No Panacea for NK Nukes,” *Korea Times*, April 22, 2005, in Lexis-Nexis.

²³ “Hill Plans Trip to Region Next Week to Try to Kickstart Negotiation,” *Korea Herald*, April 22, 2005, <http://www.koreaherald.co.kr>; Yonhap News Agency, April 21, 2005, in “ROK’s Yonhap: GNP to Push for Parliamentary Hearing on N. Korean Nukes,” FBIS Document ID: KPP20050421000055.

Korean Peninsula” and urged all concerned parties to “do everything necessary for North Korea’s return to the six-nation talks format.”²⁴ However, a Russian diplomat told the Interfax News Agency that because “Russia has not received any official statement on the [reactor shutdown] from the North Korean side,” the Russian government would not yet formally comment on the development.²⁵

Meanwhile, Konstantin Kosachev, chairman of the Russian Duma’s International Relations Committee and a member of an official delegation scheduled to visit Pyongyang May 5-7, 2005, said that “North Korea continues to avoid the resumption of serious international talks on this problem in six-party format and insists only on talks with the U.S.A. while not hiding that it is increasing its nuclear potential. This is extremely dangerous and taking into account our special relations with Pyongyang, we are trying to convince our North Korean counterparts to facilitate a change to this position.”²⁶

Japanese Response

Although preoccupied recently with its deteriorating relationship with China over accusations that Tokyo is trying to gloss over its World War II era atrocities, Japan has been monitoring the situation with North Korea. Chief Cabinet Secretary Hiroyuki Hosoda stated on April 20, “The fact that fuel for nuclear arms is being produced continuously is an extremely worrying situation.”²⁷ However, the Japanese government has yet to confirm officially that Pyongyang has shut down its nuclear reactor or imply how such a decision might alter Japan’s security environment.

On April 23, a “Japanese diplomatic source” said that Japan intends to “promote coordination with the United States and South Korea” to resolve the North Korean nuclear issue. The source added that during the up-coming 2005 Review Conference on the Treaty on the Non-Proliferation of Nuclear Weapons Nonproliferation beginning May 2, 2005 in New York, Japan will seek a “a final document urging [North Korea to] return to the Six-Party Talks and to [Pyongyang’s] safeguard agreement with the International Atomic Energy Agency.”²⁸

What’s Next? Implications of the Reactor Shutdown

There are three possible explanations for the shutdown of the Yŏngbyŏn reactor. First, the shutdown could be due to a malfunction or technical problem. Second, the reactor could have been shutdown to raise the stakes in the nuclear standoff, bolstering

²⁴ “Russian Defence Minister Urges Pyongyang’s Return to Six-Nation Talks,” ITAR-TASS, April 22, 2005, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>.

²⁵ “Russian Duma Delegation to Discuss Six Part Talks in North Korea,” Interfax News Agency, April 20, 2005, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>.

²⁶ Ibid.

²⁷ Kyodo News Service, April 20, 2005 in “Japan Says North Korea’s Nuclear Fuel Production ‘Extremely Worrying’,” FBIS Document ID: JPP20050420000031.

²⁸ Kyodo News Service, “U.S., Japan Eye NPT Accord Urging N. Korea to Return to 6-way Talks,” Japan Economic Newswire, April 23, 2005, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>.

Pyongyang's demand for bilateral talks and security assurances from Washington. The third alternative is that the reactor has been shut down in a determined effort to reprocess the plutonium from the spent fuel and to produce nuclear bombs. The amount of plutonium that could be reprocessed depends upon how the reactor was operated and the efficiency of North Korea's reprocessing campaign. However, the maximum amount of weapons-grade plutonium that could be extracted from the reactor core is about 14.5 kg, although a more likely amount would be about 8-11 kg considering the likelihood that North Korea was unable to operate the reactor at 100 percent capacity, reprocessing losses of 5-15 percent, and losses of up to 20 percent during metallurgical processing when manufacturing plutonium bomb cores. In sum, this would give North Korea enough plutonium for 1-3 nuclear bombs.

Technical Problems

The 5MW(e) is a gas-cooled, graphite-moderated reactor based on the British Calder Hall reactor design of the 1950s. The reactor uses natural uranium for fuel and graphite as a neutron moderator, and both substances are abundant in North Korea. There are several technical problems that could have arisen that necessitated the shutdown of the reactor. For example, fuel rod damage is a common problem in the operation of nuclear reactors, but there is no evidence that the reactor has any damage that would compromise its operation. Damaged fuel rods can cause nuclear fuel to leak into the reactor coolant, increasing the gas' radioactivity. In the case of graphite-moderated reactors, the graphite can turn into an amorphous, green substance, losing some of its effectiveness as a moderator. Both of these situations could necessitate reactor repair or maintenance.

Under the Agreed Framework of October 1994, operation of the 5MW(e) reactor was frozen for over eight years. This is the first time the reactor has been taken off line since it was re-started in February 2003. This shutdown could be aimed at removing and replacing damaged fuel rods—an explanation that Pyongyang provided for the 1989 shutdown—and to conduct tests on the operation of the reactor. Under this scenario, the reactor could be restarted within a few weeks, or if there are more serious technical problems, it could take months.

While this scenario would ease fears about North Korean plans to remove all or most of the 8,000 spent fuel rods in order to reprocess weapons-grade plutonium, it could provide North Korean technicians an opportunity to test equipment and refresh their skills for dealing with spent fuel. North Korea could, as it has admitted in its "initial declaration" to the International Atomic Energy Agency (IAEA) regarding its 1989 reactor shutdown, reprocess the damaged fuel rods and then separate out small amounts of plutonium for training purposes and to test the performance of reprocessing equipment and personnel.

A Negotiating Tactic

Given North Korea's history of brinksmanship and hard bargaining, the DPRK may be using the reactor shutdown to strengthen its bargaining position. The Six-Party Talks have been stalled since June 2004, and Washington and Pyongyang are currently at

loggerheads over how to resolve the nuclear standoff. The United States refuses to accept North Korean demands for bilateral talks, instead insisting on the continuation of the six-party process, which also includes China, Japan, Russia, and South Korea. U.S. officials have recently been calling attention to the possibility of referring the North Korean nuclear issue to the United Nations Security Council. But according to North Korean government statements, economic sanctions imposed by the Security Council would be considered a declaration of war.

In January 2004, North Korean scientists at the Yŏngbyŏn nuclear complex told Dr. Siegfried Hecker, former director of and a senior fellow at the Los Alamos National Laboratory, that “the length of time the reactor is expected to operate with the current load of fuel depends on how the situation with the United States develops.” They also claimed to have had corrected some previous operational problems with the reactor.²⁹ Unless these comments are misrepresentations, they support the notion that the reactor was shut down to strengthen Pyongyang’s bargaining position. Shutting down and then restarting the reactor later with the same batch of fuel would have no effect on the integrity of the spent fuel. This would allow North Korea to shut down the reactor for a short-term diplomatic maneuver while not adversely affecting its goal of generating weapons-grade plutonium in the medium-term.

Reprocessing the Spent Fuel for Nuclear Weapons

Another explanation for the North Korean reactor shutdown is that Pyongyang has concluded that nuclear weapons are necessary for national security, and that the fissile material in the reactor core must be extracted now for reprocessing and assembly into nuclear weapons. Obviously, this scenario would be most detrimental to regional and global security.

The time needed to reprocess the spent fuel is of pivotal importance for gauging the immediacy of the threat posed by the reactor shutdown. The first step in extracting the plutonium is unloading the spent fuel rods from the reactor core. Depending on the amount of fuel rods removed, the process should take no more than two months, based on similar removals in the past, particularly in 1994.³⁰ Because of the extreme radioactivity and temperature of the spent fuel rods, they must immediately be placed into cooling ponds for sufficient radioactive decay of the most radioactive isotopes.

There is an inherent trade-off in plutonium production. A higher burn-up rate (higher operating capacity) produces more weapons-grade plutonium, but it also produces more highly radioactive fission products that require more time for radioactive decay before safe handling. If a reactor is operated with a lower burn-up rate, and with intermittent

²⁹ Siegfried S. Hecker, “Visit to the Yongbyon Nuclear Scientific Research Center in North Korea,” presented to the U.S. Senate Committee on Foreign Relations Hearing on January 21, 2004.

³⁰ David Albright, “How Much Plutonium Does North Korea Have?” *Bulletin of the Atomic Scientists*, Vol. 50, No. 5 (September/October 1994), pp. 46-53; U.S. Department of Defense, “Proliferation: Threat and Response,” April 11, 1996, <http://www.defenselink.mil/pubs/prolif/>; Michael Gordon, “North Korea Said to Have A-Bomb Fuel,” *New York Times*, June 8, 1994, p. A7, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>.

shutdowns, fewer highly radioactive isotopes are produced, which reduces the amount of time before reprocessing can begin. In this case, reprocessing can begin within weeks, but the amount of plutonium available for extraction is reduced. To date, there is no evidence that North Korea has shut down or powered down the reactor during the last two years, and North Korean scientists and technicians told Siegfried Hecker in January 2004 that the reactor was operating “smoothly at 100 percent.”³¹ It should take a minimum of six months before the spent fuel rods can be handled for reprocessing. Since North Korean leaders are likely to value the nuclear program’s human resources, they are more likely to wait up to 12 months before starting the reprocessing campaign. It should be noted that some of the rods located farthest away from the center of the reactor core could be ready for reprocessing in a shorter period of time, while those closer to the center of the core (and with a higher concentration of plutonium-239) would need to remain in the cooling ponds for a longer period.

Based on IAEA estimates during the 1994 reactor shutdown, North Korea could complete the reprocessing and separation processes in about two months after the fuel rods have sufficiently cooled.³² The spent fuel rods cannot be transported from the nuclear complex for at least several months, but the extracted plutonium can be transported to other locations after reprocessing.

North Korea has already produced enough weapons-grade plutonium to manufacture 6-8 nuclear weapons. The 5MW(e) reactor was operational for over 25 months before it was shut down in early April 2005. The reactor can produce about 5.5 kg of plutonium per year, although that number can vary slightly depending upon the operation of the reactor and the efficiency of North Korea’s reprocessing efforts. If North Korea reprocesses the current batch of spent fuel, Pyongyang could obtain a maximum of about 14.5 kg of weapons-grade plutonium, but a more likely amount is 8-11 kg considering inefficiencies in reprocessing and metallurgical processes.³³ In sum, North Korea could extract enough plutonium for 1-3 nuclear bombs.

Two major signatures are present and detectable when reprocessing occurs. The first is the emission of krypton-85 (Kr-85), a radioactive gas, from a reprocessing facility. Kr-85 is released when the cladding surrounding the fuel rods is cut, and the gas can be detected by air sampling relatively far from the site. While the United States is capable of using

³¹ Siegfried S. Hecker, “Visit to the Yongbyon Nuclear Scientific Research Center in North Korea,” presented to the U.S. Senate Committee on Foreign Relations Hearing on January 21, 2004.

³² Stewart Stogel, “N. Korea Defueling Quickly, Could Make Plutonium Soon,” *Washington Times*, June 9, 1994, p. A13; Mark Hibbs, “Low I-131 Means DPRK Reprocessing Could Begin ‘Immediately,’” *Nucleonics Week*, June 9, 1994, p. 3, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>; Kevin Rafferty, “Seoul Urges China to Back Sanctions,” *The Guardian* (London), June 9, 1994, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>; Michael Gordon, “North Korea Said to Have A-Bomb Fuel,” *New York Times*, June 8, 1994, p. A7, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>.

³³ Even if the reactor had been operating at 100 percent capacity, which is unlikely, it is impossible to recover 100 percent of the plutonium during reprocessing. Technology and training can increase efficiency, but it’s safe to assume a 5-15 percent loss rate for North Korea’s reprocessing facility. Furthermore, up to 20 percent of the plutonium can be lost during metallurgical processing in the manufacture of bomb cores.

such monitoring technology to detect reprocessing, technology has not been developed to neutralize or mask the release of Kr-85 gas.

A second indicator that reprocessing has begun is thermal signatures emanating from a reprocessing facility, which can be detected remotely by infrared sensors on satellites. Other signatures would include commensurate surges in water consumption and water output that is slightly radioactive. Also, general activity of personnel at a facility should increase, as technicians arrive and materials are delivered to the reprocessing facility.

5MW(e) Reactor Description³⁴

North Korea's 5MW(e) reactor is a graphite-moderated, gas-cooled reactor with a thermal power in the range of 20-25MW. Construction of the reactor began in either 1979 or 1980, and was reportedly under construction by at least July 1980. The reactor was modeled after the British Calder Hall gas cooled reactor that was first built in 1956. This reactor design held several advantages for North Korea. The Calder Hall design has been unclassified and widely available for a number of years, and it uses natural uranium for its fuel, which is abundant in North Korea. Another advantage of this reactor design is the cooling system, which uses carbon dioxide, and therefore requires no heavy water. Additionally, the Calder Hall reactor uses graphite, which is also available in North Korea, as a moderator. Finally, North Korea may have also found it advantageous that the spent fuel for this type of reactor is a good source of weapons-grade plutonium. However, one problem with this type of reactor is the difficulty in storing the spent fuel for an extended period.

According to David Albright, the 5MW(e) reactor in Yŏngbyŏn-kun has 812 fuel channels for guiding control rods and stacking fuel rods, with each channel holding as many as 10 fuel rods stacked on top of one another. Each fuel rod is about 50 centimeters long and three centimeters in diameter, with a weight of roughly 6.2 kilograms. Taken together, the reactor core contains about 50 metric tons of fuel in the form of natural uranium.³⁵ Theoretically, if this reactor were operated at 100 percent capacity, it could produce one gram of plutonium per thermal megawatt for every day it is in operation. The Center for Nonproliferation Studies assumes an operational capacity of about 75 percent and a subsequent annual production capacity of about 5.5 kg of weapons-grade plutonium.

Operational History of the 5MW(e) Reactor³⁶

The 5MW(e) reactor reached criticality on August 14, 1985 and became operational in 1986. The reactor was shut down and its operation frozen under the terms of the Agreed

³⁴ Much of this description is based upon the CNS "North Korea Country Profile, 5MW(e) Experimental Reactor," Nuclear Threat Initiative, http://www.nti.org/e_research/profiles/NK/45_551.html.

³⁵ David Albright, "How Much Plutonium Does North Korea Have?" *Bulletin of the Atomic Scientists*, Vol. 50, No. 5 (September/October 1994), pp. 46-53.

³⁶ Much of this operational history is based upon the CNS "North Korea Country Profile, 5MW(e) Experimental Reactor," Nuclear Threat Initiative, http://www.nti.org/e_research/profiles/NK/45_551.html

Framework in October 1994. During its eight years of operation, the reactor was shut down three times: for about 70 days in 1989; for about 30 days in 1990; and roughly 50 days in 1991. These periods provided an opportunity to remove and reprocess spent nuclear fuel. While U.S. satellite imagery detected the shutdowns on all three occasions, the reactor was not being monitored by the International Atomic Energy Agency (IAEA) during these periods because Pyongyang did not ratify a safeguards agreement with the IAEA until April 1992.

The amount of plutonium extracted from the reactor's spent fuel in the past depends upon the reactor's operational history, North Korea's reprocessing efficiency, and whether North Korea exploited the opportunities provided by the reactor shutdowns in 1989, 1990, and 1991. According to data collected by IAEA inspectors, particularly samples of Americium-241 and the distribution of the plutonium isotopes in the sample provided with Pyongyang's initial declaration, North Korea almost certainly reprocessed plutonium in 1989, 1990, and 1991. However, the 1990 and 1991 shutdowns were most likely insufficient to replace the entire reactor core, thus decreasing the amount of plutonium that could have been reprocessed. Most analysts agree with David Albright's assessment that an upper bound for the amount of plutonium that could have been reprocessed from this reactor's spent fuel is about 6.9-10.7kg.³⁷ Given the approximate 4.0 kg that could have been reprocessed from the Soviet-supplied IRT-2000 Nuclear Research Reactor also housed in Yŏngbyŏn,³⁸ by 1994 North Korea could have had enough weapons-grade plutonium for two nuclear bombs.

In May 1994, North Korea shut down the 5MW(e) reactor and began to discharge the spent fuel rods. Under the terms of the Agreed Framework, the spent fuel was later canned and moved to a temporary storage pond at the Yŏngbyŏn nuclear complex. However, following the December 2002 expulsion of IAEA inspectors who had been monitoring the nuclear freeze, North Korea removed the spent fuel rods and had completed the reprocessing of the spent fuel by October 2, 2003.³⁹ This should have given North Korea enough fissile material for 4-6 nuclear bombs, increasing its total number of weapons to 5-8. If North Korea discharges and reprocesses the spent fuel currently in the reactor, Pyongyang could have 11 nuclear bombs by next year.

³⁷ David Albright, "How Much Plutonium Does North Korea Have?" *Bulletin of the Atomic Scientists*, Vol. 50, No. 5 (September/October 1994), pp. 46-53.

³⁸ Jared S. Dreicer, "How Much Plutonium Could Have Been Produced in the DPRK IRT Reactor?" *Science and Global Security*, 2000, Volume 8, pp. 273-286.

³⁹ "DPRK to Continue Increasing Its Nuclear Deterrent Force," Korean Central News Agency, October 2, 2003, <http://www.kcna.co.jp>; "조선외무성 대변인 8,000 여대의 폐연료봉재처리 성과적으로 끝냈다 [Korean Foreign Ministry Spokesman: The Reprocessing of about 8,000 Spent Fuel Rods Has Successfully Been Completed]," Korean Central News Agency, October 2, 2003, <http://www.kcna.co.jp>; Sang-hun Choe, "North Korea Says It Is Using Plutonium to Make Bombs," Associated Press, October 2, 2003, in Lexis-Nexis Academic Universe, <http://www.lexis-nexis.com>.