A Step-by-step Approach to a Fissile Cutoff

Steve Fetter and Frank von Hippel *

Despite its centrality to the future of nuclear arms control and nonproliferation, progress toward a fissile cutoff has lost momentum. To regain momentum, and to capture many of the security benefits of a cutoff as soon as possible, groups and countries advocating nuclear nonproliferation and disarmament should press the nuclear-weapon and threshold states to commit themselves publicly to a moratorium on the production of fissile material for weapons.

Fissile materials—plutonium and highly enriched uranium—are the fundamental ingredients of all nuclear weapons. They are also the most difficult and expensive part of a nuclear weapon to produce. A global, verified ban on the production of fissile materials for nuclear explosives is therefore an essential part of any comprehensive nuclear disarmament and nonproliferation regime. A cutoff would limit the size of potential nuclear arsenals. It would make reductions irreversible if fissile material were transferred from dismantled weapons and other unsafeguarded stocks to nonweapons use or disposal under international safeguards. A cutoff would also strengthen the nonproliferation regime by opening up nuclear facilities in *all* states to international inspection.

Negotiations on a Global Cutoff

The cutoff was first proposed as a U.S.-Soviet arms control measure by President Eisenhower in 1956, but was rejected by Moscow which saw it as a tactic to freeze the Soviet Union into a quantitatively inferior status. In January 1989, President Gorbachev embraced the proposal but the Bush administration was opposed.

In September 1993, as a result of a Clinton-administration review of U.S. nonproliferation policy, the United States turned from an isolated opponent of a fissile cutoff into its leading advocate. Three months later, the UN General Assembly passed a resolution without opposition calling for negotiations on a "non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons and other explosive devices." The beginning of these negotiations at the Geneva Conference on Disarmament (CD) was delayed by an effort, led principally by Pakistan, Egypt, Iran and Algeria, to broaden the mandate to include negotiations of reductions so

that "unsafeguarded stocks are equalized at the lowest possible level."[1] Ultimately, however, a compromise was reached which preserves the focus of the negotiations on a production cutoff but allows for the discussion of existing stocks. At the May 1995 NPT extension conference, the five nuclear-weapon states committed to the "early conclusion" of negotiations on a cutoff. However, the start of negotiations has been delayed by a group led by Pakistan, this time with Indian support, which is insisting that cutoff negotiations be linked to parallel talks on nuclear disarmament.[2]

There are a number of other reasons why negotiations could drag on for years. Britain, France and Russia have made it clear that, since the five weapons states have stopped (or almost stopped) production, they consider the verification arrangements more trouble than they are worth unless India and Pakistan participate. Pakistan is not eager to sign an agreement that would lock in its inferiority relative to India. India's government is under increasing pressure from nationalist forces to delay a fissile cutoff, which would cap India's stockpile of weapons material at a level far less than that of China.[3] China is reluctant to sign any agreement that would make permanent its quantitative inferiority to the United States and Russia—especially given that the U.S. is moving to loosen the constraints of the Anti-Ballistic Missile Treaty. Israel is not interested in even discussing the subject and the United States is reluctant to press Israel on the matter, so as not to divert political attention from the peacemaking process between Israel, Syria and the Palestinians.

Given this situation, the most effective way to make progress toward a fissile cutoff during the next few years will be through incremental advances in parallel with the CD negotiations. The purpose of these intermediate steps would be to:

- reinforce the commitments of the countries that have ceased production;
- increase transparency to build confidence in these commitments; and
- increase pressure on countries that continue production.

Cost will be a major consideration in such arrangements. Although the cost of verifying a fissile cutoff might appropriately be measured against other security investments—most notably defense budgets—foreign-policy bureaucracies tend to measure it against the safeguards budget of the IAEA. Preliminary estimates of the cost of verifying a fissile cutoff would require a doubling or tripling of the IAEA's annual safeguards budget, which now stands at about $70 million. Although we believe that the long-term security benefits of a cutoff are well worth this cost, interim steps could be considerably less costly.

The Linkage To Reductions

A fissile cutoff would reduce the discriminatory nature of the nonproliferation regime by stripping the weapon and threshold states of their exclusive title to produce unsafeguarded fissile material. No objection should therefore be expected from the non-weapon-state members of the nonproliferation treaty.

As the negotiations have already revealed, however, the middle nuclear-weapon and threshold states are highly sensitive to the fact that, while "nondiscriminatory" on its face, in imposing the same requirements on all states, the fissile cutoff would be highly discriminatory in locking-in the huge disparities between their existing stockpiles. None of these concerns is so serious as to have driven any of these countries (with the possible exception of Pakistan)[4] to invest in a build-up under current conditions. Fortunately, there is considerable skepticism in the governing elites of all of these counties as to whether more nuclear weapons can provide more security, and the costliness of the nuclear arms race to the Soviet Union provides a cautionary example. However, in every country there is a significant segment of public opinion that frets at perceived inferiorities, and the large disparities in fissile-material stockpiles could create enough friction to be a serious obstacle to a cutoff.

It would help a great deal with at least China and France if the United States and Russia made more significant commitments to irreversible reductions. Even after the planned elimination of hundreds of tonnes of weapons plutonium and uranium, each will retain perhaps 50 tonnes of plutonium and a few hundred tonnes of weapon-grade HEU—enough to make over 10,000 thermonuclear warheads. Much deeper reductions will be required before the "superpowers" will be seen as having as having internalized the repeated joint statement by presidents Reagan and Gorbachev that "nuclear war cannot be won and must never be fought."

It seems unlikely, however, that even such dramatic reductions would be sufficient to persuade China to make reductions to India's level or India to Pakistan's level. The only way to eliminate completely the discriminatory nature of the nuclear nonproliferation regime will be the elimination of all national stocks of nuclear warheads and unsafeguarded fissile materials.

One of the purposes of the cutoff is to help make the world safe for disarmament by blocking the upward growth of *all* existing stockpiles—just as the NPT helps block an increase in the number of nuclear-weapon states. In order for such restraint to be accepted by states with smaller arsenals, however, the agreement must be combined with arrangements to maintain the pressure for disarmament.

In the case of the NPT, it was decided that such pressure would be generated by a strengthened review process. The implicit threat in this review process is that, if the weapons states do not live up to their commitment at the May 1995 NPT extension conference to a "determined pursuit…of systematic and progressive efforts to reduce nuclear weapons globally, with the ultimate goal of eliminating those weapons," then the legitimacy of the treaty and the determination of the international community to hold non-nuclear-weapon states to their commitments might decline. The cutoff is linked into this NPT review process because the weapons states committed themselves at the NPT-extension conference to the "early conclusion" of a fissile-cutoff agreement. Pakistan and India are demanding a further linkage of the fissile cutoff to reductions. We oppose a formal linkage but believe that early commitments to further reductions beyond START II are required in order to create a climate in which Israel, India, and Pakistan could be subject to international pressure to join in a cutoff.

A Declared Production Moratorium

A recent attempt by the United States to secure a declared moratorium did not meet with much success. Prior to the May 1995 NPT extension conference, the United States tried to orchestrate a joint announcement by the five weapons states that they were halting the production of fissile materials for weapons. The United States and Russia had already announced production halts, and the United Kingdom announced at the extension conference that it had "ceased the production of fissile material for explosive purposes." But China and France declined to join in a such an announcement, even though China had informed the United States privately that it had stopped production and France had announced in May 1993 that it had halted the production of plutonium for weapons.

India and Israel are believed to be producing fissile material for weapons. Then Foreign Secretary Shahryar Khan stated in a 1992 interview that Pakistan had "permanently frozen production of highly enriched uranium and weapons cores" in 1991.[5] However, in the absence of either reciprocal action by India or the lifting of U.S. sanctions imposed under the Pressler amendment, Pakistan's government is under pressure to end its unilateral production moratorium.[6] The resumption of HEU production by Pakistan would deal a serious blow to the cause of nuclear arms control in South Asia. If, on the other hand, China joined publicly in a moratorium, that would increase the pressure on India.

Confidence-building Measures

A declared moratorium would be valuable even without verification arrangements. Under current conditions, countries could be expected to live up to their commitments, motivated by the expectation that non-nuclear weapons states would demand evidence, after a formal cutoff enters into force and their nuclear facilities come under international safeguards, that they had halted production for weapons when they joined the moratorium.

The credibility of such declarations could be enhanced, however, by implementing a set of confidence-building measures, beginning with those facilities which are known to have produced fissile material for weapons. Such measures would, moreover, help prepare the way for full verification after a formal cutoff is in force. This is especially important when one considers that it might take ten years after a cutoff convention is signed to fully implement IAEA inspections in the nuclear-weapon and threshold states.[7]

Confidence-building measures could take different forms in different countries depending upon the nature of the facilities and activities in those countries and their international relationships. In the United States and Russia, for example, such measures could build on bilateral agreements that are now being implemented.

United States and Russia. As already mentioned, the United States and Russia have stopped producing fissile material for weapons. In fact, the United States has suspended the production of fissile material for *all* purposes. All 14 U.S. plutonium-production reactors have been shut down permanently. Two of four military reprocessing plants have been shut down; the other two are in stand-by mode for possible clean-up operations. One uranium-enrichment facility is shut down, and the other two produce only low-enriched uranium (LEU) for civilian nuclear reactors.

The situation in Russia is somewhat more complicated. All four enrichment facilities operate, producing LEU fuel. Ten of 13 plutonium-production reactors have been shut down. The remaining three—two at Tomsk-7 and one at Krasnoyarsk-26—continue to operate, however, because they provide heat for nearby cities. The huge quantities of spent fuel discharged by these reactors are reprocessed, resulting in the continued separation of one to two tonnes of weapon-grade plutonium per year. Russia also separates plutonium from civil nuclear-reactor fuel at the Mayak complex near Cheylabinsk.

In a June 1994 meeting of Vice President Gore and Prime Minister Chernomyrdin, the U.S. and Russia formally agreed to halt the production of plutonium for nuclear weapons. Under this agreement, Russia would shut down the remaining three plutonium-production reactors by 2000 and allow the United States to verify that any plutonium produced by these reactors in the interim is not used for weapons. In exchange, the United States would "facilitate" the acquisition of alternative energy to supply the heat now provided by the reactors.

Following the Gore-Chernomyrdin agreement, U.S. and Russian experts negotiated arrangements for the bilateral monitoring of the plutonium produced by the three still-operating Russian plutonium-production reactors. These arrangements, which are much less intrusive and less costly than standard IAEA safeguards, involve estimating the amount of plutonium that is produced in the reactors, and then confirming that this much plutonium of the appropriate isotopic and chemical composition is subsequently placed in a jointly monitored storage facility.

The amount of plutonium produced in a production reactor is proportional to the amount of fission energy released: about one gram per megawatt-day of thermal energy. The first element of the monitoring program therefore involves estimating the amount of thermal energy produced, by recording the flow rate and temperature increase of the reactor coolant. Flow rates and temperatures can be measured using existing Russian instrumentation or by installing a strap-on ultrasonic device. The estimate of the amount and isotopic composition of the plutonium can be refined by knowing the design of the reactor and how long fuel is loaded in the core (e.g., by examining operating records). This information would allow the United States to estimate plutonium production in the Russian reactors with an accuracy of 5 to 10 percent. The plutonium, after it is separated and delivered to the monitored storage facility, would be compared to the estimates of the amount and isotopic composition produced in the reactors. Heat and radiation measurements from outside the plutonium containers could verify the plutonium's isotopic composition and age, as well as its chemical form (oxide rather than the metal form used in weapons).

The agreed verification arrangements do not include inspections at the reprocessing plants at which the plutonium is separated from the spent fuel. It is difficult to envision an effective, inexpensive, and nonintrusive monitoring system for reprocessing facilities—especially older facilities not built with safeguards in mind. IAEA-type inspections would require considerable investment in monitoring equipment and a continuous on-site presence by inspectors, costing perhaps $10 million per year for the Tomsk and Krasnoyarsk facilities. For comparison, we

estimate that the simple inspection regime described above would cost about $1 million per year or less.[8]

Unfortunately, the negotiated monitoring arrangements have not come into force due to Russian dissatisfaction with the nature and level of U.S. effort to facilitate the acquisition of alternative energy sources. If this problem can be overcome, however, the agreement could be extended to Russia's third reprocessing plant, the RT-1 plant at Mayak. Mayak was not included in the first round of negotiations because the reactor-grade plutonium being separated there has not been used for weapons and has been accumulating in storage. However, it is weapons-useable and would come under international safeguards as part of a fissile-cutoff agreement.

Mayak reprocesses fuel from many different types of reactors: LEU fuel from light-water power reactors; medium-enriched fuel from two prototype breeder reactors; and HEU fuel from isotope-production, research, and naval reactors. The one to two tonnes of reactor-grade plutonium recovered at Mayak annually is separated from the spent fuel of the power and breeder reactors.[9] Much of this spent fuel comes from countries that are non-weapon-state members of the NPT, which must report the export of their spent fuel and its estimated plutonium content to the IAEA. It should be straightforward to extend these same reporting requirements to the Russian power reactors whose fuel is reprocessed at Mayak. It would then only remain to reach an agreement for bilateral monitoring of the plutonium storage facility at Mayak to verify that the separated plutonium is being deposited there.

A further extension of the U.S.-Russian bilateral monitoring arrangements would be to cover enrichment plants. The United States produces no HEU and has no plans to do so. Future demand for HEU (mostly for naval-reactor fuel for U.S. and U.K. submarines) will be met from existing stockpiles. The gaseous-diffusion enrichment facilities in Paducah, Kentucky, and Portsmouth, Ohio, are being privatized and will produce only LEU fuel for civil reactors. A third enrichment plant at Oak Ridge has been shut down since 1985, a fact that could be verified with occasional on-site inspections. In the case of Paducah, which has never produced HEU, a moratorium could be verified by taking advantage of the inevitable small leaks of uranium gas by taking environmental samples in and around the plant (e.g., by wiping wall surfaces or collecting vegetation) and checking to make sure they contain no HEU particles. This technique would not work at Portsmouth, however, which produced HEU as recently as 1992. In this case, one could verify with on-site inspections that the HEU portion of the cascade had been mothballed.

Russia no longer produces weapon-grade HEU because it too has a surplus. Four centrifuge enrichment facilities at Sverdlovsk-44, Tomsk-7, Krasnoyarsk-45, and Angarsk produce LEU fuel. Of these, only Angarsk has never produced HEU and would be a suitable candidate for environmental monitoring. Verifying that HEU is not being produced at the other facilities would require installation of devices that monitor the enrichment of the uranium gas in the cascade, as is now done by the IAEA at civil centrifuge facilities in western Europe.

Thus, it would be relatively straightforward for the United States and Russia to implement a fairly comprehensive set of bilateral confidence-building measures to demonstrate, to each other and the world, that plutonium and HEU are no longer being produced for weapons. It would also be relatively inexpensive: we estimate a total cost of roughly $2 million per year, including on-site inspections at shut-down reactors and enrichment facilities.[10]

United Kingdom and France. The United Kingdom and France have ceased the production of plutonium for weapons. Eight of ten U.K. plutonium-production reactors still operate to produce electricity, but they are scheduled to be shut down in the next few years.[11] France has shut down three production reactors; the two remaining reactors continue to operate to produce tritium for nuclear weapons.[12] The United Kingdom has not produced HEU for many years, and has shut down its military enrichment facilities at Capenhurst. France, on the other hand, continues its production of HEU at the Pierrelatte gaseous-diffusion plant.[13] This HEU may be needed for naval or tritium-production reactors, but France's refusal to agree to a moratorium suggests that at least some of it may be earmarked for new nuclear weapons.

The mechanism for monitoring British and French production moratoria already is in place in the form of Euratom, an organization which is responsible for applying the equivalent of IAEA safeguards to all civilian nuclear materials within the European Economic Union. According to this mandate, Euratom should now extend its safeguards to cover the reactors and reprocessing plants that formerly produced and separated weapons plutonium for the British and French nuclear arsenals, as well as all enrichment facilities when France joins a production moratorium. It should not be difficult to extend safeguards to these facilities, since in most cases comparable civil facilities are already subject to safeguards.[14] Euratom could then issue a report certifying that plutonium and HEU are no longer being produced for weapons in these countries.

Limitations on this proposal may arise if France needs a continuing supply of HEU for its naval or tritium-production reactors. However, unlike the United States and the United Kingdom, which fuel their naval reactors with HEU, France has used LEU fuel (except in its first-generation *Redoubtable*-class ballistic-missile submarines, which are to be retired by 2005). The motivation for moving to LEU apparently was to avoid having to build a new plant for producing HEU after Pierrelatte is shutdown around the year 2000. The tritium-production reactors could be fueled with LEU.

China. China has plutonium-production centers at Jiuquan and Guangyuan. Each site has a single production reactor and reprocessing plant. China also has built two gaseous-diffusion enrichment plants: one at Lanzhou and one at Heping. More recently, China has contracted with Russia for a large gas-centrifuge uranium-enrichment plant near Hong Kong. Little information is available publicly about the status of these reprocessing and enrichment facilities. As noted above, China has informed the United States privately that it is not producing fissile material for weapons, but no formal announcement has been made.

There have been reports that one or both of the production reactors produce electric power. If so, the situation may be similar to that in Russia, where production reactors are kept in operation because they produce energy for civil needs, and with reprocessing continuing because the fuel is not easily storable. Monitoring arrangements similar to those negotiated for the Russian production reactors could be adopted (by expanding the U.S.-Russia agreement to include China, negotiating a separate bilateral agreement between China and the United States, or having the IAEA monitor compliance by all three countries). Any of these arrangements could be extremely difficult to achieve politically. Without such monitoring arrangements, however, the continued operation of Chinese production reactors and associated production of unsafeguarded weapon-grade plutonium—even if not used or intended for weapons purposes—would greatly reduce confidence in China's production halt.

According to the head of the China Nuclear Energy Industry Corporation, China stopped producing HEU for weapons in 1987. To the best of our knowledge, both enrichment plants continue to operate, presumably to produce LEU fuel for power and naval reactors. Verifying a moratorium on HEU production could be accomplished as described above for the United States, by verifying that the upper stages of the gaseous-diffusion plants were mothballed. In the case of the future centrifuge plant, which will produce only LEU, environmental sampling would suffice.

Israel. Israel is believed to be producing weapon-grade plutonium and tritium with its Dimona reactor. Israel, which has neither a civilian nuclear-power or a naval nuclear-propulsion program, is very sensitive about maintaining the opacity of its nuclear weapons program. We therefore expect that Israel would prefer to shut down this reactor rather than allow on-site inspections. Reactor shutdown could be monitored from space, even by commercial satellites, by verifying the absence of the waste heat that would be produced if the reactor was operating.

Shutting down the Dimona reactor might create problems if Israel's weapons rely on tritium, but this is a problem that may have to be dealt with in any case given the reactor's age (over 30 years in operation). Israel could produce a ten-year supply of tritium in just two years of operation,[15] buying time to develop another source. Israel has a safeguarded research reactor that could be used for this purpose, or an accelerator could be used.

India and Pakistan. India's weapons plutonium is produced in two isotope-production reactors, Cirus and Dhruva, and separated in the Trombay reprocessing facility at the Bhabba Atomic Research Center near Bombay. Six unsafeguarded heavy-water power reactors (HWRs) are also large potential sources of weapons-grade plutonium, but they do not appear to have been used for that purpose. India has a breeder-reactor program, however, and it has built a second reprocessing facility at Tarapur which has been used to recover plutonium from HWR fuel to provide start-up fuel for a proposed demonstration breeder reactor. A third reprocessing facility, the Kalpakkam plant, has been built near Madras but is not yet operational. None of these facilities are subject to international safeguards unless they are used to reprocess fuel from one of India's four IAEA-safeguarded power reactors.

Pakistan has produced HEU for weapons in secret gas-centrifuge enrichment facilities. Although Pakistan announced that production of weapon-grade HEU was suspended in 1991, the enrichment of uranium to lower levels continues, and this material could be easily and quickly upgraded to HEU.[16] Pakistan is also building a high-power "research" reactor at Khusab and a reprocessing plant near Chasma, which would allow it to produce unsafeguarded weapon-grade plutonium. Pakistan's other reactors—a heavy-water power reactor and a small research reactor—are under safeguards, as will be the light-water power reactor being built near Chasma by China.

The United States has for some time been promoting a fissile cutoff in South Asia, with India rejecting measures limited to the region. If India would accept a

moratorium that included the nuclear-weapon states, the confidence-building measures could, as in the case of Russia, focus on the reactors whose fuel was being reprocessed and on the resulting plutonium. The thermal power of the Cirus and Dhruva reactors—and any power plant whose fuel was being reprocessed—could be monitored and the plutonium assayed when it was delivered to a monitored storage facility. Better still, reprocessing could be suspended and the spent fuel from these reactors stored. These measures could be extended to Pakistan's Khusab reactor when it is completed. Pakistani enrichment facilities could be shut down altogether—which would protect the secrets of their design and capacity—or monitoring devices similar to those at Eurenco facilities could be used to verify that HEU was not being produced.

If on-site monitoring were required in South Asia, there arises the tricky issue of who would do the monitoring. India is likely to reject a strictly bilateral arrangement with Pakistan. Monitoring under a special agreement with the IAEA might be possible; such agreements are permitted under the Agency's charter. Another possibility would be an informal trilateral arrangement between the United States, India, and Pakistan, or a set of bilateral arrangements. This would allow the United States to offer its expertise and good offices to build confidence between India and Pakistan, while permitting Indians and Pakistani to visit U.S. production facilities to confirm that they no longer produce fissile materials.

In early 1994, former senior Indian officials indicated that the India might place its civilian nuclear power reactors and reprocessing plants under international safeguards if the U.S. government facilitated the transfer of high-technology items to institutions not connected with India's nuclear and missile programs and considered cooperation in the development of safer power reactors. There has been no U.S. response to this "trial balloon" for an obvious reason: at the urging of the United States, all the nuclear-supplier countries (except China) have adopted "full-scope safeguards" requirements that commit them to refuse nuclear technology to non-signatories of the NPT. So much effort was expended in achieving this policy that something more than the proposed Indian offer would be required for a modification to be considered.

In our view, if India were willing to place *all* its nuclear facilities under international safeguards (but not previously produced fissile material), that would be sufficient to justify a reconsideration of the position of the nuclear suppliers' group. However, India would almost certainly reject such a move as discriminatory before

the ratification of a fissile cutoff by the five weapon states, Pakistan, and perhaps even Israel.

Under either a fissile cutoff or a moratorium, the suppliers' group would still want to maintain a distinction between India and non-nuclear-weapons states that have signed the NPT. One possibility would be to provide India with safety assistance for its existing power reactors but to refuse to supply it with light-water reactor technology. Light-water reactors were offered to North Korea, but only for complete adherence to its NPT commitments. The United States might also narrow its controls over the export to India of dual-use technologies not directly related to weapons of mass destruction, such as telecommunications and computer technologies.

Other Facilities

The confidence-building measures suggested above deal only with major facilities which are known to have produced significant amounts of fissile material. Other types of unsafeguarded facilities that could be used to produce fissile materials will have to dealt with on the way to a fully verified cutoff, including naval and tritium-production reactors, numerous research facilities, and especially possible clandestine production facilities. The most likely candidates for clandestine facilities today are gas-centrifuge enrichment plants. In the future, there may similar concerns about possible laser enrichment facilities, which would also be difficult to detect without human intelligence. Such plants would be of greatest concern in the threshold states, where clandestine production could occur at rates that are significant relative to existing stockpiles. Indeed, Israel and India, as well as Pakistan, are reported to have gas-centrifuge plans, although information on their size and status is unavailable.

States will have to make political judgments about whether to press for additional confidence-building measures under a moratorium or to wait until an formal cutoff has been achieved to address these concerns. A good compromise could be to ask countries joining a production moratorium to indicate all the sites at which they are conducting uranium-enrichment or reprocessing activities. The owning country would have the choice of allowing some type of on-site monitoring or shutting down the facility—and perhaps allowing it to be sealed by inspectors from another country or the IAEA. If a site were not declared, that would become an embarrassment when it was revealed later under a fissile-cutoff agreement.

Conclusion

A declared moratorium and associated confidence-building measures would be the best way to make progress toward a formal cutoff convention. Some may fear that a moratorium would undercut a formal cutoff by relieving international pressure to conclude such an agreement. But a formal cutoff is years away at best, and in the meantime Israel and India continue to produce plutonium for weapons. Continued production by India may soon cause Pakistan to resume production of HEU and begin production of plutonium, further fueling the nuclear arms race on the subcontinent.

A production moratorium probably will have to be pieced together one country at a time—just as the nuclear-testing moratorium was. The U.S.-Russia-U.K. declared moratorium provides a good base from which to begin.

China should be next, because of its impact on India's position, and because it has already been willing to state officially—but not publicly—that it has stopped producing material for weapons. In view of the strained U.S.-China relationship, the United States may not be very effective in persuading China to take the next step. But many non-nuclear-weapon states, such as Japan, Canada, Germany, and Australia, care a great deal about a fissile cutoff and might be able to persuade China to make a public declaration.

France would be next. France would feel the pressure—especially from European countries such as Germany—if all the other nuclear-weapon states had signed on. We do not know why France is hanging back, and whether its reasons are deeply felt. It would be difficult for France to persuade the world that it needs more HEU for weapons—especially in the wake of the public uproar over its renewed nuclear testing.

With all five nuclear-weapon states on board, pressure from the non-weapon states would begin to mount on India and Israel and serious discussions with these countries could begin. If India could be brought on board, then it is very likely that Pakistan would as well.

Given the lack of enthusiasm for the fissile cutoff among most of the nuclear-weapon and threshold states, much will depend upon the efforts of non-weapon states to press for progress. At the moment, nuclear disarmament advocates are focused on the Comprehensive Test Ban. When the CTB is moving smoothly toward a successful conclusion, however, they should begin to campaign for

progress on the fissile cutoff, and forward movement can begin. A moratorium, in which countries are pressed to sign up one by one—rather than resisting progress together at the Conference on Disarmament—may be a crucial way station to a formal production ban.

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* Steve Fetter is an associate professor at the School of Public Affairs, University of Maryland, College Park. Frank von Hippel is a professor at Princeton University's Woodrow Wilson School.

[1] Ahmad Kamal, Pakistan's representative to the CD, speech to the CD Plenary, June 9, 1994, CD/PV.681.

[2] Rebecca Johnson, ***Nuclear Proliferation News***, No. 29 (July 11, 1995), p. 2.

[3] C. Raja Mohan, "India Losing Ground on N-option," *The Hindu*, March 6, 1995.

[4] Mark Hibbs, "Bhutto May Finish Plutonium Reactor Without Agreement on Fissile Stocks," *Nucleonics Week*, October 6, 1994, p. 10.

[5] Jeffrey R. Smith, "Pakistan Can Build One Nuclear Device," ***Washington Post***, February 2, 1992.

[6] On April 1, 1995, the Pakistan Muslim League passed a resolution stating that "Pakistan must continue the nuclear programme in the light of India's refusal to reciprocate Pakistan's unilateral decision to freeze the nuclear programme in 1989, and India's massive missile and nuclear proliferation." The resolution also stated that Pakistan "must reject any attempt to monitor or inspect its nuclear facilities by any physical means or through 'non-intrusive' verification" ("Pakistani Opposition Says Nuclear Weapons Vital," Reuters, April 1, 1995).

[7] A doubling or tripling of the IAEA safeguards budget would correspond to 7 to 11 percent annual growth over ten years in the number of trained inspectors and person-days of inspection effort—a very high rate of growth.

[8] We assume 10 inspector-days per year (at $5,000 per inspector day) plus $50,000-100,000 per year for data-analysis and $200,000-400,000 in equipment (amortized over five years) for each of the three operating reactors, and 20-40 inspector-days per storage facility per year for one or two facilities, for a total of $0.5 to 1.1 million.

[9] The reprocessing of HEU fuel does not result in the separation of plutonium because the concentration of undesirable plutonium isotopes is very high in HEU fuel. It is standard practice when reprocessing HEU fuel to separate the enriched uranium but not the relatively small amount of plutonium, which remains with the fission products in the high-level waste.

[10] In addition to the $0.5–1.1 million estimated above for monitoring Tomsk-7 and Krasnoyarsk-26, we assume 2 person-days per year (pd/yr) at $5,000/pd for 24 shut-down production reactors; 5 pd/yr for one shutdown enrichment facility; 10 pd/yr for two operating enrichment facilities that never produced HEU, and 20-30 pd/yr for four other enrichment facilities. Also included are the costs of environmental sampling at operating enrichment facilities (5 samples/yr at $10,000/sample), as well as equipment costs for operating enrichment plants that produced HEU ($???? per plant) recovered over 5 to 10 years.

[11] The eight dual-purpose (plutonium and power production) nuclear power stations at Calder Hall and Chapelcross are to be decommissioned in 1996 and 1998, respectively (*Nukem Market Report*, December 1993). The fuel from these reactors has been reprocessed at the B205 plant in Sellafield. Two earlier reactors near Calder Hall were shut down in 1957 following an accident.

[12] The three Magnox plutonium-production reactors at Marcoule were shut down by 1984. The Celestin heavy-water production reactors at Marcoule are reported to be operating on an alternating basis to produce tritium. Plutonium produced by these five reactors was separated at the UP1 reprocessing plant at the same site, which is scheduled for shutdown in 1997.

[13] HEU production in the United Kingdom ended in 1963, after which U.K. plutonium was bartered for U.S. HEU and tritium. A military centrifuge-enrichment facility built at Capenhurst to supply LEU for enrichment to HEU in

the United States has been shut down, and a civil centrifuge plant at the same site operates under full IAEA safeguards. Future U.K. demand for HEU (mostly for submarine-reactor fuel) will be met from existing U.S. stocks.

France produced its military HEU at the Pierrelatte gaseous-diffusion plant. The LEU portions of this plant were shut down several years ago; the HEU portions are still operating, with LEU feed supplied by the (otherwise) civil gaseous-diffusion plant at Tricastin. Neither plant is subject to international safeguards.

[14] There are four reprocessing and two enrichment facilities in the United Kingdom. The B205 reprocessing plant is already under Euratom safeguards when handling civil fuel; the Thorp and Dounreay reprocessing plants are under safeguards, and the B204 plant is shut down. The civil enrichment facility at Capenhurst is under IAEA safeguards; the military enrichment facility is shut down. Thus, Euratom would have to safeguard fuel from the Calder Hall and Chapelcross reactors and verify that B204 is shut down.

France has three reprocessing plants and two enrichment facilities. The UP2 and UP3 plants at La Hague are partially under IAEA safeguards; UP1 is not, but it will be shut down in 1997. Thus, it would be necessary to safeguard the enrichment plants at Pierrelatte and Tricastin.

[15] The reactor power required to maintain the tritium in a weapons stockpile is one-eighth the average power that would have been required to produce, over 30 years, the amount of plutonium in the weapons stockpile, if there is one thousand times more plutonium than tritium in the weapons. Operating at the power level used to produce the plutonium, one could produce in two years enough tritium to make additional production unnecessary for ten years.

[16] The separative work required to produce weapon-grade HEU (90 percent U-235) from LEU (5-percent U-235) is 70 percent less than that required using natural uranium feed. Thus, Pakistan can do 70 percent of the work to produce weapon-grade HEU even while complying with a commitment not to produce HEU.