VIEWPOINT:

VERIFYING A MULTILATERAL BAN ON NUCLEAR WEAPONS: LESSONS FROM THE CWC

by Jonathan B. Tucker

The once utopian idea of total nuclear disarmament is now being taken seriously by the nuclear weapon states, at least rhetorically. At the 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in New York, the five nuclear weapon states reaffirmed their earlier commitment in Article VI of the NPT to the "determined pursuit… of systematic and progressive efforts to reduce nuclear weapons globally, with the ultimate goal of eliminating those weapons…."[1] In an interview published in August 1997, U.S. Defense Secretary William Cohen said with respect to nuclear arms reductions, "I feel that we are on the right track, that the Joint Chiefs are committed to going lower, that there is a national commitment to get lower and lower levels—to the point where we don't have them."[2] Similarly, Deputy National Security Advisor James Steinberg stated in June 1997 that the United States was committed to total nuclear disarmament by the end of the next century.[3]

Non-nuclear weapon states and non-governmental organizations, however, are pressing for a faster pace. In July 1996, the International Court of Justice in The Hague concluded unanimously that "There exists an obligation [under international law] to pursue in good faith and bring to a conclusion negotiations leading to nuclear disarmament in all its aspects under strict and effective international control."[4] In December 1996, 61 retired generals and admirals from 17 countries—including 19 from the United States—issued a statement calling for the eventual abolition of nuclear weapons.[5] In January 1997, the Canberra Commission on the Elimination of Nuclear Weapons issued a report proposing a multi-step program for total nuclear disarmament.[6] And in April 1997, an international consortium of lawyers, scientists, and disarmament experts coordinated by the Lawyer's Committee on Nuclear Policy published a model Nuclear Weapons Convention (NWC) that would require nuclear weapon states to destroy their arsenals in a series of coordinated phases and would prohibit any future development, testing, production, stockpiling, transfer, use, or threatened use of nuclear weapons.[7] A grass-roots campaign known as Abolition 2000 is pressing for multilateral negotiations on an NWC to begin by the turn of the century.[8]

Since the bilateral U.S.-Russian nuclear arms reduction process has stalled, it is useful to consider innovative multilateral approaches to nuclear disarmament. Although the negotiation of an NWC probably lies several years in the future, now is an opportune time to begin thinking about how such a regime would be structured and implemented. A major challenge is to develop measures to verify the nonproduction of nuclear weapons and materials and the complete elimination of existing nuclear stocks. To date, verification regimes for nuclear arms control treaties have focused on delivery systems such as ballistic missiles and bombers, which can be counted with national technical means such as reconnaissance satellites. The NWC, in contrast, would require a system of controls on nuclear materials and warheads, necessitating far more intrusive verification measures.[9]

In crafting the model treaty, the drafters looked for guidance to the 1993 Chemical Weapons Convention (CWC), which entered into force in April 1997 and is currently the only multilateral *disarmament* treaty that

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has extensive provisions for monitoring and verification. The CWC requires parties to eliminate their existing stockpiles of chemical weapons within 10 years—with a possible five-year extension in exceptional cases—and to renounce the development, production, stockpiling, transfer, or use of chemical agents for offensive military purposes. While some CWC verification provisions would be relevant to a nuclear weapons ban, the value of other measures would be limited by the technical differences between chemical and nuclear weapons and the divergent perceptions of their military and political roles.

SIMILARITIES AND DIFFERENCES

The CWC and the model NWC share some basic characteristics. Both seek to eliminate existing weapons stockpiles, materials, and production facilities and to prevent their acquisition in the future. In both cases, the vast majority of existing chemical and nuclear weapon stocks are concentrated in the United States and the Russian Federation, the chief inheritor of the Soviet arsenal. Finally, both treaties must contend with the fact that the capability to produce chemical or nuclear weapons is hard to isolate from the beneficial applications of synthetic chemistry and nuclear energy. While banning chemical weapons, the CWC does not infringe on the right of states to employ chemicals for peaceful purposes. Similarly, given the important role of nuclear power in meeting the energy needs of some countries, the NWC must take into account the legitimate civil applications of nuclear technology while preventing its diversion for military purposes.

Despite these parallels, however, a number of technical differences between chemical and nuclear weapons should also be considered. First, chemical weapons cannot be considered true weapons of mass destruction, except for purposes of terrorism against unprotected civilians. Whereas a single nuclear weapon can obliterate an entire city including people, buildings, and infrastructure, hundreds of tons of the chemical nerve agent sarin would be required to inflict a comparable number of casualties, and a chemical attack would not destroy buildings or infrastructure. Moreover, whereas soldiers can defend themselves fairly well against chemical weapons with protective suits and antidotes, defense against the immediate blast and thermal effects of nuclear weapons is effectively impossible.

This difference in destructive power between chemical and nuclear weapons has important implications for disarmament. Unlike chemical weapons, small quantities of nuclear weapons and fissile materials are militarily significant. Nuclear weapons are so destructive that only a few bombs could confer major military and political advantages over non-possessors. Moreover, since the knowledge of how to design and manufacture nuclear weapons will remain after their elimination, a former nuclear weapon state that had dismantled its nuclear arsenal could reconstitute it fairly rapidly from civilian nuclear materials. The time required for such a "breakout" scenario would depend on several factors, such as whether the country in question had engaged in nuclear testing or retained a secret cache of fissile materials, but it could be as little as a few weeks.

Indeed, Steve Fetter has observed that "no conceivable verification regime could provide absolute assurance that former nuclear-weapon states had not hidden a dozen or even a hundred 'bombs in the basement' (or enough [fissile materials] to build such a stockpile), no matter how cooperative and transparent the parties had agreed to be."[10] Because of these inherent uncertainties, Fetter concludes that total nuclear disarmament will become possible only when nations are sufficiently trusting in each others' intentions that the risk of cheating no longer seems particularly threatening. A report by the U.S. National Academy of Sciences' Committee on International Security and Arms Control makes a similar assessment, concluding that "a regime for comprehensive nuclear disarmament must… be embedded in an international security system that would make the possibility of cheating or breakout highly unlikely."[11] In sum, whereas chemical disarmament is feasible in the current international system, the security dilemmas associated with total nuclear disarmament are so acute that they will require a major transformation of international relations. At the same time, effective verification measures can increase transparency and consolidate trust among nations, making the risks of disarmament more tolerable.[12]

Important political differences also exist between chemical and nuclear weapons. An international legal norm against chemical weapons use—enshrined in the 1925 Geneva Protocol—was in place for more than 70 years before the CWC entered into force. Although the United States did not ratify the Geneva Protocol until 1975, in 1969 President Nixon reaffirmed U.S. renunciation of the first use of lethal chemicals and extended this pledge to cover incapacitating agents. Finally, beginning in the late 1980s, chemical weapons were progressively delegitimated by the major powers, until these countries were finally prepared to halt production and destroy their existing stockpiles.

The current situation with nuclear weapons is quite different. Although a strong *de facto* norm against the use of nuclear weapons has existed for more than 50 years, the major powers still view nuclear arms as a source of political power and prestige, and their strategy of retaining a nuclear monopoly through nonproliferation measures has been largely successful. The perceived value of nuclear weapons as a strategic deterrent also retains political legitimacy, particularly within the national security establishments of the nuclear weapon states. Russian Defense Ministry officials hinted in November 1993, and have since stated more explicitly, that Moscow was abandoning its long-held "no first use" policy and increasing its reliance on nuclear deterrence to offset the deteriorating strength and quality of its conventional forces.[13] Similarly, the recent debate in the United States over whether to threaten nuclear retaliation to deter an adversary's resort to chemical or biological weapons suggests that the first use of nuclear weapons remains "thinkable," even when this option would violate existing U.S. "negative security assurances"—pledges not to use nuclear weapons against non-nuclear weapon states.[14]

Given these political trends, it seems likely that general nuclear disarmament will only become possible when the nuclear weapon states renounce any military use of these weapons beyond deterrence of a nuclear attack. This shift to a policy of minimal deterrence might be preceded or accompanied by the de-alerting of nuclear forces and the removal of warheads from delivery systems.[15] Since the United States and Russia possess by far the largest nuclear arsenals, the onus is on these two countries to take the first steps toward denuclearization. At the same time, the broader implications of general nuclear disarmament should be carefully studied, particularly with respect to minimizing strategic instabilities as nuclear arsenals diminish in size. Indeed, total nuclear disarmament may require a fundamental reorganization of international relations to avoid making the world "safe" once again for large-scale conventional conflict.

Without addressing in detail the ultimate desirability of eliminating nuclear weapons, this paper examines some of the problems of verifying a future NWC and draws lessons from the CWC. Although the relevance of the chemical treaty to nuclear disarmament is limited by the technical, military, and political differences between chemical and nuclear weapons, the parallels are worth considering.

SCOPE OF TREATY PROHIBITIONS

CWC provisions. The technology and materials for chemical weapons production generally have commercial as well as military applications. As a result, any state with a moderately advanced chemical industry can manufacture chemical warfare agents such as mustard gas and sarin, and many key ingredients ("precursors") for chemical weapons are also used in the manufacture of legitimate products such as ballpoint pen ink, pesticides, and fire retardants. The CWC addresses this dual-use dilemma by focusing its basic prohibitions on purposes rather than specific chemicals or technologies. Article I of the Convention bans all toxic chemicals except "where intended for purposes not prohibited... as long as the types and quantities are consistent with such purposes." This *general-purpose criterion* allows the CWC to prohibit the application of chemicals for offensive military purposes, while permitting their peaceful use in commercial industry, agriculture, medical therapeutics, scientific research, and the development of defensive equipment and antidotes. Moreover, the inclusiveness of the definition means that a state party could not legally circumvent the Convention by inventing new types of chemical weapons in the future.[16]

The CWC verification regime does not attempt to cover all possible toxic chemicals, since that would be prohibitively costly. Instead, the regime applies to the subset of relevant chemicals and activities that, as a practical matter, can be subjected to monitoring and verification. The treaty incorporates an extensive inventory of known chemical warfare agents and their most important precursors, which are grouped into three lists or "schedules" based on their military potential and extent of legitimate civilian use.[17] To prevent the verification regime from being overtaken by future technological developments, the CWC has an expedited procedure for amending the schedules of chemicals as new chemical warfare agents and precursors are identified.

Relevance to the model NWC. Much as precursor chemicals are needed to make chemical weapons, "special nuclear materials" (SNM) are the essential ingredients of nuclear weapons, and their acquisition presents the greatest technical and financial hurdles to acquiring a nuclear capability.[18] (Although the design of nuclear weapons is non-trivial, the basic concepts are no longer secret.) The fissile materials used in bombs are highly enriched uranium (HEU) and Plutonium-239. Both materials are difficult and expensive to produce, although they might also be acquired by illicit purchase or theft from nuclear facilities in the former Soviet Union and elsewhere.[19]

Since HEU (defined as uranium enriched to more than 20 percent Uranium-235) and Plutonium-239 are derived from clearly defined precursor materials and are militarily significant in small quantities, there is no need for detailed schedules of agents as in the CWC. The NWC could simply ban any further production of HEU and plutonium in either military or civilian facilities. However, the following non-weapons applications will complicate accounting and elimination of these materials.

- Many research reactors around the world are fueled with HEU rather than low-enriched uranium (LEU). Although the United States has urged other countries to convert these facilities to LEU fuel, some have been reluctant because the U.S. government has not provided adequate assurance of its willingness to take back the spent fuel cores.[20]
- HEU is employed as a fuel in nuclear propulsion reactors for many military submarines and some civilian icebreakers. Here again, it is possible to convert these reactors to LEU fuel, albeit with some space penalty.
- Enrichment facilities used to produce LEU for civilian reactors could be modified to produce HEU for military purposes. Enrichment technology is so widely used in the civilian sector that it would take several decades to phase out. Moreover, the alternative to production of LEU is the use of heavy-water reactors that burn natural uranium fuel. These reactors are not necessarily more proliferation-resistant, since plutonium can be produced in them more easily.[21]
- Although the United States has renounced the use of plutonium for commercial power generation, it is been unable to persuade its close allies to follow suit. France, Germany, Japan, and the United Kingdom have pursued efforts to recover plutonium from civil spent reactor fuel and to convert it into MOX fuel (mixed oxides of plutonium and natural or low-enriched uranium) for use in commercial power reactors. Japan and France also have "fast breeder" programs designed to burn MOX in commercial reactors while generating additional plutonium in the process.
- In Russia, three graphite-water plutonium production reactors near Tomsk and Krasnoyarsk are still in operation because they generate heat and electricity for nearby communities. Although Russia has agreed to convert these reactors to cores that produce far less plutonium, the deadline for halting production of non-reactor-grade plutonium is not until December 31, 2000.[22]

Large stocks of HEU and separated plutonium retained for civilian purposes would create the potential for rapid breakout and thus greatly complicate the verification of a future nuclear-weapons ban. For this reason, it would be desirable to build a "firewall" between military and civilian uses of fissile materials by halting the reprocessing of spent fuel and phasing out all civil applications of HEU and Plutonium-239 over a period of several years.

A conditional ban would be more appropriate for *fusionable* isotopes used in boosted-fission and thermonuclear weapons, namely tritium, deuterium, and lithium enriched in Lithium-6. Since these isotopes have some legitimate uses (tritium is used in luminous paints and fusion research, deuterium as a moderator in heavy-water reactors, and lithium in batteries and for alloying certain metals), low levels of production may be warranted for peaceful purposes. Following the example of the CWC's general-purpose criterion, production of fusionable isotopes could be prohibited *except* in types and quantities that can be justified for peaceful purposes, such as energy generation, medical therapy, and research. Countries would be required to declare these legitimate applications, which would be closely monitored by an international inspectorate.

A similar conditional ban should be applied to *fertile* isotopes (including Uranium-238, thorium, and neptunium), which when bombarded with neutrons yield fissile isotopes. For example, Uranium-238 can be converted in a reactor to Plutonium-239, and Thorium-232 to the fissile isotope Uranium-233. As long as there is a civil nuclear power industry, the use of Uranium-238 will remain widespread. Nevertheless, the use of thorium, currently employed in a few experimental power reactors, and neptunium, a residual isotope produced in light water reactors, could be more easily banned outright.

TREATY ORGANIZATION

CWC provisions. The CWC mandated the creation of a new international agency to oversee its implementation known as the Organization for the Prohibition of Chemical Weapons (OPCW), headquartered in The Hague, the Netherlands. The OPCW consists of three bodies. All countries that have ratified the treaty automatically become members of the Conference of States Parties, a policymaking body that meets annually and may also be convened for special sessions. Day-to-day decisionmaking is the responsibility of an Executive Council made up of 41 states parties according to a specified geographical distribution; some members are permanent while others rotate for two-year terms. Finally, the Technical Secretariat is a professional international staff responsible for compiling and processing data declarations and conducting on-site inspections.

Relevance to the model NWC. An agency with extensive experience in nuclear matters, the International Atomic Energy Agency (IAEA), already exists. Under its current statute, however, the IAEA's verification activities are limited to monitoring peaceful nuclear activities at declared civilian facilities and ensuring that fissile materials are not diverted to illicit uses. The agency is not authorized to safeguard fissile materials at military facilities, to verify the dismantlement of nuclear warheads, or to engage in other activities related to nuclear disarmament. Giving the IAEA the authority to oversee the implementation of a future NWC would therefore require amending the agency's statute.[23]

An alternative approach would be to create a new international organization to monitor the NWC along the lines of the OPCW or the new Comprehensive Test Ban Treaty Organization (CTBTO) in Vienna. In addition to monitoring compliance with the NWC, the new agency would be responsible for containment and surveillance of special nuclear materials, both military and civilian. If a treaty organization separate from the IAEA is established, it would not make sense to create parallel administrative structures at great expense. Instead, the NWC organization should be collocated in Vienna and rely on the IAEA for basic services and support facilities such as libraries and laboratories. Indeed, the CTBTO plans to utilize two existing IAEA laboratories for technical work and to contract with the agency for isotopic analyses of environmental samples.

PHASES OF DISARMAMENT

CWC provisions. The CWC requires state parties that possess chemical weapons to destroy their stockpiles within 10 years, with the possibility of a five-year extension in exceptional cases. Destruction is broadly defined as a process—such as high-temperature incineration or chemical neutralization—that converts chemical warfare agents and munitions irreversibly into a form in which they are unusable as weapons. Although the choice of destruction method is left to the discretion of each state party, it must be approved by the OPCW.

Relevance to the model NWC. The model NWC envisions a series of coordinated phases for the elimination of nuclear warheads and fissile materials. For HEU, the model NWC proposes that weapons-grade material be diluted with natural uranium to yield LEU, which would be burned in commercial power reactors or otherwise disposed of. The major obstacle to blending down HEU is economic: uranium-mining companies worry that flooding the market with LEU derived from weapons-grade material would depress the price of natural uranium.

The method for disposing of separated plutonium is also controversial. One option is to convert the plutonium into MOX fuel for use in special civilian reactors, yet this approach would entail an increased risk of diversion.[24] An alternative approach is to mix plutonium with high-level radioactive wastes and immobilize this mixture in ceramic or glass for storage in deep-underground cavities.[25] Russian officials, however, view weapons plutonium as a valuable energy resource and have refused to dispose of it as a hazardous waste.[26] Until a safe method of final disposition for fissile materials can be agreed upon, existing stockpiles should be stored in a few highly secure facilities, with physical protection to be provided by sovereign states in conjunction with international inspectors.

Under the model NWC, nuclear weapons production facilities would either be destroyed or converted temporarily for the disassembly of warheads, after which the plants would be shut down. During the period a converted facility was engaged in warhead dismantlement, systematic verification measures would ensure that all other weapons-related activities had ceased. The model NWC also calls for the elimination of delivery systems designed solely for the purpose of delivering nuclear weapons, such as ballistic missiles with a range greater than 300 kilometers. This provision is unrealistic, however, since long-range ballistic missiles could be used to deliver conventional munitions against high-value targets such as oil refineries and command centers. Other nuclear delivery systems such as aircraft and cruise missiles are explicitly dual-capable, and civilian space-launch missiles could be modified to deliver nuclear warheads. Because of these complexities, the NWC should probably not include limits on nuclear delivery systems, which could be controlled under other treaties.

CRITERIA FOR FACILITY DECLARATIONS

CWC provisions. All parties to the CWC are required to declare and host routine inspections of chemical weapons production, storage, and destruction facilities, and a subset of chemical industry plants. Commercial chemical plants are declarable if they produce, process, or consume one or more of the toxic chemicals and precursors listed on the CWC schedules in amounts exceeding specified quantitative thresholds.[27] An early lesson of CWC implementation has been that countries with large chemical industries have taken longer than expected to identify the full set of declarable commercial facilities. Because the treaty did not require data collection prior to entry into force, it has been difficult for these countries to meet the declaration deadlines.[28]

Relevance to the model NWC. The verification regime for the model NWC should ensure the elimination of existing stockpiles of warheads and materials, prevent future acquisition or production, and increase the risks and costs of violations. As a first step, states parties would declare all inventories and facilities related to nuclear weapons, including numbers and types of warheads, fissile material stocks, and production and assembly plants. According to the model NWC, these data would be maintained in a central registry and would serve as the baseline from which reductions would proceed.

Although the number of facilities involved in production of nuclear weapons is far smaller than that potentially relevant to chemical weapons, the need for precise accounting of fissile materials means that verification of an NWC will be highly demanding. Declaration criteria for nuclear facilities should be broad enough to cover all sites that produce nuclear weapons or nuclear materials of any type, whether civilian or military, since it is the nature of the material and not its source that is of concern.

The current safeguards regime implemented by the IAEA applies only to certain civilian nuclear facilities and not to the full scope of weapons-related activities. Under a future NWC, however, countries would have to declare all HEU and plutonium ever produced in military and civilian facilities. Verifying the historical production of fissile materials is difficult, but this task was accomplished successfully in the case of South Africa.[29] The United States has also taken a useful first step by declaring its historical production of weapons-grade plutonium from 1945 to 1994, although other nuclear weapon states have yet to follow suit.[30]

Another source of uncertainty is the large amount of "material unaccounted for" at plutonium reprocessing plants, presumably retained inside pipes within these facilities. Indeed, the United States has been unable to account for 2.8 metric tons of weapons-grade plutonium.[31] Even under the best accountancy regime, this level of uncertainty will be problematic, since only about five kilograms of plutonium are needed to make a bomb. In any event, a full accounting of fissile-material stockpiles is likely to lag considerably behind the warhead dismantling process. Experience with CWC implementation suggests that the participating states should begin compiling baseline data on their stocks of fissile materials well in advance of the Convention's entry into force.

ROUTINE ON-SITE INSPECTIONS

CWC provisions. To ensure that dual-capable chemical facilities and equipment are not diverted for chemical weapons production, OPCW inspection teams are conducting routine inspections of declared facilities to verify that they are being used exclusively for legitimate purposes. The aim of routine inspections is to force potential cheaters to move illicit production to clandestine facilities, increasing the financial costs and political risks of noncompliance and helping to deter violations.

Relevance to the model NWC. Routine inspections under the NWC would serve to verify the accuracy and completeness of declarations. Since relatively small amounts of fissile materials can be used to make a nuclear weapon, the CWC concept of quantitative declaration thresholds does not apply. Ideally, every gram of fissile material should be accounted for. In practice, however, even the best safeguards system is imperfect because of fundamental technical limits on detecting the diversion of weapon-usable materials. This limitation applies particularly to facilities that handle large quantities of fissile materials, such as plutonium reprocessing and uranium enrichment plants and fuel fabrication plants for MOX and breeder reactors. Baseline inspections of such bulk-processing facilities will require a "physical inventory," a highly intrusive type of inspection in which the plant is shut down and the fissile material inside is counted with portable gamma-ray and neutron detectors. Once such baseline inspections have been completed, less intrusive routine inspections could be conducted on a periodic basis.

CHALLENGE INSPECTIONS

CWC provisions. The CWC supplements routine inspections with the right of any state party to request the international inspectorate to conduct a challenge inspection of a suspect facility, declared or undeclared, on the territory of another state party. Challenge inspections provide a "safety net" to detect—and hence deter—chemical weapons development and production at undeclared clandestine facilities. Since challenge inspections require one government to accuse another of a treaty violation, they are likely to be rare, politically high-profile events.

After a challenge inspection has been initiated, the host state must give the inspectors some access to the challenged facility not later than 108 hours after their arrival at the point of entry. This timeline is designed to give the challenged facility enough time to protect confidential equipment and information unrelated to the CWC but not to engage in a thorough clean-up that could remove all traces of illicit activity. Once the inspectors are on-site, the inspected party may also engage in "managed access," a process of negotiation with the inspection team that is designed to satisfy the inspectors' compliance concerns while protecting legitimate national-security and proprietary business information. Examples of managed-access techniques include placing cloth shrouds over pieces of equipment, turning off computers, locking up documents, specifying locations where samples may be taken, and allowing inspectors to visit rooms selected at random. Although officials from the challenged country have the right to deny access to certain sensitive areas, they must make "every reasonable effort" to satisfy the inspectors' compliance concerns by suggesting alternative means of verification, such as record audits.

Whether a challenge inspection uncovers clear-cut evidence of a CWC violation will depend on the nature and scale of the prohibited activity, the intelligence supporting the inspection regime, and the sophistication of the violator's efforts to conceal its illicit behavior. While it is unlikely that inspectors will find a "smoking gun," challenge inspections may reveal a pattern of anomalies or discrepancies strongly indicative of a treaty violation.

Relevance to the model NWC. Challenge inspections under a NWC compliance regime would aim to deter violations by increasing the risks and costs of clandestine activities, much as the new "93+2" protocol developed by the IAEA seeks to detect illicit nuclear activities at undeclared sites not covered by existing safeguards.[32] The model NWC also proposes a system of "safety controls" to *prevent* diversions through enhanced physical protection and surveillance and restricted physical access.[33] To this end, key nuclear facilities might be subjected to perimeter and portal continuous monitoring—as was applied to missile production plants under the START I and Intermediate-range Nuclear Forces (INF) treaties—to ensure that they have not been recommissioned or diverted to military use.

An obvious limitation of challenge inspections is that they can expose violations only if undeclared nuclear facilities can be identified. Research and development activities and the machining and assembly of nuclear warheads can take place in small, easily concealed locations. Thus, without tip-offs from intelligence sources, no inspection regime could search more than a fraction of the possible locations where nuclear weapons or materials might be hidden.

In contrast, the production of fissile materials generally requires facilities that are quite large and have characteristic "signatures." To separate plutonium chemically from spent fuel, for example, the fuel rods are chopped up and dissolved in nitric acid, releasing the radioactive isotope Krypton-85, which can be detected in air samples. Neutron or gamma-ray detectors can also determine the distinctive isotopic signatures of a nuclear facility, even if attempts have been made to clean up the site or to filter emissions.[34] Nevertheless, experimental techniques such as Magnetic Laser Isotope Separation (MLIS) and Atomic Vapor Laser Isotope Separation (AVLIS) could permit highly efficient uranium enrichment in much smaller facilities. While these new methods have only been demonstrated on a pilot scale and have yet not been ramped-up successfully to the industrial level, they have the potential to complicate the verification of a future NWC.

A less traditional approach to compliance monitoring, known as "societal verification," has been advocated by Nobel Peace Laureate Joseph Rotblat.[35] This method would supplement formal verification measures by encouraging scientists and other whistleblowers to provide timely warning that a country was secretly attempting to acquire nuclear weapons. The future NWC might seek to encourage such behavior by requiring states parties to enact domestic legislation protecting nuclear whistleblowers against government retaliation. Nevertheless, while societal verification might be effective in open, democratic societies such as the United States and France, it would be much less reliable in harshly authoritarian states such as Iraq and North Korea, where the vast majority of scientists could be intimidated from speaking out.

PROTECTION OF CONFIDENTIAL INFORMATION

CWC provisions. The CWC on-site inspection regime reflects a balance between effective verification and the need to protect national-security and confidential business information unrelated to treaty compliance. For routine inspections, prenegotiated "facility agreements" specify which parts of a plant are subject to inspection and where sampling, photography, and other intrusive activities may take place. For challenge inspections, the CWC provides for managed access. The treaty also includes a lengthy "Confidentiality Annex" that ensures the secure storage and handling of sensitive information derived from declarations and inspections.

These measures for the protection of proprietary information were developed with the active participation of the international chemical industry during the CWC negotiations at the Conference on Disarmament in Geneva. In 1978, the U.S. delegation to the talks invited representatives from the Chemical Manufacturers Association (CMA), a leading U.S. chemical trade association, to advise them on issues affecting chemical industry, a relationship that continued for several years. Other chemical trade associations from Australia, Western Europe, and Japan also advised their respective delegations during the treaty negotiations. As a result of CMA's extensive involvement in shaping the provisions on managed access and confidentiality, the association pledged its "unqualified support" for the Convention.[36] This strong endorsement by the U.S. chemical industry later proved crucial in obtaining the Senate's consent to CWC ratification.

Relevance to the model NWC. Since relatively few nuclear technologies are commercially sensitive, protection of confidential business information is less of a concern at nuclear facilities than at chemical or pharmaceutical plants. To develop provisions for protecting trade secrets related to fuel fabrication, enrichment, and reprocessing technologies, countries negotiating an NWC should invite representatives of the nuclear industry to serve as advisors to national delegations.

Another concern is that inspectors from states parties that are covert proliferators might seek information useful for the acquisition of nuclear weapons. To minimize this threat, all international inspectors should be carefully vetted and required to sign a nondisclosure agreement making them liable to criminal prosecution if they divulge privileged information. The future treaty organization should also establish detailed procedures for managed access at sensitive nuclear sites and for storage, handling, and classification of weapons-related data contained in declarations and inspection reports.

CONCLUSIONS

Because of the technical differences between chemical and nuclear weapons and their methods of production, the wholesale adoption of verification measures from the CWC in the model NWC is not appropriate. Nevertheless, some basic elements of the CWC verification regime are relevant to a future nuclear weapons ban.

First, the model NWC should follow the lead of the CWC in establishing an array of mutually reinforcing verification measures, including mandatory declarations, routine inspections of declared facilities, and challenge inspections of declared and undeclared facilities.

Second, although the number of relevant nuclear facilities is far smaller than the number of relevant chemical plants, small amounts of fissile materials are militarily more significant than comparable quantities of chemical precursors. Thus, the NWC will need to go far beyond the CWC in provisions for intrusive monitoring and precise accounting of fissile materials, including historical production, to deter and prevent diversions. In addition, a provision similar to the CWC's general-purpose criterion could be applied to future production and use of dual-use fusionable and fertile materials under the NWC. Because of the complexity of accounting for past production of special nuclear materials, collection of relevant historical data should begin long before the treaty enters into force.

Third, fissile material accounting would be greatly facilitated by banning or phasing out all civilian uses of weapons-grade materials, such as the use of HEU in research reactors or for nuclear propulsion and the use of plutonium in MOX and breeder reactors. If a plutonium fuel cycle for commercial power generation were to be widely adopted, it would greatly complicate the monitoring and control of fissile materials. Priority should therefore be given to developing nuclear fuel cycles that are proliferation-resistant, with the ultimate goal of building a "firewall" between military and civil uses of nuclear energy.

Fourth, the basic prohibitions and verification provisions of the NWC should cover nuclear warheads, special nuclear materials, and relevant civilian and military facilities. Attempting to extend the scope of the treaty to cover multipurpose delivery systems such as aircraft and missiles would be unwise, since the complexity of this area would greatly prolong the negotiations. As an alternative, nuclear delivery systems might be controlled under other existing and future treaties.

Fifth, the NWC should include managed-access provisions and other measures similar to those in the CWC to protect national-security and proprietary business information unrelated to treaty compliance. To gain the cooperation and support of the nuclear industry, representatives of trade associations should be invited to advise national delegations on treaty language for the protection of trade secrets.

In conclusion, practical experience with CWC declarations and on-site inspections of chemical facilities will provide useful lessons for a future NWC. Serious problems with CWC implementation could undermine future efforts to negotiate a multilateral ban on nuclear weapons. Conversely, successful implementation of the CWC would build confidence in the arms control process and give impetus to multilateral nuclear disarmament.

[1] 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Final Document, Part I: Organization and Work of the Conference*, New York, 1995, Document No. NPT/CONF.1995/32 (Part I), "Decision 2: Principles and Objectives for Nuclear Non-Proliferation and Disarmament," paragraph 4(c).

[2] James Carroll, "War Inside the Pentagon," *The New Yorker*, August 18, 1997, p. 60.

[3] James Steinberg, Keynote Address at the Carnegie Endowment Nonproliferation Conference, Washington, D.C., June 9, 1997.

[4] Burrus M. Carnahan, "World Court Delivers Opinion On Legality of Nuclear Weapons Use," *Arms Control Today* 26 (July 1996), p. 24.

[5] Craig Cerniello, "Retired Generals Re-Ignite Debate Over Abolition of Nuclear Weapons," *Arms Control Today* 26 (November/December 1996), p. 14.

[6] Canberra Commission on the Elimination of Nuclear Weapons, Homepage (http://www.dfat.gov.au/dfat/cc/cchome.html).

[7] Lawyer's Committee on Nuclear Policy, "Model Nuclear Weapons Convention: Statement of Purpose, Outline, Draft Preamble and Summary," April 1997.

[8] Abolition 2000, Homepage (http://www.abolition2000.org.statement.html).

[9] Steve Fetter, *Verifying Nuclear Disarmament* (Washington, D.C.: The Henry L. Stimson Center, Occasional Paper No. 29, October 1996), p. 40.

[10] *Ibid.*

[11] U.S. National Academy of Sciences, Committee on International Security and Arms Control, *The Future of U.S. Nuclear Weapons Policy* (Washington, D.C.: National Academy Press, 1997), p. 86.

[12] Fetter, *Verifying Nuclear Disarmament*, p. 42.

[13] David Hoffman, "Yeltsin Approves Doctrine of Nuclear First Use if Attacked," *The Washington Post*, May 10, 1997, p. 21; Bill Gertz, "Russia to Slash Ground Forces, Rely on Nukes," *The Washington Times*, October 17, 1997, p. 1.

[14] Jonathan S. Landay, "US Quietly Adds a Bunker-Buster to Nuclear Arsenal," *The Christian Science Monitor*, April 8, 1997; Robert Waller, "Libyan CW Raises the Issue of Pre-emption," *Jane's Intelligence Review*, November 1996, pp. 522-526; Victor A. Utgoff, *Nuclear Weapons and the Deterrence of Biological and Chemical Warfare* (Washington, D.C.: The Henry L. Stimson Center, Occasional Paper No. 36, October 1997); R. Jeffrey Smith, "Clinton Directive Changes Strategy on Nuclear Arms," *The Washington Post*, December 7, 1997, p. 1.

[15] For a discussion of de-alerting proposals, see Bruce G. Blair, Harold A. Fieveson, and Frank N. von Hippel, "Taking Nuclear Weapons Off Hair-Trigger Alert," *Scientific American* 277(5), November 1997, pp. 74-81.

[16] For example, the Soviet Union and then Russia allegedly developed a new family of binary nerve agents known as *novichok*. See "Mirzayanov, Fedorov Detail Russian CW Production" [Interview], *Novoye Vremya*, No. 44, October 1992, pp. 4-9; in JPRS-TAC-92-033 (14 November 1992), pp. 44-49.

[17] Schedule 1 includes known CW agents (such as mustard gas and sarin) and immediate CW precursors that have few if any peaceful applications. Schedule 2 lists toxic chemicals and CW precursors that are also employed in small quantities for peaceful purposes (such as thiodigycol, which is both a precursor for mustard gas and a key component of ballpoint pen ink). Schedule 3 lists dual-use chemicals (such as phosgene and hydrogen cyanide) that were used as chemical weapons in World War I but are now produced and consumed in large quantities by commercial industry. Chlorine gas, the first chemical weapon of the modern era, has so many peaceful applications that it was considered impractical to include it in the verification regime.

[18] U.S. Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, OTA-BP-ISC-115 (Washington, D.C.: U.S. Government Printing Office, December 1993), p. 155.

[19] "Weapons-grade" HEU has been enriched to 90 percent or more of Uranium-235 to ensure a high degree of weapon reliability and efficiency. HEU enriched to between 20 and 90 percent can also be used in a weapon, but a larger amount of the material is required to produce an explosive chain-reac-

tion. Similarly, "weapons-grade" plutonium typically contains six percent or less of the non-fissile isotopes Plutonium-240 and Plutonium-242, but less pure plutonium (even reactor-grade plutonium containing at least 20 percent non-fissile isotopes) can be used to make a bomb, albeit with reduced explosive yield. In several incidents between 1992 and 1996, kilogram quantities of weapons-usable (but not weapons-grade) HEU were stolen from nuclear facilities in Russia and later seized by government authorities. Graham T. Allison, Owen R. Cote, Jr., Richard A. Falkenrath, and Steven E. Miller, *Avoiding Nuclear Anarchy: Containing the Threat of Loose Russian Nuclear Weapons and Fissile Material* (Cambridge, MA: The MIT Press, 1996).

[20] Lawrence R. Scheinman, Monterey Institute of International Studies, telephone conversation with author, October 15, 1997.

[21] Martin Kalinowski, *et al.*, "Cutoff of Nuclear-Weapons-Usable Materials," in International Network of Engineers and Scientists Against Proliferation (INESAP), *Beyond the NPT: A Nuclear-Weapon-Free World* (Darmstadt, Germany: University of Darmstadt, April 1995), p. 87.

[22] "Agreement Between the Department of Defense of the United States of America and the Ministry of the Russian Federation for Atomic Energy Concerning the Modification of the Operating Seversk (Tomsk Region) and Zheleznogorsk (Krasnoyarsk Region) Plutonium Production Reactors," September 23, 1997.

[23] A possible way around this problem would be for the nuclear weapons states to reassign all of their military stockpiles of fissile materials irrevocably for peaceful uses, in which case the IAEA could legally assume responsibility for safeguarding them.

[24] U.S. Academy of Sciences, Committee on International Security and Arms Control, *Management and Disposition of Excess Weapons Plutonium* (Washington, D.C.: National Academy Press, January 1994).

[25] Adam Bernstein, "Getting Burnt by Weapons Plutonium: Security Implications of U.S. Disposition Options," *The Nonproliferation Review* 4 (Winter 1997), pp. 72-81.

[26] Charles N. Van Doren, "Getting to Burn Weapons Plutonium: Principal Issues and Obstacles," *The Nonproliferation Review* 4 (Fall 1996), pp. 98-105.

[27] The quantitative declaration thresholds specified in the CWC are as follows: no threshold for the known CW agents listed on Schedule 1; a threshold of 1 kilogram, 100 kilograms, or 1 metric ton for the various subcategories of chemicals on Schedule 2; and a threshold of 30 metric tons for the chemicals on Schedule 3. The CWC declaration requirements also cover "other" production facilities that manufacture more than 200 metric tons per year of unscheduled "discrete organic chemicals," on the grounds that such plants could be used to manufacture scheduled chemicals at some time in the future.

[28] John Gee, "A Strengthened BWC: Lessons to be Learned from the Chemical Weapons Convention," *UNIDIR Newsletter*, No. 33/96, p. 77.

[29] Adolf von Baeckmann, Gary Dillon, and Demetrius Perricos, "Nuclear Verification in South Africa," International Atomic Energy Agency website (http://www.iaea.or.at/worldatom/inforesource/bulletin/bull371/baeckmann.html).

[30] U.S. Department of Energy, Office of Nonproliferation and National Security, "Declassification of the United States Plutonium Inventory and Release of the Report 'Plutonium: The First 50 Years," Fact Sheet, February 6, 1996.

[31] *Ibid.*

[32] Howard Diamond, "IAEA Approves '93+2' Protocol; Awaits Adoption by Member States," *Arms Control Today* 27 (May 1997), pp. 27, 30.

[33] Lawyer's Committee on Nuclear Policy, "Model Nuclear Weapons Convention," p. 14.

[34] Fetter, *Verifying Nuclear Disarmament*, p. 30.

[35] Joseph Rotblat, "Societal Verification," in J. Rotblat, J. Steinberger, and B. Udgaonkar, eds., *A Nuclear-Weapon-Free World – Desirable? Feasible?* (Oxford: Westview Press, 1993), pp. 103-118.

[36] Chemical Manufacturers Association, News Release, October 19, 1992. This news release quotes then CMA president Robert A. Roland, who states that the CWC "is vitally important to the chemical industry. It will help us immeasurably in our efforts to guard against the diversion and misuse of our legitimate, commercial products." See also, Testimony of Will D. Carpenter on behalf of the Chemical Manufacturers Association, in U.S. Senate, Committee on Foreign Relations, 103rd Congress, 2nd session, *Hearing: Chemical Weapons Convention (Treaty Doc. 103-21)*, June 9, 1994, p. 88-92.