CUTTING OFF THE PRODUCTION OF FISSILE MATERIAL FOR NUCLEAR WEAPONS

Harold A. Feiveson and Frank von Hippel
Center for Energy and Environmental Studies
Princeton, University

...the United States would be prepared to work out, with other nations, suitable and safeguarded arrangements so that future production of fissionable materials anywhere in the world would no longer be used to increase the stockpiles of explosive weapons.

—President Eisenhower in letter to Premier Bulganin, March 1, 1956

Current Stockpiles and Production Rates

In 1956, when Eisenhower first proposed a freeze in the production by the superpowers of fissile materials for nuclear weapons (plutonium and highly enriched uranium), U.S. stockpiles of these materials and of nuclear warheads were on the order of one-tenth their current size. Today, based on the statements of government officials, one can estimate that the U.S. has approximately 25,000 nuclear warheads. And, based on the history of AEC uranium purchases, enrichment capacity and radioactive waste generation, one can estimate that the U.S. inventory of weapon-grade fissile material—both inside and outside of nuclear warheads—is several hundred metric tonnes of highly enriched uranium and about one hundred tonnes of plutonium. As far as we know, *the order of magnitude* of the corresponding inventories in the Soviet Union is comparable.

These are enormous inventories of fissile material—even without the amplification of the explosive power of nuclear weapons which was introduced with the development of thermonuclear weapons. The 20-kiloton Nagasaki bomb contained only 6 kilograms of plutonium. The U.S. stockpile of weapon-grade plutonium is therefore sufficient for the production of about 15,000 Nagasaki-type bombs—equal to more than half the number of nuclear weapons in the U.S. stockpile. If one adds 500 tonnes of highly enriched uranium and assumes that all this heavy metal could be fissioned with 30 percent efficiency (the efficiency of the Nagasaki bomb was 20 percent) the total fission yield would be about 3000 megatons—equal to about one-third the total estimated yield of the U.S. stockpile.

The U.S. stockpile of nuclear warheads reached its peak in 1967. Since that time obsolete warheads have been retired about as fast as new ones have been produced (on the order of 1000 per year), and their fissile material has been recycled. As a result the demand for the production of new fissile material fell dramatically in the mid-1960's. The U.S., therefore, stopped production of highly enriched uranium for nuclear weapons purposes in 1964 and shut down between 1964 and 1971 ten of the fourteen plutonium production reactors located at the Department of Energy's facilities at Savannah River, South Carolina and at Richland, Washington. Of the four operating production reactors, only the three at Savannah River have been producing "weapon-grade"* plutonium in recent years—and those not at full capacity. Their combined average production rate has been only about 1.5 tonnes of plutonium per year. The Department of Energy (DOE) is currently undertaking a program to almost triple this rate of weapon-grade plutonium production by the mid-1980's.

Rationale for a Production Cutoff

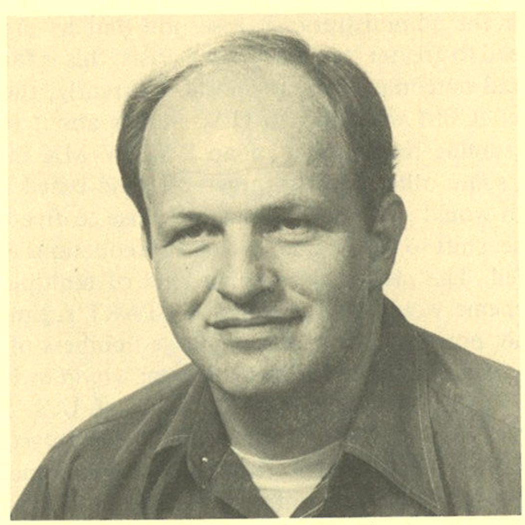
Although a complete cutoff in the production of fissile materials for weapons would not by itself stop the production of higher-yield, and even a somewhat increased number of, nuclear warheads, it would at least put an upper limit on the total number of warheads which the superpowers could produce. It would certainly be an essential part of any wider agreement to freeze nuclear weapons production. By undertaking to halt fissile material production for weapons and to accept the necessary safeguards on their peaceful nuclear programs, the superpowers would also be removing one of the long-standing inequities between the nuclear weapons and non-nuclear weapons signatories of the Non-proliferation Treaty; and they would place pressure on critical "threshold" states such as Argentina, Brazil, India, Israel, Pakistan, and South Africa to accept such restrictions as well.

Verification of a Cutoff

It appears likely that, while verification of a fissile material production cutoff could not be perfect, the uncertainties involved could be reduced to levels which are small relative to the sizes of the already existing stockpiles.

There are four principal areas of concern:

- The safeguarding of the huge amounts of weapons-usable materials which would continue to build up in the civilian nuclear energy systems of the superpowers;
- The assurance that shut-down military production facilities really were shut down;
- The assurance that no clandestine production facilities of significant sizes were in operation; and
- The assurance that plants producing highly enriched uranium for naval nuclear reactors and producing replacement tritium required for the maintenance of existing



Frank von Hippel

*Any mixture of plutonium isotopes can be used to make a nuclear explosive. Weapons designers, however, prefer relatively pure plutonium-239 with an admixture of less than 7 percent plutonium-240.

nuclear weapons were not used to produce large amounts of new fissile material for weapons purposes.

Civilian Nuclear Energy Systems: Safeguards would be needed on the nuclear energy activities of the superpowers because of the huge quantities of nuclear weapons-usable materials involved in these civilian programs. At present, for example, approximately 50 tonnes of fissile plutonium are in spent fuel at U.S. nuclear power plants. Fortunately, international machinery already exists for implementing safeguards on such material, and these safeguards, which are administered by the International Atomic Energy Agency (IAEA), have been accepted by the non-nuclear weapons states which have signed the Treaty on the Non-proliferation of Nuclear Weapons. Although there is some question as to whether IAEA safeguards can guarantee the detection under all circumstances of the diversion of enough fissile material to make a few nuclear weapons, they could certainly detect diversions on a scale sufficient to have a significant effect on the nuclear weapons balance between the superpowers.

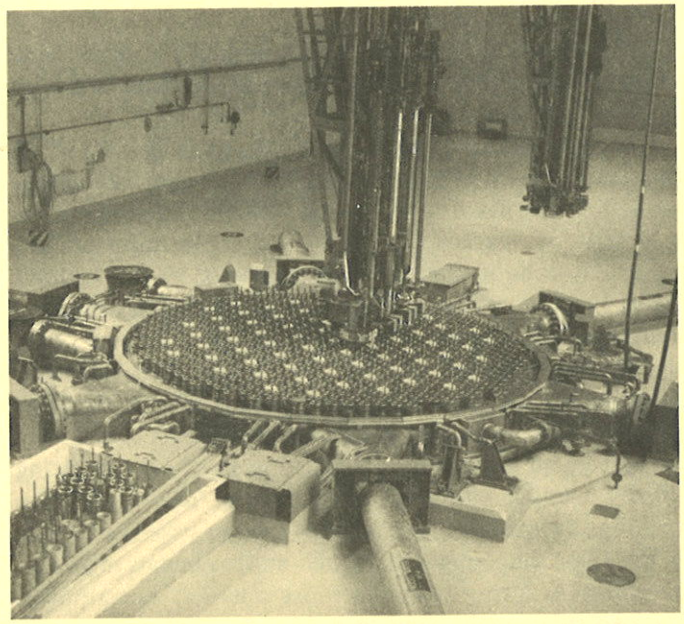
Shut-down Military Production Facilities: Monitoring shut-down military plutonium production reactors and uranium enrichment plants would be even easier than safeguarding the material being processed by an operating civilian plant and could conceivably even be done remotely—by using infrared sensors on satellites, for example, to detect the waste heat discharges associated with the operations of these facilities.

Clandestine Facilities: For the foreseeable future, there would appear to be no realistic alternative to the use of "national technical means"—satellites in particular—to confirm that no fissile material production facilities of significant scale were being constructed or operated clandestinely. The detailed information published by the U.S. government on the numbers and locations of Soviet missiles and weapons subassembly plants suggests that the observation technologies are equal to the task. In its most recent (1969) proposal concerning a fissile production cutoff, the U.S. expressed no concern about the danger of undetected clandestine production facilities.

Naval Reactor Fuel: In U.S. nuclear powered ships, the uranium in the reactor fuel is highly enriched. Therefore, since there is no intention in a freeze to stop the refueling of these warships, either they would have to be fueled from stockpiled highly enriched uranium or special arrangements would have to be made to allow a continued supply of highly enriched uranium for this purpose.

For some years, the easiest option, for the U.S. at least, might be to use stockpiled highly enriched uranium. The current annual requirements of weapon-grade uranium for U.S. naval propulsion are on the order of 5 tonnes. This is only approximately one percent of the existing U.S. stockpile of this material and is about one-tenth of the 60 tonnes of weapon-grade uranium which the U.S. offered as recently as 1969 to transfer to "peaceful purposes" provided that the Soviet Union similarly transferred 40 tonnes.

Tritium: In many U.S. nuclear warheads the heavy radioactive isotope of hydrogen, tritium, is present as an active ingredient. The primary purpose of this tritium is to provide extra neutrons via a fusion reaction with deuterium. These neutrons are then used either to "boost" the efficiency of fission explosions, to simplify the design of variable-yield warheads, or to contribute the enhanced radiation effects of low-yield ("neutron") warheads designed for battlefield use.



Fuel and target assemblies being loaded into a production reactor at the Savannah River Plant, Aiken, South Carolina.

Because the radioactive half-life of tritium is about 12 years, a cutoff of tritium production would severely limit not only the number but also the lifetime of enhanced radiation weapons. It would also, after a number of years, result in a reduction in the peak yields of the boosted- and variable-yield fission weapons.

If, in light of (or despite) these consequences, a replenishment of tritium reservoirs were deemed essential, production could be allowed without creating large new opportunities for the circumvention of a fissile material cutoff. It is true that nuclear reactors designated to produce tritium might be used to produce plutonium instead, but according to an estimate published by Thomas B. Cochran et al (*Science,* May 12, 1982), U.S. tritium production has averaged only about 3 kilograms per year over the past decade. This is well within the capabilities of a single production reactor which, even if diverted fully to plutonium production, could produce annually the equivalent of less than a percent of the current U.S. inventory of weapon-grade plutonium.*

Acknowledgment

We would like to thank Thomas B. Cochran and William M. Arkin for sharing with us some of their findings prior to the publication of their *Nuclear Weapons Databook* (Ballinger, 1983).

*Since it takes the capture of one neutron to produce either one atom of tritium or one of plutonium, which weighs 80 times as much as a tritium atom, a reactor producing 3 kilograms of tritium per year could alternatively produce one quarter of a tonne of plutonium per year.