Dangerous diagnostics

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World Inventory of Plutonium and Highly Enriched Uranium 1992. By David Albright, Frans Berkhout and William Walker. *Oxford University Press: 1993. Pp. 246. £25, $39.95.*

THIS volume provides the only comprehensive assessment of how much plutonium and highly enriched uranium — the basic ingredients of nuclear weapons — exists in the world today, and where and in which form they are to be found. Given the crucial importance of this information for global security, the *World Inventory* is essential reading for all interested in international affairs and an indispensable reference book for researchers.

The authors analyse in detail the inventories in the nuclear-weapon states (the United States, the former Soviet Union, the United Kingdom, France and China), the *de facto* nuclear-weapon states (Israel, India and Pakistan), countries suspected of having ambitions to produce nuclear weapons (Iraq, North Korea, Iran and Algeria) and countries "backing away from nuclear weapons" (Argentina, Brazil, South Africa and Taiwan). The surprising omission of South Korea from the last group is not explained.

Some of the most important data in the *World Inventory* is given in the accompanying box. The authors estimate that the error margins on their figures, by far the best nongovernmental ones available, are ±15% for plutonium (Pu) and ±30% for highly enriched uranium (HEU). Most uncertain is the size of military inventories in the former Soviet Union. This is a serious matter. Some 25 tonnes of ex-Soviet military Pu cannot be accounted for. There is particular concern that when ex-Soviet nuclear weapons are dismantled in Russia and the Pu in them transferred from military to civil control, some of the Pu will be stolen and sold on the black market. Weapon-grade Pu is worth at least a million dollars a kilogram on the black market. Given the very poor salaries of Russian scientists and technicians, the temptation to sell Pu must be almost irresistible.

Whereas the world's stocks of military Pu and HEU are roughly constant, amounts of civil Pu are increasing steadily. According to present plans, about 310 tonnes of civil Pu will be separated by the year 2000. Of this, about 60 tonnes will be stored in the United Kingdom, about 50 tonnes in Japan, about 40 tonnes in each of Germany and Russia, and about 15 tonnes in France. Unilateral and bilateral disarmament agreements may lead to the dismantlement during the 1990s of 30,000 or so US and ex-Soviet nuclear weapons containing about 90 tonnes of Pu and about 450 tonnes of HEU.

The *World Inventory* stimulates one to consider how Pu and HEU should be disposed of. Discarding HEU is fairly straightforward. By mixing HEU with enough natural or depleted U to reduce the concentration of ^{235}U from 90 to 2 or 3%, it can be used as fuel in civilian light-water power reactors. The United States has agreed to buy 500 tonnes of HEU from Russia for this purpose.

The disposal of Pu is not so easy. Its use as reactor fuel — for breeder or ordinary reactors — is not economic. The electricity produced by commercial breeder reactors will be relatively expensive until the price of uranium increases considerably. This will not happen for decades. Mixed oxide fuel for light-water reactors is expensive — about twice the cost of ordinary uranium oxide fuel.

Other suggested methods for getting rid of Pu include firing it into the Sun using rockets, transmuting it into other elements in special reactors or particle accelerators, 'burning' it in fast (non-breeding) reactors, and mixing it with high-level radioactive waste. The risk that a rocket might accidentally fall back to Earth with its Pu payload is environmentally unacceptable. Machines for transmuting large amounts of Pu and suitable fast reactors have not yet been developed. The best way of dealing with Pu would be to incorporate it in silica glass with high-level radioactive waste and to place it in a geological depository.

Until the world's Pu is permanently disposed of, it should be owned, stored and safeguarded by the International Atomic Energy Agency. The international management of Pu would be much better than the current chaotic situation of national ownership and storage and give some confidence that Pu was not being diverted to military uses. The safe storage of HEU is perhaps even more important. As Luis Alvarez has reminded us, the background neutron rate in weapon-grade HEU is so low that terrorists would have a good chance of setting off a high-yield nuclear explosion by simply dropping 30 kg of the material onto another 30 kg. □

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World amounts of Pu and HEU

■ Total amounts. The amounts of plutonium (Pu) and highly enriched uranium (HEU) in the world's civil and military inventories are huge — currently about 1,100 tonnes of Pu and 1,400 tonnes of HEU (excluding roughly 150 tonnes of HEU in naval reactors and their fuel cycles). About a quarter of Pu and almost all the HEU is used for military purposes, mostly in nuclear weapons. HEU consists mainly of weapon-grade uranium containing at least 90% of the fissile isotope ^{235}U. The world's nuclear arsenals contain about 50,000 nuclear warheads, about 95% of them US and ex-Soviet. On average, each warhead contains about 3 kg of Pu (weapon-grade Pu contains at least 93% ^{239}Pu) and 15 kg of HEU.

■ Civil plutonium. The inventory of civil Pu is increasing at about 62 tonnes a year, contained in the roughly 9,300 tonnes of spent fuel discharged annually by the world's nuclear power reactors. Of the world's 780 or so tonnes of civil Pu, about 81% is still in spent reactor fuel; about 135 tonnes have been separated from spent reactor fuel. Of the separated Pu, about 86 tonnes is kept in store; the rest is in the breeder reactor fuel cycle and in mixed oxide fuel for ordinary (thermal) reactors (in mixed oxide fuel, plutonium oxide is mixed with uranium oxide). Of the Pu in store, about 35% is in Russia and about 47% is in the United Kingdom.

■ Military plutonium. Of the world's 260 or so tonnes of military Pu, about 70% is in warheads; the rest is stored outside warheads. Most is in the United States (about 112 tonnes) and the former Soviet Union (about 125 tonnes). The United Kingdom is estimated to have about 11 tonnes of military Pu, France about 6 tonnes, and China about 2.5 tonnes. The best estimate for the amount of military Pu produced so far by Israel is about 250–450 kg. The figure for India is about 330 kg. The Israeli figure is questionable. According to the information given by Mordechai Vanunu, the Israeli whistle-blower, the Israelis probably produced at least 500 kg up to 1986. They may have produced about 300 kg since. There is no reason to doubt Vanunu's figures, which are based on first-hand knowledge, and it is hard to understand why the authors have done so.

■ Highly enriched uranium. The bulk (97%) of the world's HEU is held by the United States and the former Soviet Union. There are about 40 tonnes of HEU in the United Kingdom, France and China put together. Pakistan is estimated to have produced between 200 and 300 kg of HEU. The amount of HEU produced by South Africa is very uncertain, with a potential inventory of between 200 and 525 kg. This presents a serious challenge to the International Atomic Energy Agency to verify independently South Africa's declaration of its HEU inventory. According to President F. W. de Klerk, South Africa produced only six nuclear weapons. The authors' estimate indicates that South Africa had enough HEU to produce between 10 and 25 nuclear weapons. The cynic will wonder whether a few have been hidden.