

**U.S. Inventories of Nuclear Weapons
and
Weapon-Usable Fissile Material**

by

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PREFACE

This report provides NRDC's latest estimates of U.S. inventories of nuclear weapons, plutonium and highly-enriched uranium (HEU).¹ These data may be helpful in policy discussions related to achieving further reductions in the number of nuclear weapons, both deployed and those kept in reserve, and the disposition of fissile materials removed from weapons. Despite Secretary of Energy Hazel O'Leary's efforts to declassify U.S. nuclear weapon and fissile material inventories through DOE's "Openness Initiative," some of the government's inventory data remain classified. In these cases NRDC's estimates are pieced together from unclassified sources. In addition, there are minor errors and uncertainties in some of the data released by DOE which DOE acknowledges and is attempting to identify and correct.

The U.S. plutonium inventory data are taken primarily from U.S. Department of Energy (DOE), "Plutonium: The First Fifty Years," February 1996. This report is available from DOE in hard copy and is on DOE's web site at:

<http://www.doe.gov/html/osti/opennet/documents/pu50yrs/pu50y.html>

We have attempted to refine the DOE plutonium inventory data by breaking it down into weapon-grade plutonium (WGPu), fuel-grade plutonium (FGPu), and reactor-grade plutonium (RGPu), where:

<u>Category</u>	<u>Percent Pu-240</u>
WGPu	less than 7
FGPu	7 to less than 19
RGPu	19 or greater

The NRDC Nuclear Program staff seeks to refine, update and correct any errors in our (and DOE's) estimates, and therefore welcomes comments from the reader.

¹ The initial version of this report was presented at the 24 Pugwash Workshop on Nuclear Forces, London, 22-24 September 1995. It was revised 26 September 1995 and released as an NRDC "Nuclear Weapons Databook" report.

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Table 1. U.S. Nuclear Weapons Stockpile (end FY 1995).

Table 2. U.S. Nuclear Weapons Stockpile.

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SUMMARY

- * The U.S. stockpile as of 1990 was about 21,500 warheads.
- * Since then about 30 percent of the U.S. stockpile has been dismantled. The U.S. still has about 15,000 intact warheads.
- * The U.S. nuclear weapons stockpile is currently about 11,000 warheads, made up of about 7,800 operational strategic warheads, 1,150 operational non-strategic warheads, about 900 spares and about 1,100 warheads in active and inactive reserve.
- * Another 4,400 U.S. warheads have been removed from the operational arsenal and are stored in depots and awaiting dismantlement.
- * Since end-FY 1990 the U.S. has dismantled about 7,800 warheads, a rate of about 1,550 per year. Over the next five years the U.S. could dismantle an additional 8,000 warheads.
- * The U.S. operational stockpile scheduled for 2003 will be about 5,000 warheads, with another 2,500 warheads kept in reserve for possible redeployment.
- * The U.S. Department of Energy (DOE) inventory of plutonium is about 98 metric tons (t). Approximately 84 t is weapon-grade (WGPu) for weapons, and about 15 t is fuel-grade plutonium (FGPu) for civil R&D.
- * Of the 84 t WGPu, some 64 t is in weapons or intact pits, and the remaining 19 t is in the form of solutions, scrap and waste material at the Rocky Flats Plant and other DOE sites.
- * The U.S. plans to retain a strategic reserve of about 23 t of WGPu in intact pits--roughly 7,800 pits--and has declared that 38 t of WGPu, including 19 t in roughly 6,300 pits, is in excess of weapon requirements and will no longer be available for weapons. The other half of the WGPu that has been declared to be excess is the 19 t of solutions, scrap and waste materials.
- * Thus, only 19 t out of 64 t (30%) of the WGPu currently in weapons or intact pits has been declared surplus. Under current plans the remaining 45 t (70%) will be retained under START II as intact warheads or intact strategic reserve pits.

I. The U.S. Nuclear Weapon Stockpile (end FY 1995).

The U.S. nuclear weapons stockpile peaked in 1967 at about 32,500 warheads (Figure 1).² The estimated inventory of U.S. nuclear warheads, as of the end of FY 1995 (ending 31 September 1995), is given in Table 1.³ As of the end of FY 1995 there are about 9,900 warheads in the Department of Defense's (DOD's) operational (deployed) stockpile and another 1,100 warheads in the active and inactive reserve.⁴ The total DOD stockpile is about 11,000 warheads. In addition, there are an estimated 4,430 retired warheads in Air Force, Navy and Department of Energy (DOE) depots that are in a queue, awaiting their turn on the Pantex disassembly line (Table 2). We have included in the operational stockpile (Table 1) the sixteenth Trident submarine which is just now entering the force with its 24 Trident-II SLBMs. Even now, the mindless momentum of the arms race continues, as the U.S. operational stockpile will actually *increase* over the next two years as the Navy deploys two additional Trident submarines.

The number of U.S. nuclear warheads dismantled annually by the DOE is given in Table 2. The dismantlement goal for FY 1995 was 2,000 warheads, but by the end of August only 1,316 warheads had been dismantled, and only about 1,400 are expected to be retired by end-FY 1995. As of May 8, 1995 there were 7,239 pits in storage at Pantex, so we estimate there will be about 7,650 in storage as of end-FY 1995.⁵

While the public perception is that the U.S. and Russian nuclear weapon stockpiles will be reduced to about 3,500 warheads by 2003 under the START II treaty, the truth is the Clinton Administration is planning a stockpile more than twice as large--close to 7,400 warheads (Table 1). In addition to the 3,500 operational strategic warheads in the U.S. arsenal in 2003, the Pentagon plans to retain another 950 warheads for non-strategic forces, i.e., the "strategic reserve" and presumably additional spares which we estimate will equal about 10 percent of the active inventory. The strategic reserve, originally created for use after a nuclear war with Russia, now is conceived as a force allowing the U.S. to resist potential coercion by such nations as China, North Korea, and Iran who might attempt to take advantage of the United States following a nuclear war. The reserve force could also be directed towards these or other countries irrespective of the Russian context, should the national command authorities so decide.

² Thomas B. Cochran, William M. Arkin, and Milton M. Hoenig, *Nuclear Weapons Databook, Volume I: U.S. Nuclear Forces and Capabilities*, (Cambridge, MA: Ballinger Publ. Co., 1984), p. 15.

³ This table was compiled by Robert S. Norris with the assistance of other members of NRDC's Nuclear Program staff. Dr. Norris updates this estimate on a regular basis. Dr. Norris and William Arkin publish an annual update of the U.S. nuclear weapon stockpile in the "NRDC Nuclear Notebook" section of the *Bulletin of the Atomic Scientists* (see the July/August 1995 issue, pp. 77-79).

⁴ The "inactive reserve" is reportedly composed of intact warheads stored without the limited-life components, such as plutonium-238 batteries, neutron generators, and deuterium-tritium boost gas reservoirs.

⁵ Pantex Public Affairs Office to Robert S. Norris, private communication, May 1995; there were 7,239 pits in storage as of May 8, therefore there will be an estimated 7,700 pits in storage at end-FY 1995 [7,239-986+1,400=7,653].

Finally, another 2,500 warheads are destined for what the Pentagon calls the "hedge." When fully implemented in 2003, the hedge will be a contingency stockpile made up of warheads removed from active strategic forces, but not dismantled. The purpose of retaining them intact is so that they can be rapidly "reconstituted," to use the Pentagon's word. By redeploying them on bombers and missiles the Pentagon could return to something close to START I force levels if the need should arise. Thus, the real size of the future U.S. stockpile will be approximately 7,400 warheads after START II.

Assuming the U.S. retains 7,400 warheads under START II, by then the number of pits in storage should be about 15,700.⁶ Below we estimate that the U.S. has about 64.4 tonnes (t) of plutonium in assembled warheads and pits. This 64.4 t is spread among an estimated 22,730 pits, which works out to just under 2.8 kg per pit. Since a small fraction of the warheads, e.g. the B53, contain no plutonium, those pits containing plutonium would have on average something closer to 3 kg of plutonium per pit.

II. U.S. Government Owned Plutonium.

A. U.S. Government Owned Plutonium Production, Inventory, and Balance Sheet.

Table 3 is a balance sheet that summarizes the production, acquisition, removals, and remaining inventory of U.S. government owned plutonium in units of metric tons (t). This table excludes plutonium owned by U.S. commercial firms, including plutonium in spent fuel owned by private electric utilities. The notes along the right hand side identify from where within the DOE's report, "Plutonium: the First Fifty Years," the data are derived. The total plutonium entries in Table 3 are the same as, or refinements of, the balance sheet entries in Table 1 and Figure 1, of DOE's report, "Plutonium: The First Fifty Years," February 1996. In Table 3, we have provided more significant figures, where such data are available, and we break down the entries according to whether the plutonium is WGPu [$<7\%$ Pu-240], FGPU [$7\% \leq \text{Pu-240} < 19\%$], or RGPu [$\text{Pu-240} \geq 19\%$], which DOE does not do. Some of the entries in Table 3 are elaborated in more detail in subsequent tables in this report.

The DOE's plutonium inventory balance sheet excludes transactions that remain classified (see DOE, "Plutonium: The First Fifty Years," page 1, footnote 4). We believe this refers to supergrade and fuel-grade plutonium that was shipped during the 1980s by the U.K. to the U.S. for blending into weapon-grade plutonium. The total amount of still classified plutonium that shipped to the U.S. was probably less than three tonnes. Footnote 4 in the DOE report indicates that less than 100 kg of plutonium was retained by the U.S. We have assumed that amount was 50 kg (midway between zero and 100 kg).

⁶ From Tables 1 and 2 and footnote 4: $7,653 + (15,430 - 7,395) = 15,688$.

B. Location of U.S. Government Owned Plutonium Inventory.

Table 4 gives the location of the U.S. government owned plutonium as of the end of FY 1994, broken out by site, category of material, and grade of plutonium. From WGPu material balance considerations we estimate that as of the end of FY 1994 there were 66.1 t of plutonium in an estimated 15,375 weapons and 7650 separated pits. Assuming the same average of about 2.87 kg of WGPu per pit, the 66.1 t is distributed as follows: 32.7 t of WGPu (labeled DOD in Table 4) in the total inventory of stockpiled nuclear weapons; 11.5 t in warheads awaiting dismantlement; and 22.0 t in separated pits at Pantex.

C. Plutonium Produced in U.S. Government Production Reactors.

Table 5 summarizes the amount of plutonium that was produced by the DOE at its 14 production reactors--nine at the Hanford Reservation and five at the Savannah River Site--now all shut down. The 14 production reactors produced 103.442 t of plutonium, of which 90.542 t was WGPu. Only a very small amount, if any, reactor-grade plutonium was produced, and thus the remaining 12.901 t is categorized as FGPu. The cumulative production figures in Table 5 are not corrected for the radioactive decay of plutonium-241 (Pu-241).

As indicated in Table 3, in the 1980s the DOE blended 2.8 t of FGPu [12% Pu-240] with about 5.6 t of supergrade plutonium [3% Pu-240] produced at Savannah River to make 8.4 t WGPu [6%Pu-240]. This has the effect, as indicated in Table 3, of shifting 2.8 t Pu from the FGPu inventory to the WGPu inventory. Also in the 1980s, 425 kg of weapon-grade plutonium was recovered from spent fuel elements that were culled out of spent fuel discharged from the N-reactor that had been previously categorized as containing fuel-grade plutonium based on the overall average concentration of Pu-240.

D. Plutonium Produced in U.S. Government Non-Production Reactors.

Table 6 summarizes the amount of plutonium that was produced annually by the DOE at its various non-production reactors between 1952 and 1994. This table is a reproduction of Table 4 in the DOE report, "Plutonium: The First Fifty Years." Rounding the 551 kg up to 0.6 t the DOE report indicates that 0.1 t is WGPu and 0.5 t is FGPu. Actually, the report should have said 0.5 t is non-WGPu. To obtain DOE's material balance values in Table 3, we have assigned 71 kg as WGPu and 480 kg as RGPu.

E. Separated Plutonium Received by the U.S. Government From NFS West Valley.

Table 7 [copied from DOE, "Plutonium: The First Fifty Years," Table 5, p. 39] identifies that portion of the plutonium that was recovered by the commercial reprocessing plant owned by Nuclear

Fuel Services (NSF) at West Valley, New York, between 1966 and 1972, and sent to the Department of Energy. In the material balance sheet (Table 3), in order to avoid double counting, we do not include the AEC owned plutonium that was processed at West Valley.

F. Spent Fuel Received by the U.S. Government From U.S. Commercial Reactors.

The starting point for constructing Table 8 is DOE report, "Plutonium: The First Fifty Years," Table 6, p. 41. The DOE report indicates that there is 672.6 kg of plutonium in spent fuel received from commercial sources, and it lists the contributions to the total by electric utility/reactor. DOE indicates that almost all of the spent fuel is stored at three sites: Idaho National Engineering Laboratory (INEL), Savannah River Site (SRS), and West Valley Demonstration Project. Inquiries to these three sites gives slightly different values for some entries, and the storage locations for some entries in DOE's table have not yet been identified. Also, there are inconsistencies in the plutonium isotopic concentrations and fuel burnup values.

G. U.S. Government Owned Plutonium Exports and Imports.

Table 9 combines two tables from the DOE report, "Plutonium: The First Fifty Years.," namely Table 7 and 13 on pp. 44 and 71-72 respectively. This table does not include exports or imports of commercially owned plutonium, e.g., plutonium in commercially owned spent fuel.

H. Plutonium Losses Resulting From Radioactive Decay.

In Table 10 we have attempted to reconstruct the DOE estimate of the plutonium losses through radioactive decay of plutonium-241 (Pu-241) into americium-241 (Am-241). Pu-241 has a half-life of 14.35 years. The decay of other plutonium isotopes can be ignored. The DOE claims that 0.4 t of plutonium was lost through radioactive decay. As seen from Table 10, we arrive at a total of 345.6 kg (0.346 t) by tracking the decay of plutonium produced at the DOE production reactors at Hanford and Savannah River Site and the DOE non-production reactors. Here we have assumed that the average concentrations of Pu-241 in WGPu, FGpu, and RGPu are:

<u>Category</u>	<u>(%)</u>
WGPu	0.33
FGpu	1.2
RGPu	9.0

I. Excess Weapon-Grade Plutonium.

President Clinton announced on 1 March 1995, that "To further demonstrate our

commitment to the goals of the [Non-Proliferation] Treaty, today I have ordered that 200 tons of fissile material--enough for thousands of nuclear weapons--be permanently withdrawn from the United States nuclear stockpile. It will never again be used to build a nuclear weapon."⁷ Added to one tonne of WGPu-oxide and 10 t of highly enriched uranium (HEU) previously declared excess, a total of 38.2 t of WGPu and 174.3 t HEU have been declared to be in excess of U.S. national security needs, for a total of 212.5 t of weapon-usable fissile materials.⁸ The form and location (as of February 6, 1996) of the WGPu is given in Table 11, taken from DOE, "Plutonium: The First Fifty Years," Table 15, p. 76. Of the 38.2 t WGPu declared to be in excess of weapon requirements, 21.3 t is in pits at Pantex or among warheads to be dismantled in the future.

The Committee on International Security and Arms Control of the National Academy of Sciences recommended in 1994 that "The United States and Russia should make formal commitments that specific quantities of fissile material from dismantled weapons (*representing a very large fraction of those materials*) will be declared excess and committed to non-weapons use or disposal."⁹ (emphasis supplied) However, as seen from Tables 4 and 11, only one-third [21.9/66.1] of the plutonium in retired weapons is being declared excess of future weapon needs.

III. U.S. Government Owned Highly Enriched Uranium.

In Table 9 we present our accounting of DOE's HEU inventory. The uncertainties associated with some of our HEU inventory estimates are considerably greater than the uncertainties associated with our plutonium estimates. We have assumed that in recent years the U.S. had about 500 t of or alloy (~93.5% U-235) in weapons or assigned for weapon use.¹⁰ We believe this estimate is accurate to within ± 10 t. In addition, some thermonuclear secondaries contain uranium that has been enriched to something between 20% and 90% U-235, as evidenced by the fact that the DOE recently transferred to the U.S. Enrichment Corporation (USEC) 50 t of weapons HEU, of which 5 t was 70%-enriched and 45 t of 37.5%-enriched.¹¹ Although technically this is HEU because it is enriched to $\geq 20\%$ U-235, we will refer to it as medium-enriched uranium (MEU), to distinguish it from or alloy (~93.5% U-235).

The amount of MEU produced for weapons is not known by us. We have assumed it was on

⁷ President William Jefferson Clinton, Address to the Nixon Center for Peace and Freedom Policy Conference, Washington, D.C., 1 March 1995.

⁸ DOE, Openness Press Conference, February 6, 1996, Fact Sheets.

⁹ Committee on International Security and Arms Control, National Academy of Sciences, *Management and Disposition of Excess Weapons Plutonium*, (Washington, D.C.: National Academy Press, 1994), p. 108.

¹⁰ Thomas B. Cochran, William M. Arkin, Robert S. Norris and Milton M. Hoenig, *Nuclear Weapons Databook, Volume II: U.S. Nuclear Warhead Production*, (Cambridge, MA: Ballinger Publ. Co., 1987), p. 191.

¹¹ William Broad, "Quietly, U.S. Converts Uranium into Fuel for Civilian Reactors," *New York Times*, 19 June 1995, p. A10.

the order of 100 t of oralloy equivalent, and further assumed that 10% was at 70%-enriched and 90% was 37.5%-enriched, similar to the material turned over to USEC. Thus, we assume that there were about 23 t of 70%-enriched uranium and 206 t of 37.5%-enriched uranium. These estimates appear reasonable in that DOE has announced that through 1992 it produced 994 t of HEU for all purposes. We have identified from unclassified DOE sources about 50 t of HEU--exclusive of HEU for weapons and naval fuel--that were in storage prior to the transfer of the 50 t to USEC. Subtracting this 50 t and the 730 t we have allocated to weapons from the 994 t total leaves about 220 t of HEU to fuel naval reactors, civil reactor and test reactors and makeup fuel for the Savannah River production reactors over the 1945-1992 period. This seems reasonable in light of what we know about these reactor requirements.¹²

The 50 t of HEU in storage noted above includes 24.4 t of HEU, containing about 50% U-235 and about 35% U-234. This HEU started as fresh 97.3%-enriched naval reactor fuel, was subsequently recovered from spent naval fuel, then used to make fresh Savannah River production reactor fuel, and then recovered again, which accounts for the high concentration of U-234. Also in storage is some very highly-enriched uranium that was intended to be naval fuel but which did not meet Navy specifications. In this category are 13.2 t in the chemical form UF₆, and a few tonnes (we have assumed 3 t) of metal. Also, there are the 10 t of oxide in Vault 16 at Y-12 under IAEA safeguards. There may be other stocks that we have missed.

In Table 9, the 175 t that has been declared excess consists of the 165 t associated with Clinton's 1 March 1995 declaration and the 10 t already in Vault 16 at Y-12. We are told that the Navy has refused to permit any oralloy metal from being included in the 175 t excess, in order to retain it for future use as naval reactor fuel. Under these assumptions we estimate that of the 175 t of HEU declared excess, about 125 t is from weapons, and it is all MEU. Of these 125 t of MEU, 50 t has already been turned over to USEC and is being blended down to make low-enriched uranium (LEU) fuel for future use in commercial power reactors. About 40 t of the 175 t declared excess was never meant for weapons. This 40 t includes the 16 or so tonnes of scrap naval fuel and the 24 t of high U-234 content uranium at the Savannah River site.

¹² *Nuclear Weapons Databook, Volume II: U.S. Nuclear Warhead Production, Appendix D.*