# Military and Excess Stocks of Highly Enriched Uranium (HEU) in the Acknowledged Nuclear Weapon States

**June 11, 2004*, Revised June 30, 2005***

## Table 1 Estimated Military and Excess Stocks of Highly Enriched Uranium (HEU) in the Acknowledged Nuclear Weapon States, end of 2003 (in tonnes)

| | **Total(a,b,c)** | **Assigned to Naval Propulsion** | **Other Stocks(d)** | **Declared Excess** | | **Safeguarded** | **Primary Military Stocks(e,f)** |
|---|---|---|---|---|---|---|---|
| | | | | **Original** | **Remaining** | | |
| Britain | 21.9 (±?)(g) | 5-7(h) | ? | 0 | n.a. | n.a. | 16 |
| China | 21 (±5) | ?(i) | none? | 0 | n.a. | n.a. | 21 |
| France | 29 (±7) | 1(j) | 3.5(k) | 0 | n.a. | n.a. | 25 |
| Russia | 1070(±300)(l) | 40-70(m) | 5-10(n) | 500(o) | 300 | 0 | 710 |
| U.S. | 700 (±50) | 100 | --(p) | 174.3(q) | 123 | 10 | 480(r) |
| **Total(s)** | **1840 (±360)** | **150-180** | **8-14** | **674** | **423** | **10** | **1250** |

**Notes and Comments**

(a) The values in the parentheses are the uncertainty ranges of the total estimated stock. The British value is an official declaration, and no uncertainty was provided by the government.
(b) The composition of military HEU stocks includes warhead parts, metals, oxides, process residues, compounds, solutions, fresh and irradiated reactor fuel, hold-up materials in facilities, sources, and standards.
(c) The values in this table represent estimates and characteristics of total stocks of military HEU as of the end of 2003. These numbers include the amount of HEU in naval and production reactor programs.
(d) This column includes mainly HEU used in military production reactors. See relevant footnotes for more details.
(e) This column lists estimates of the primary military stocks that contain HEU, mostly weapon-grade, assigned to nuclear weapons, reserves, or slated for future use in naval propulsion, other military programs or civil reactors. In the case of the United States, some of this HEU will be sold or assigned to civil research reactors. This stock does not include any HEU already declared excess to military requirements or already scheduled to be excess HEU, as in the case of Russia's commitment to down blend 500 tonnes of HEU into LEU.
(f) These values represent central estimates only and are rounded.
(g) In 1998, Britain declared that it had 21.9 tonnes of HEU in its military stock. It did not declare any of this amount excess to military requirements, announcing that any HEU not required for nuclear weapons would be used instead in its naval propulsion program. In addition, the declared stock reportedly did not account for fission and transmutation of the contained uranium 235 in reactors, particularly naval reactors.
(h) The value assigned to the British naval propulsion program is highly uncertain, and most of this value would represent irradiated HEU stored in Britain. It has not been reduced by the amount of uranium 235 that fissioned in reactors. One would expect that on order of a tonne of uranium 235 fissioned.
(i) In the mid-1980s, Chinese naval propulsion reactors were reported to use LEU fuel. The type of fuel used after this date is unknown.
(j) The bulk of France's nuclear powered vessels used LEU fuel. However, one or two of its strategic submarines used HEU fuel. These submarines were reportedly designed to need only one refueling during their lifetime.
(k) The Celestin military production reactors use HEU fuel. Through the end of 2003, these reactors are estimated to have required about 5 tonnes of weapon-grade uranium fuel. Assuming a uranium 235 consumption of about 40 percent, the amount of irradiated HEU is estimated at 3.5 tonnes.
(l) Russia's HEU inventory remains difficult to estimate. Little public information is available about Russian HEU production or stocks, and thus the uncertainty in the total estimated stock remains large. Although Russia's production of HEU for weapons

ended in 1987 or 1988, it is believed to have continued making HEU into 1989 and to have stopped by 1990. Because this estimate factors in total Russian HEU production, it is greater than earlier estimates made by this author in the 1990s.

(m) Russia is estimated to have roughly 40-70 tonnes of HEU assigned to its naval program. The lower value is less than a DOE estimate of 60 tonnes of weapons-usable material, assumed to be almost all HEU, discussed in official literature about U.S./Russian MPC&A measures on naval fuel. The reason is that this 60 tonne estimate may not have accounted for fission and transmutation, and thus it would represent initial masses of HEU in the fuel. The higher value assumes that some HEU remains in the naval program outside the scrutiny of the MPC&A effort, such as at naval fuel fabrication facilities or in storage following recovery prior to the demise of the Soviet Union.

(n) Russia is reported to have used HEU in its plutonium production reactors and its tritium production reactors. Although the practice prior to the demise of the Soviet Union was reportedly to recover the HEU from the irradiated fuel and recycle it in naval reactors, not all the HEU may have been recycled. In addition, since the early 1990s, this HEU may not have been recycled.

(o) Russia has committed to blending down 500 tonnes of HEU to LEU. As of the end of 2003, about 201 tonnes of HEU had been blended down.

(p) The HEU in fresh and irradiated production reactor fuel is included in the excess value.

(q) In late 1994, the United States declared as excess to military requirements about 174.3 tonnes of HEU (average enrichment is 60 percent). This stock is dynamic, in the sense that more HEU has been added to it and a significant amount has been blended down to low enriched uranium. Subsequent to its original announcement, the DOE has not released an updated value for this excess inventory. Through the end of 2003, about 51 tonnes of this HEU were blended down into low enriched uranium. About 48 tonnes were downblended by USEC for sale as power reactor fuel. About 3 tonnes of “off-spec” HEU were recently blended down for use in TVA power reactors starting in 2005. About a half tonne of HEU was blended down to slightly below 20 percent uranium 235 for use in research reactors. Subtracting the amount of HEU down blended from the original declared quantity leaves an excess stock of 123 tonnes as of the end of 2003.

(r) This stock has an average enrichment of about 90 percent.

(s) Rounded.

## Table 2 Status of Highly Enriched Uranium Production in the Five Acknowledged Nuclear Weapon States, end 2003

| | Has uranium enrichment for nuclear weapons ended? | ISIS Estimate of When Uranium Enrichment for Nuclear Weapons Ended | Official Announcement of End to Uranium Enrichment for Nuclear Weapons | Did HEU production continue for other purposes? | Has all HEU production ended? | Did the military plant(s) continue to operate to produce LEU? |
|---|---|---|---|---|---|---|
| France | Yes | 1996 | 1996 | No | n.a. | No (a) |
| China | Yes | 1987 | No Announcement | Possibly | n.a. | Yes (b) |
| Russia | Yes | 1987-88 | 1989 | Yes | Yes – by Early 1990s | Yes |
| United Kingdom | Yes | 1962 (c) | 1995 | No (d) | n.a. | Yes (e) |
| United States | Yes | 1964 | 1991 | Yes | Yes – 1992 (f) | Yes |

(a) France made HEU in the Pierrelatte facility, which shut down in 1996.
(b) After 1987 or 1988, Chinese enrichment plants continued to produce LEU for civil purposes and probably for naval propulsion. It is unclear if any HEU was produced for naval propulsion after this date.
(c) Under agreements with the United States, the UK could buy HEU from the United States after the UK ended domestic production.
(d) Between 1984 and 1991, the Capenhurst facility continued to make 4.5% enriched uranium which was sent to the United States for final enrichment to weapons grade.
(e) Urenco has operated the Capenhurst plant since 1993, and it is under Euratom and IAEA safeguards.
(f) Although enrichment ended in 1992, small (kilogram) quantities were withdrawn from the cascades over the next several years

## Table 3 Current and Projected US and Russian Stocks of Excess Highly Enriched Uranium (HEU) based on Plans of the Department of Energy (DOE) and United States Enrichment Corporation (USEC), (in tonnes)

| | Total Declared | Disposition Scheduled to End | End 2003 | 2010 | 2018 |
|---|---|---|---|---|---|
| **Russia** | **500** | **2013** | **298** | **88** | **0** |
| **United States** | | | | | |
| Transferred to USEC | 64 | 2006 | 16 | 0 | 0 |
| Research reactor fuel | 10 | 2010 | 9.5 | 0 | 0 |
| To be blended and sold by DOE | 28 | 2018 | 28 | 28 | 0 |
| Off-spec fuel program (TVA) | 33 | 2015 | 30 | 17 (a) | 0 |
| Other off-spec HEU | 18 | 2018 | 18 | 4.8 (a) | 0 |
| Spent fuel and other waste | 21 | 2018 | 21 | 21 (b) | 21 (b) |
| **US totals** | **174** | | **123** | **71** | **21** |
| **Total** | **674** | | **421** | **159** | **21** |

(a) ISIS projections based on assumption of a linear decrease in the values. The actual rate of decrease may differ significantly. Six additional tonnes of off-spec HEU were assigned to the Tennessee Valley Authority (TVA) program in 2004. This HEU is to be transferred to TVA by 2007 for use by 2015. For the purpose of these calculations, it is arbitrarily assumed that transfer of all six tonnes from 'Other off-spec HEU' to the TVA program occurs in 2007, the last year given by the DOE for such a transfer.

(b) This HEU is in forms that are not suitable for downblending and use. It will likely be held in its current state until disposal can be arranged.