



CH04A0005

**SUPPLY OF LOW ENRICHED (LEU)
and HIGHLY ENRICHED URANIUM (HEU)
FOR RESEARCH REACTORS**

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Abstract

Enriched uranium for research reactors in the form of LEU (= low enriched uranium at 19.75 % U-235) and HEU (= highly enriched uranium at 90 to 93 % U-235) was and is - due its high U-235 enrichment - a political fuel other than enriched uranium for power reactors.

The sufficient availability of LEU and HEU is a vital question for research reactors, especially in Europe, in order to perform their peaceful research reactor programs.

In the past the USA were in the Western hemisphere sole supplier of LEU and HEU.

Today the USA have de facto stopped the supply of LEU and HEU, for HEU mainly due to political reasons.

This paper deals, among others, with the present availability of LEU and HEU for European research reactors and touches the following topics:

- Historical US supplies
- Influence of the RERTR-Program
- Characteristics of LEU and HEU
- Military HEU enters the civil market
- What is the supply situation for LEU and HEU today?
- Outlook for safe supplies of LEU and HEU

1. Historical US-supplies of LEU and HEU

Following President Eisenhower's "Atoms for Peace" initiative (1953) and subsequent US legislation (Atomic Energy Act), the USA transferred to Europe a "flood" of secret information about the peaceful use of atomic energy, and the first research reactors were constructed in Western Europe. The enriched uranium in the fuel elements was in most cases at the beginning below 20 %, i. e. 19.75 % U-235 (LEU).

In the sixties the U-235 assay in the fuel elements could be easily adapted to the assay of weapons grade material of 93 % U-235 (HEU) and the USA made without difficulties HEU available to research reactors in Western Europe. Until 1974 the HEU could be leased from the former US Atomic Energy Commission (AEC); the research reactor operators had only to pay a relatively low lease charge of less than 5 % per year on the value of the HEU.

In 1974 the former AEC changed its supply policy and research reactor operators had to purchase the HEU. In 1977, however, US-President Carter became concerned about the "wide spread of weapons usable material" in research reactors. He initiated the International Fuel Cycle Evaluation (INFCE) and specially its working group 8 to minimize the traffic of HEU. As a result of the working group 8 it was decided that the ideal U-235 assay in the sense of non-proliferation should be less than 20 %, namely 19.75 % +/- 0.2 %. The development of such a high density fuel was initiated by the Reducing Enrichment in Research and Test Reactors (RERTR) Program of the US-Department of Energy (DOE) with international cooperation.

2. Influence of the RERTR-Programme on LEU and HEU supplies

What influence/success has now the RERTR-Program on the supplies of LEU and HEU outside the USA?

Table 5 contains a breakdown of US-HEU exports from the 50ties until 1991 which was prepared by the United States Regulatory Commission (NRC) to the US Congress in 1993. After checking of these figures I personally came to the conclusion that the report includes under the HEU amounts also 19.75 % U-235 uranium and intermediate assays such as 35 % and 45 % U-235 which have also been exported together with HEU. EURATOM countries are said to have received from the USA around 21 metric tons (mt) of HEU and non-EURATOM countries around 4.6 mt, totally to approx. 26 mt of HEU (which I believe contain the figures for LEU). If you are looking more close to these figures (see Table 6) it can be easily noted that Germany received the biggest portion (around 11.3 mt) followed by France (7.2 mt) and UK (2 mt).

Where can now the influence of the RERTR programme be seen in the present supply situation?

Table 7 shows the annual average exports of LEU (19.75 %), MEU (45 %) and HEU (93 % U-235) by the US-DOE to Europe.

My comments with regard to these figures are as follows:

19.75 % enriched uranium:

Table 7 shows annual exports of only 80 kgs from 1983 to 1993. The relatively small quantities are due to the fact that there were sufficient stocks outside the USA. Consequently there was no need for the export of LEU from the USA. The stocks of LEU outside the USA are due to the availability of LEU which was no longer used at the time of termination of certain research projects.

45 % enriched uranium:

Some countries (especially Japan) elected their own way during the conversion of the enrichment of 93 % to 19.75 %. They used fuel elements with uranium having a U-235 assay of 45 % as an intermediate enrichment for a certain time. The procurement of 45 % enriched uranium was terminated in 1991; the USA exported in the decade 1983 to 1991 approx. 600 kgs of uranium (45 % U-235 enriched).

93 % enriched uranium:

In the period 1983 to 1993 the USA exported approx. 1300 kgs of HEU. In 1994 supplies came to a complete stop due to the implementation of the U.S. Energy Act 1992 which de facto stopped all HEU exports. In addition safeguards problems occurred at the Y-12 plant in Oak Ridge which prevented physically the supply of HEU.

3. Characteristics of LEU and HEU

As the research reactor community is aware, NUKEM developed in collaboration with fabricators of fuel elements for research reactors standard specification form "Commercial grade LEU" as per Tables 8 to 10 for LEU. Specification for HEU are similar, take, however, into account higher values for U-232, U-234 and U-236.

4. Military HEU enters the civil market

In the past years there has been a lot of speculation about the amount of stocks of military HEU accumulated by the weapon states USA and Russia.

NUKEM published closer information in its monthly NUKEM Market Report (NMR) in the past. The facts are seemingly as follows:

The USA produced altogether approx. 1000 metric tonnes (mt) HEU and Russia approx. 1500 mt, totalling to approx. 2500 mt HEU (see table 11). U.S Energy Secretary's Hazel R. O'Leary's "new openness" initiative lifted the veil of secrecy on America's stockpile of military HEU - and how much of it would never be used again to build nuclear weapons. Accordingly approx. 483 mt have been produced by the K-25 plant at Oak Ridge and 511 mt at the Portsmouth Plant (Table 12). This year, the U. S. Energy Secretary declared 174.3 mt of the HEU excess (Table 13).

This excess material plus additional declassified material is so far is in the order of 259 mt, leaving the U.S. government with 735 mt. If one were to subtract HEU requirements for past government bomb testing, nuclear navy and research , the amount in the U. S, stockpile would drop to about 500 mt of highly quality material.

In 1993 a government-to-government agreement was concluded between the U. S. and Russian and calling for USD 12 billion worth of LEU from Russian weapons-grade HEU (500 mt) to be converted into 15.000 mt of LWR-fuel over a period of 20 years (Tables 14 and 15). The blended 4.4 % U-235 enriched uranium has a content of 152.000 mt of natural uranium equivalent which corresponds to a factor of 4.4 of the world production of natural uranium (34.200 mt in 1995, Table 16).

The enormous quantity of natural uranium equivalent contained in the downblended 500 mt of HEU of Russian origin will certainly influence the market for natural uranium in the following years.

5. What is the supply situation for LEU and HEU today?

Table 17 shows the suppliers of LEU today.

US-DOE can at the moment not supply due to safeguards problems at the Y-12 plant. Resumption of production of LEU is anticipated in 1998.

UKAEA remains a supplier for LEU and performs processing and recovery services.

Russia, by several suppliers, remains supplier for LEU and performs processing and recovery services.

NUKEM disposes of large stocks of LEU.

China is not in the market.

Cogéma remains a supplier for LEU and performs processing and recovery services.

6. Outlook for safe supplies of LEU and HEU and conclusion

Due to available stocks and production possibilities the supply of LEU for research reactors is safe far beyond the year 2000.

Certain European Research Reactors, however, must furthermore use HEU in order not to stop reactor operation. Since the USA de facto have stopped after 1993 exports of HEU. Ways have to be found to ensure its availability in Europe; i. e. by using available stockpiles, even if the enrichment is less than 93 % and purchases from other sources.

It was a great pleasure to present this paper to you and I thank you for your attention.